Australian Apple & Pear Growers Association Inc

Horticulture Australia

AA0033

Pomefruit Pesticide reduction strategies for the 2000's

Final report

Photograph taken by Andy Jordan in the apple 'pesticide reduction orchard' block of Eric, John and Roger Haynes - Pozieres Queensland.

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Queensland Government
Department of Primary Industries

FINAL REPORT FOR PROJECT AA0033

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MEDIA SUMMARY

Apple and pear growers throughout Australia have funded research and development technology projects to reduce pesticide use to the value of $3 million. This has assisted in the development and grower application of these technologies in orchard plant protection practices such as practical prediction systems for monitoring pest and disease outbreaks, non-pesticide pest and disease management methods and improvements in spray application technology.

Pest and disease monitoring is the key to avoiding losses from primary as well as secondary pests, when reducing pesticide use in apple orchards, where the biological balance and plant protection management is complex. Practical monitoring methods for major pests such as codling moth and predictive disease bulletins for apple scab (black spot) has enabled pesticide decisions to be made by growers on current pest and disease activity, rather than by 'gut feeling' or 'what I did last year worked' methods. Regular information updates of pest and disease occurrences give growers the confidence to alter plant protection strategies on a weekly basis, rather than yearly based on fruit losses, when the crop is harvested.

Monitoring of commercial apple orchards blocks over a number of seasons has shown, that pesticide rates required for pest and disease control are dependent on the level of pest and disease in each orchard, as well as pesticide application efficiency. Data from one season's monitoring enables a grower to plan plant protection needs for the next season. For example, if codling moth numbers are low, alternative non-pesticide methods such as pheromone mating disruption technology (twisties) may be used to reduce total pesticide use by up to 20%. Assessing potential apple scab disease in autumn allows a grower to reduce inoculum in fallen leaves over-winter by leaf sweeping and mulching and reduce fungicides in spring by 20%. Information 'Warning' services, which predict apple scab ascospore release, allow reduction of post-infection fungicides by 20 – 30%. Predatory mites, monitoring and use of non-disruptive pesticides has resulted in the reduction of mite sprays to between 0 and 2 sprays per season.

Adoption of technologies to improve pesticide spray application efficiencies allows pesticide reductions of 20-50%. These reductions are achieved through calibration of orchard sprayers, spray nozzle changes and matching spray volume to tree canopy size. Spraying time can be reduced by more 50% with efficient spray application techniques using lower volumes of spray. Hail netting of orchards reduces pesticide spray drift and has potential to exclude fruit damaging pests such as fruit flies, birds and flying foxes.

When pesticides are applied, when the dose is determined by the orchard pest and disease population, tree canopy size and pesticide application method, environmental contamination and fruit residues are minimal.

Growers who are adopting this technology are enabling the apple and pear industries to be recognized as 'world class' in plant protection management and ensuring the safety of their product and orchard environment for themselves, family and workers.

TECHNICAL SUMMARY

This project has shown growers how to apply plant protection technologies in orchards such as practical prediction systems for monitoring pest and disease outbreaks, non-pesticide pest and disease management methods and improvements in spray application technology and reduced pesticide use by more than 75 percent.

Pheromone mating disruption technology (twisties) for codling moth and light-brown apple moth has been used to reduce total pesticide use by up to 20%; reducing apple scab (black spot) disease inoculum in fallen leaves over-winter by either leaf sweeping and mulching or urea ground sprays in early spring and the advice of 'Warning' services, which predict apple scab ascospore releases allowed reduction of post-infection fungicides by 30 – 50%; predatory mites, monitoring and use of non-disruptive pesticides has resulted in the reduction of mite sprays by 40 -100 percent. Pesticide spray application efficiencies allowed pesticide reductions of 20-50%.

The complex biological balance of apple orchards demands close monitoring to avoid losses from primary as well as secondary pests and diseases. Regular information updates of pest and disease occurrences give growers the confidence to alter plant protection strategies on a weekly basis, rather than on a yearly basis from fruit losses when the crop is harvested. Practical monitoring methods for major pests such as codling moth and predictive disease bulletins for apple scab has enabled pesticide decisions to be made by growers on current pest and disease activity, rather than by 'gut feeling' or 'what I did last year worked' methods. Monitoring of two commercial apple orchards blocks over a number of seasons has shown, that pesticide rates required are dependent on the level of pest and disease in each orchard, as well as pesticide application efficiency. Data from one season's monitoring enables a grower to plan plant protection needs for the next season.

Our field trial results show pesticide rates can be reduced by 20% after simple modifications to low-profile air blast sprayers by changing spray nozzle, using air baffles and matching spray volume to tree canopy size and 40% using tower sprayers, while maintaining excellent control of pests and diseases. Low Profile orchard sprayers were less efficient when tree height exceeds 3.5 metres, so tower sprayers are recommended for trees above this tree height to ensure pest and disease control efficiency. Our trial results show that spraying time can be reduced by more 50% with efficient spray application techniques using lower volumes of spray. Grower surveys show that pesticide spray volumes vary for most apple orchards from 900 to 2000 litres per hectare at 'dilute label rates'. Often these orchards have similar size trees. Where pest and disease levels are known, the lower rates can be applied with confidence that fruit losses will not occur. Our results show that fruit residues are not altered regardless of the concentration of the pesticide application, when applied as per label recommendations.

Growers have opportunities to reduce pesticide in new orchards, where pest and disease levels are low and canopy size and tree structure are managed to enable good spray penetration. Hail netting of orchards reduces pesticide spray drift and has potential to exclude fruit damaging pests such as fruit flies, birds and flying foxes.

Pesticide labels for apples and pears recommend volumes from 1800 to 2800 litres per hectare. Our orchard research trials show that, when applied efficiently the optimum spray volumes for any tree size and training system should not exceed 2500 litres per hectares as a 'dilute' spray applications, because any additional pesticide captured by the canopy has a higher proportional loss to off target areas as drift or runoff.
A common application spray volume for apple and pear growers across Australia is 1000 litres per hectare at twice (2X) the dilute rate per 100 litres on the label. Pesticide labels recommend product rates per 100 litres and /or per hectare. These methods of calculating pesticide dose are inappropriate on three-dimensional tree crops of variable size, where low spray volumes are applied. The pesticide residues levels on fruit, following applications of pesticide concentrations in lower spray volumes, were not increased.

When pesticides are applied, when the dose is determined by the orchard pest and disease population, tree canopy size and pesticide application method, environmental contamination and fruit residues are minimal

INTRODUCTION

The pomefruit industry has pesticide reduction as a high priority issue as signatory to the Pesticide Charter 1991, which was developed by environmental, conservation, health, consumer and grower groups. The Charter was drafted as the basis for a national policy on pesticides within the framework of the 'Towards a National Food Policy' with long term aims to reduce pesticide residue contamination of food, soil and water.

In a project 'Pesticide reduction in pomefruit for year 2000' prior to this project commencing, we demonstrated that significant reductions in pesticide use were possible through orchard sprayer modifications and limited pest and disease monitoring. Pomefruit growers throughout Australia have reduced pesticide use to comply with Industry policy in the Pesticide Charter. A number of growers in the apple and pear growing areas of Australia have made significant changes to their plant protection programs and reductions in pesticide use. Many of these growers have reduced pesticide use by more than 75 percent, but with little recognition of their efforts in reducing pesticide in marketed fruit. This project interviewed growers from a number of regions and document and publicised the positive impact of their plant protection practices, as well as the improvements in their orchard plant protection systems and orchard health.

Monitoring of pest and disease populations allows adoption of alternative plant protection strategies for pest and disease control such as:

- pheromone 'twisties' for codling moth and light brown apple moth control to replace insecticides;
- urea sprays in Autumn or Spring or leaf sweeping and mulching during winter, to reduces apple scab carryover enabling reduced fungicide to be applied in spring;
- 'softer' pesticides to ensure predator survival particularly for integrated mite control;
- precise pesticide applications and often at reduced pesticide rates.

We applied these plant protection strategies to two commercial orchards and monitored results over two seasons.

Our previous research indicated that reduced spray volumes are as efficient for canopy coverage as higher spray volumes, particularly if the spray application equipment is matched to the tree size and canopy density. In addition less off-target losses occurred from low-volume spraying. As orchards increase in size, the time taken for pesticide application also increases, where conventional methods of high volume application are maintained. To reduce the time needed to spray the orchard, many orchards are reducing application volumes of pesticides and increasing the concentration so that similar pesticide rates as high volume application are applied. For pesticides without a rate per hectare or a concentration rate on the label, this 'low volume' practice cannot be recommended. A series of trials on commercial apple orchards were conducted over the life of this project to test the effectiveness and efficiency of low volume spray applications of pesticides. Our aim was not only to increase the pesticide deposit on the orchard trees by improving the coverage throughout the height and depth of the tree canopy, but also reduce off-target losses through run-off and drift. We wished to confirm that a sprayer performance could be greatly enhanced by using air baffles, nozzle extension arms and by using more of the same size nozzle (i.e. nozzle doubles or triples) in place of large orifice nozzles. In our field trials we tested commercial sprayers, which were normally fitted with these modifications. In these trials we placed greater emphasis on testing concepts and practical methods that would assist growers in more efficient use of pesticides. Our spray application research in this project tested:

- effect of a range of spray application volumes on:
  - canopy deposit on a range of tree sizes
  - pesticide deposit on fruit and residues breakdown prior to harvest,
  - off-target pesticide losses as direct ground spray or drift
- efficiency of low-profile orchard sprayer modifications
- relationship of low-volume application deposit to travel speed and tree size
- effect of alternate row spraying on tree canopy deposit.

The effects of low volume concentrate pesticide application on fruit residues is important, for domestic and export market assurance for public safety and for the development of generic pesticide label changes for tree crops by the National Registration Authority.

MATERIAL AND METHODS

1. Grower pesticide reduction case studies

To highlight pesticide reduction successes of the pomefuit industry, a number of growers from regions throughout Australia were interviewed and their present and plant protection methods were documented with the positive impacts these practices were having on their attitude to plant protection and their production methods. Grower case studies from Queensland, South Australia and New South Wales were publicised in a number of grower magazines such as Good Fruit and Vegetables and Pome Fruit News, also many locally produced newspapers in apple and pear growing districts of these states as well as national newspapers and magazines.

Appendix 1 outlines these grower case studies and the various pest and disease that are of significance to each of these growing areas as well as the alternative strategies that particular growers were using to manage these plant protection problems, while also reducing pesticide use.

Growers interviewed included;
Eric, John and Roger Haynes, Pozieres, Queensland;
Michael and Sharon Smart, Batlow , New South Wales;
Roger Flavell and Kim Green, Lenswood, South Australia.

2. Monitored commercial grower blocks

Two commercial grower blocks were monitored over 2 seasons to determine the potential for reduced pesticide use and resultant fruit damage. The orchard blocks were 8 and 10 year old mixed double rows of Red Delicious and Granny Smith. The blocks were assessed each autumn for leaves with apple scab (black spot) to determine potential ascospore dose (PAD) or apple scab disease potential for the coming spring. These blocks were also monitored for codling moth with pheromone traps, which were checked each week from October and stick bases in these traps replaced monthly. Plant protection programs, monitoring data and resultant fruit losses were discussed with growers each season and possible pesticide reduction changes suggested for the following season.

3. Spray application orchard trials.

a. Experimental sites and sprayers

Field trials were conducted in three commercial apple orchards as well as the Applethorpe Deciduous Fruits Research Station at Stanthorpe, Queensland. The sprayers used were low profile airblast sprayers (Vendrame and Hardi TE1075) and a tower air-shear sprayer (Silvan HiLow configuration). The emphasis of the testing was not specifically on the sprayer performance but rather testing concepts and strategies for utilising pesticides more effectively. Where appropriate we did make minor enhancements to some sprayers and these tested against the original set-up to determine whether the sprayer performance was improved.

b. Spray Deposit Measurements

Spray coverage of leaves and fruit is required for assessment of spray machinery when

considering protectant fungicide, insecticide, miticide and nutrient thinning applications in pomefruit. In the field experiments, a fluorescent tracer was used for analysis of the leaf and fruit deposits. The formulation comprised of a suspension concentrate of 500g/L of Uvitex OB. In most trials the tracer was used at rates ranging from 30 to 50 g/ha.
A sample was always taken from the spray tank after thorough agitation, during and after spraying each treatment. The tank sample was required to establish the exact concentration of tracer so that we could determine the actual amount applied per hectare.

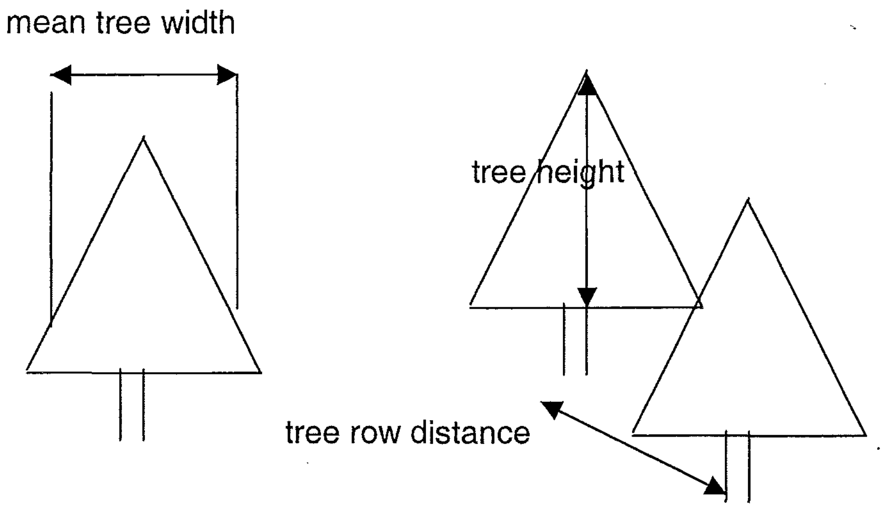
c. Field Sampling
After spraying, trees were allowed to dry and three or more leaves collected from six sites on each tree. The six sites usually comprised of three heights (bottom, middle and top) and two canopy positions an inner and outer. The height positions varied from trial to trial and depended on the overall tree height. The aim of sampling was to obtain an unbiased estimate of the average tracer deposit in the whole tree as well as determine the within tree variability. When sampling, trees of the same size were selected to minimise the tree to tree variation within treatments. In some trials the tree size was the treatment (i.e. we interested in how tree size affected spray deposition and recovery). Depending on the number of treatments conducted in each trial, anywhere from four to six trees were sampled. The sample heights shown on the tree diagrams represent the mid point of the sampling region. Samples were always stored in paper bags and then placed in large black garbage bags and placed in the shade. All samples were usually processed within two days of having conducted the trial. Previous developmental work with this tracer has shown no appreciable difference in the tracer recovery after this period.

d. Deposit Units
All the results are presented as the weight of tracer per unit area i.e. nanograms of dye per square centimetre of target, per gram of tracer applied per hectare, $(ng/cm^2)/(g/ha)$. The later allows direct comparison of two treatments even when the rate of tracer applied per hectare is different as it normalises it to every gram of tracer. It also allows the deposit level to be compared irrespective of the total application volume applied.

e. Tracer Technique Development
Over the duration of this project and through trials undertaken in other crops the fluorescent tracer technique used to quantify spray deposits has been greatly enhanced. Chlorophyll extracted from leaves quenches the fluorescent reading and produces lower readings than expected. This biases the results and the tracer concentration is actually underestimated. To overcome this higher rates of tracer, up to 50g/ha are used. In the laboratory samples are diluted and this eliminates the chlorophyll quenching whilst still having sufficient tracer to quantify the spray deposit.

f. Tree Row Volume Measurements
Included in the trial description page are the approximate tree row volumes (TRV) in m^3/ha for the orchard sites where trials were conducted. The TRV's are approximate as the formula used assumes the tree is a rectangular box and is continuous along the row. This is rarely the case and often we have taken an average tree height and width. The formula used to calculate tree row volume is shown below.

$$\text{Volume (m}^3\text{/ha)} = \frac{\text{tree canopy height (m) x tree width (m) x 10,000}}{\text{row distance (m)}}$$



Spray application orchard trials tested:
The details of seven field trials on a range of orchard sprayers in pomefruit are contained in *Appendix 2.* The details and results of 41 distinct treatments are presented, showing a diagrammatic view of the orchard sprayer tested, nozzle configuration, spray travel speed, volume applied, operating pressure, approximate tree canopy volume, tree height, orchard tree spacing, training system and variety with tree diagrammatic pictures showing the dye deposit captured on the leaf canopy or fruit from the sprayer tested. These trials were undertaken over three seasons, the 1997/2000. The trials build on the 17 trials that were conducted as part of HRDC project "Pesticide Reduction in Pomefruit for the year 2000".

Effects of spray application volumes on canopy deposit on a range of tree sizes and spray losses direct to ground and drift.
A modified Vendrame orchard sprayer applied 839, 1006 and 508L/ha across 4 tree canopy shapes and sizes (tree row volumes) to determine canopy capture of each volume and tree size as well as potential tree loss as spray drift. *(see Appendix 2 - pages 3-20).*

Effect of spray application volumes on canopy coverage and deposit, fruit pesticide deposit (dose) and pesticide breakdown on fruit prior to harvest.
A Hardi low-profile orchard sprayer applied 235, 470, 1063, 1850 and 3700L/ha to blocks of 4 apple trees in an orchard trial, where a spray dye was applied at proportional

concentrations as 8, 4, 2, 1 and 1 times concentration respectively, then leaf samples were taken to determine canopy coverage and deposit *(see Appendix 2 - pages 20-27).*

A similar range of pesticide volumes and concentrations of commonly used pesticides were also applied by the Hardi low-profile orchard sprayer to the same trees, then fruit collected over the pre-harvest period and tested for pesticide residues as outlined in Fruit residue trials 1 and 2.

Fruit residue trial 1

Gusathion and Captan at 235, 470, 1063, 1850, 3700 litres per hectare at respective spray concentration of 8X, 4X, 2X, 1X and 1X were applied to 4 Red Delicious apple trees (3-3.5m in height) by a Hardi low-profile orchard sprayer, 4 weeks before harvest to determine pesticide residue breakdown on fruit from these pesticide application methods. Four fruit per tree were then collected, from the inner/outer/lower and higher sections of the canopy of each of 4 sprayed trees, at 0, 1, 7, 14, 21,28 days post chemical applications then analysed for fruit residues of these pesticides.

Treatment number	Chemical	Product/formulation	Mixing rate	Concentration	Spray volume/ha
1	captan azinphos methyl	Captan 800g/kg Gusathion 200g/L	75g/L 150ml/L	1X	3700L/ha
2	captan azinphos methyl	Captan 800g/kg Gusathion 200g/L	75g/L 150ml/L	1X	1850L/ha
3	captan azinphos methyl	Captan 800g/kg Gusathion 200g/L	150g/L 300ml/L	2X	1063L/ha
4	captan azinphos methyl	Captan 800g/kg Gusathion 200g/L	300g/L 600ml/L	4X	470/ha
5	captan azinphos methyl	Captan 800g/kg Gusathion 200g/L	600g/L 1200ml/L	8X	235L/ha

Fruit residue trial 2

Gusathion, Lorsban and Captan at 252, 1018, 1960 litres per hectare at respective spray concentration of 8X, 2X, 1X were applied to 4 Granny Smith apple trees (3.5 - 4m in height) by a Hardi low-profile orchard sprayer, 4 weeks before harvest to determine pesticide residue breakdown on fruit from these pesticide application methods. Four fruit per tree were then collected, from the inner/outer/lower and higher sections of the canopy of each of 4 sprayed trees, at 0, 1, 7, 12, 20, 27 days post chemical applications then analysed for fruit residues of the pesticides applied.

Treatment number	Chemical	Product/formulation	Mixing rate	Concentration	Spray volume/ha
1	captan azinphos methyl chloropyrifos	Captan 800g/kg Gusathion 200g/L Lorsban 500g/L	75g/L 150ml/L 100ml/L	1X	1960L/ha
2	captan azinphos methyl chloropyrifos	Captan 800g/kg Gusathion 200g/L Lorsban 500g/L	150g/l 300ml/L 200ml/L	2X	1018l/ha
3	captan azinphos methyl chloropyrifos	Captan 800g/kg Gusathion 200g/L Lorsban 500g/L	600g/L 1200ml/L 800ml/L	8X	252L/ha
4	Unsprayed				

Effectiveness of low profile orchard sprayer modifications in improving canopy and fruit coverage and deposit.

Low-profile orchard sprayer modifications of air baffles, and nozzle extension arms were tested for their effectiveness in improving canopy coverage and deposit on a Vendrame orchard sprayer fitted with Albuz single and double nozzles, setup to give optimum tree coverage *(see Appendix 2 - pages 28-31).*

Effectiveness of a Silvan Turbomiser (P55, HiLow) low-volume tower sprayer at various travel speeds to a range of tree sizes in canopy coverage and deposit.

A Silvan Turbomiser (P55, HiLow) low-volume tower sprayer was tested for canopy coverage and deposit at spraying speeds of 4, 5, 6.1 and 9.2 and 10 km/hr on two orchards with adjustment to the spray volumes from each spray head *(see Appendix 1 - pages 32-43).*

Effectiveness of a Silvan Turbomiser (P55, HiLow) low-volume tower sprayer in deposits across nine tree canopy sizes with a set volume.

A spray application volume of 200L/ha was applied to nine tree sizes (tree row volumes) to determine the effect of tree size and shape on spray delivery to these various canopies. *(see Appendix 1 - pages 44-50).*

Efficiency of alternate row spraying on tree canopy deposit

A Vendrame low-profile air blast orchard sprayer with the same application volume and dye concentration in the tank was sprayed on alternate rows or every row in a central leader, high-density orchard *(see Appendix 1 - pages 51-52).*

RESULTS

Table 1. The potential savings in pesticide applications in two monitored commercial orchards over two seasons.

Grower A			
Apple scab	Number	. **Recommended**	**Change in number of spray applications**
Autumn leaf assessment of the number of scabbed leaves from 600 shoots examined from 60 trees	0	Reduction in early Spring fungicide protective sprays and/or mid summer sprays	9 to 6* (30%)
Codling moth			
Codling moth caught in pheromone traps (10X) the previous season	3	Use of pheromone 'twisties' with 10x and 'black light' traps due to low codling populations present	6 to 0 (100%)
Mites			
Leaf ratings in summer to assess mite predator numbers		Avoid predator mite disruptive chemicals. Delayed miticide spray applications	3 to 0 (100%)
Grower B			
Apple scab	Number	. **Recommended**	**Change in number of spray applications**
Autumn leaf assessment of the number of scabbed leaves from 600 shoots examined from 60 trees	0	Reduction in early Spring fungicide protective sprays and/or mid summer sprays	10 to 8* (20%)
Codling moth			
Codling moth caught in pheromone traps (10X) the previous season	2	Use of pheromone 'twisties' with 10x and 'black light' traps due to low codling populations present	6 to 0 (100%)
Mites			
Leaf ratings in summer to assess mite predator numbers		Avoid predator mite disruptive chemicals. Delayed miticide spray applications	3 to 1 (66%)

Spray application orchard trials:
The results of seven field trials on a range of sprayers in apple orchards are contained in *Appendix 2*. For each trial there is a summary page that shows the trial number and description, orchard and sprayer information and a summary of the results. Spray application efficiency on leaves and fruit from these trials are shown as tree drawings or sometimes as scatter graphs to illustrate trends to indicate the spray deposit of a tracer dye applied to these trees. The tree drawings show the tree shape, the sampling heights with the treatment description located beneath the tree.

Effect of spray application volumes on canopy deposit on a range of tree sizes.
The results of three spray volumes 1839, 1006 and 508L/ha each applied across 4 orchard trial sites A, B, C and D are shown in *Appendix 2, pages 3-20,* and tree canopy capture in Table 2, drift or off-tree losses in Tables 3 and 4 below.
Trial 1-A:
At this site the approximate tree row volume was 18,750m ^{3}/ha (3.75m tall, 2m wide). Trees trained in a central leader structure. The average whole tree leaf deposit was lowest with the highest of the three volumes applied. The lowest volume used on this tree size gave the highest average recovery *(see Appendix 2, pages 5-6).* On these trees it would be feasible to apply 500L/ha or less, using conventional airblast sprayers. A scatter graph shows the losses to the ground due to run-off or direct ground spray. The lower application volume (508L/ha) produced the least loss to the ground
Trial 1-B:
At this site the approximate TRV was 4,200m 3 /ha (1.4m tall, 1.2m wide). Trees trained as a central leader structure. The same trend was evident in this size tree with the lowest applied volume delivering the highest average leaf dose and the highest volume delivering the lowest dose. The 1006L/ha application volume produced the least loss to the ground with the greatest loss occurring with the 1,839L/ha application volume. *(see Appendix 2, pages 9-10).*
Trial 1-C:
At this site the approximate TRV was 15,800m 3 /ha (3.95m tall, 2m wide trees). The trees in this block formed a continuous hedge in a tight vase structure. The average tree deposit was almost identical for all three volumes applied to this site. This demonstrates that lower volumes can be used to deliver the same dose per target as a higher volume. In this instance the 1008 L/ha is the dilute spray volume (1X) and 508 L/ha is the concentrate spray volume (2X). The lowest volume produced the least loss to the ground. There was very little variation in the losses between the other two volumes. *(see Appendix 2, pages 13-14).*
Trial 1-D:
At this site the approximate TRV was 26,207m 3 /ha (4.0m tall, 3.8m wide). The tree structure in this block was open vase. This TRV is overestimated, as the trees in this block did not form a hedge, 30% of the distance between the trees was open space. Again the lowest volume produced the highest average tree deposit. At this site the average deposit was lowest compared with the other sites when averaged across the three volumes used. There was no difference in the losses to the ground between three volumes. The major contributing factor to this loss was direct ground spray as the spray cloud moved between the large gaps in the row and was deposited on the adjacent row. *(see Appendix2,-pages 17-18).*

Table 2. Average dye deposit in (ng/cm²)/(g/ha) obtained on apple foliage from using 3 application volumes on 4 sites of differing canopy size.

Application Volume (L/ha)	Orchard Tree Row Volume m³/ha				
	18,750	4,200	15,800	26,207	Mean*
508	1.710	2.747	1.713	1.515	1.921a
1,006	1.492	1.632	1.713	1.350	1.547ab
1,839	1.132	1.221	1.766	1.268	1.347b
Mean	1.444	1.866	1.731	1.378	

* Main effect means for volume followed by the same letter are not significantly different at the 5% level

Table 3. Average dye deposit in (ng/cm²)/(g/ha) obtained from 3 application volumes and 4 canopy sizes on artificial targets placed on the ground.

Application Volume (L/ha)	Orchard Tree Row Volume m³/ha				
	18,750	4,200	15,800	26,207	Mean
508	0.348	0.620	0.431	0.905	0.576
1,006	0.526	0.437	0.654	0.919	0.634
1,839	0.428	0.674	0.629	0.807	0.634
Mean*	0.434b	0.577b	0.571b	0.877a	

* Main effect means for site followed by the same letter are not significantly different at the 5%

Table 4. Average dye deposit in (ng/cm²)/(g/ha) obtained from 3 application volume and 4 canopy sizes on artificial drift targets placed two rows from the outermost sprayed row.

Application Volume (L/ha)	Orchard Tree Row Volume m³/ha				
	18,750	4,200	15,800	26,207	Mean
508	0.041	0.012	0.019	0.011	0.021
1,006	0.011	0.010	0.011	0.010	0.011
1,839	0.018	0.008	0.008	0.008	0.011
Mean	0.023	0.010	0.013	0.001	

The average canopy deposit across all tree sizes was statistically higher at the lowest volume of 508L/ha. There was no statistical difference between spray volumes for spray losses as direct to ground spray of drift at these spray volumes.

