Preliminary assessment of control options for powdery mildew and two spotted mite in field grown fresh tomatoes

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Industry Development Committe

Project Number: VT06000

VT06000

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EVALUATION OF FUNGICIDES AND CULTURAL PRACTICES TO CONTROL POWDERY MILDEW OF FRESH TOMATOES

Horticulture Australia Limited Project Number: VT06000

By David Morey, Emma Pearce and Meaghan Ritchie

1 MEDIA SUMMARY

Powdery mildew species *Leveillula taurica* and *Oidium lycopersici* have become a significant problem for field grown tomato growers in the Goulburn Valley. Control is multi faceted with both fungicide and cultural practices being of equal importance. As a result of the increasing pressure powdery mildew is placing upon the production of tomatoes, the evaluation of fungicides registered for tomatoes and alternative chemistry registered on other crops is a priority.

The trial work conducted in season 2006-07 evaluated the efficacy of five fungicides, three existing products commonly in use for the control of powdery mildew and two unregistered products. The treatments and an untreated control were visually assessed at various growth stages and the rate of infection on each occasion was recorded. This information was then used to apply statistical analysis, to determine if the use of alternative products had produced a significant reduction in the infection rate of powdery mildew. In addition, leaves from plants in each treatment plot were harvested, collated and assessed according to the severity of infection. Fruit from the two unregistered product treatments were also subjected to chemical residual testing.

Season 2008-09 provided an opportunity to follow up on previous work, with an aim of encouraging growers to test a best practice approach to the control of powdery mildew in comparison to their standard program. The key management areas that differed between the two programs included; the incorporation of new fungicides, improvement of soil health through strategic applications of organic products and the balancing of plant nutrition. Assessments on the rate of infection in the treated and untreated comparisons were conducted as in the previous trial, as well as evaluating yield improvements.

2 TECHNICAL SUMMARY

Tomatoes grown in the Goulburn Valley face an increasing threat in the form of powdery mildew species *Leveillula taurica* and *Oidium lycopersici*. If climatic and physical conditions are favourable to powdery mildew significant reduction in yield can result. A curative is currently not available for powdery mildew, preventatives however are in common use. Tomatoes, once infected provide little resistance to the disease and the situation becomes a matter of minimising the impact.

Because of the economic impact posed by powdery mildew, measures to combat its effect require continuing investigation. Season 2006-07 saw comparative trials of three registered and two unregistered fungicides. The products were applied three times according to label rates and visually assessed on four occasions, within a twenty five day period, for percentage of leaf area affected. Statistical analysis was used to determine significant difference between the products if any. Fruit of the two unregistered products were tested for chemical residual by an independent laboratory.

The results of the trial showed a marginal increase in control of powdery mildew by the two unregistered products when compared to the existing products, residual active constituent was not detected for either of these unregistered products.

Following this trial, in season 2008-09 a best management approach was adopted and compared to the gowers current program. The trial program included the analysis of soil microbial health before and after strategic applications of several organic products. Improvements were made in most of the parameters tested. Once again two alternative fungicides were trialled and tested for residual chemicals.

The trial undertaken on the alternative fungicides showed increased activity on powdery mildew when evaluated against existing products. None of the products exceeded residual limits. These results highlight the benefit of continued assessment of alternative fungicide chemistry to minimise the impact of powdery mildew on tomatoes grown in the Goulburn Valley. Organic products may also have a place in improving soil health and therefore producing a tomato plant that is less susceptible to disease.

Research into the control of powdery mildew is an ongoing process, a disease of such significance to the tomato industry requires the adoption of new practices and products to lessen the impact of infection when it occurs.

3 INTRODUCTION

Powdery Mildew has become a major problem for the fresh tomato growers of the Goulburn Valley during the last three seasons. Trellis tomatoes have been particularly affected in the later part of the seasons, reducing fruit yield, size and quality. There are several different pathogens that cause Powdery Mildew of tomatoes. There are two known pathogens of Powdery Mildew on tomatoes found in the Goulburn Valley; *Leveillula taurica* and *Oidium lycopersici*.

The common symptoms of *Leveillula taurica* are light green to bright yellow blotches on the upper surface of leaves, sometimes with necrotic spots in their centres (Paulus and Correll, 1993). Lower leaf surfaces may have a light powdery mycelium covering, and under certain conditions, "growth of conidia and conidiophores may develop on the upper and lower leaf surfaces". Lesions do not occur on stems or fruit and there is no vascular discolouration. Leaves with severe infection die but seldom drop from the plant (University of California, 1998). Plants infected with the disease are weakened, leading to reduced yields, smaller fruit and sunburned fruit (Watterson, 1985).

Leveillula taurica conidia can travel long distances on air currents (Watterson, 1985). It can germinate over a wide range of air temperatures from 10 to 35^0C, with temperatures above 30^0C accelerating both the development of the disease and leaf necrosis (Paulus and Correll, 1993). High relative humidity, greater than 40%, favours the disease development (UC Davis, 2007).

The symptoms of *Oidium lycopersici* are powdery white lesions on stems, leaves and petioles but not on the fruit (Jones, et al 2001). Severe mycelium infection is followed by desiccation, necrosis and defoliation (LaMondia et al, 1999). It particularly affects late season tomato plantings (LaMondia et al, 1999). "Powdery mildew development is favoured by dry plant surfaces" (Zitter, 2004).

Vast amounts of research has been conducted worldwide on the various options for the control of powdery mildew species. The aim of this trial was to evaluate new and existing fungicide products, the impact of cultural and climatic conditions on the disease and if a best management practice approach can significantly minimize the impact of powdery mildew.

4 PART A – Season 2006 - 2007

5 AIM

1. To evaluate the efficacy of currently registered fungicides and alternative unregistered fungicides on tomatoes to control tomato powdery mildews caused by *Leveillula taurica* and *Oidium lycopersici.*

2. To measure the residue levels of two treatments that are unregistered for use in tomatoes.

6 METHOD

Trial Site

Location:	Corner of Punt and Bayunga Roads, Murchison, Victoria
Grower:	Mr Jo Vraca
Crop:	Red Ruby Tomatoes
Soil Types:	Red loam at north end, red clay loam at south end
Topography:	Slight northerly slope
Site history:	Second year tomato ground
Crop management:	Single trellis tomatoes
Irrigation:	Sub-surface tape irrigation
Planting Date:	15th January 2007
1st Pick:	16th March 2007
Seasonal conditions:	High temperatures and high relative humidity

Experimental Design

The trial was conducted using a Completely Randomised Block Design incorporating seven replicates. The trial covered two standard size tomato bays, nine rows wide. The plot size was three trellis panels wide by three trellis panels long. Trellis panel length was 5.2 metres, row width was 1.5 metres and average plant width was 0.5 metres. There were approximately one hundred and two tomato plants per plot. Refer to Appendix. 1 for trial layout.

Treatments

Details of the application treatments are available in Table 1.

Table 1. Products, rates and water volumes applied.

	Treatment	**1st application**		**2nd & 3rd applications**	
		Rate Product / ha	Volume Water / ha	Rate Product / ha	Volume Water / ha
1	Untreated Control	-	-	-	-
2	Aero Fungicide	2035 g/ha	407 L