The scatter plot diagrams *(see Appendix 1 – page 19-20)* show that as the spray volume increases average leaf deposits do not increase but generally decrease, while spray losses to the ground increase.

Effect of spray application volumes on fruit pesticide residues (dose) and resultant fruit pesticide breakdown prior to harvest.

Fruit residue trial 1

Table 5. Azinphos methyl residue on Granny smith apples after spraying with low and high volumes 28 days pre-harvest.

Time of fruit sampling from spray application	Unsprayed	230l/ha (8X)	470L/ha (4X)	1063L/ha (2X)	1850L/ha (1X)	3700L/ha (1X)
Prespray	NDR*					
1 day		.30	.40	.35	.25	.39
7 days		.28	.31	.22	.21	.24
14 days		.08	.13	.12	.08	.22
21 days	NDR	.07	.21	.08	.09	.13
28 days	NDR	.09	.09	NDR	NDR	.12

*NDR no detectable residue by chemical analysis

Table 6. Captan residue on Granny smith apples after spraying with low and high volumes 28 days pre-harvest.

Time of fruit sampling from spray application	Unsprayed	235l/ha (8X)	470L/ha (4X)	1063L/ha (2X)	1850L/ha (1X)	3700L/ha (1X)
Prespray	.11					
1 day		.24	.35	.40	.40	.42
7 days		.21	.30	.32	.34	.30
14 days		.11	.17	.16	.10	.29
21 days	NDR	.10	.18	.13	.13	.19
28 days	NDR	.09	.13	NDR	.10	.16

**NDR no detectable residue by chemical analysis*

There is no statistical difference in fruit residues of captan or azinphos methyl, whether applied either by low-volume concentrate or by high-volume dilute spraying techniques, immediately after spraying or in the period to harvest.

At 14 days all treatments were below the maximum residue limit (MRL) of azinphos methyl (2mg/kg) except the highest application volume of 4000L/ha.

Fruit residue trial 2

Table 7. Azinphos methyl residue on Granny smith apples after spraying with low-volume concentrate and high volumes dilute spraying techniques 28 days pre-harvest.

Time of fruit sampling from spray application	252l/ha (8X)	1018L/ha (2X)	1960L/ha (1X)
Prespray	NDR*	.23	.16
1 day	1.05	1.00	1.24
7 days	.18	.36	.50
12 days	.15	.13	.11
20 days	.15	.09	.10
27 days	.10	.15	.23

**NDR no detectable residue by chemical analysis*

Table 8. Captan residue on Granny smith apples after spraying with low and high volumes 28 days pre-harvest.

Time of fruit sampling from spray application	252l/ha (8X)	1018L/ha (2X)	1960L/ha (1X)
Prespray	.15	.24	.24
1 day	1.11	1.03	.87
7 days	.20	.33	.46
12 days	.19	.16	.29
20 days	.15	.12	.17
27 days	.11	.17	.19

**NDR no detectable residue by chemical analysis*

Table 9. Chlorpyrifos residue on Granny smith apples after spraying with low and high volumes 28 days pre-harvest.

Time of fruit sampling from spray application	252l/ha (8X)	1018L/ha (2X)	1960L/ha (1X)
Prespray	NDR	NDR	NDR
1 day	.11	.08	.12
7 days	NDR	.04	.04
12 days	NDR	NDR	NDR
20 days	NDR	.02	NDR
27 days	NDR	NDR	.05

**NDR no detectable residue by chemical analysis*

There is no statistical difference in fruit residues of azinphos methyl, captan or chlorpyrifos when these were applied as low-volume concentrate of high-volume dilute spraying techniques, immediately after spraying or in the period to harvest.
At 14 days all treatments were below the maximum residue limit.

Effectiveness of a Silvan Turbomiser (P55, HiLow) tower sprayer in canopy coverage by low-volume spray applications.

Trial 6-A:

Tree row volume 17,500m3/ha (3.5m tall, 2.5m wide). Tree structure in this block was closed vase. In the small trees the deposit was highest and most even at the slowest speed tested (4km/hr). The deposit distribution still looks good as the speed was increased to 6 and 9km/hr. The deposit at the bottom and middle inner was reduced however at 9km/hr. The deposit in the top inner sampling position was almost always equal to the bottom outer, this is the benefit of using a tower sprayer *(see Appendix 2, pages 34-35).* This was ideal as most low profile airblast sprayers have a tendency to overdose the bottom outer zone and not deliver sufficient volume to the top of the tree.

Trial 6-B:

Tree row volume 30,000m/ha (5.0m tall, 3.m wide). Tree structure in this block was open vase. The average deposit on the bigger trees is greatest at 9km/hr, almost double that at 4km/hr *(see Appendix 2, pages 38-39).* This is contrary to the test results on the smaller tree size and what we would have expected. The spray deposit on leaves at the top inner position is considerably lower than the bottom outer at all speeds. These were very large trees and in a subsequent trial we set the same sprayer up to deliver increased volumes from the top outlets, this improved the coverage in top sections of the tree canopy.

Trial 11

Tree row volume 27,000 m3/ha (4.5m tall, 3.3m wide). Tree structure was open vase. Spraying speeds were 5 and 10 km/hr applying volumes of 200 and 500L/ha. In comparison to Trial 6, the increased flow through the top heads improved the deposit in the top sections of the tree canopy *(see Appendix 2, pages 41 and 43).*

Effectiveness of low profile orchard sprayer modifications in improving canopy and fruit coverage and deposit.

Trial 5

Low-profile orchard sprayer modifications with the nozzle extension arms produced an average increase of spray deposit of 21 percent on leaves and 24 percent on fruit *(see Appendix 2 - pages 30-31).* The air deflectors had no effect in this trial, but in previous trials the deflectors with Albuz nozzle doubles or triples increased deposits up to 30 percent.

Effectiveness of a Silvan Turbomiser (P55, HiLow) low-volume tower sprayer in deposits across nine tree canopy sizes with a set volume.

Trial 12

The scatter diagram *(see Appendix 1 – page 50)* shows that the average deposit decreases linearly with increase in tree canopy size. This infers that where a fixed rate of pesticide is recommended per hectare regardless of tree size, small tress are overdosed or large tress are under-dosed.

Efficiency of alternate row spraying on tree canopy deposit

From alternate row spraying the leeward side of the tree received and average dose that was 42% less than the side directly sprayed. There was 30% difference in the average deposit between the two sides of the tree that was sprayed directly on both sides *(see Appendix 1 - pages 51-52).* Alternate row spraying may be an effective strategy on narrow

row spacing and on small trees with an open canopy structure. Although these trees appear to be tall with an upper sampling height of 3.9m the bulk of the foliage and fruit set was well below this position. The results demonstrate that in selected orchards alternate row spraying is a useful technique in improving the efficiency of spraying.

DISCUSSION

Many growers have reduced pesticide use through modifications to orchard sprayers, while some have been reluctant to alter their present pesticide plant protection practices, because the cost of pesticides are minimal in comparison of total production costs and non pesticide plant protection practices, require constant monitoring, because of the complex biological interactions within orchards. A number of technologies and information to dramatically reduce pesticide use is available for growers. Developing these technologies and information into knowledge, as demonstration trials on commercial orchards in this project, has assisted grower adoption of these technologies as orchard plant protection practices.

Current and updated information through pest and disease monitoring is the cornerstone to widespread pesticide reduction for the apple and pear industries. A number of research projects have developed technologies and monitoring techniques, which can be practically applied to orchard systems by growers or consultants. Monitoring of pest or disease levels assures growers that plant protection management methods, which reduce pesticide use, can be introduced without fruit damage occurring. The MothWatch project led by Stephen Tancred of Orchard Services, which developed an area-wide approach to Codling moth monitoring and provided regular reports of pest numbers in orchards to Stanthorpe growers, was highly successful in reducing the population of this pest in orchards by more than 50 percent. This monitoring information also enabled that more than 50 percent of the apple area in the Stanthorpe district to adopt pheromone mating disruption technology. The Improving scab management in pomefruit project led by Bill Washington developed autumn leaf monitoring to predict scab levels the following spring. Leaf sweeping and mulching trials and spring urea ground sprays reduced in apple orchards reduced inoculum by more than 90 percent. Fungicide sprays were reduced in spring by 25 percent without any disease increase on fruit.

Growers have opportunities to reduce pesticide in new orchards, where pest and disease levels are low and canopy size and tree structure are managed to enable good spray penetration. Trials conducted in commercial grower orchards showed that pesticide use can be substantially reduced by more 60%, while still maintaining effective pest and disease control and a high fruit packout. These trials included practical prediction systems for monitoring pest and disease outbreaks, non-pesticide pest and disease management methods and spray application technology improvements. In these trials we improved sprayer capability by nozzle setup and calibration to match the tree canopy. We monitored pest and disease levels and advised when critical sprays were needed and reduced sprays applications where possible. When pest populations were low we recommended alternative non-pesticide methods. The evolving biology of orchards has made the management of secondary pests such as woolly apple aphid, weevils and mealy bugs also a concern of growers with dimpling bugs, thrips and fruit flies also pest problems in some growing areas.

The results of the orchard spray trials reported here should assist growers choose appropriate spray volumes and hence not over spray or use excessive pesticides, that could result in either increased fruit residues as well as greater pesticide losses to the environment. Our apple pesticide spray application research trials show that pesticides spray application volumes less than 2000 litres per hectare (L/ha) were more efficient in canopy coverage and reduced pesticide wastage from runoff and drift. Surveys show that most growers use less than 2,000 L/ha and more than 60 percent use concentrate spray volumes less than 900L/ha. We have obtained quantitative data from spray application trials from a range of project work that could be used to develop a methodology to calculate appropriate pesticide doses for a range of tree sizes regardless of the volume used. This could allow growers to adjust pesticide dose, so that the same dose is applied to the tree canopy, irrespective of tree size, by manipulating spray volume and pesticide concentration. This calculation requires further testing on a range of fruit tree canopy sizes, before precise information could be incorporated into a pesticide label.

The information from low-volume concentrate sprayer testing and fruit residue data from this project were presented to the National Registration Authority (NRA) and agrochemical companies through AVCARE, so that a modified pesticide label for tree and vine crops could be developed. This new label, when accepted by the regulatory authorities in all Australian states, will enable the legal use of concentrate sprays for pesticides where appropriate. This use will depend on the product and the advice of the chemical companies, as some products may require to be applied as dilute sprays due to possible crop damage or efficacy problems as concentrate sprays.

TECHNOLOGY TRANSFER

A poster and talk *Pesticide Reduction in Pomefruit Towards 2000* was presented to the Australian Horticultural Conference in 1999.

The results of this project have been presented in detail at grower field days and seminars in Tasmania and Queensland.

Orchard sprayer calibration workshop for resellers and consultants held at Applethorpe Research Station in July 1998.

Apple Growers Technical Seminar, Applethorpe Research Station Feb. 1999.

A poster was presented at the Apple & Pear Growers Conference at Canberra, 2000.

Article *Technology adoption by growers enables less pesticide use* in Apple and Pear Growers News, June 2002.

Article *Pesticide reduction strategies* in Queensland Deciduous Fruits Spray Schedule, 2001.

Workshop Manual *Efficient Pesticide Use in Pomefruit* second edition, 1997.

Article *Calibrating orchard sprayers* in Orchard Plant Protection Guide for Inland New South Wales.

A presentation and report of orchard spray trial results of tree canopy coverage and fruit pesticide residues using low volume concentrate spraying were presented to the National Registration Authority staff at Canberra on Thursday 22 July, 2000. These results were also sent to the Australian Veterinary and Agricultural Chemical Association sub-committee to substantiate the case to allow low-water volume application of concentrate pesticide in tree crops.

RECOMMENDATIONS

It is recommended that a national workshop involving key stakeholders be held, which evaluates advances of pesticide reduction and prioritise research and development and develops strategies to enhanced speed of adoption by growers.

It is recommended that greater support for education, training and adoption of pesticide reduction technologies and methods with active hands-on involvement by growers in commercial orchards are undertaken on a national scale.

It is recommended that consultants, chemical resellers, retail supply firms be specifically targeted as the key agents of technology transfer and adoption of practices for pesticide reduction.

It is recommended that regional area wide monitoring of pest and diseases and information services to growers, retail supply firm staff and chemical resellers be encouraged through funding and developed as part of Integrated Fruit Production.

It is recommended that the pesticide requirement methodology developed in this project be tested on a range of tree crops, to calculate appropriate pesticide doses on a range of orchard and sizes regardless of the volume used, so that precise information can be written for pesticide labels.

ACKNOWLEDGMENTS

I wish to gratefully acknowledge the input of the project team members, Ms Halina Kruger, Mr Robert Battaglia, Mr Peter Hughes, Mr Stephen Tancred, Mr Frank Page, Mr Peter Nimmo and Mr Andy Jordan for technical assistance of throughout the project. The spray technology assistance of Mr Steve Harper and Mr Glen Geitz and the assistance of the Applethorpe farm staff in conducting spray trials are also acknowledged.

We are grateful to the orchardists, who co-operated in the project research by making their sprayers, orchards and employees available for this work. We appreciated their comments and practical knowledge on the proposed testing of the orchard sprayers.

I wish to acknowledge the assistance of Messrs Ugo and Stephen Tomasel (Pozieres, Q), Mr Celeste, Tony and John Pozzebon (Applethorpe, Q) and Mr Michael Bertinazzi (Pozieres, Q) for providing orchard sites and orchard spray machinery as required for field trials and advice on the practicality of the trial practices undertaken.

Funding of this project was provided by the Australian Apple and Pear Growers, the Horticultural Australia Limited and the Queensland Department of Primary Industries.

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Appendix 1

Milestone 1

HRDC Project AA0033
Pomefruit Pesticide Reduction Strategies for the 2000's

Objective 1. *Undertake grower >case studies= to demonstrate the pesticide reduction successes of the pomefruit industry for use in media releases.*

Milestone 2. Publish grower >case studies= outlining pesticide reduction achievements, strategies and options. (Date Due: 30 March 1998).

News Release Title	Sent to	Date Sent	Date Published
Cleaner Apples & Pears	Good Fruit and Vegetables	5 January 1998	Planned for April
NSW, SA & QLD Growers produce cleaner apples & pears (3 releases)	Pome Fruit Australia	25 March 1998	Planned for May
NSW Growers produce cleaner apples & pears	Weekly Times Stock & Land Rural News The Land Agriculture Today Daily Telegraph Sydney Morning Herald Cumberland Newspaper Group Border Morning Mail Western Advocate Tumut Times Riverina Leader Wagga Daily Advertiser	24 March 1998	
SA Growers produce cleaner apples & pears	Weekly Times Farmer & Stockowner Australian Farm Journal Sustainable Agriculture The Grower Adelaide Advertiser City Messenger Loxton News Murray Valley Standard Murray Pioneer Southern Argus Whyalla News The Times Flinders News The Bunyip Border Watch	24 March 1998	requested slides 24/3

Qld Growers produce cleaner apples & pears	Qld Country Life QFVG News Courier Mail City News Group Stanthorpe Border Post Toowoomba Chronicle Gatton Star Caboolture News Qld Small Farms Warwick Daily News Cairns Post Gympie Times Townsville Bulletin Bundaberg News Sunshine Coast Daily Chinchilla News Mackay Daily Mercury Maryborough Chronicle Biloela Central Telegraph Whitsunday Times	24 March 1998	requested slides 24/3
Environmentally Friendly Apples and Pears	The Australian Canberra Times Daily Telegraph Sun Herald Sydney Morning Herald The Age Courier Mail Adelaide Advertiser West Australian The Mercury Good Health Magazine New Scientist Consuming Interest Australian Family Circle Australian Good Taste Australian Vegetarian Australian Slimming Conscious Living Good Life Magazine Health Forum Healthy Life News Nature and Health New Vegetarian and Natural Health Weight Watchers Magazine Well Being Magazine	30 March 1998	Requested slides for May/June issue

	Zest! Magazine Men's Heath Women's Health Australasian Science Women's Weekly Cleo Cosmopolitan For Me HB&B Magazine Marie Claire New Idea New Woman She That's Life! Women's Day ABC Radio Radio National		

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SA Growers produce cleaner apples and pears	Weekly Times Farmer and Stockowner Australian Farm Journal Sustainable Agriculture The Grower Adelaide Advertiser City Messenger Loxton News Murray Valley Standard Murray Pioneer Southern Argus Whyalla News The Times Flinders News The Bunyip Border Watch	24 March 1998

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Environmentally Friendly Apples and Pears	The Australian Canberra Times Daily Telegraph Sun Herald Sydney Morning Herald The Age Courier Mail Adelaide Advertiser West Australian The Mercury Good Health Magazine New Scientist Consuming Interest Australian Family Circle Australian Good Taste Australian Vegetarian Australian Slimming Conscious Living Good Life Magazine Health Forum Healthy Life News Nature and Health New Vegetarian and Natural Health Weight Watchers Magazine Well Being Magazine Zest! Magazine Men's Health	30 March 1998

	Women's Health Australasian Science Women's Weekly Cleo Cosmopolitan For Me HB and B Magazine Marie Claire New Idea New Woman She That's Life! Women's Day ABC Radio Radio National	

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CLEANER APPLES AND PEARS

Apple and pear growers around Australia are keeping their end of a bargain made with consumer groups in 1990 to cut pesticide use by 50 per cent in 1996, and a 75 per cent reduction by 2000. And they're doing it at their own expense: growers are not being paid a higher price for the product.

The growers have funded a number of research and extension projects through HRDC to help the apple industry achieve its pesticide reduction aims. One such project, entitled "Pesticide Reduction in Pomefruit for Year 2000" involved Queensland Department of Primary Industries (QDPI) staff with backgrounds in entomology, plant pathology, extension, engineering and horticultural consulting. It began with a national workshop, which brought together farmers, consultants, chemical company representatives, retail supply firms and a range of scientists to prioritise the project work from a national perspective.

The pesticide reduction project, led by Shane Dullahide, QDPI Applethorpe Research Station, focussed on research and extension relating to spray application, sprayer calibration and pest and disease monitoring.

"We published a booklet of orchard sprayer field trial results and distributed 500 copies throughout the industry," Shane said. "It explains the how modifying sprayers with air deflectors and multiple nozzles on standard low profile orchard sprayers can reduce pesticide use by over 20 per cent and sprayers with towers fitted give up to 40 per cent savings."

The booklet also explains how alternate row spraying every 7-14 days rather than every 10-21 days leads to a further 25 per cent reduction in pesticides with no increase in fruit damage. "These improvements in sprayer efficiency have allowed immediate reductions in pesticide use for growers," said Shane.

"We carried out detailed monitoring for mites, coddling moth and apple scab on four commercial blocks," Shane continued. "We found that pheromone 'twisties' for codling moth control lead achieved a 30 per cent reduction."

Shane and his team also ran sprayer calibration workshops for over 100 retail supply staff and 300 growers across the country, from Queensland to Tasmania and Western Australia. "We trained people in standard methods of orchard sprayer calibration, so they are confident they are applying pesticides efficiently, effectively, and at the correct rate," Shane said.

"The future of pesticide reduction relies on intensive orchard monitoring to determine pest and disease levels in each block, and using this information to make a better spray decision," Shane said. "By varying the spray application method, pesticide volumes and concentrations to suit different tree sizes and shapes, further reductions in pesticide use are possible. We are continuing our work in a new HRDC funded project to determine which combination of methods gives the best coverage with least wastage, as well as effective pest and disease control with minimum pesticide residue on the fruit," Shane concluded.

Grower Case Studies

IPM Group, Lenswood, South Australia

In September 1994, a small group of far-sighted apple growers in Lenswood, near Adelaide, initiated an Integrated Pest Management (IPM) group to help growers learn together. The group involves 12 growers, Dennis Matthews of the Lenswood Co-op, CIBA and IAMA chemical resellers and Paul James, the Industry Development Officer from Primary Industries South Australia (PISA).

"Growers in this district had reduced chemical use by at least 50 per cent by 1994, well ahead of schedule," according to Dennis Matthews of the Co-op. Hardly any broad spectrum pesticide sprays are used now, and growers are not using as much herbicide in the orchard any more. In Kym's words, "Growers have done it off their own bat."

Initiators Roger Flavell and Kym Green quickly point out that the IPM group is organised and driven by growers. The government and chemical industry members have been invited into the group as a technical resource.

Kym said the group is 'a real support thing.' He explained that implementing IPM often involves taking a couple of steps forward, and then one back. Sometimes growers are under a lot pressure from their brothers and fathers to spray, so the support from other growers using IPM really helps. "It takes time to build up predators in the orchard to help Mother Nature," he said.

IPM in apples involves using 'softer' more specific pesticides targeted at pests and not harmful to beneficial insects, along with mating disruption pheromones (twisties) to prevent pests from breeding. "Before, with the 'hard' chemicals, we used to knock out the good guys as well as pests," Kym said.

"The Apple industry really began thinking about integrated pest management in 1983, when some growers started using integrated mite management," explained Paul James. "However, it really fired up in 1986 when we lost the use of some chemicals."

It involves introducing predatory mites into the orchard to control pest mite numbers. This means that pesticides used against other pests must be chosen carefully, to avoid killing the good mites and other beneficial insects such as ladybirds and lacewings. "Integrated mite management really made apple growers conscious of the need to look after the good insects," Paul said. "Now we are aware of the good guys out there and are looking after them," Kym added.

The IPM group has helped local growers reduce their pesticide use even further, by requesting a blackspot warning service. "We wanted to reduce our blackspot sprays, but needed more information to be able to do it," Kym explained. The Lenswood Co-op responded by setting up a service which provides site specific warnings for blackspot based on weather.

The group also realised they wanted to know more about how to successfully use IPM. They have run 3 training workshops in conjunction with the Lenswood Agriculture and Forestry Bureau covering the identification of pests and beneficial insects, and how to monitor their orchards. Group members also offered their orchards for research trials, which improved communication between growers and researchers.

The growers have also educated themselves about improving spray practices to reduce pesticide use. They have been able to reduce the chemicals used by ensuring they get good coverage while using lower volume sprays. A trend towards smaller, more efficient trees also helps reduce the volume of sprays required.

"Years ago I used to use a calendar spray program, but now I only spray when my monitoring results show the need," Roger said. "Now everyone is careful about using chemicals - they look at every other avenue first."

Kym checks coddling moth/light brown apple moth traps each week. "By monitoring you know what's going on in the orchard, and you know what the enemy is," he said. He also uses a monitoring service for mite management, as a microscope is needed to count the numbers of pest and predator mites on the leaves. "When I have to use miticides, I'm just aiming to drop pest pressure so the predators can work. I'm not trying to knock out all the mites," he said.

Their knowledge about the ecology, the balances between insects in their orchards has changed the IPM growers' attitudes towards orchard management. "We accept more damage to our orchards than we previously did," Kym explained. "Even though we have mite damage on the leaves, we know the predators will work in the long run."

The group is now learning how to deal with the secondary pests such as woolly aphid which has become a problem now that broad spectrum pesticide use has been cut. "Earwigs can keep woolly aphid under control, but you need lots of aphids before the earwigs can work," Paul explained. The growers had to learn to accept higher aphid numbers in the IPM system. "They also had to get used to the idea that earwigs were good guys in apple orchards, even though they are a pest in cherries," he said.

Kym described how they had to change their way of thinking."Six or seven years ago we killed lots of ladybird larvae, thinking they were a pest," he said with remorse. "Just because it's an insect doesn't mean it has to be killed. We have a booklet on insect identification which is a real help," he said.

But every property is different - there will be different pest/predator ratios and different micro-climates, so growers have to deepen their understanding to use IPM. Through a process of step by step learning, the grower's skill levels have increased. "The group has learnt more about pest and beneficial insects in all life stages," Paul said. This has lead to them asking entirely different questions, such as what effect a pesticide will have on a predator, when buying chemicals and Dennis can give them the answers. "The whole group is doing it together - chemical companies, resellers, growers, researchers and PISA. If people aren't interested, it can't happen," Dennis said.

Where does the group see itself looking next? They believe the next step is integrated fruit production - improving the management of the whole orchard. "We really need an industry approach to integrated fruit production, a national approach," Kym said. "Growers want to be part of making the environment better, and it is the responsibility of the industry and growers to want to do it."

The chemical companies are helping by putting softer spray options on the market. They also have to change to become more environmentally friendly, and in some European countries they are being forced to change by regulation.

And is IPM worth it? "Many of the new chemicals are more expensive, but it hasn't been an excuse not to do it," Roger said. He estimates that his IPM "spray" bill (including pheromones) is as much as before, and may cost more due to the labour of monitoring, but "it's a much cleaner, nicer environment to work in." Kym and Roger reported more small, insect eating birds as well as frogs and worms in IPM orchards - indicators of environmental health. They take it as a sign that they're doing well.

"Ultimately IPM is safer for the farmer, worker and consumer," Kym said, "and the fruit quality is still very good."

CHANGES IN PESTICIDE USE IN APPLE PRODUCTION IN LENSWOOD, SA

Target Pest	1992	1997
Mites	2 or 3 full strength miticides used over whole farm.	Treat 'hot spots' only (5% of a full spray) & some haven't sprayed mites for 5 years.
Codling Moth & Light Brown Apple Moth	Spray every 21 days from late Oct to Mar.	Pheromones ('twist-ties') for mating disruption. Sometimes 1 spray for LBAM & heliothis in Oct/Nov. (IS THIS INSEGAR?)
Overall approach	Calendar spray. Control pests - try to eradicate.	Monitor pest numbers and decide whether to spray based on that information. Keep pest pressure low, below economic thresholds.

Michael and Sharon Smart, Batlow, New South Wales

Michael and Sharon Smart of Batlow, NSW, have made significant savings on spray costs for their 80 acre orchard through regular pest monitoring. Monitoring gives Michael enough information to decide whether to delay or avoid sprays even though he may see pests in the orchard. For example, monitoring showed that the first 'standard' spray for apple dimpling bug was not needed this year because pest numbers were low, allowing Michael to save a spray.

"We also used to spray every time we saw a mite and consequently wore those chemicals out," Michael said. "Monitoring helps with the timing of the sprays. I remember using five, sometimes six mite sprays in the early 1980's and now I'm back to one mite spray."

The Smarts employ the expertise of Kevin Dodds from the Batlow Field Services Section to monitor for apple dimpling bug, codling moth, mites and predators. He monitors two blocks regularly and spot samples any 'hot spots' he or Michael find throughout the orchard. Michael considers Kevin's monitoring to be the backup "but I make the final decision." Together they make a good team, combining Michael's knowledge of the orchard and day-to-day observations with Kevin's knowledge of pests and beneficial insects.

"We made a big saving when Kevin started calculating degree days as part of the codling moth monitoring," Michael said. "We used to spray azinphos every two to three weeks from early November for up to six sprays. Last year monitoring allowed us to delay our first spray by a month, cutting our number of sprays by at least a third and I think we could have gotten away with less," he said. Since then, the Smarts have started using Isomates (pheromone twisties) to disrupt codling moth mating. "It has meant an increase in costs but this was off-set last year because we didn't use a moth spray at all," he said. They are also testing the effect of using reduced rates of isomates, to see if they can emulate the Victorian's success on their farm.

"Overall, we've reduced both pesticides and herbicides in this orchard," Michael said. "We've virtually taken azinphos out of the system, a saving of $4000 in chemical, and have nearly eliminated Lorsban as well - a further reduction of about $2000."

The Smarts have had difficulty reducing chemicals for black spot in Batlow's high rainfall climate. "We always spray black spot to a very tight schedule early, so that we save sprays later," Michael explained. "In a clean spring we stop spraying by Christmas, only using spot sprays on black spot pressure points after that."

"Black spot is still a major issue," Kevin added. "It is going to take a major scientific breakthrough before we can change control practices."

The changes in pesticide use have had a noticeable effect on the farm. "The ecology of the orchard is constantly changing. We have more butterflies and ladybirds now," Michael said. "Also, dropping azinphos out of the system helps me manage the workload around the farm as staff do not have to worry about re-entry periods. As an orchardist, I like the environment to be good as well, particularly as we're raising our children on the farm," Michael said.

"Batlow is a very challenging place to achieve significant pesticide reductions without sacrificing the very high product quality on which the district prides itself," Kevin said. However, he commented that growers are changing their spray practices across the district. He estimated that three out of four growers are using some of the pest management services offered by the Batlow Fruit Co-operative Field Services Section. More than half use codling moth and mite/predator monitoring services, one in three uses apple dimpling bug monitoring, and some use the soil moisture monitoring and spray machine calibration services.

Eric Haynes and sons, Pozieres, Queensland

Eric Haynes farms 90 acres of apples at Pozieres, on Queensland's Granite Belt, with his two sons John and Roger. He explained how they dramatically cut pesticide use on their farm over the past few years through altering their sprayer and introducing pheromone 'twisties' for codling moth management into their orchard.

"We've put pheromone twisties on 25 acres this year, which was so effective we didn't have to spray an insecticide for moth on that part of the farm," Eric said. "Twisties do cost more than insecticides, but we prefer to use them because they don't kill all the other insects in the orchard, and are less dangerous to the operators." Despite the cost, the Haynes have decided to expand their use of twisties to the whole farm over the next two or three years.

Eric also said that using twisties allows him to be more flexible with other pest management practices. "In the past we would spray for black spot and codling moth together as a time saving, even if both sprays weren't really needed. Now, because we don't spray codling moth, we only go out and spray black spot when the DPI warning service indicates it is needed, so we spray less often," he explained.

The Haynes monitor for codling moth in the areas without twisties, so they know how many pests are around and when to spray. "We used to spray on a program every two or three weeks, but now we monitor our own pheromone traps. If we get anything over two moths in a trap over a week, and the numbers are increasing over time, we may decide to spray," Eric said. They are also trialing a light trap in conjunction with Stephen Sexton of Biocontrol, Warwick, to allow them to monitor codling moth where twisties, which make pheromone traps ineffective, are in use.

"We also monitor for European red mite and two-spotted mite every week in season by taking leaf samples and inspecting them under a hand lens," said Eric. This information has allowed them to reduce their mite sprays, by only spraying the mite infested areas of the orchard. "Next year we may buy and release predatory mites into the orchard, because we don't seem to have very many here," Eric said.

"We still have to spray once for apple dimpling bug when the trees are flowering, and sometimes need a second or third spray," Eric said. "We also trap for fruit fly in the twistie blocks, and spray with a baited spray to the bottom leaves of the trees when we find high enough numbers."

Improving the focus of sprays onto the parts of the tree where it is needed has also allowed the Haynes to reduce their use of pesticides by at least 20 to 30 per cent. Shane Dullahide, a senior experimentalist based at QDPI's Granite Belt Research Station, has helped the Haynes to modify their air-blast sprayer. With the addition of 'baffles' they now prevent spray being wasted onto the ground or up into the air. They also changed the type of nozzles, and inserted 'double adapters' to allow two nozzles to spray the thicker parts of the tree canopy. With this set-up, they can drive faster, using less spray per hectare, but still getting effective coverage. "It was amazing to me that he made such a difference with such simple ideas," Eric said.

Like many growers in the district, the Haynes are gradually replacing their old, big, widely spaced trees with smaller varieties, planted more densely at 1500 trees per hectare, and pruned for the central leader. This style of orchard is more efficient, not only to pick and prune, but also for pest and disease management, as the open style canopy assists spray penetration and improves air circulation. "Shane also advised us we could spray alternate rows in the young, closely planted trees, allowing us to cut our pesticide use in half on those blocks," Eric added.

NEWS RELEASE

ENVIRONMENTALLY FRIENDLY APPLES AND PEARS

Australian apple and pear growers are relying more on Mother Nature and less on pesticides to manage fruit-damaging pests. They are using Integrated Pest Management (IPM) which allows nature to help produce cleaner, greener fruit.

"Growers want to be part of making the environment better. It is our responsibility to manage our environment in a more sustainable way", said apple grower, Kym Green of Lenswood in South Australia's Adelaide Hills.

"Ultimately, IPM improves safety for consumers as well as farmers and farm workers and, unlike some organic produce, the fruit is still very good quality", he added. Other growers commented that IPM gives them a much cleaner, nicer environment to work and raise their families in.

An industry funded project to develop pomefruit pesticide reduction strategies has found that growers and contacts from all apple growing regions of Australia relay the same message of 'new age' fruit production methods. According to project leader, Shane Dullahide of Queensland's Department of Primary Industries, Stanthorpe, Australian apple and pears are now produced using methods which are environment and consumer friendly.

This increase in use of IPM is orchardists response to an agreement made with consumer groups in 1990 to cut pesticide use by 50 percent in 1996, and a 75 percent reduction by 2000.

And it is not only consumers who are benefiting. As less broad-spectrum pesticides are being used, the orchard ecosystems are recovering their diversity.

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NEWS RELEASE

Queensland

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NEWS RELEASE

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In September 1994, a small group of far-sighted apple growers in Lenswood, near Adelaide, initiated an Integrated Pest Management (IPM) group to help growers learn together. The group involves 12 growers, Dennis Matthews of the Lenswood Co-op, CIBA and IAMA chemical resellers and Paul James, the Industry Development Officer from Primary Industries South Australia (PISA).

"Growers in this district had reduced chemical use by at least 50 percent by 1994, well ahead of schedule", according to Dennis Matthews of the Co-op. Hardly any broad spectrum pesticide sprays are used now, and growers are not using as much herbicide in the orchard any more. In Kym's words, "Growers have done it off their own bat".

Initiators Roger Flavell and Kym Green quickly point out that the IPM group is organised and driven by growers. The government and chemical industry members have been invited into the group as a technical resource.

Kym said the group is 'a real support thing'. He explained that implementing IPM often involves taking a couple of steps forward, and then one back. Sometimes growers are under a lot of pressure from their brothers and fathers to spray, so the support from other growers using IPM really helps. "It takes time to build up predators in the orchard to help Mother Nature", he said.

IPM in apple involves using 'softer' more specific pesticides targeted at pests and not harmful to beneficial insects, along with mating disruption pheromones (twist-ties) to prevent pests from breeding. "Before, with the 'hard' chemicals, we used to knock out the good guys as well as pests", Kym said.

"The Apple industry really began thinking about integrated pest management in 1983, when some growers started using integrated mite management", explained Paul James. "However, it really fired up in 1986 when we lost the use of some chemicals".

It involves introducing predatory mites into the orchard to control pest mite numbers. This means that pesticides used against other pests must be chosen carefully, to avoid killing the good mites and other beneficial insects such as ladybirds and lacewings. "Integrated mite management really made apple growers conscious of the need to look after the good insects", Paul said.

"Now we are aware of the good guys out there and are looking after them", Kym added.

The IPM group has helped local growers reduce their pesticide use even further, by requesting a black spot warning service. "We wanted to reduce our black spot sprays, but needed more information to be able to do it", Kym explained. The Lenswood Co-op responded by setting up a service which provides site specific warnings for black spot based on weather.

The group also realised they wanted to know more about how to successfully use IPM. They have run three training workshops in conjunction with the Lenswood Agriculture and Forestry Bureau covering the identification of pests and beneficial insects, and how to monitor their orchards. Group members also offered their orchards for research trials, which improved communication between growers and researchers.

The growers have also educated themselves about improving spray practices to reduce pesticide use. They have been able to reduce the chemicals used by ensuring they get good coverage while using lower volume sprays. A trend towards smaller, more efficient trees also helps reduce the volume of sprays required.

"Years ago I used to use a calendar spray program, but now I only spray when my monitoring results show the need", Roger said. "Now everyone is careful about using chemicals - they look at every other avenue first".

Kym checks codling moth/light brown apple moth traps each week. "By monitoring you know what's going on in the orchard, and you know what the enemy is", he said. He also uses a monitoring service for mite management, as a microscope is needed to count the numbers of pest and predator mites on the leaves. "When I have to use miticides, I'm just aiming to drop pest pressure so the predators can work I'm not trying to knock out all the mites", he said.
Their knowledge about the ecology, the balances between insects in their orchards has changed the IPM growers' attitudes towards orchard management. " We accept more damage to our orchards than we previously did", Kym explained. "Even though we have mite damage on the leaves, we know the predators will work in the long run".

The group is now learning how to deal with the secondary pests such as woolly aphid which has become a problem now that broad spectrum pesticide use has been cut. "Earwigs can keep woolly aphid under control, but you need lots of aphids before the earwigs can work", Paul explained. The growers had to learn to accept higher aphid numbers in the IPM system. "They also had to get used to the idea that earwigs were good guys in apple orchards, even though they are a pest in cherries", he said.

Kym described how they had to change their way of thinking. "Six or seven years ago we killed lost of ladybird larvae, thinking they were a pest", he said with remorse. "Just because it's an insect doesn't mean it has to be killed. We have a booklet on insect identification which is a real help", he said.

But every property is different - there will be different pest/predator ratios and different micro-climates, so growers have to deepen their understanding to use IPM. Through a process of step by step learning, the growers skill levels have increased. ":The group has learnt more about pest and beneficial insects in all life stages", Paul said. This has lead to them asking entirely different questions, such as what effect a pesticide will have on a predator, when buying chemicals and Dennis can give them the answers. "The whole group is doing it together - chemical companies, resellers, growers, researchers and PISA. If people aren't interested, it can't happen", Dennis said.

Where does the group see itself looking next? They believe the next step is integrated fruit production - improving the management of the whole orchard. "We really need an industry approach to integrated fruit production, a national approach", Kym said. "Growers want to be part of making the environment better, and it is the responsibility of the industry and growers to want to do it"

The chemical companies are helping by putting softer spray options on the market. They also have to change to become more environmentally friendly, and in some European countries they are being forced to change by regulation.

And is IPM worth it? "Many of the new chemicals are more expensive, but it hasn't been an excuse not to do it", Roger said. He estimates that his IPM "spray" bill (including pheromones) is as much as before, and may cost more due to the labour of monitoring, but "it's a much cleaner, nicer environment to work in". Kym and Roger reported more small, insect eating birds as well as frogs and worms in IPM orchards - indicators of environmental health. They take it as a sign that they're doing well.

"Ultimately IPM is safer for the farmer, worker and consumer", Kym said, "and the fruit quality is still very good".

NEWS RELEASE

New South Wales

APPLE GROWERS CUT PESTICIDES

Apple growers around Australia are keeping their end of a bargain made with consumer groups in 1990 to cut pesticide use by fifty percent. And they're doing it at their own expense - growers are not being paid a higher price for the product.

Michael and Sharon Smart of Batlow, NSW, have made significant savings on spray costs for their 80 acre orchard through regular pest monitoring. Monitoring gives Michael enough information to decide whether to delay or avoid sprays even though he may see pests in the orchard. For example, monitoring showed that the first 'standard' spray for apple dimpling bug was not needed this year because pest numbers were low, allowing Michael to save a spray.

"We also used to spray every time we saw a mite and consequently wore those chemicals out", Michael said. "Monitoring helps with the timing of the sprays. I remember using five, sometimes six mite sprays in the early 1980s' and now I'm back to one mite spray".

The Smarts employ the expertise of Kevin Dodds from the Batlow Field Services Section to monitor for apple dimpling bug, codling moth, mites and predators. He monitors two blocks regularly and spot samples any 'hot spots' he or Michael find throughout the orchard. Michael considers Kevin's monitoring to be the backup "but I make the final decision". Together they make a good team, combining Michael's knowledge of the orchard and day-to-day observations with Kevin's knowledge of pests and beneficial insects.

"We made a big saving when Kevin started calculating degree days as part of the codling moth monitoring", Michael said. "We used to spray azinphos every two to three weeks from early November for up to six sprays. Last year monitoring allowed us to delay our first spray by a month, cutting our number of sprays by at least a third and I think we could have gotten away with less", he said. Since then, the Smarts have started using Isomates to disrupt codling moth mating. "It has meant an increase in costs but this was off-set last year because we didn't use a moth spray at all", he said. They are also testing the effect of using reduced rates of isomates, to see if they can emulate the Victorians success on their farm.

"Overall, we've reduced both pesticides and herbicides in this orchard", Michael said. "We've virtually taken azinphos out of the system, a saving of $4000 in chemical, and have nearly eliminated Lorsban as well - a further reduction of about $2000".

The Smarts have had difficulty reducing chemicals for black spot in Batlow's high rainfall climate. "We always spray black spot to a very tight schedule early, so that we save sprays later", Michael explained. "In a clean spring we stop spraying by Christmas, only using spot sprays on black spot pressure points after that".

“Black spot is still a major issue”, Kevin added. “It is going to take a major scientific breakthrough before we can change control practices”.

The changes in pesticide use have had a noticeable effect on the farm. “The ecology of the orchard is constantly changing. We have more butterflies and ladybirds now”, Michael said. “Also, dropping azinphos out of the system helps me manage the workload around the farm as staff do not have to worry about re-entry periods. As an orchardist, I like the environment to be good as well, particularly as we’re raising our children on the farm”, Michael said.

“Batlow is a very challenging place to achieve significant pesticide reductions without sacrificing the very high product quality on which the district prides itself”, Kevin said. However, he commented that growers are changing their spray practices across the district. He estimated that three out of four growers are using some of the pest management services offered by the Batlow Fruit Co-operative Field Services Section. More than half use codling moth and mite/predator monitoring services, one in three uses apple dimpling bug monitoring, and some use the soil moisture monitoring and spray machine calibration services.

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Environmentally Friendly Apples & Pears

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CLEANER APPLES AND PEARS

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The growers have funded a number of research and extension projects through HRDC to help the apple industry achieve its pesticide reduction aims. One such project, entitled "Pesticide Reduction in Pomefruit for Year 2000" involved Queensland Department of Primary Industries (QDPI) staff with backgrounds in entomology, plant pathology, extension, engineering and horticultural consulting. It began with a national workshop, which brought together farmers, consultants, chemical company representatives, retail supply firms and a range of scientists to prioritise the project work from a national perspective.

The pesticide reduction project, led by Shane Dullahide, QDPI Applethorpe Research Station, focussed on research and extension relating to spray application, sprayer calibration and pest and disease monitoring.

"We published a booklet of orchard sprayer field trial results and distributed 500 copies throughout the industry," Shane said. "It explains the how modifying sprayers with air deflectors and multiple nozzles on standard low profile orchard sprayers can reduce pesticide use by over 20 per cent and sprayers with towers fitted give up to 40 per cent savings."

The booklet also explains how alternate row spraying every 7-14 days rather than every 10-21 days leads to a further 25 per cent reduction in pesticides with no increase in fruit damage. "These improvements in sprayer efficiency have allowed immediate reductions in pesticide use for growers," said Shane.

"We carried out detailed monitoring for mites, coddling moth and apple scab on four commercial blocks," Shane continued. "We found that pheromone 'twisties' for codling moth control lead achieved a 30 per cent reduction."

Shane and his team also ran sprayer calibration workshops for over 100 retail supply staff and 300 growers across the country, from Queensland to Tasmania and Western Australia. "We trained people in standard methods of orchard sprayer calibration, so they are confident they are applying pesticides efficiently, effectively, and at the correct rate," Shane said.

"The future of pesticide reduction relies on intensive orchard monitoring to determine pest and disease levels in each block, and using this information to make a better spray decision," Shane said. "By varying the spray application method, pesticide volumes and concentrations to suit different tree sizes and shapes, further reductions in pesticide use are possible. We are continuing our work in a new HRDC funded project to determine which combination of methods gives the best coverage with least wastage, as well as effective pest and disease control with minimum pesticide residue on the fruit," Shane concluded.

Grower Case Studies

IPM Group, Lenswood, South Australia

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Kym said the group is 'a real support thing.' He explained that implementing IPM often involves taking a couple of steps forward, and then one back. Sometimes growers are under a lot pressure from their brothers and fathers to spray, so the support from other growers using IPM really helps. "It takes time to build up predators in the orchard to help Mother Nature," he said.

IPM in apples involves using 'softer' more specific pesticides targeted at pests and not harmful to beneficial insects, along with mating disruption pheromones (twisties) to prevent pests from breeding. "Before, with the 'hard' chemicals, we used to knock out the good guys as well as pests," Kym said.

"The Apple industry really began thinking about integrated pest management in 1983, when some growers started using integrated mite management," explained Paul James. "However, it really fired up in 1986 when we lost the use of some chemicals."

It involves introducing predatory mites into the orchard to control pest mite numbers. This means that pesticides used against other pests must be chosen carefully, to avoid killing the good mites and other beneficial insects such as ladybirds and lacewings. "Integrated mite management really made apple growers conscious of the need to look after the good insects," Paul said. "Now we are aware of the good guys out there and are looking after them," Kym added.

The IPM group has helped local growers reduce their pesticide use even further, by requesting a blackspot warning service. "We wanted to reduce our blackspot sprays, but needed more information to be able to do it," Kym explained. The Lenswood Co-op responded by setting up a service which provides site specific warnings for blackspot based on weather.

The group also realised they wanted to know more about how to successfully use IPM. They have run 3 training workshops in conjunction with the Lenswood Agriculture and Forestry Bureau covering the identification of pests and beneficial insects, and how to monitor their orchards. Group members also offered their orchards for research trials, which improved communication between growers and researchers.

The growers have also educated themselves about improving spray practices to reduce pesticide use. They have been able to reduce the chemicals used by ensuring they get good coverage while using lower volume sprays. A trend towards smaller, more efficient trees also helps reduce the volume of sprays required.

"Years ago I used to use a calendar spray program, but now I only spray when my monitoring results show the need," Roger said. "Now everyone is careful about using chemicals - they look at every other avenue first."

Kym checks coddling moth/light brown apple moth traps each week. "By monitoring you know what's going on in the orchard, and you know what the enemy is," he said. He also uses a monitoring service for mite management, as a microscope is needed to count the numbers of pest and predator mites on the leaves. "When I have to use miticides, I'm just aiming to drop pest pressure so the predators can work. I'm not trying to knock out all the mites," he said.

Their knowledge about the ecology, the balances between insects in their orchards has changed the IPM growers' attitudes towards orchard management. "We accept more damage to our orchards than we previously did," Kym explained. "Even though we have mite damage on the leaves, we know the predators will work in the long run."

The group is now learning how to deal with the secondary pests such as woolly aphid which has become a problem now that broad spectrum pesticide use has been cut. "Earwigs can keep woolly aphid under control, but you need lots of aphids before the earwigs can work," Paul explained. The growers had to learn to accept higher aphid numbers in the IPM system. "They also had to get used to the idea that earwigs were good guys in apple orchards, even though they are a pest in cherries," he said.

Kym described how they had to change their way of thinking."Six or seven years ago we killed lots of ladybird larvae, thinking they were a pest," he said with remorse. "Just because it's an insect doesn't mean it has to be killed. We have a booklet on insect identification which is a real help," he said.

But every property is different - there will be different pest/predator ratios and different micro-climates, so growers have to deepen their understanding to use IPM. Through a process of step by step learning, the grower's skill levels have increased. "The group has learnt more about pest and beneficial insects in all life stages," Paul said. This has lead to them asking entirely different questions, such as what effect a pesticide will have on a predator, when buying chemicals and Dennis can give them the answers. "The whole group is doing it together - chemical companies, resellers, growers, researchers and PISA. If people aren't interested, it can't happen," Dennis said.

Where does the group see itself looking next? They believe the next step is integrated fruit production - improving the management of the whole orchard. "We really need an industry approach to integrated fruit production, a national approach," Kym said. "Growers want to be part of making the environment better, and it is the responsibility of the industry and growers to want to do it."

The chemical companies are helping by putting softer spray options on the market. They also have to change to become more environmentally friendly, and in some European countries they are being forced to change by regulation.

And is IPM worth it? "Many of the new chemicals are more expensive, but it hasn't been an excuse not to do it," Roger said. He estimates that his IPM "spray" bill (including pheromones) is as much as before, and may cost more due to the labour of monitoring, but "it's a much cleaner, nicer environment to work in." Kym and Roger reported more small, insect eating birds as well as frogs and worms in IPM orchards - indicators of environmental health. They take it as a sign that they're doing well.

"Ultimately IPM is safer for the farmer, worker and consumer," Kym said, "and the fruit quality is still very good."

CHANGES IN PESTICIDE USE IN APPLE PRODUCTION IN LENSWOOD, SA

Target Pest	1992	1997
Mites	2 or 3 full strength miticides used over whole farm.	Treat 'hot spots' only (5% of a full spray) & some haven't sprayed mites for 5 years.
Codling Moth & Light Brown Apple Moth	Spray every 21 days from late Oct to Mar.	Pheromones ('twist-ties') for mating disruption. Sometimes 1 spray for LBAM & heliothis in Oct/Nov. (IS THIS INSEGAR?)
Overall approach	Calendar spray. Control pests - try to eradicate.	Monitor pest numbers and decide whether to spray based on that information. Keep pest pressure low, below economic thresholds.

Michael and Sharon Smart, Batlow, New South Wales

Michael and Sharon Smart of Batlow, NSW, have made significant savings on spray costs for their 80 acre orchard through regular pest monitoring. Monitoring gives Michael enough information to decide whether to delay or avoid sprays even though he may see pests in the orchard. For example, monitoring showed that the first 'standard' spray for apple dimpling bug was not needed this year because pest numbers were low, allowing Michael to save a spray.

"We also used to spray every time we saw a mite and consequently wore those chemicals out," Michael said. "Monitoring helps with the timing of the sprays. I remember using five, sometimes six mite sprays in the early 1980's and now I'm back to one mite spray."

The Smarts employ the expertise of Kevin Dodds from the Batlow Field Services Section to monitor for apple dimpling bug, codling moth, mites and predators. He monitors two blocks regularly and spot samples any 'hot spots' he or Michael find throughout the orchard. Michael considers Kevin's monitoring to be the backup "but I make the final decision." Together they make a good team, combining Michael's knowledge of the orchard and day-to-day observations with Kevin's knowledge of pests and beneficial insects.

"We made a big saving when Kevin started calculating degree days as part of the codling moth monitoring," Michael said. "We used to spray azinphos every two to three weeks from early November for up to six sprays. Last year monitoring allowed us to delay our first spray by a month, cutting our number of sprays by at least a third and I think we could have gotten away with less," he said. Since then, the Smarts have started using Isomates (pheromone twisties) to disrupt codling moth mating. "It has meant an increase in costs but this was off-set last year because we didn't use a moth spray at all," he said. They are also testing the effect of using reduced rates of isomates, to see if they can emulate the Victorian's success on their farm.

"Overall, we've reduced both pesticides and herbicides in this orchard," Michael said. "We've virtually taken azinphos out of the system, a saving of $4000 in chemical, and have nearly eliminated Lorsban as well - a further reduction of about $2000."

The Smarts have had difficulty reducing chemicals for black spot in Batlow's high rainfall climate. "We always spray black spot to a very tight schedule early, so that we save sprays later," Michael explained. "In a clean spring we stop spraying by Christmas, only using spot sprays on black spot pressure points after that."

"Black spot is still a major issue," Kevin added. "It is going to take a major scientific breakthrough before we can change control practices."

The changes in pesticide use have had a noticeable effect on the farm. "The ecology of the orchard is constantly changing. We have more butterflies and ladybirds now," Michael said. "Also, dropping azinphos out of the system helps me manage the workload around the farm as staff do not have to worry about re-entry periods. As an orchardist, I like the environment to be good as well, particularly as we're raising our children on the farm," Michael said.

"Batlow is a very challenging place to achieve significant pesticide reductions without sacrificing the very high product quality on which the district prides itself," Kevin said. However, he commented that growers are changing their spray practices across the district. He estimated that three out of four growers are using some of the pest management services offered by the Batlow Fruit Co-operative Field Services Section. More than half use codling moth and mite/predator monitoring services, one in three uses apple dimpling bug monitoring, and some use the soil moisture monitoring and spray machine calibration services.

Eric Haynes and sons, Pozieres, Queensland

Eric Haynes farms 90 acres of apples at Pozieres, on Queensland's Granite Belt, with his two sons John and Roger. He explained how they dramatically cut pesticide use on their farm over the past few years through altering their sprayer and introducing pheromone 'twisties' for codling moth management into their orchard.

"We've put pheromone twisties on 25 acres this year, which was so effective we didn't have to spray an insecticide for moth on that part of the farm," Eric said. "Twisties do cost more than insecticides, but we prefer to use them because they don't kill all the other insects in the orchard, and are less dangerous to the operators." Despite the cost, the Haynes have decided to expand their use of twisties to the whole farm over the next two or three years.

Eric also said that using twisties allows him to be more flexible with other pest management practices. "In the past we would spray for black spot and codling moth together as a time saving, even if both sprays weren't really needed. Now, because we don't spray codling moth, we only go out and spray black spot when the DPI warning service indicates it is needed, so we spray less often," he explained.

The Haynes monitor for codling moth in the areas without twisties, so they know how many pests are around and when to spray. "We used to spray on a program every two or three weeks, but now we monitor our own pheromone traps. If we get anything over two moths in a trap over a week, and the numbers are increasing over time, we may decide to spray," Eric said. They are also trialing a light trap in conjunction with Stephen Sexton of Biocontrol, Warwick, to allow them to monitor codling moth where twisties, which make pheromone traps ineffective, are in use.

"We also monitor for European red mite and two-spotted mite every week in season by taking leaf samples and inspecting them under a hand lens," said Eric. This information has allowed them to reduce their mite sprays, by only spraying the mite infested areas of the orchard. "Next year we may buy and release predatory mites into the orchard, because we don't seem to have very many here," Eric said.

"We still have to spray once for apple dimpling bug when the trees are flowering, and sometimes need a second or third spray," Eric said. "We also trap for fruit fly in the twistie blocks, and spray with a baited spray to the bottom leaves of the trees when we find high enough numbers."

Improving the focus of sprays onto the parts of the tree where it is needed has also allowed the Haynes to reduce their use of pesticides by at least 20 to 30 per cent. Shane Dullahide, a senior experimentalist based at QDPI's Granite Belt Research Station, has helped the Haynes to modify their air-blast sprayer. With the addition of 'baffles' they now prevent spray being wasted onto the ground or up into the air. They also changed the type of nozzles, and inserted 'double adapters' to allow two nozzles to spray the thicker parts of the tree canopy. With this set-up, they can drive faster, using less spray per hectare, but still getting effective coverage. "It was amazing to me that he made such a difference with such simple ideas," Eric said.

Like many growers in the district, the Haynes are gradually replacing their old, big, widely spaced trees with smaller varieties, planted more densely at 1500 trees per hectare, and pruned for the central leader. This style of orchard is more efficient, not only to pick and prune, but also for pest and disease management, as the open style canopy assists spray penetration and improves air circulation. "Shane also advised us we could spray alternate rows in the young, closely planted trees, allowing us to cut our pesticide use in half on those blocks," Eric added.

Appendix 2

Pesticide Application Trials 1997/2000

Application trials were conducted by:

Robert Battaglia and Shane Dullahide Queensland Department of Primary Industries (Qld Horticulture Institute)

Grower Co-operators were:

Ugo and Stephen Tomasel
Michael Bertinazzi
Pozzabon and Co.

Acknowledgments: We are grateful to the grower cooperators for giving us access to their spray equipment, tractors and orchard sites. The assistance of Matthew Jones, Glenn Geitz and Halina Kruger is also gratefully acknowledged for their valuable support in both the field and in the laboratory with the processing of samples.

INTRODUCTION

These notes present the results from nine field trials conducted on a range of orchard sprayers in pomefruit. In total, the results from 45 distinct treatments are presented. These trials have been undertaken over two seasons, the 1997/98 and the 1998/99. Further field trials are planned for the 1999/2000-summer period, results from these trials will be included in an updated edition of this booklet at the completion of the project in July 2000. The trials were conducted as part of the project "Pomefruit Pesticide Reduction Strategies for the 2000's" and builds on the 17 trials that were conducted as part of HRDC project "Pesticide Reduction in Pomefruit for the year 2000".

The results in these notes follow the same format as those presented in the previous project "Pesticide Application Trials 1994-96". For each trial there is a summary page that shows the trial number and description, orchard and sprayer information and a summary of the results. In addition, the spray deposit results are presented on tree drawings or sometimes as scatter graphs to illustrate trends. The tree drawings show the tree shape, the sampling heights with the treatment description located beneath the tree.

Similar to previous trials our aim was not only to increase the pesticide deposit on the orchard trees by improving the coverage throughout the height and depth of the tree canopy but also reduce off-target losses through run-off and drift.

It is our intention for this work to help growers choose appropriate spray volumes and hence not overspray and use excessive pesticides that could result in either increased fruit residues and greater losses to the environment.

We are grateful to the orchardist who co-operated by making their sprayers, orchards and employees available for this work. We appreciated their comments and practical knowledge on the proposed testing of the orchard sprayers. We also acknowledge the Apple and Pear Growers levies, the Horticultural Research and Development Corporation and the Queensland Department of Primary Industries for the funding of the project.

1. Experimental sites and sprayers

The field trials were conducted in three commercial Pomefruit orchards as well as the Applethorpe Deciduous Fruits Research Station at Stanthorpe, Queensland. The trials in this report include two seasons of field testing (1997/98 to 1998/99). The sprayers used consisted of a range of low profile airblast sprayers (Vendrame, Hardi TE1075) and a tower sir-shear sprayer (Silvan HiLow configuration). The emphasis of the testing was not specifically on the sprayer performance but rather testing concepts and strategies for utilising pesticides more effectively. Where appropriate we did make minor enhancements to some sprayers and these tested against the original set-up to determine whether the sprayer performance was improved.

Trial Number. 1-A. Modified Vendrame (1839 L, 1006L and 508L/ha in close planted, high density apple orchard).

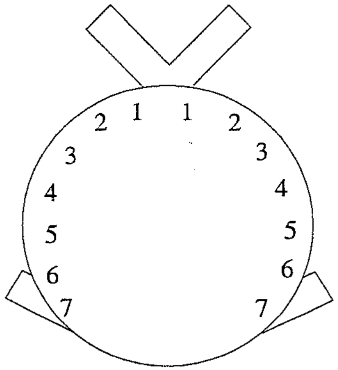
(Trial code Q022 – Site 1)

In this trial we compared the spray deposit on leaves, ground and drift from three application volumes and in four canopy types/sizes. Each volume was applied to all canopy types, hence there were 12 treatments in total.

GROWER	A			
DATE	MARCH 1997			
ORCHARD SPACING	4.0m x 2.0m (Site 1)			
VARIETY	ROYAL GALA			
TREE SIZE	3.75 m (Height)	2.0 m(width)	**APPROXIMATE CANOPY VOLUME**	18,750 (m^3/ha)

All blocks sprayed where under hail netting. We estimated as much as 30% of the canopy volume is open space.

Modified Vendrame (1839L/ha)

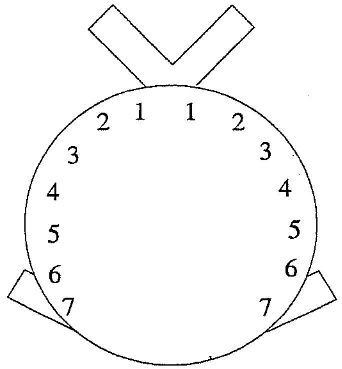


Travel speed 4.9 km/h
Rate of application 1839 L/ha
Operating pressure 11.5 Bar

Modifications

Configuration (16 Albuz blue)
1. off
2 1 x Albuz Blue
3 2 x Albuz Blue
4 3[1] x Albuz Blue
5 off
6 2 x Albuz Blue
7 off

Modified Vendrame (1006L/ha)



Travel speed 4.9 km/h
Rate of application 1006 L/ha
Operating pressure 10.5 Bar

Modifications

Configuration (18 Albuz red)
1 off
2 1 x Albuz Red
3 2 x Albuz Red
4 3 x Albuz Red
5 1 x Albuz Red
6 2 x Albuz Red
7 off

[1] These number refer to the number of nozzles at each positions (ie. 2 x Albuz blue indicates a nozzle doublet with two nozzles)

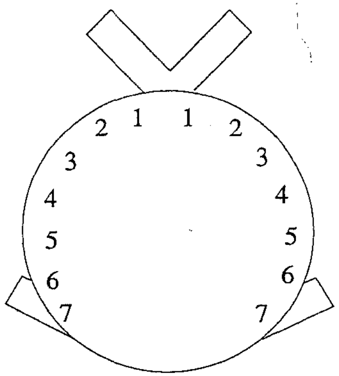
Trial Number. 1-A. (continued)

(Trial code Q022 – Site 1)

GROWER	A			
DATE	MARCH 1997			
ORCHARD SPACING	4.0m x 2.0m (Site 1)			
VARIETY	ROYAL GALA			
TREE SIZE	3.75 m (Height)	2.0 m(width)	**APPROXIMATE CANOPY VOLUME**	18,750 (m^3/ha)

All blocks sprayed where under hail netting. We estimated as much as 30% of the canopy volume is open space.

Modified Vendrame (508L/ha)



Travel speed 4..9 km/h
Rate of application 508 L/ha
operating pressure 14 Bar

Modifications

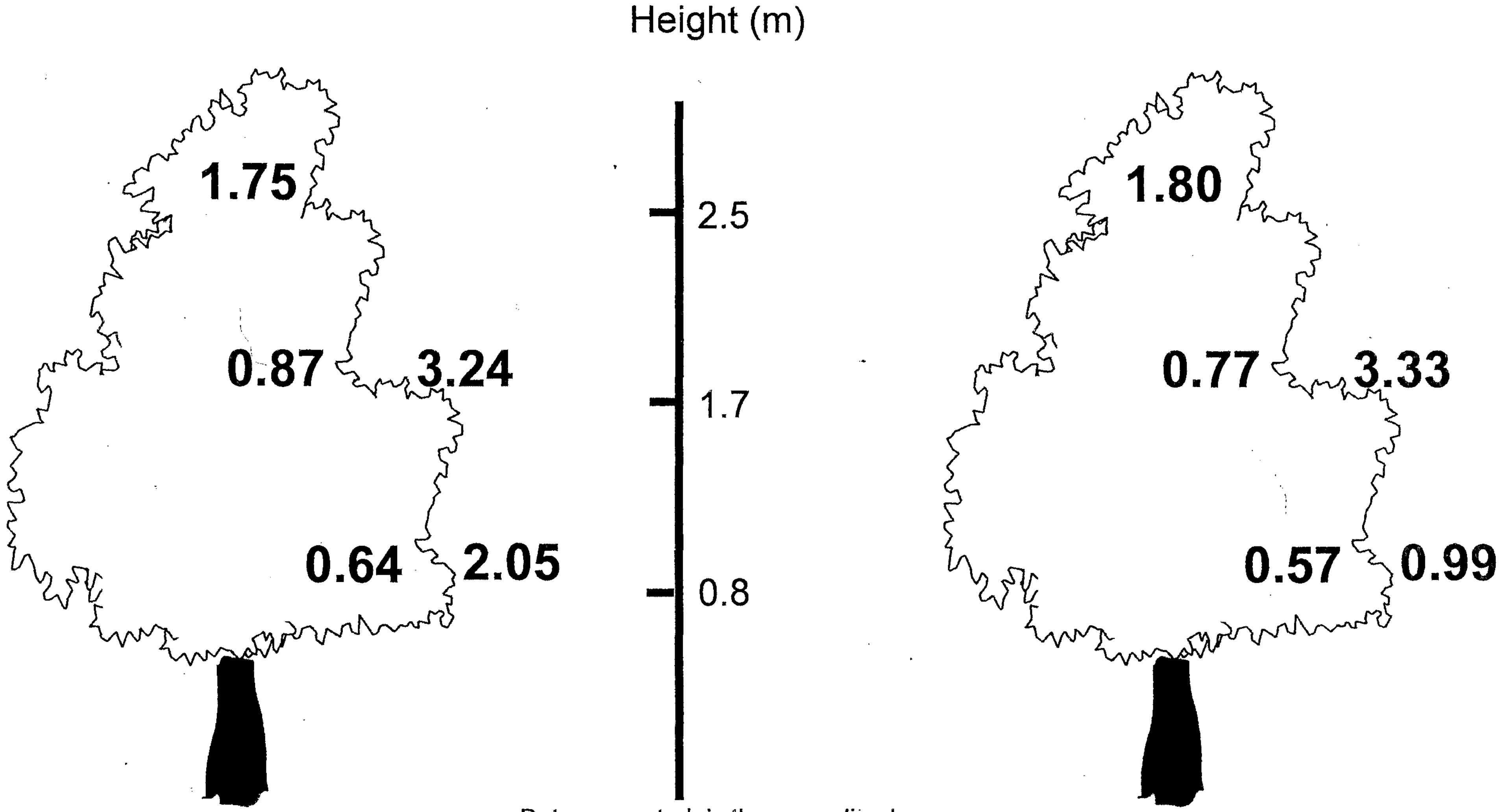
Configuration (14 Albuz orange)
1 off
2 1 x Albuz orange
3 2 x Albuz orange
4 2 x Albuz orange
5 off
6 2 x Albuz ornage
7 off

Summary At this site the approximate tree row volume was 18,750m^3/ha. The average whole tree deposit was lowest with the highest of the three volumes applied. The lowest volume used on this tree size gave the highest average recovery. On these trees it would be feasible to apply 500L/ha or less, using conventional airblast sprayers. A scatter graph shows the losses to the ground due to run-off or direct ground spray. The lower application volume (508L/ha) produced the least loss to the ground.

Trial no. 1-A

Leaf Deposit

Approximate Tree Row Volume = 18,750m^3/ha



Vendrame
508 L/ha

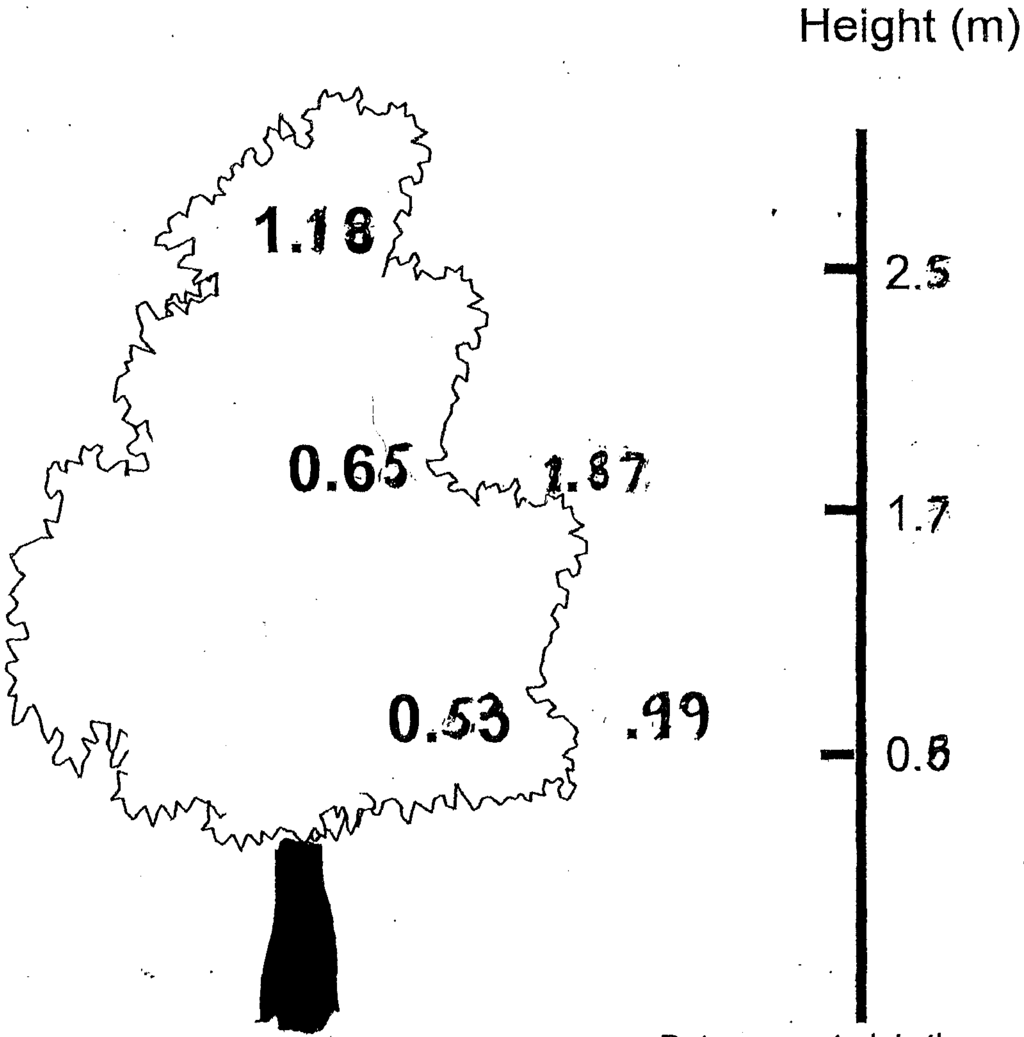
Data presented is the normalised spray deposit in (ng/cm²)/(g/ha) of tracer applied for the inner and outer canopy at 3 heights.

Vendrame
1006 L/ha

Trial no. 1-A

Leaf Deposit

Approximate Tree Row Volume = 18750 m^3/ha



Vendrame
1,839 L/ha

Data presented is the normalised spray deposit in (ng/cm²)/(g/ha) of tracer applied for the inner and outer canopy at 3 heights.

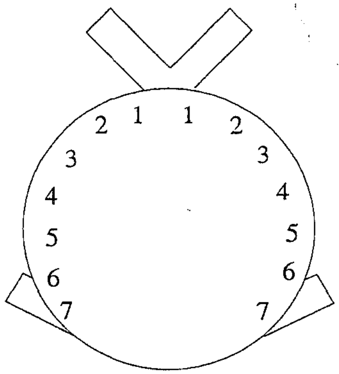
Trial Number. 1-B. Modified Vendrame (1839 L, 1006L and 508L/ha in close planted, high density apple orchard).

(Trial code Q022 – Site 3)

GROWER	A				
DATE	MARCH 1997				
ORCHARD SPACING	4.0m x 2.0m (Site 3)				
VARIETY	ROYAL GALA				
TREE SIZE	1.4 m (Height)	1.2 m(width)	**APPROXIMATE CANOPY VOLUME**	4,200	(m^3/ha)

This block was under hail netting.

Modified Vendrame (1839L/ha)

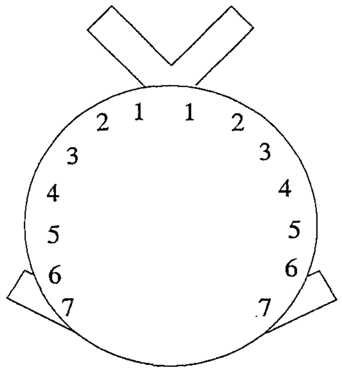


Travel speed 6.4 km/h
Rate of application 1839 L/ha
Operating pressure 10.5 Bar

Modifications

Configuration* (24 Albuz blue)
1. off
2 1 x Albuz blue
3 2 x Albuz blue
4 3 x Albuz blue
5 3 x Albuz blue
6 2 x Albuz blue
7 1 x Albuz blue
* 1 = single nozzle, 2 = double & 3 = triple

Modified Vendrame (1006L/ha)



Travel speed 6.4 km/h
Rate of application 1006 L/ha
Operating pressure 12.5 Bar

Modifications

Configuration (22 Albuz red)
1 off
2 1 x Albuz Red
3 2 x Albuz Red
4 3 x Albuz Rede
5 3 x Albuz Red
6 2 x Albuz Red
7 off

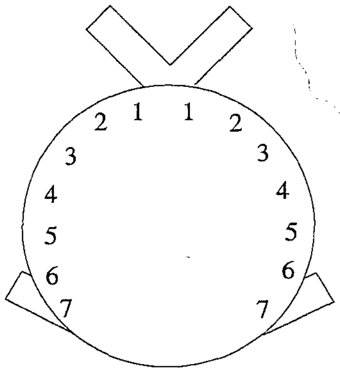
Trial Number. 1-B. (continued)

(Trial code Q022 – Site 3)

GROWER	A				
DATE	MARCH 1997				
ORCHARD SPACING	4.0m x 2.0m (Site 3)				
VARIETY	ROYAL GALA				
TREE SIZE	1.4 m (Height)	1.2 m(width)	**APPROXIMATE CANOPY VOLUME**	4,200	(m^3/ha)

This block was under hail netting.

Modified Vendrame(508L/ha)



Travel speed 6.4 km/h
Rate of application 508 L/ha
operating pressure 10.5 Bar

Modifications

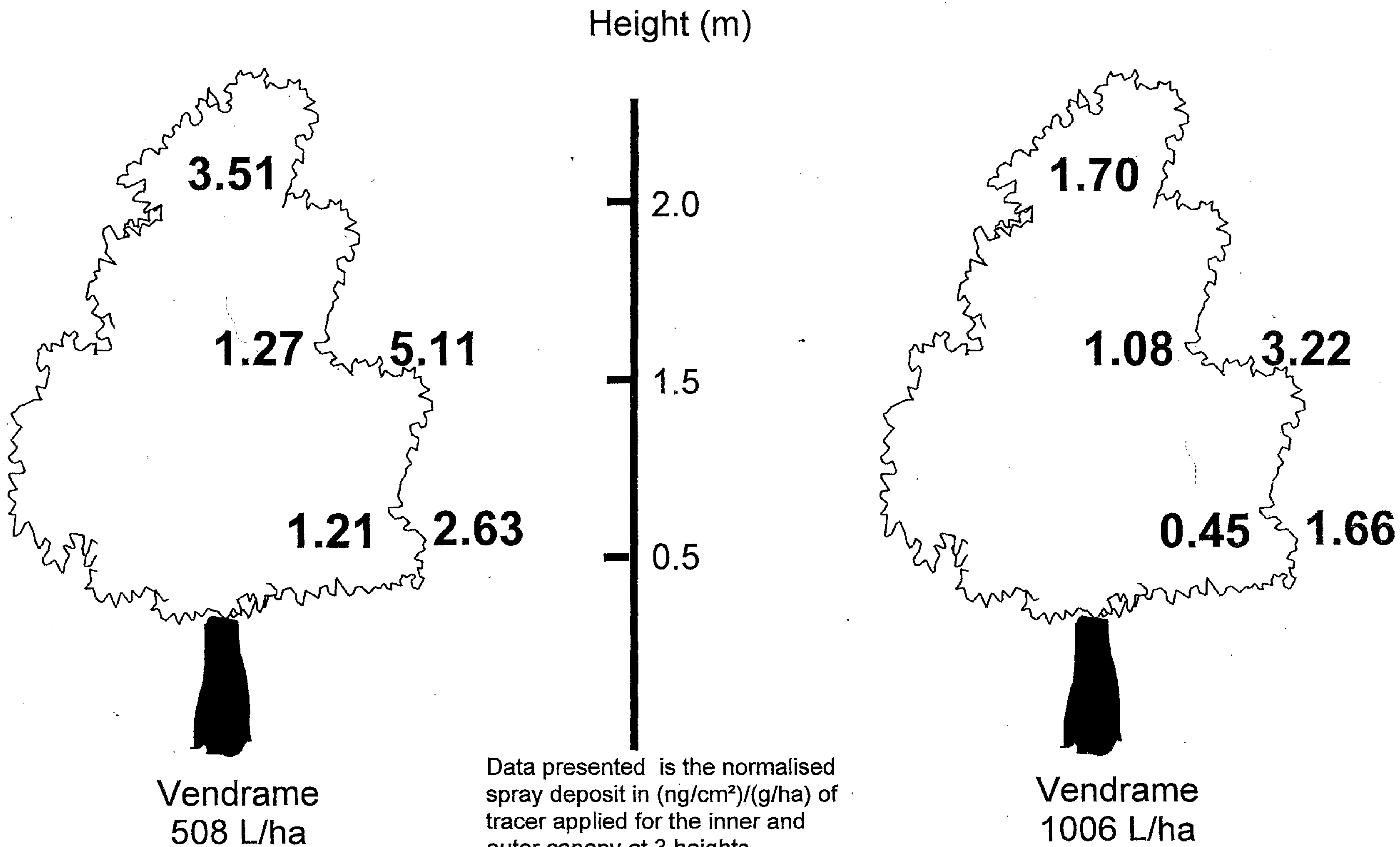
Configuration 16 Orange
1 off
2 1 x Albuz orange
3 2 x Albuz orange
4 3 x Albuz orange
5 off
6 2 x Albuz orange
7 off

Summary At this site the approximate TRV was 4,200m^3/ha. The same trend was evident in this size tree with the lowest applied volume delivering the highest average dose and the highest volume delivering the lowest dose. The 1006L/ha application volume produced the least loss to the ground with the greatest loss occurring with the 1,839L/ha application volume.

Trial no. 1-B

Leaf Deposit

Approximate Tree Row Volume = 4,300m^3/ha



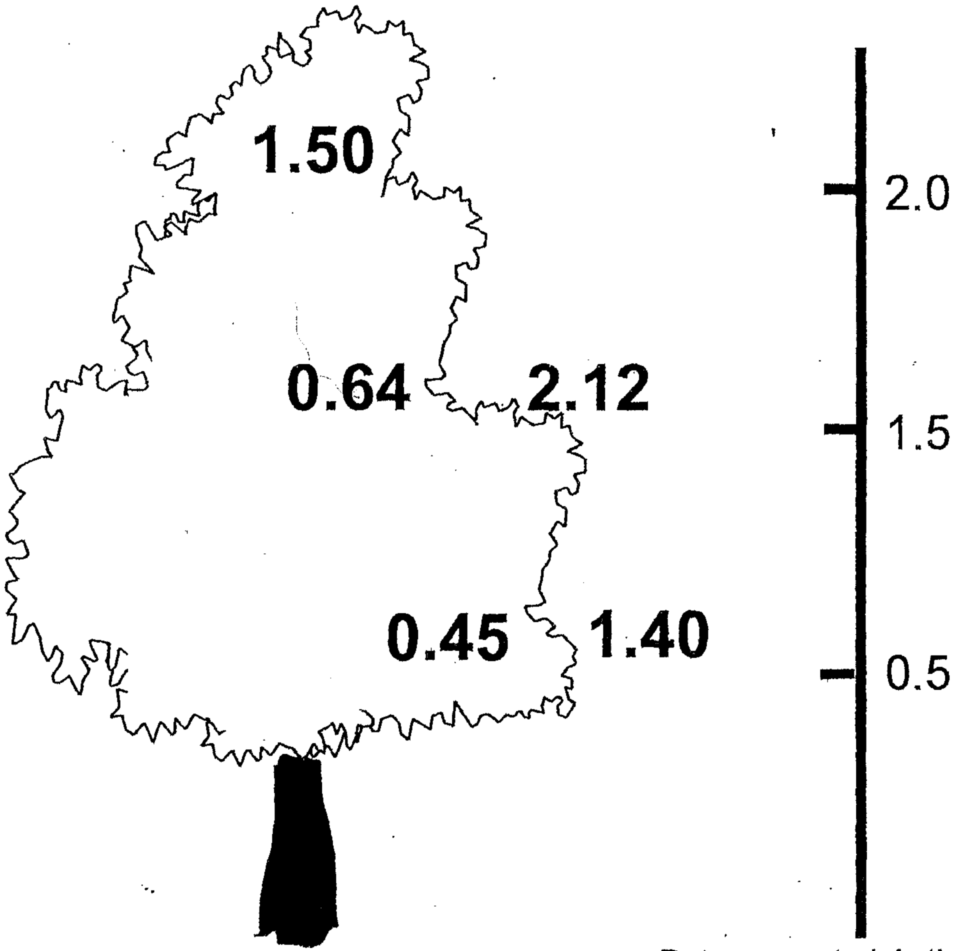
Data presented is the normalised spray deposit in (ng/cm²)/(g/ha) of tracer applied for the inner and outer canopy at 3 heights.

Trial no. 1-B

Leaf Deposit

Approximate Tree Row Volume = 4,300m^3/ha

Height (m)



Vendrame
1,839 L/ha

Data presented is the normalised spray deposit in (ng/cm²)/(g/ha) of tracer applied for the inner and outer canopy at 3 heights.

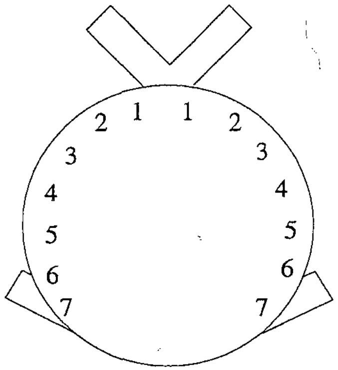
Trial Number. 1-C. Modified Vendrame (1839 L, 1006L and 508L/ha in tight vase, medium density apple orchard).

(Trial code Q022 – Site 4)

GROWER	A				
DATE	MARCH 1997				
ORCHARD SPACING	5.0m x 2.5m (Site 4)				
VARIETY	High Early Delicious				
TREE SIZE	3.95 m (Height)	2 m(width)	**APPROXIMATE CANOPY VOLUME**	15,800	(m^3/ha)

This block was under hail netting.

Modified Vendrame (1839L/ha)

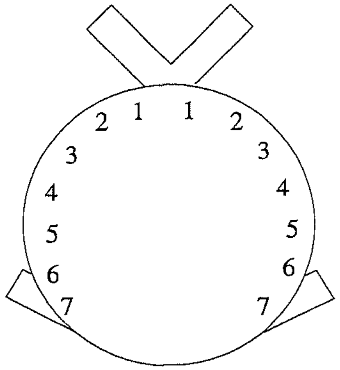


Travel speed 4.9 km/h
Rate of application 1839 L/ha
Operating pressure 10.5 Bar

Modifications

Configuration* (24 Albuz blue)
1. off
2 1 x Albuz blue
3 2 x Albuz blue
4 3 x Albuz blue
5 3 x Albuz blue
6 2 x Albuz blue
7 1 x Albuz blue
* 1 = single nozzle, 2 = double & 3 = triple

Modified Vendrame (1006L/ha)



Travel speed 4.9 km/h
Rate of application 1006 L/ha
Operating pressure 12.5 Bar

Modifications

Configuration (20 Albuz red)
1 off
2 1 x Albuz Red
3 1 x Albuz Red
4 3 x Albuz Rede
5 2 x Albuz Red
6 2 x Albuz Red
7 1 x Albuz red

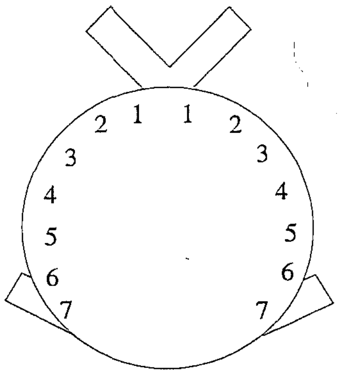
Trial Number. 1-C. (continued)

(Trial code Q022 – Site 4)

GROWER	A			
DATE	MARCH 1997			
ORCHARD SPACING	5.0m x 2.5m (Site 4)			
VARIETY	High Early Delicious			
TREE SIZE	3.95 m (Height)	2 m(width)	**APPROXIMATE CANOPY VOLUME**	15,800 (m^3/ha)

This block was under hail netting.

Modified Vendrame (508L/ha)



Travel speed 4.9 km/h
Rate of application 508 L/ha
operating pressure 10.5 Bar

Modifications

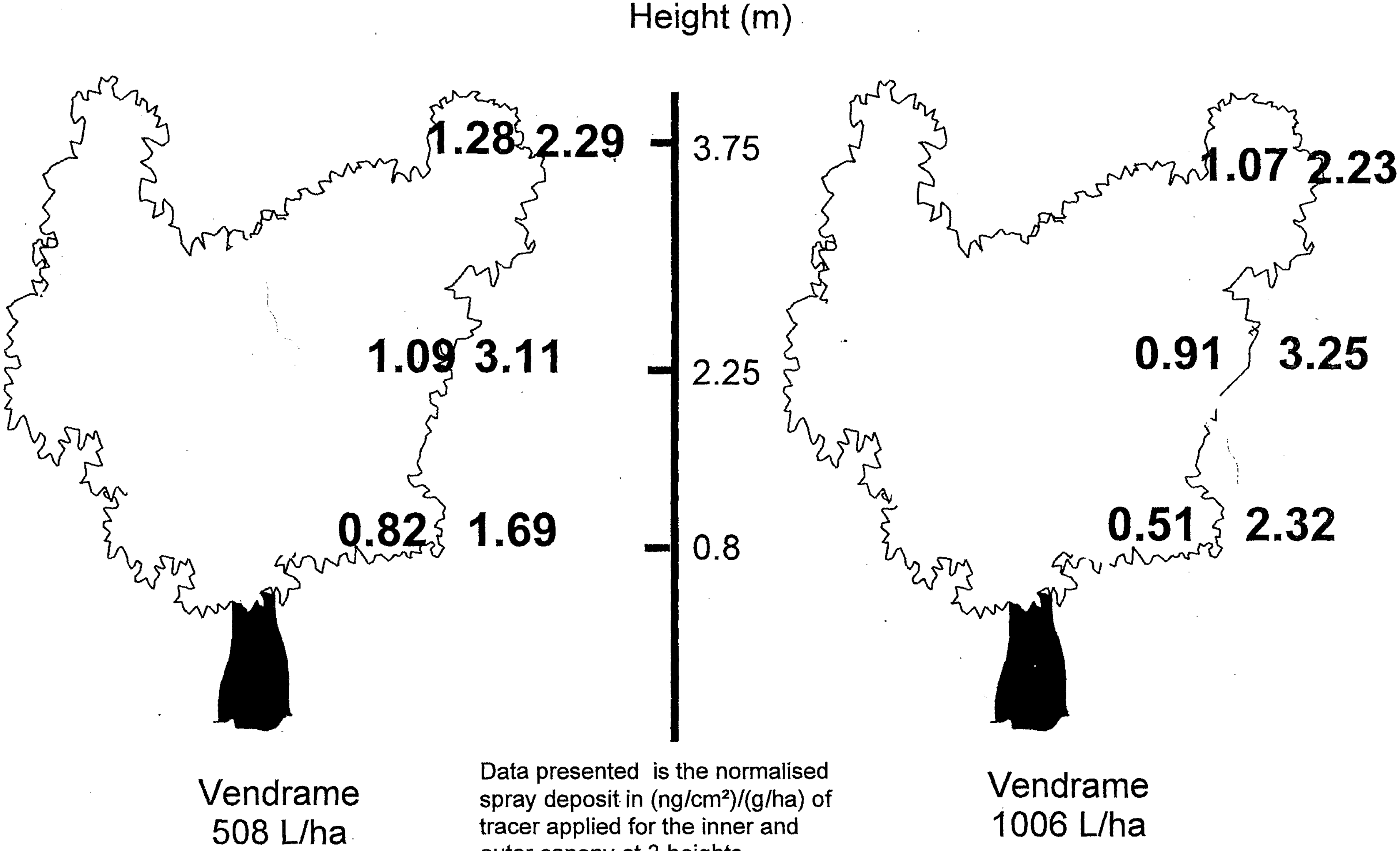
Configuration 16 0range
1 1 x Albuz orange
2 1 x Albuz orange
3 3 x Albuz orange
4 2 x Albuz orange
5 2 x Albuz orange
6 1 x Albuz orange
7 off

Summary: At this site the approximate TRV was 15,800m^3/ha. The trees in this block formed a continuous hedge and were characterised as being a tight open vase structure. The average tree deposit was almost identical for all three volumes applied to this site. This demonstrates that lower volumes can be used to deliver the same dose per target as a higher volume. In this instance the 1008 L/ha is the dilute spray volume (1X) and 508 L/ha is the concentrate spray volume (2X). The lowest volume produced the least loss to the ground. There was very little variation in the losses between the other two volumes.

Trial no. 1-C

Leaf Deposit

Approximate Tree Row Volume = 15,800m³/ha

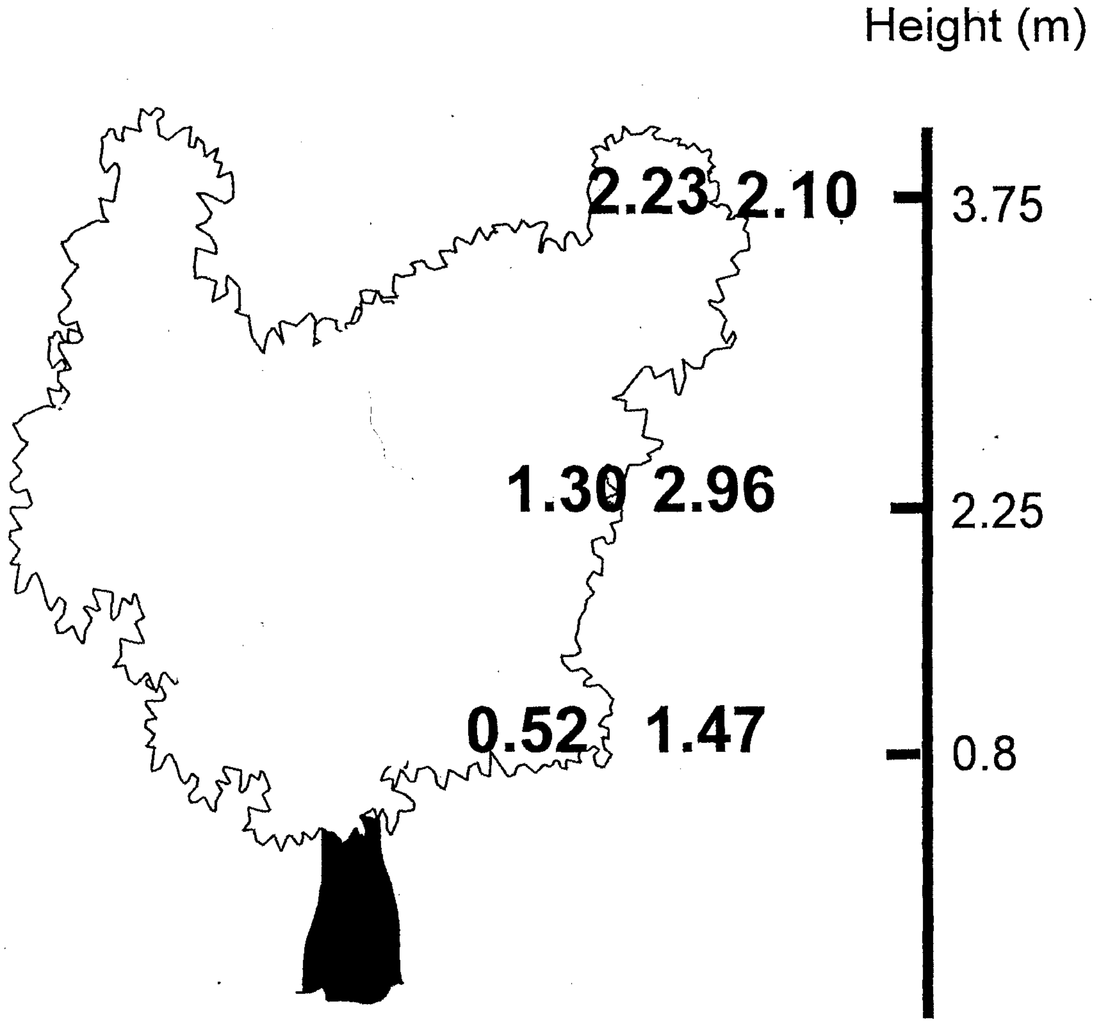


Data presented is the normalised spray deposit in (ng/cm²)/(g/ha) of tracer applied for the inner and outer canopy at 3 heights.

Trial no. 1-C

Leaf Deposit

Approximate Tree Row Volume = 15,800m^3/ha



Vendrame
1,839 L/ha

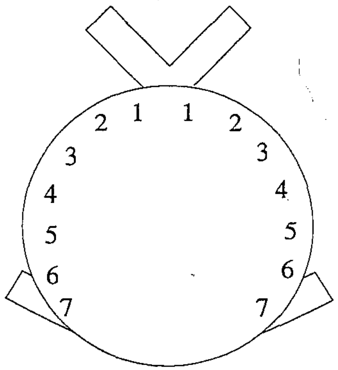
Data presented is the normalised spray deposit in (ng/cm^2)/(g/ha) of tracer applied for the inner and outer canopy at 3 heights.

Trial Number. 1-D. Modified Vendrame (1839 L, 1006L and 508L/ha in conventional spacing, vase, shaped apple trees). (Trial code Q022 – Site 5)

GROWER	A				
DATE	MARCH 1997				
ORCHARD SPACING	5.8m x 5.8m (Site 5)				
VARIETY	Granny Smith				
TREE SIZE	4.0 m (Height)	3.8 m(width)	**APPROXIMATE CANOPY VOLUME**	26,207	(m^3/ha)

This block was under hail netting. These trees did not form a hedge. We estimated as much as 30% of the canopy volume is open space.

Modified Vendrame (1839L/ha)

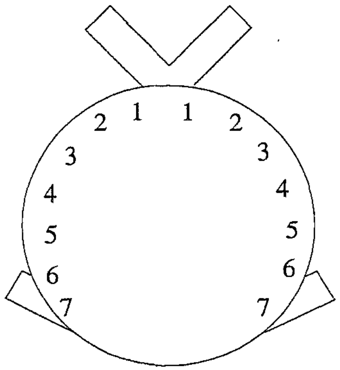


Travel speed 4.9 km/h
Rate of application 1839 L/ha
Operating pressure 14.5 Bar

Modifications

Configuration* (22 Albuz blue)
1. off
2 1 x Albuz blue
3 1 x Albuz blue
4 3 x Albuz blue
5 3 x Albuz blue
6 2 x Albuz blue
7 1 x Albuz blue
* 1 = single nozzle, 2 = double & 3 = triple

Modified Vendrame (1006L/ha)



Travel speed 6.4 km/h
Rate of application 1006 L/ha
Operating pressure 11.5 Bar

Modifications

Configuration (24 Albuz red)
1 off
2 1 x Albuz red
3 2 x Albuz red
4 3 x Albuz red
5 3 x Albuz red
6 2 x Albuz red
7 1 x Albuz red

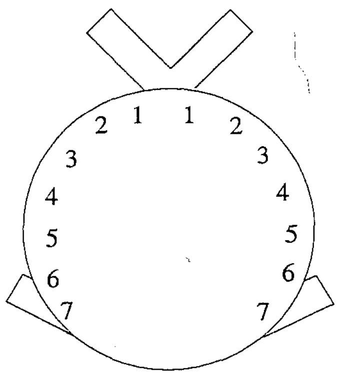
Trial Number. 1-D. (continued)

(Trial code Q022 – Site 5)

GROWER	A			
DATE	MARCH 1997			
ORCHARD SPACING	5.8m x 5.8m (Site 5)			
VARIETY	Granny Smith			
TREE SIZE	4.0 m (Height)	3.8 m(width)	**APPROXIMATE CANOPY VOLUME**	26,207 (m^3/ha)

This block was under hail netting. These trees did not form a hedge. We estimated as much as 30% of the canopy volume is open space.

Modified Vendrame (508L/ha)



Travel speed 4.9 km/h
Rate of application 508 L/ha
operating pressure 10.5 Bar

Modifications

Configuration 18 Orange
1 off
2 1 x Albuz orange
3 1 x Albuz orange
4 2 x Albuz orange
5 3 x Albuz orange
6 2 x Albuz orange
7 off

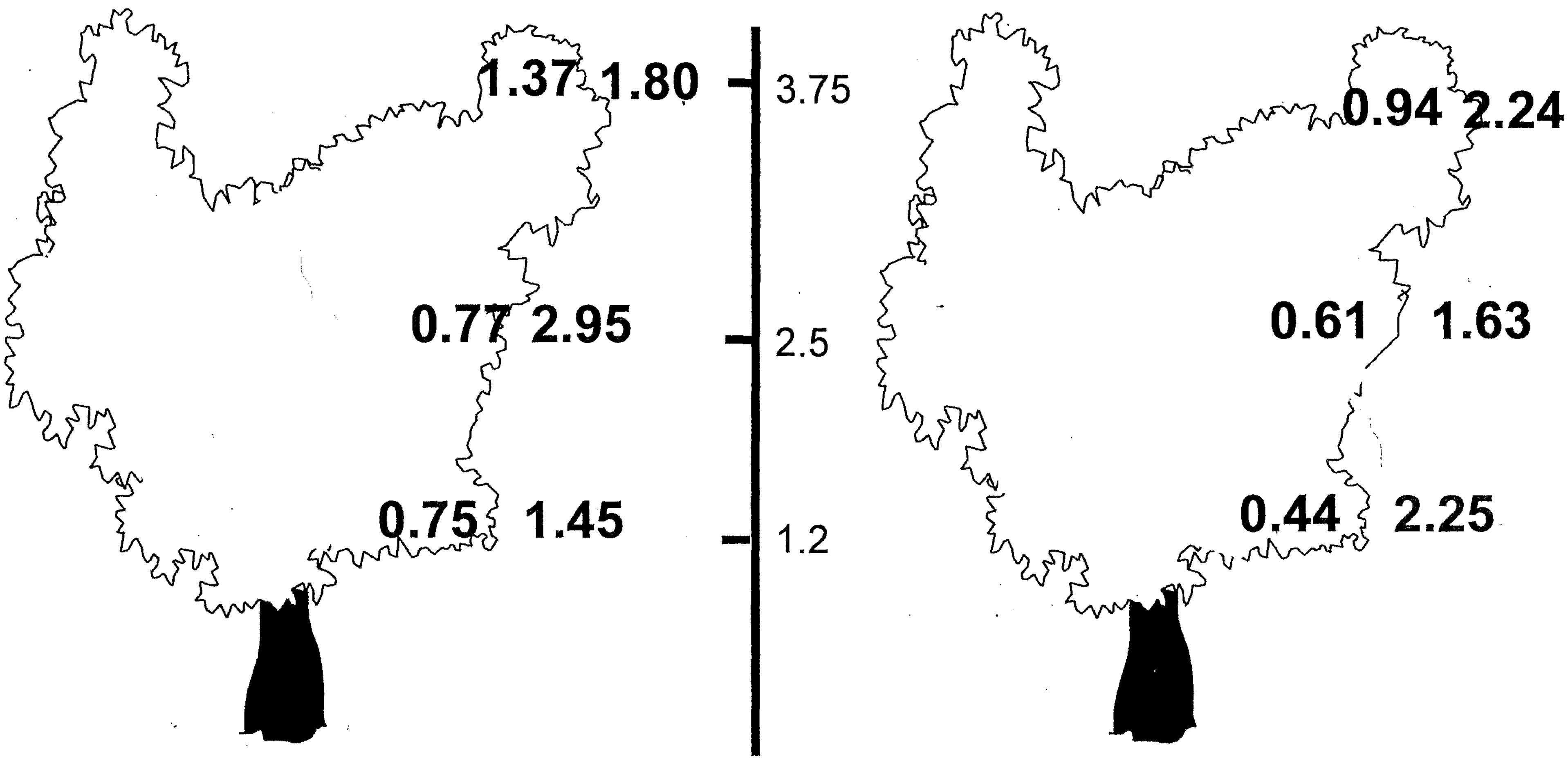
Summary: At this site the approximate TRV was 26,207m^3/ha. This TRV is overestimated, as the trees in this block did not form a hedge, 30% of the distance between the trees was open space. Again the lowest volume produced the highest average tree deposit. At this site the average deposit was lowest compared with the other sites when averaged across the three volumes used. There was no difference in the losses to the ground between three volumes. The major contributing factor to this loss was direct ground spray as the spray cloud moved between the large gaps in the row and was deposited on the adjacent row.

Trial no. 1-D

Leaf Deposit

Approximate Tree Row Volume = 26,207m^3/ha

Height (m)



Vendrame
508 L/ha

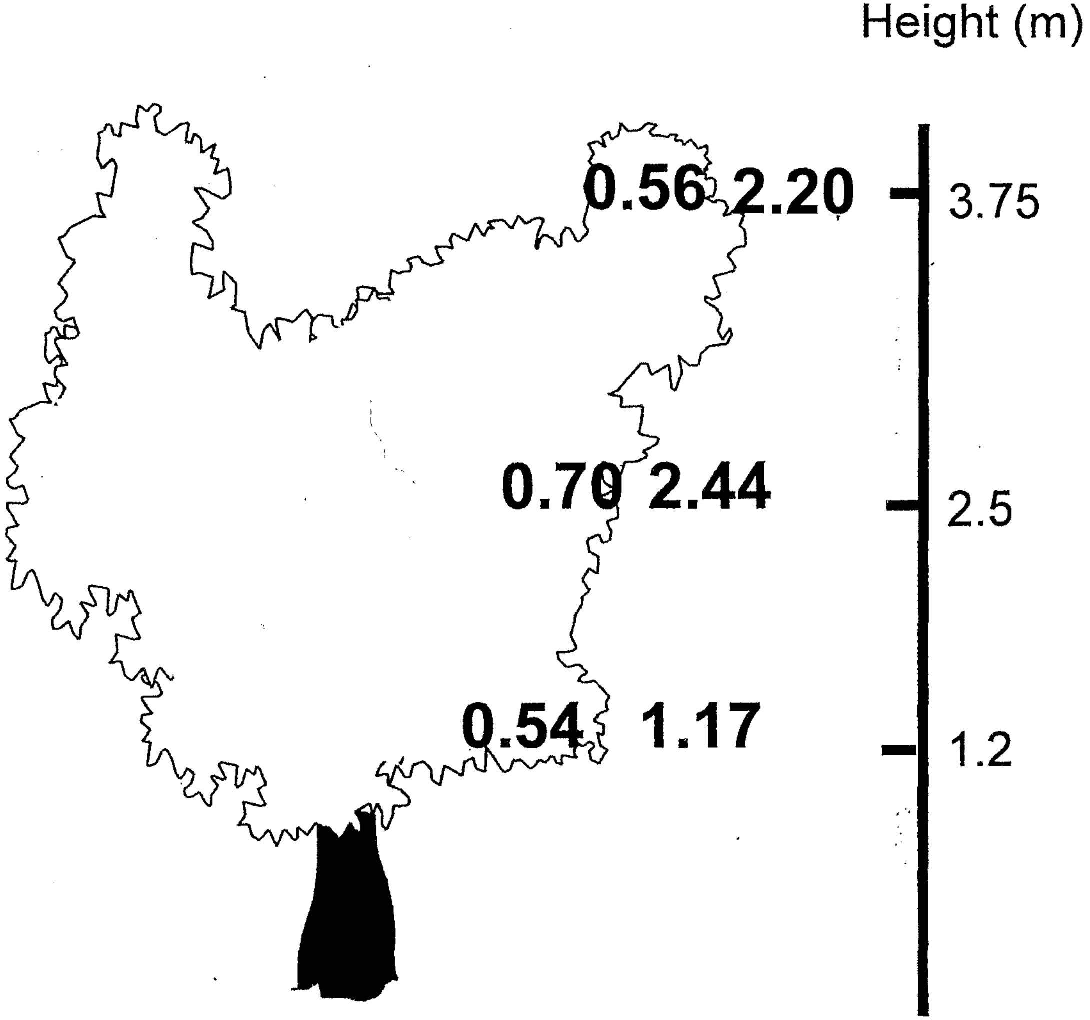
Data presented is the normalised spray deposit in (ng/cm²)/(g/ha) of tracer applied for the inner and outer canopy at 3 heights.

Vendrame
1006 L/ha

Trial no. 1-D

Leaf Deposit

Approximate Tree Row Volume = 26,207m³/ha

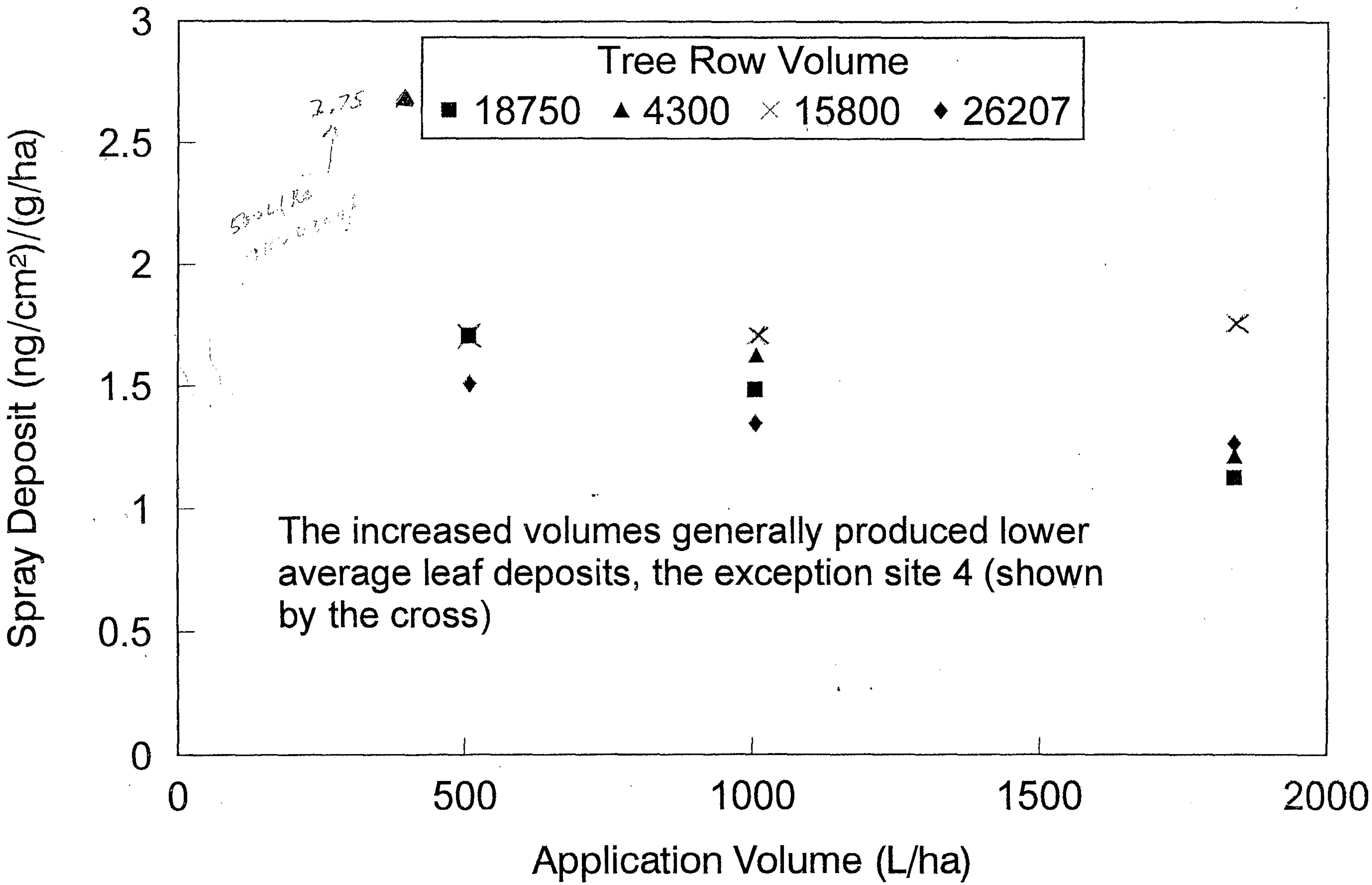


Vendrame
1,839 L/ha

Data presented is the normalised spray deposit in (ng/cm²)/(g/ha) of tracer applied for the inner and outer canopy at 3 heights.

Trial no. 1

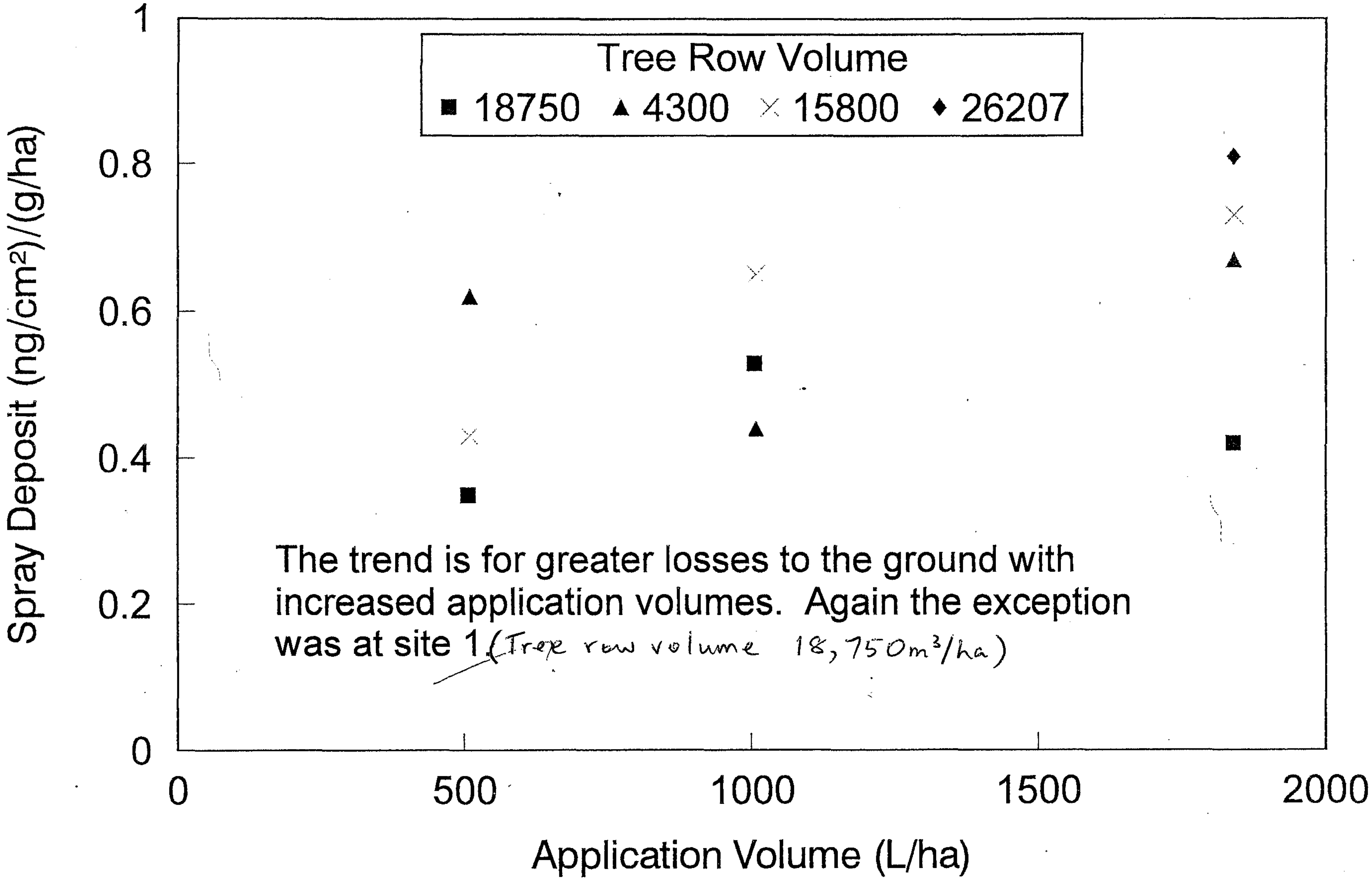
All Data: Leaf Deposit versus Application Volume



The increased volumes generally produced lower average leaf deposits, the exception site 4 (shown by the cross)

Trial no. 1

All Data: Loss to ground versus Application Volume

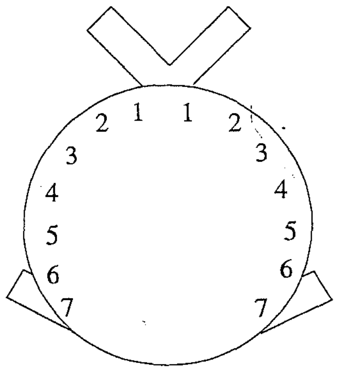


Trial Number 10. Application volume and tracer concentration trial.

(Trial code Q105)

GROWER	Applethorpe Research Station
DATE	28th January 1999
ORCHARD SPACING	6.0m x 6.05m
VARIETY	Granny Smith
TREE DIMENSIONS	3.5m HEIGHT 3m WIDTH **APPROXIMATE TREE ROW VOLUME** 17,500 m^3/ha
COMMENTS	

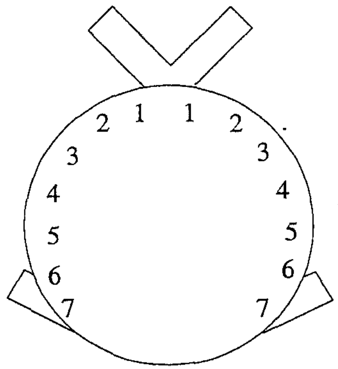
Hardi TE 1075 – 235L/ha @ 8X



Travel speed 4.0 km/h
Rate of application 235 L/ha
Operating pressure 10 Bar

Configuration :
1 off
2 1 x Albuz yellow
3 1 x Albuz yellow + 1 x blue
4 1 x Albuz yellow
5 1 x Albuz lilac
6 1 x Albuz lilac
7 off

Hardi TE 1075 – 470L/ha @ 4X



Travel speed 4.0 km/h
Rate of application 470 L/ha
operating pressure 10 Bar

Configuration: Trees sprayed twice to deliver 500L/ha. Additional water added to spray tank to make 4X.

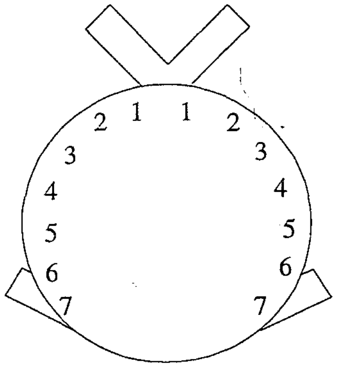
1 off
2 1 x Albuz yellow
3 1 x Albuz yellow + 1 x blue
4 1 x Albuz yellow
5 1 x Albuz lilac
6 1 x Albuz lilac
7 off

Summary: The scatter graph with the trend line summarises all the leaf deposit data for the range of volumes and concentrations tested at this site. There does not appear to be any obvious trend in the average leaf deposit for the four application volumes used. The lowest volume, 235L/ha, did give the lowest average deposit and if the point is omitted from the scatter plot the trend line would show decreasing recovery with increasing volume. The variability of deposit as quantified by the coefficient of variation is highest at the lower volume. The deposit distribution is more even at the higher volumes.

Trial Number 10 (Continued). Application volume and tracer concentration trial.
(Trial code Q105)

GROWER	Applethorpe Research Station						
DATE	28th January 1999						
ORCHARD SPACING	6.0m x 6.05m						
VARIETY	Granny Smith						
TREE DIMENSIONS	3.5m	HEIGHT	3m	WIDTH	**APPROXIMATE TREE ROW VOLUME**	17,500	m^3/ha
COMMENTS							

Hardi TE 1075 – 1063L/ha @ 2X

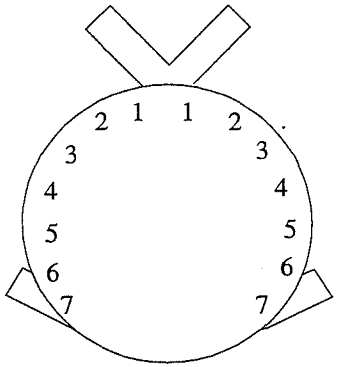


Travel speed 4.0 km/h
Rate of application 1063 L/ha
Operating pressure 15 Bar

Configuration: Water added to reduce tracer concentration.

1 off
2 1 x Albuz blue
3 1 x Albuz blue + 1 x green
4 1 x Albuz blue
5 1 x Albuz green
6 1 x Albuz red
7 off

Hardi TE 1075 – 1850L/ha @ 1X



Travel speed 4.0 km/h
Rate of application 1850 L/ha
operating pressure 20 Bar

Configuration: Water

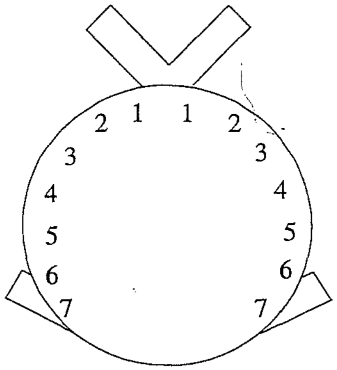
1 off
2 1 x Albuz blue
3 3 x Albuz blue
4 2 x Albuz yellow
5 1 x Albuz blue
6 1 x Albuz blue
7 off

Trial Number 10 (Continued). Application volume and tracer concentration trial.

(Trial code Q105)

GROWER	Applethorpe Research Station						
DATE	28th January 1999						
ORCHARD SPACING	6.0m x 6.05m						
VARIETY	Granny Smith						
TREE DIMENSIONS	3.5m	HEIGHT	3m	WIDTH	**APPROXIMATE TREE ROW VOLUME**	17,500	m^3/ha
COMMENTS	The spray volume was achieved by spraying the 1850L/ha volume twice.						

Hardi TF 1075 – 3700L/ha @ 1X



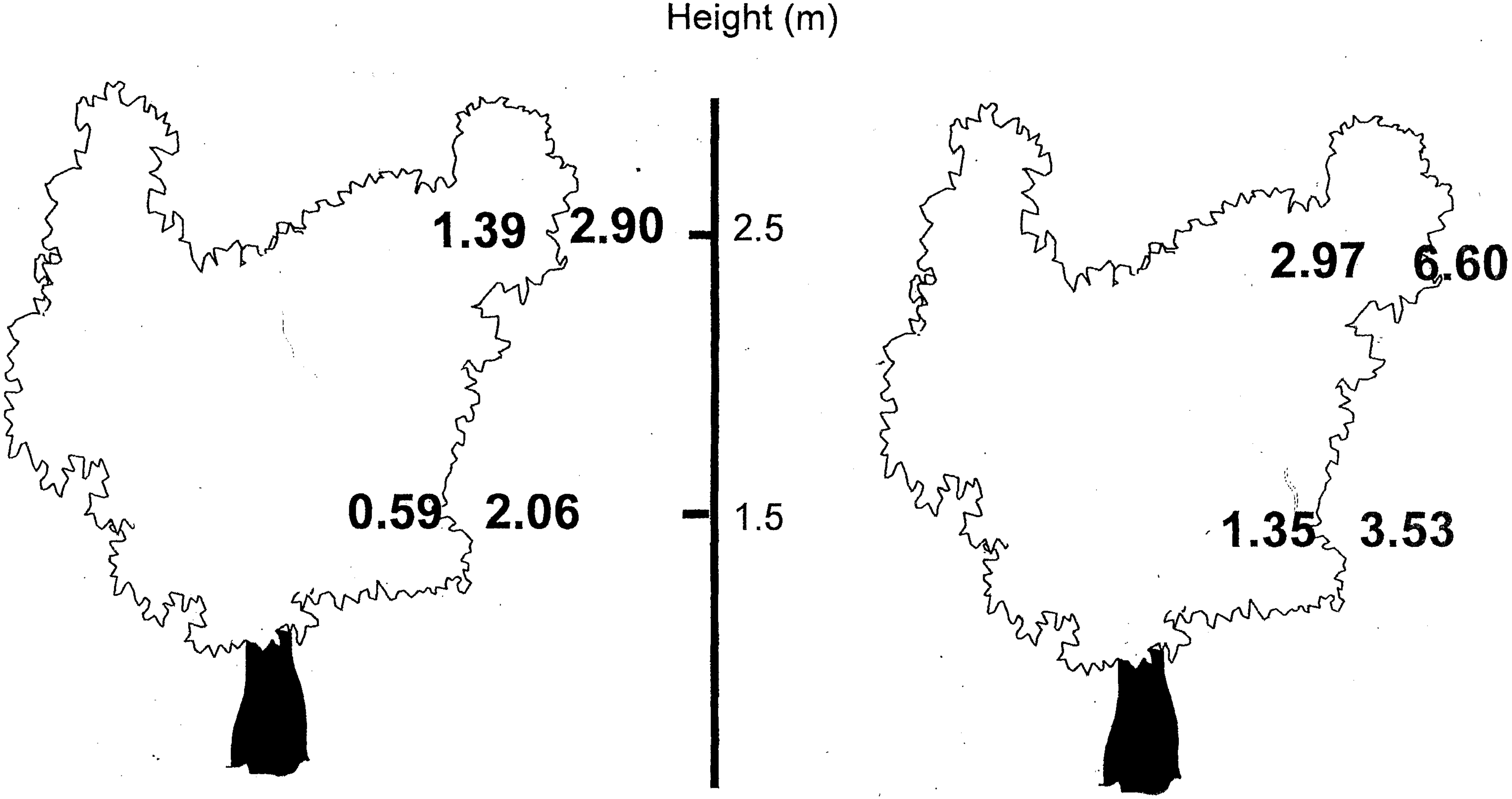
Travel speed 4.0 km/h
Rate of application 3700 L/ha
Operating pressure 15 Bar

Configuration: Water added to reduce tracer concentration.

1 off
2 1 x Albuz blue
3 3 x Albuz blue
4 2 x Albuz yellow
5 1 x Albuz blue
6 1 x Albuz blue
7 off

Trial no. 10

Leaf Deposit



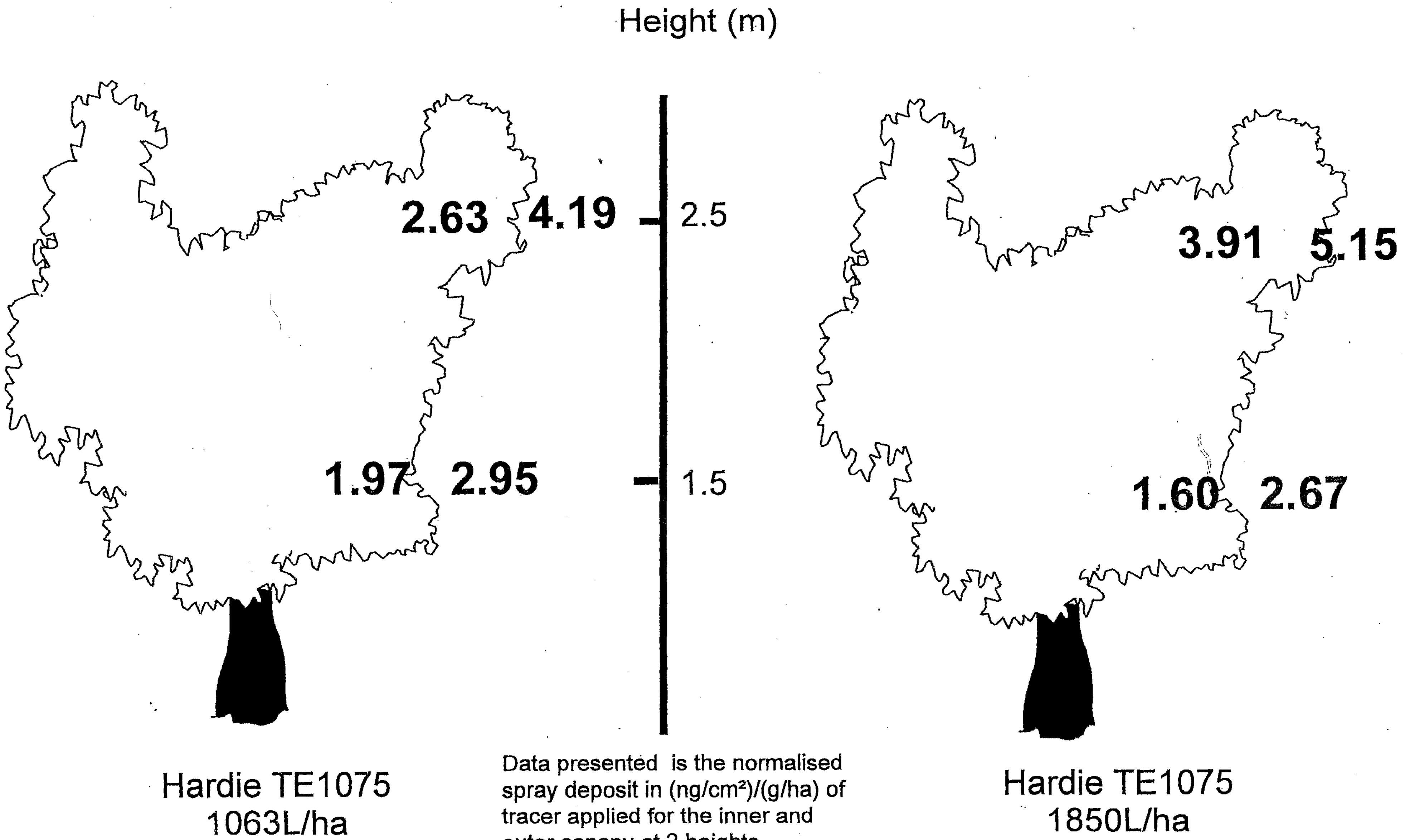
Hardie TE1075
235L/ha

Data presented is the normalised spray deposit in (ng/cm²)/(g/ha) of tracer applied for the inner and outer canopy at 2 heights.

Hardie TE1075
470L/ha

Trial no. 10

Leaf Deposit

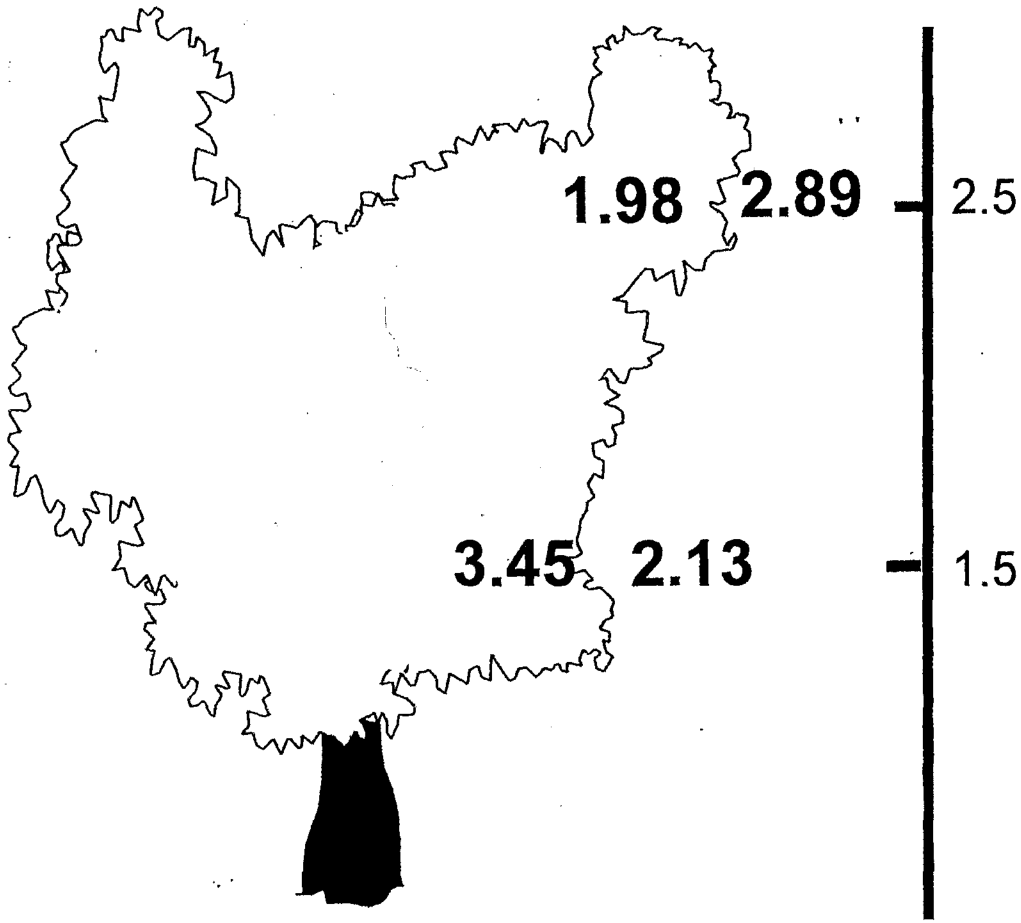


Data presented is the normalised spray deposit in (ng/cm²)/(g/ha) of tracer applied for the inner and outer canopy at 2 heights.

Trial no. 10

Leaf Deposit

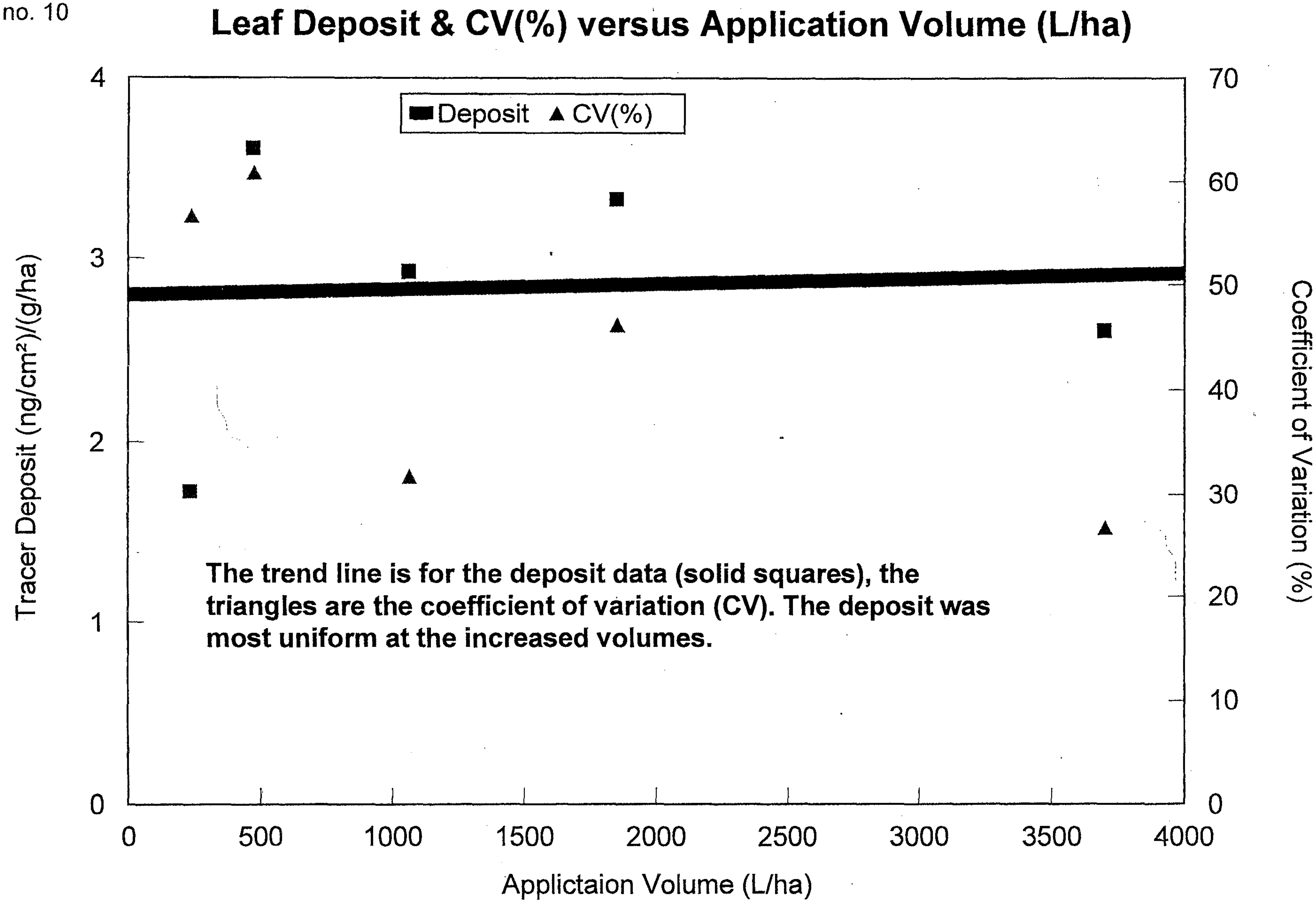
Height (m)



Hardie TF1075
3700L/ha

Data presented is the normalised spray deposit in (ng/cm²)/(g/ha) of tracer applied for the inner and outer canopy at 2 heights.

Trial no. 10

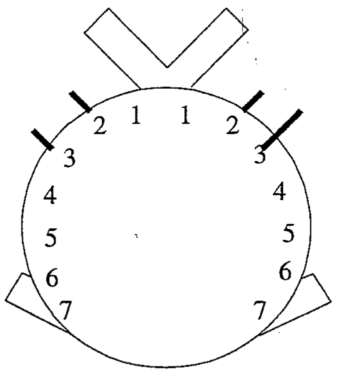

Leaf Deposit & CV(%) versus Application Volume (L/ha)
Deposit
CV(%)
Tracer Deposit (ng/cm²)/(g/ha)
Coefficient of Variation (%)
Applictaion Volume (L/ha)
0
1
2
3
4
0
10
20
30
40
50
60
70
0
500
1000
1500
2000
2500
3000
3500
4000
The trend line is for the deposit data (solid squares), the triangles are the coefficient of variation (CV). The deposit was most uniform at the increased volumes.

Trial Number 5. Low profile airblast sprayer (conventional) versus air baffles and nozzle extensions.

(Trial code Q052)

GROWER	A
DATE	11 December 1997
ORCHARD SPACING	4.9 x 2.5m
VARIETY	Red Delicious
TREE DIMENSIONS	5m HEIGHT 2.4m WIDTH **APPROXIMATE TREE ROW VOLUME** 20,000 m^3/ha
COMMENTS	

Modified Vendrame (deflectors and nozzle extensions)

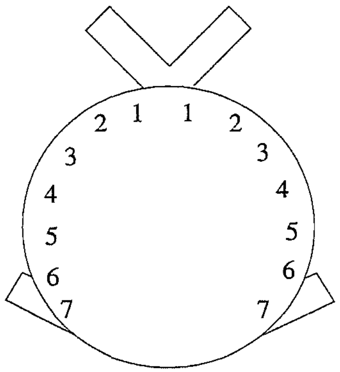


Travel speed 4.9 km/hr
Rate of application 867 L/ha
Operating pressure 13 Bar

Modifications : Rabbit ears doubles and triples with nozzle extensions

Configuration
1 Albuz Orange x 1
2 Albuz Orange x 1
3 Albuz Orange /Red
4 Albuz Orange /Orange/Red
5 Albuz Orange /Red
6 Albuz Orange x 1

Modified Vendrame (deflectors only)



Travel speed 4.9 km/hr
Rate of application 867 L/ha
Operating pressure 13 Bar

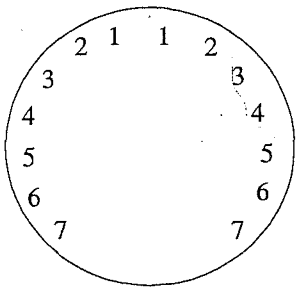
Modifications : Rabbit ears , Albuz nozzles (including 2 doubles and 1 triple nozzle bodies) no extensions

Configuration
1 Albuz Orange x 1
2 Albuz Orange x 1
3 Albuz Orange /Red
4 Albuz Orange /Orange/Red
5 Albuz Orange /Red
6 Albuz Orange x 1

Trial Number 5. (Continued)

GROWER A
DATE 11 December 1997
ORCHARD SPACING 4.9 x 2.5m
VARIETY
TREE DIMENSIONS 5m HEIGHT 2.4m WIDTH **APPROXIMATE TREE ROW VOLUME** 20,000 m^3/ha
COMMENTS

Vendrame (no modifications)



Travel speed 4.9 km/hr
Rate of application 867 L/ha
Operating pressure 13 Bar

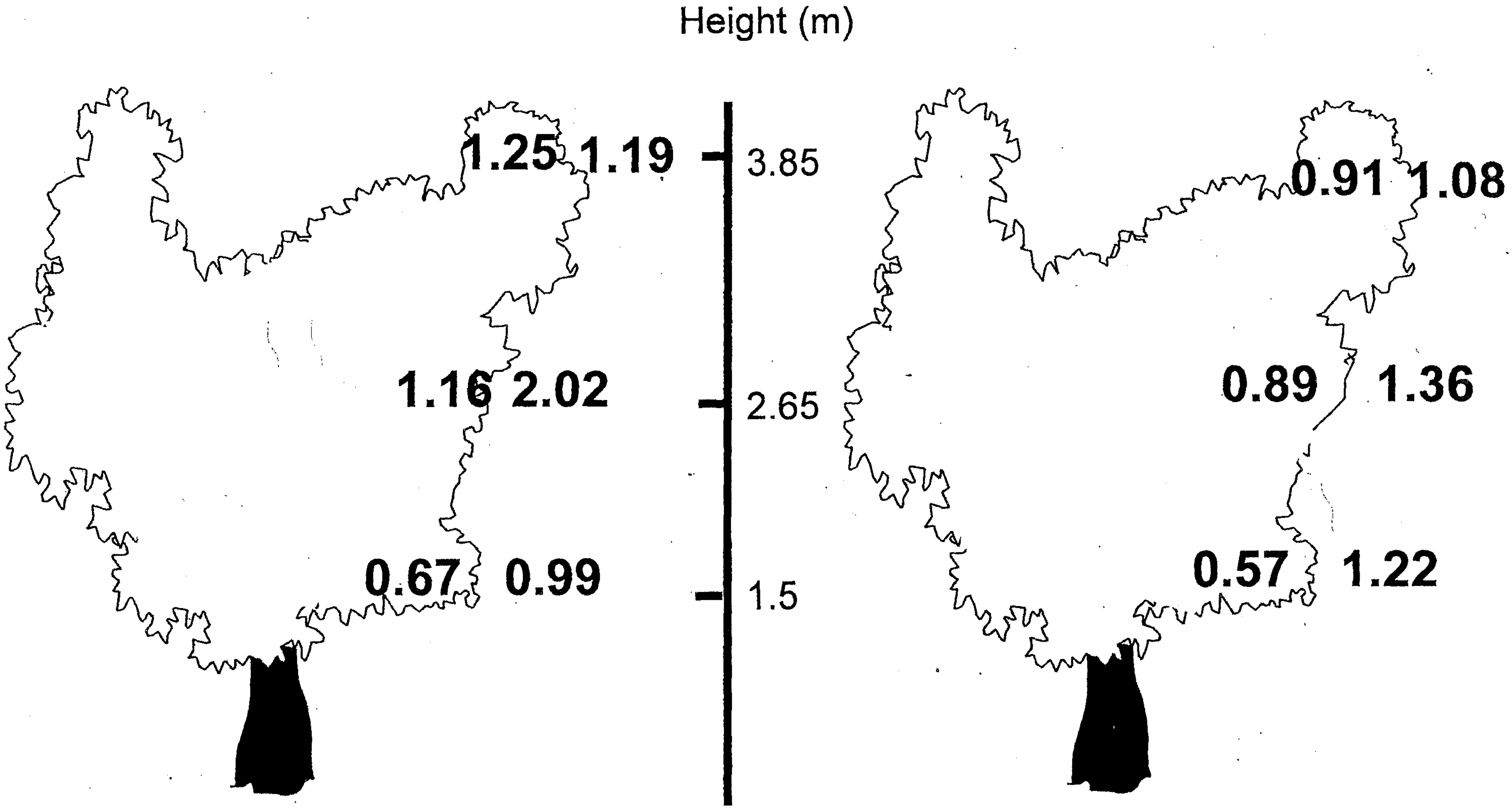
Modifications : No Rabbit ears or Nozzle extensions

Configuration
1 Albuz Orange x 1
2 Albuz Orange x 1
3 Albuz Orange /Red
4 Albuz Orange /Orange/Red
5 Albuz Orange /Red
6 Albuz Orange x 1

Summary: The configuration with the nozzle extensions on the top two nozzles on each side of the manifold produced an average deposit that was 21% higher than the other two configurations. The average deposit was equivalent with and without air deflectors however the configuration without deflectors still utilised nozzle doubles and triples. In previous trials we have obtained up to 30% increased deposit for the same volume with a combination of air deflectors and using nozzle clusters such as doubles and triples where more spray volume is required. The improvement in droplet size with more nozzles of the same size could play a significant role by itself towards improving spray distribution and coverage. The average deposit on fruit was up to 24% higher with both modified configurations compared to no air deflectors and nozzle extensions.

Trial no. 5

Leaf Deposit



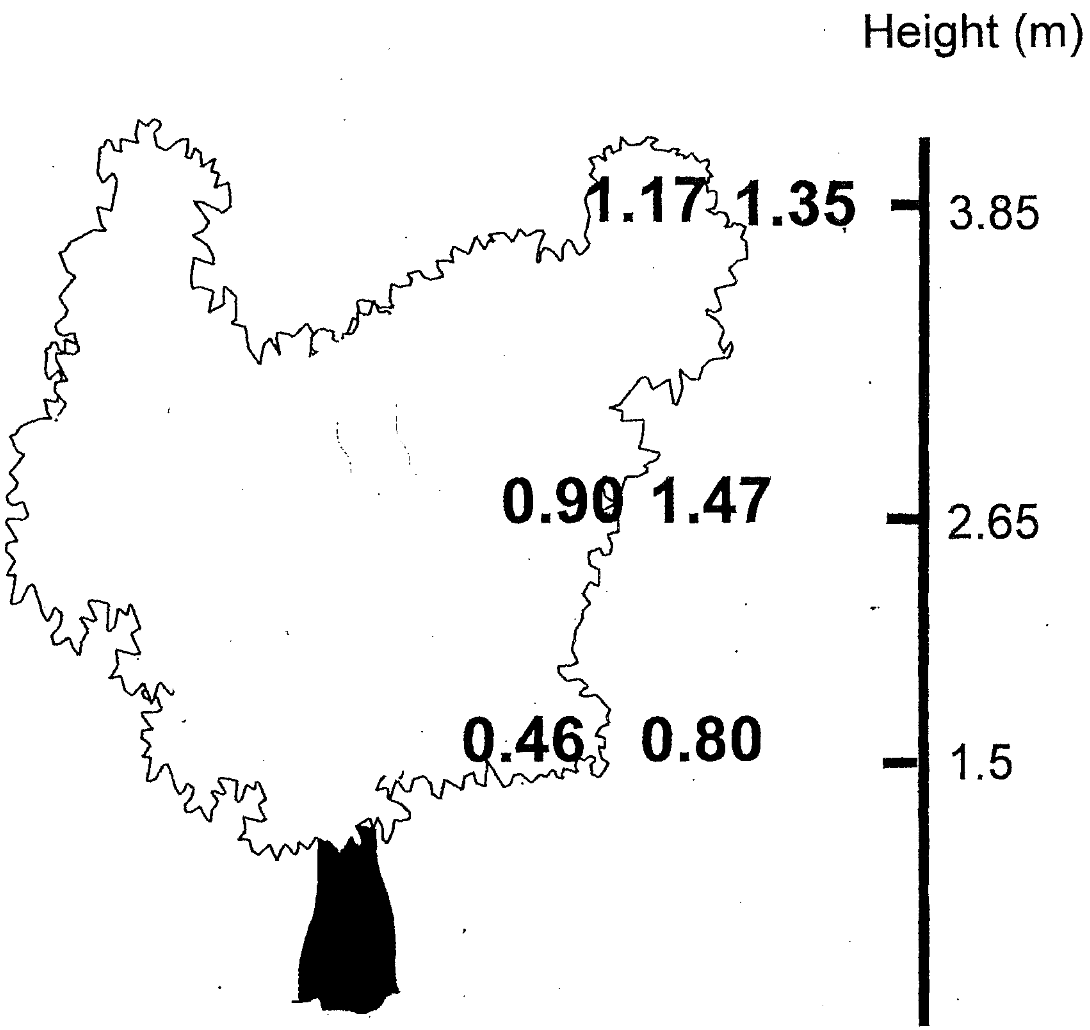
Vendrame
867 L/ha + ears & nozzle extensions

Data presented is the normalised spray deposit in (ng/cm²)/(g/ha) of tracer applied for the inner and outer canopy at 3 heights.

Vendrame
867 L/ha + ears only

Trial no. 5

Leaf Deposit



Vendrame
867 L/ha + all modifications removed

Data presented is the normalised spray deposit in $(ng/cm^2)/(g/ha)$ of tracer applied for the inner and outer canopy at 3 heights.

Trial Number 6-A. Silvan Turbomiser (P55, HiLow) 4,6.1 and 9.2 km/hr on small trees.

(Trial code Q054)

GROWER C
DATE 12th January 1998
ORCHARD SPACING 5.0 x 3m
VARIETY Red Delicious
TREE DIMENSIONS 3.5m HEIGHT 2.5m WIDTH **APPROXIMATE TREE ROW VOLUME** 17,500 m^3/ha
COMMENTS

Silvan Turbomiser (Hi Low) 4km/hr

Travel speed 4.0 km/h
Rate of application 197 L/ha
Operating pressure 0.5 Bar

Flow Rate 6.56 L/min

Schematic Only

	Volume (%)
Top	58
Bottom	42

Silvan Turbomiser (HiLow) 6.1km/hr

Travel speed 6.1 km/h
Rate of application 216 L/ha
Operating pressure 0.6 Bar

Modifications :.

Flow Rate 10.8 L/min

Schematic Only

	Volume (%)
Top	58
Bottom	42

Trial Number 6-A. (Continued)

GROWER	C
DATE	12 January 1998
ORCHARD SPACING	5.0 x 3.0m
VARIETY	Red Delicious
TREE DIMENSIONS	3.5m HEIGHT 2.5m WIDTH **APPROXIMATE TREE ROW VOLUME** 17,500 m^3/ha
COMMENTS	

Silvan Turbomiser (HiLow) 9.2 km/hr

Travel speed 9.2 km/h
Rate of application 209 L/ha
Operating pressure 1.1 Bar

Flow Rate 15.7 L/min

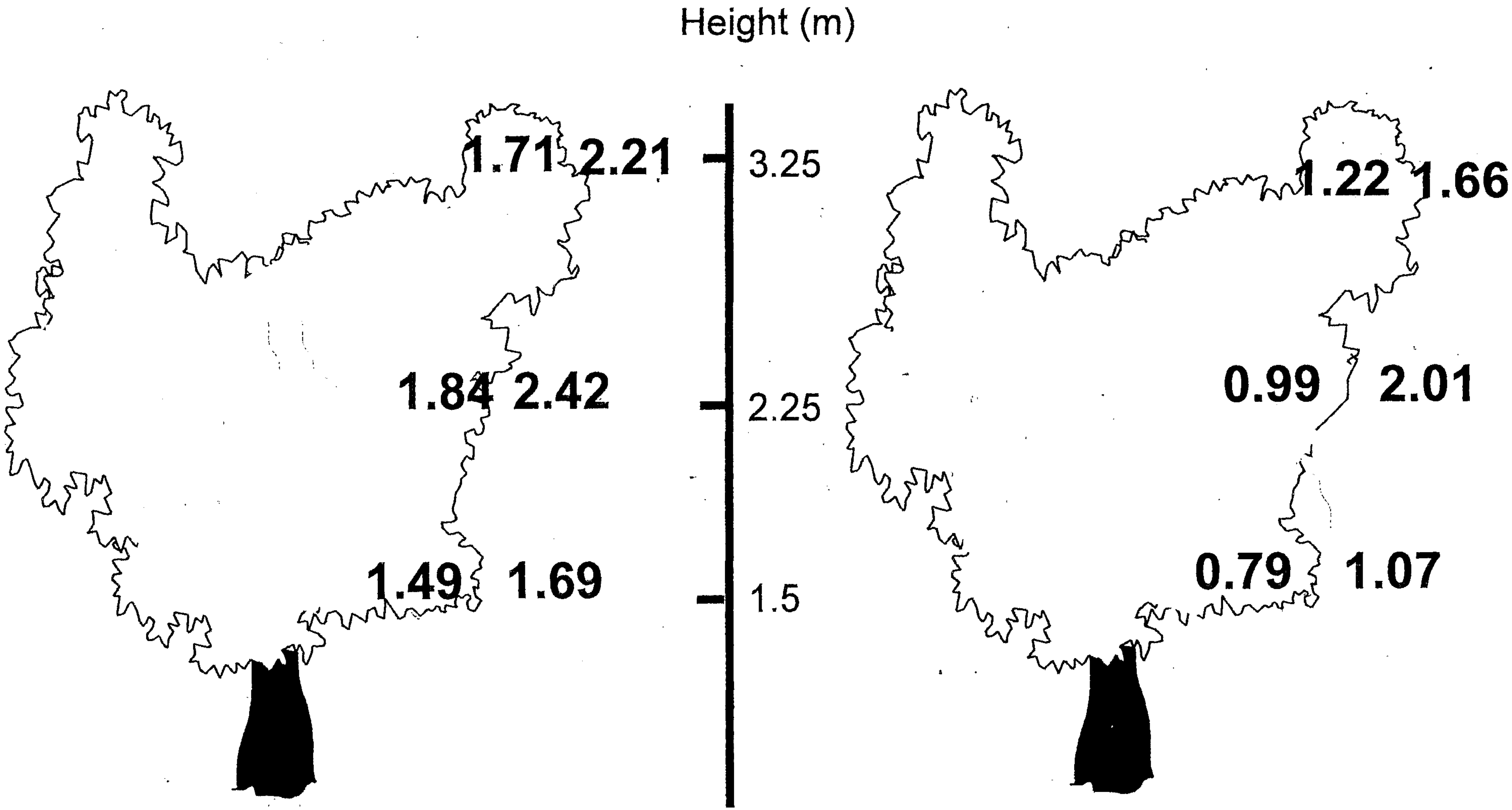
Schematic Only

	Volume (%)
Top	60
Bottom	40

Summary: In the small trees the deposit was highest and most even at the slowest speed tested (4km/hr). The deposit distribution still looks good as the speed is increased to 6 and 9km/hr. The deposit at the bottom and middle inner is reduced however at 9km/hr. The deposit in the top inner sampling position is almost always equal to the bottom outer, this is the benefit of using a tower sprayer. This is ideal as most low profile airblast sprayers have a tendency to overdose the bottom outer zone and not deliver sufficient volume to the to of the tree.

Trial no. 6-A

Leaf Deposit - small trees



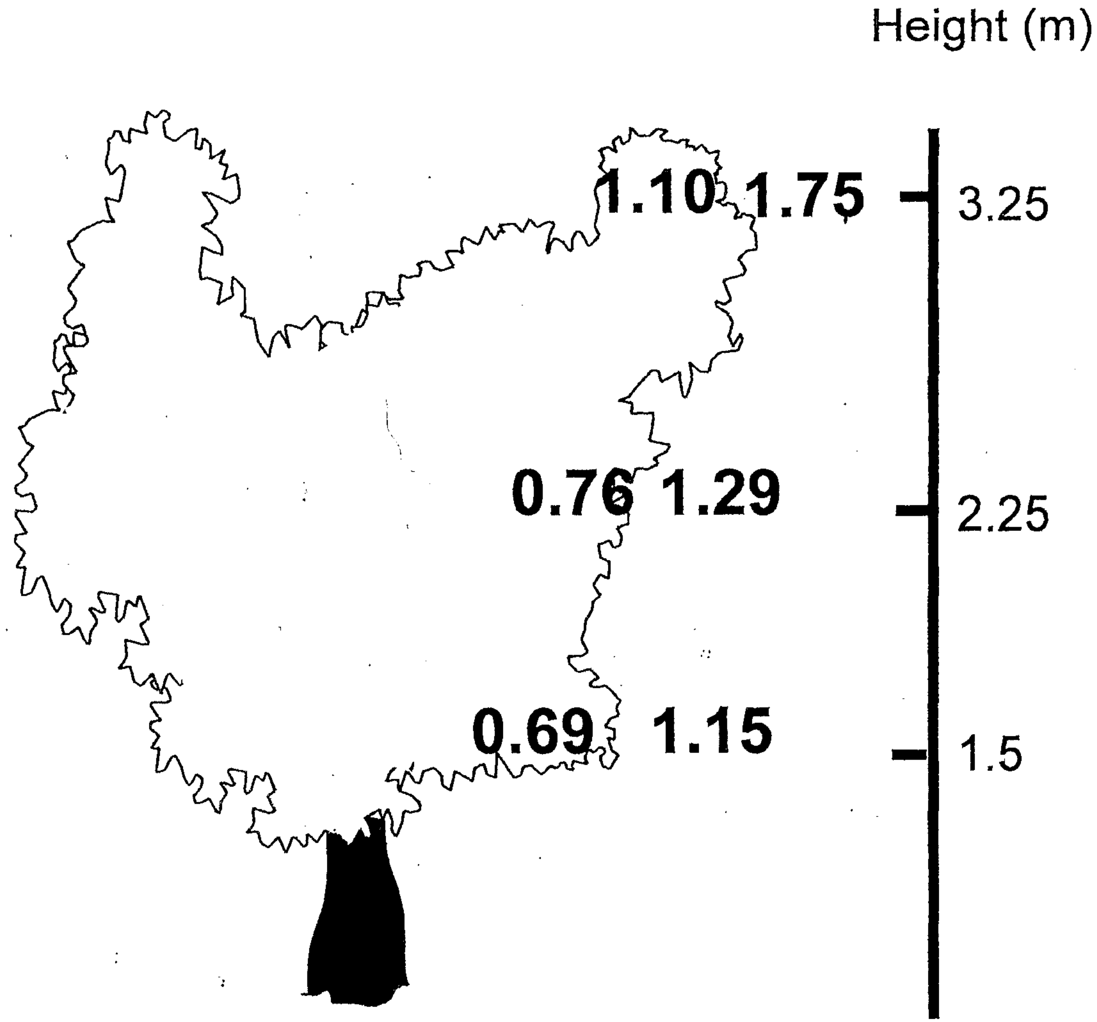
Silvan Turbomiser (HiLow)
4.0 km/hr 197L/ha

Data presented is the normalised spray deposit in (ng/cm²)/(g/ha) of tracer applied for the inner and outer canopy at 3 heights.

Silvan Turbomiser (HiLow)
6.1 km/hr 216L/ha

Trial no. 6-A

Leaf Deposit - small trees



Silvan Turbomiser (HiLow)
9.2 km/hr 209L/ha

Data presented is the normalised spray deposit in (ng/cm²)/(g/ha) of tracer applied for the inner and outer canopy at 3 heights.

Trial Number 6-B. Silvan Turbomiser (P55, HiLow) 4,6 and 9 km/hr on large trees.

(Trial code Q054)

GROWER	C
DATE	12th January 1998
ORCHARD SPACING	5.0m x 3.5m
VARIETY	Red Delicious
TREE DIMENSIONS	5.0m HEIGHT 3.0m WIDTH
COMMENTS	Airshear four fingers 2000L P55 Hi Low sprayer.

APPROXIMATE TREE ROW VOLUME 30,000 m^3/ha (Delicious)

Silvan Turbomiser (Hi Low) 4km/hr

Travel speed 4.0 km/h
Rate of application 197 L/ha
Operating pressure 0.5 Bar

Flow Rate 6.56 L/min

Schematic Only

	Volume (%)
Top	58
Bottom	42

Silvan Turbomiser (HiLow) 6.1km/hr

Travel speed 6.1 km/h
Rate of application 216 L/ha
Operating pressure 0.6 Bar

Flow Rate 10.8 L/min

Schematic Only

	Volume %
Top	58
Bottom	42

Trial Number 6-B. (Continued)

GROWER	C				
DATE	12th January 1998				
ORCHARD SPACING	5.0m x 3.5m				
VARIETY	Red Delicious				
TREE DIMENSIONS	5.0m HEIGHT	3.0m WIDTH	**APPROXIMATE TREE ROW VOLUME**	30,000	m^3/ha (Delicious)
COMMENTS	Airshear four fingers 2000L P55 Hi Low sprayer.				

Silvan Turbomiser (HiLow) 9.2 km/hr

Travel speed 9.22 km/h
Rate of application 209 L/ha
Operating pressure 1.1 Bar

Flow Rate 15.7 L/min

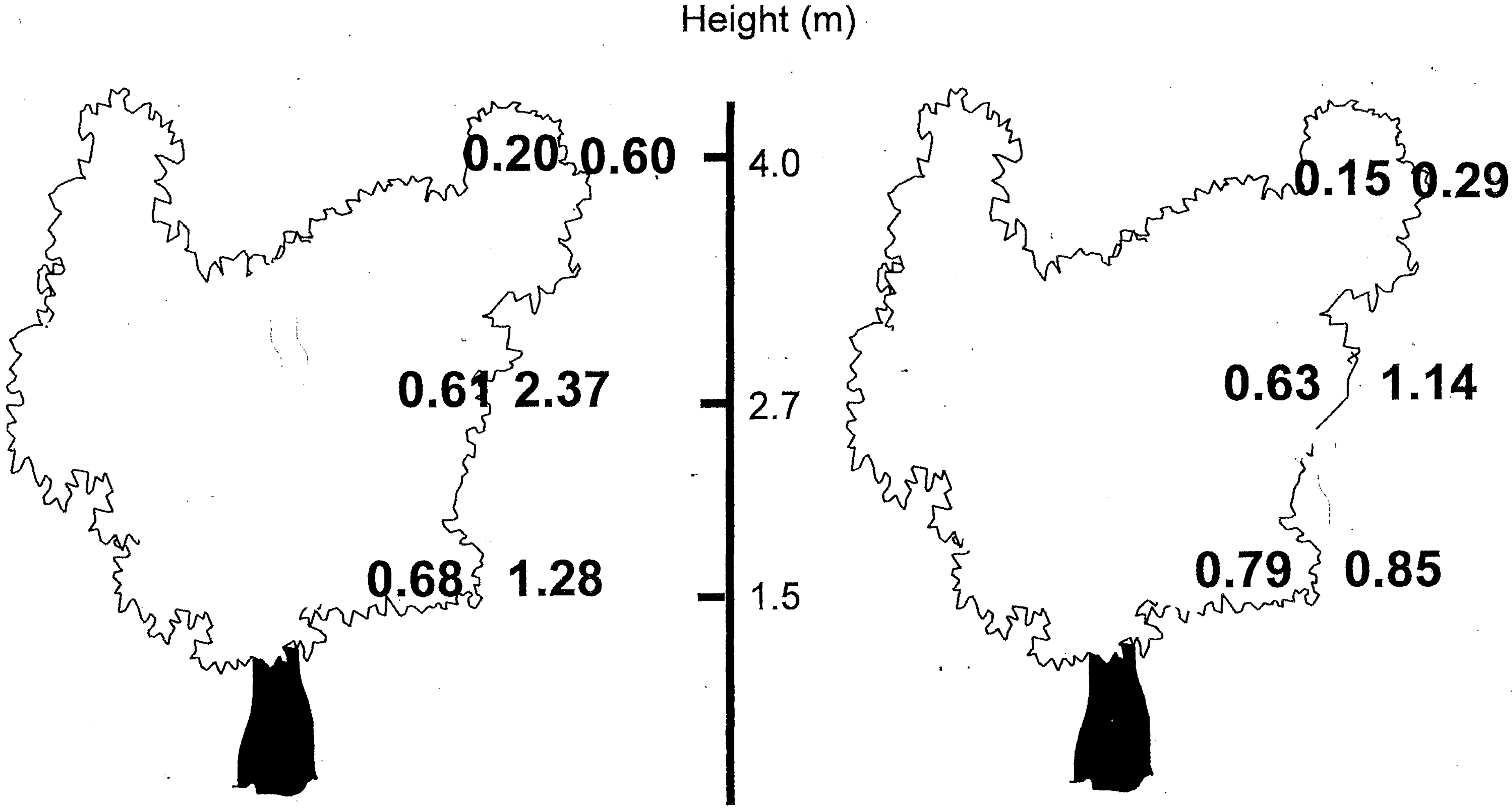
Schematic Only

	Volume (%)
Top	60
Bottom	40

Summary: The average deposit on the bigger trees is greatest at 9km/hr, almost double that at 4km/hr. This is contrary to the test results on the smaller tree size and what we would have expected. The spray deposit on leaves at the top inner position is considerably lower than the bottom outer at all speeds. These were very large trees and in a subsequent trial we set the same sprayer up to deliver increased volumes from the top outlets, this improved the coverage in top sections of the tree canopy.

Trial no. 6-B

Leaf Deposit - large trees



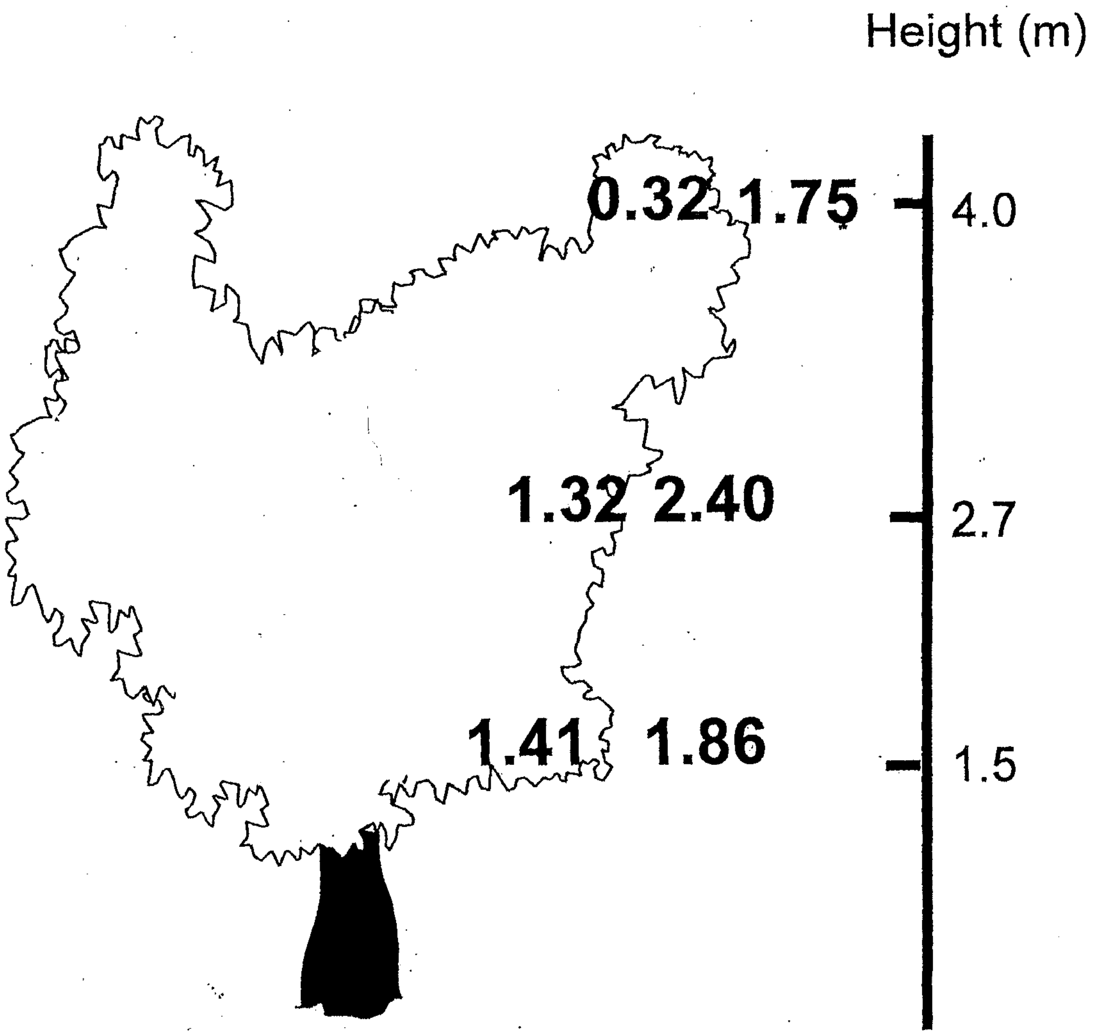
Silvan Turbomiser (HiLow)
4.0 km/hr 197L/ha

Data presented is the normalised spray deposit in (ng/cm²)/(g/ha) of tracer applied for the inner and outer canopy at 3 heights.

Silvan Turbomiser (HiLow)
6.1 km/hr 216L/ha

Trial no. 6-B

Leaf Deposit - large trees



Silvan Turbomiser (HiLow)
9.2 km/hr 209L/ha

Data presented is the normalised spray deposit in (ng/cm²)/(g/ha) of tracer applied for the inner and outer canopy at 3 heights.

Trial Number 11. Silvan (HiLow) Air-shear tower (approx. 200L/ha @ 10.5 & 5 km/hr)

(Trial code Q107)

GROWER	C
DATE	16th March 1999
ORCHARD SPACING	5.5m x 2.4m
VARIETY	Delicious
TREE DIMENSIONS	4.5m HEIGHT 3.3m WIDTH APPROXIMATE TREE ROW VOLUME 27,000 m^3/ha
COMMENTS	Trial conducted under hail netting

Airshear Tower (198L/ha @ 10.5km/hr)

Schematic Only

Travel speed 10.5 km/h
Rate of application 198 L/ha
Operating pressure 2 Bar

Configuration : Flow rate controller top disc on #7 and bottom on #10

Airshear

Airshear Tower (174L/ha @ 5km/hr)

Schematic Only

Travel speed 5.0 km/h
Rate of application 174 L/ha
operating pressure 2 Bar

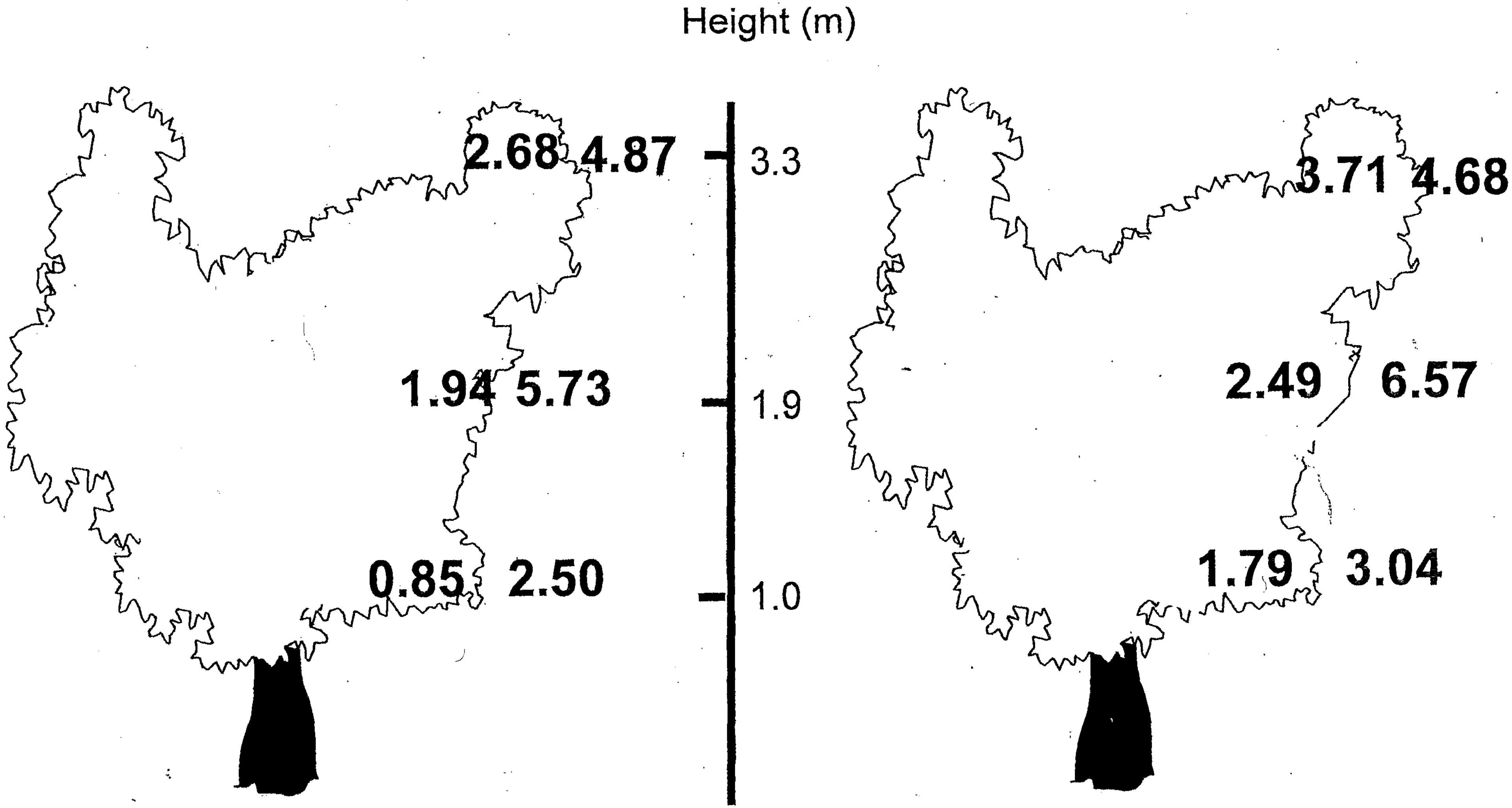
Configuration: Flow rate controller top disc on #5 and bottom on #7

Airshear

Summary: This was the same sprayer that was used in trial number six. By increasing the flow through the top heads the spray deposit was improved considerably in the top sections of the tree canopy. At approximately 200L/ha the 5km/hr travel speed gave 20% higher deposits than 10km/hr. At 10km/hr the deposit levels and distribution within tree still look impressive. To compensate for the increased speed, the flow rate must also be increased to deliver the same water volume per hectare. The droplet size produced by the air-shear outlet at 10km/hr would be larger as a result of the increased flow. This may compromise the ability to attain even coverage on small fruits. Air-shear sprayers perform best at low volume and require high velocity air to shatter liquid into droplets. An excess of liquid fed into an airstream will result in flooding.

Trial no. 11

Leaf Deposit



Silvan air-shear tower (HiLow)
198 L/ha @ 10.5km/hr

Data presented is the normalised spray deposit in (ng/cm²)/(g/ha) of tracer applied for the inner and outer canopy at 3 heights.

Silvan air-shear tower (HiLow)
174 L/ha @ 5km/hr

Trial Number 11 (Continued). Silvan (HiLow) Air-shear tower (approx. 500L/ha @ 10 & 5km/hr)

(Trial code Q107)

GROWER	C
DATE	16th March 1999
ORCHARD SPACING	5.5m x 2.4m
VARIETY	Delicious
TREE DIMENSIONS	4.5m HEIGHT 3.3m WIDTH APPROXIMATE TREE ROW VOLUME 27,000 m^3/ha
COMMENTS	Trial conducted under hail netting

Airshear Tower (480L/ha @ 10.5km/hr)

Schematic Only

Travel speed 10.5 km/h
Rate of application 480 L/ha
Operating pressure 3 Bar

Configuration : Flow rate controller
top disc on #15 and bottom on #15

Airshear

Airshear Tower (500L/ha @ 5km/hr)

Schematic Only

Travel speed 5.0 km/h
Rate of application 500 L/ha
operating pressure 3 Bar

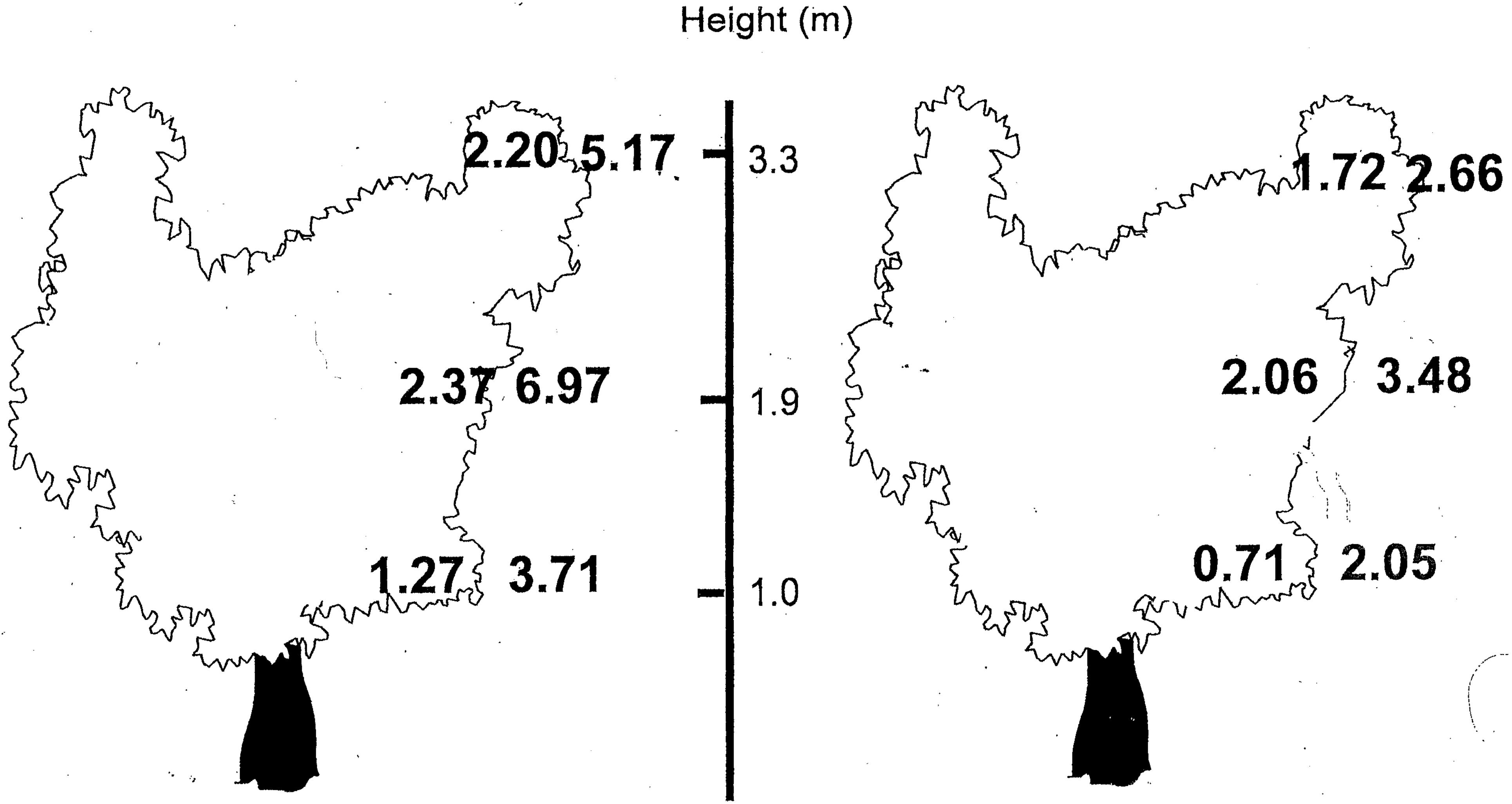
Configuration: Flow rate controller
top disc on #9 and bottom on #9

Airshear

Summary: The operator of this machine frequently uses the system at increased volumes (approximately 500L/ha). At 10km/hr the average spray deposit is 71% higher than 5km/hr. Although the deposit looks impressive at 10km/hr and 500L/ha the nozzle outlets were being flooded and this was very apparent when looking at the system in operation. By flooding the outlets, this resulted in larger droplets or in this instance, ligaments of liquid. With the outlet flooded the deposit on the middle and top outer is extremely high. Although 500L/ha is not a high volume when compared with conventional airblast spraying it is for this type of system that utilises air velocity to create droplets.

Trial no. 11

Leaf Deposit



Silvan air-shear tower (HiLow)
480 L/ha @ 10.5km/hr

Data presented is the normalised spray deposit in (ng/cm²)/(g/ha) of tracer applied for the inner and outer canopy at 3 heights.

Silvan air-shear tower (HiLow)
500 L/ha @ 5km/hr

Trial Number 12. Silvan (HiLow) Air-shear Tower (200L/ha applied nine different tree sizes.

(Trial code Q109)

GROWER	C
DATE	14th April 1999
ORCHARD SPACING	5.1 to 5.5m x 1.0 to 5.1m (Details shown on tree diagrams)
VARIETY	Delicious and Red Delicious
TREE DIMENSIONS	Dimensions and approximate tree row volume shown on tree diagrams.
COMMENTS	

Airshear Tower (200L/ha @ 5km/hr)

Schematic Only

Travel speed 5 km/h
Rate of application 200 L/ha
Operating pressure 2 Bar

Configuration : Flow rate controller
top disc on #5 and bottom on #7

Top head position always moved to
target tops of trees.

Summary: Nine treatments were conducted in this trial using the same water volume to measure the average tree deposit and its relationship to the tree row volume. The average deposit from each tree diagram is plotted against tree row volume in the scatter graph. The scatter graph shows that average deposit decreases linearly with increased tree row volume. Depending on where along the line adequate control is achieved for a particularly pest or disease you could infer that small trees are either overdosed or large trees under-dosed. This is a symptom of using a fixed hectare rate without compensating for tree size.

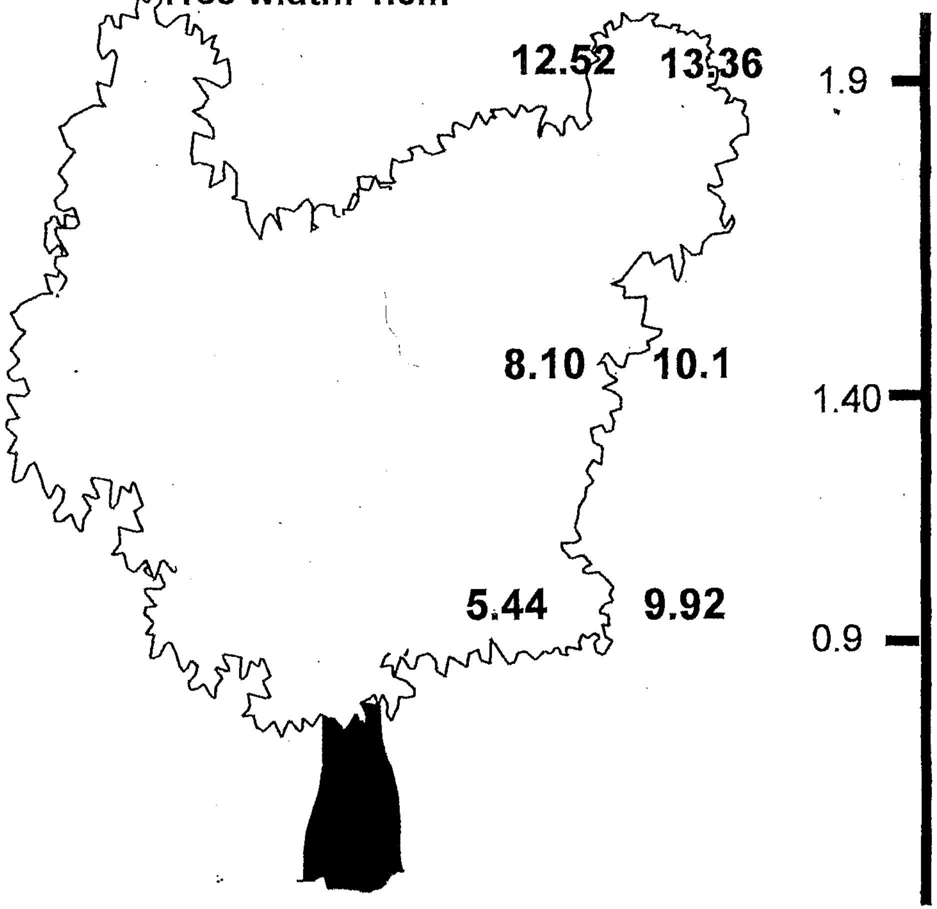
(Trial code Q094)

Trial no. 12

Leaf Deposit

Row spacing: 5.1 x 4.0m
Tree Ht: 2.3m
Tree width: 1.0m

Height (m)



TRV = 4,423 m^3/ha
block 8

Data presented is the normalised spray deposit in (ng/cm²)/(g/ha) of tracer applied for the inner and outer canopy at 3 heights.

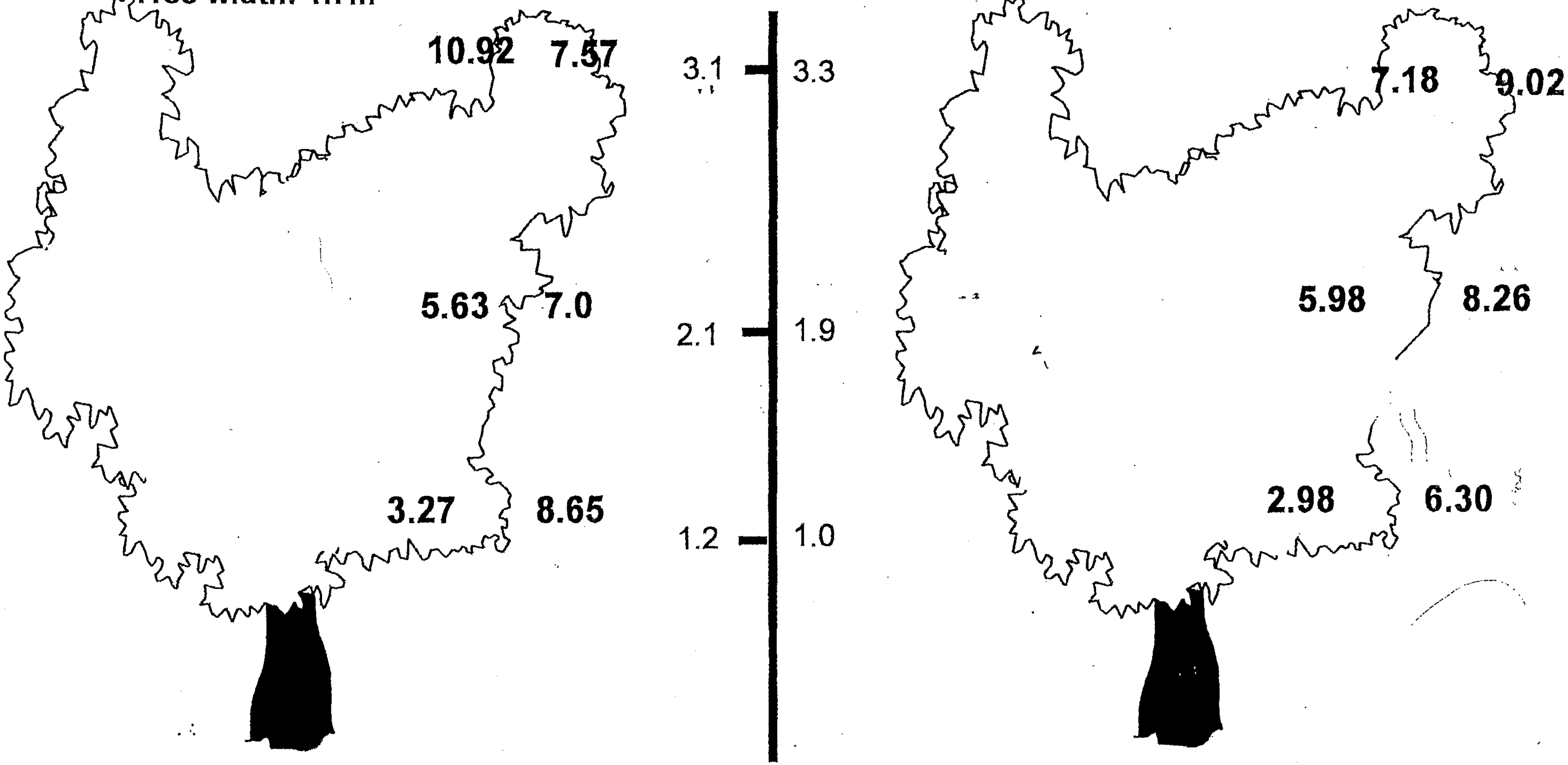
Trial no. 12

Leaf Deposit

Row spacing: 5.1 x 2.05m
Tree Ht: 3.3m
Tree width: 1.7m

Height (m)

Row spacing: 5.1 x 2.0m
Tree Ht: 3.55m
Tree width: 1.8m



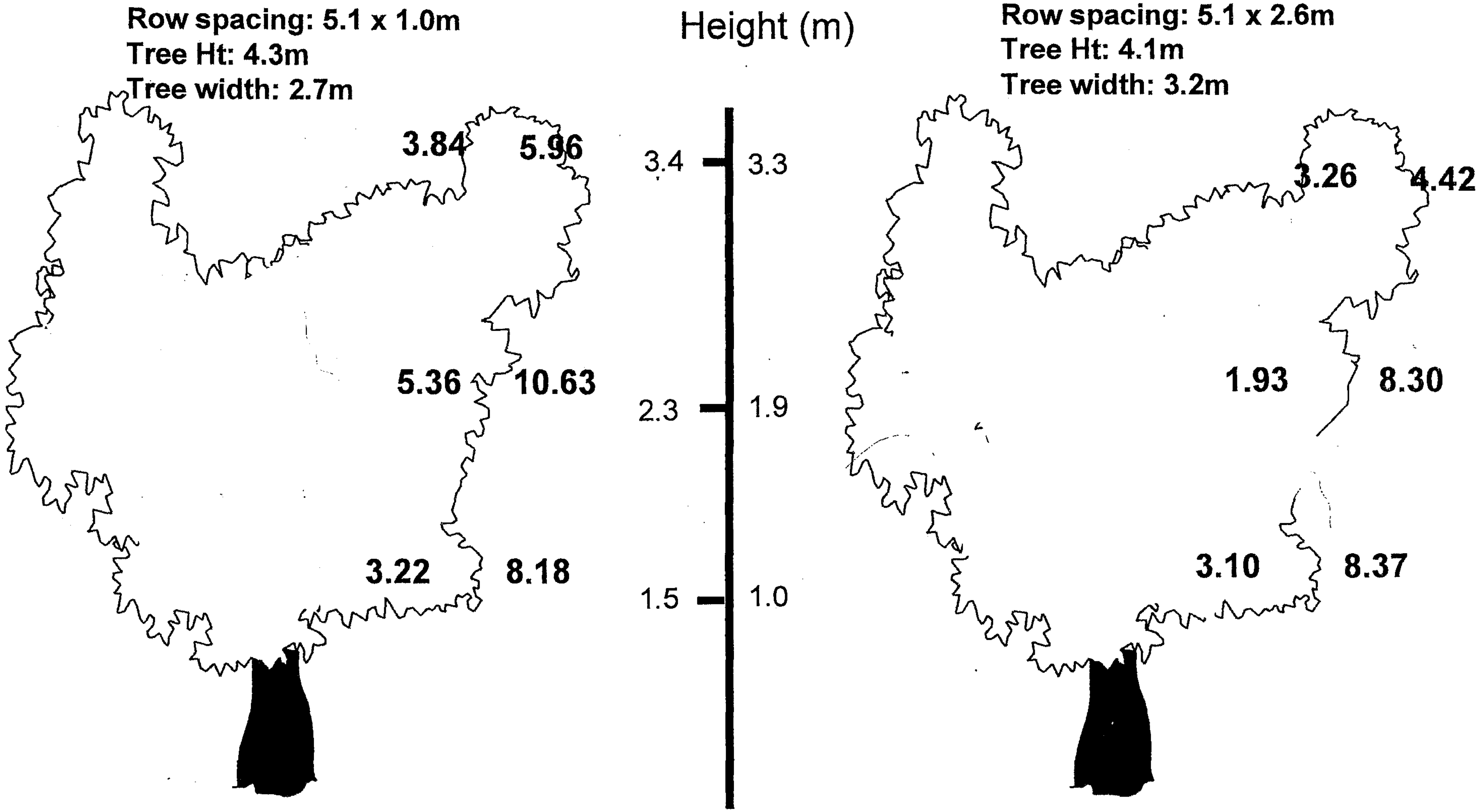
TRV = 11,000 m^3/ha
block 4

Data presented is the normalised spray deposit in (ng/cm²)/(g/ha) of tracer applied for the inner and outer canopy at 3 heights.

TRV = 12,529 m^3/ha
block 2

Trial no. 12

Leaf Deposit



TRV = 22,764 m^3/ha
block 5

Data presented is the normalised spray deposit in (ng/cm²)/(g/ha) of tracer applied for the inner and outer canopy at 3 heights.

TRV = 23,854 m^3/ha
block 6

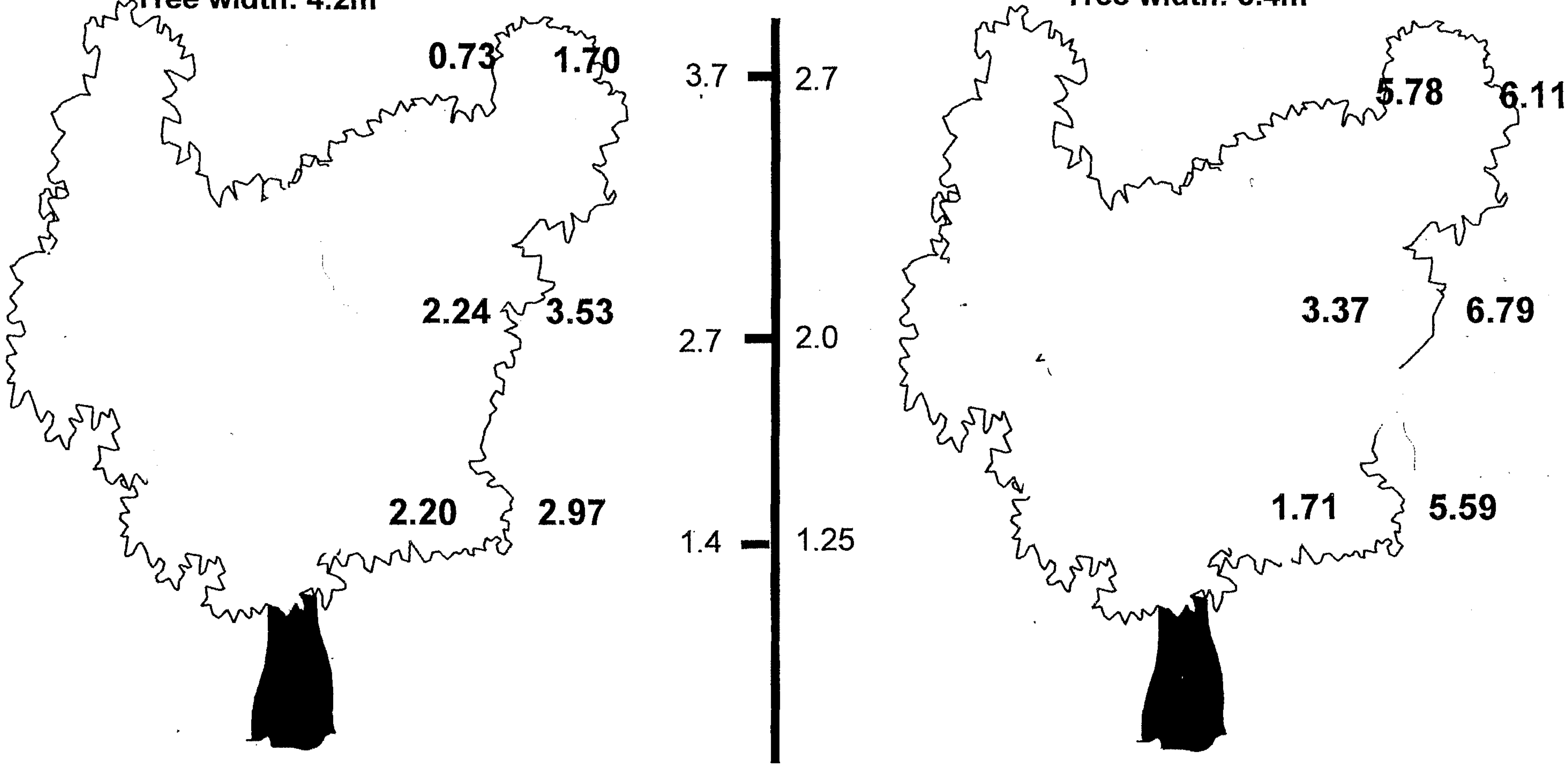
Trial no. 12

Leaf Deposit

Row spacing: 5.1 x 5.1m
Tree Ht: 3.3m
Tree width: 4.2m

Height (m)

Row spacing: 5.1 x 2.5m
Tree Ht: 3.2m
Tree width: 3.4m



TRV = 25,200 m^3/ha
block 9

Data presented is the normalised spray deposit in (ng/cm²)/(g/ha) of tracer applied for the inner and outer canopy at 3 heights.

TRV = 16,690 m^3/ha
block 10

Trial no. 12

Average Deposit versus Canopy Volume (All data)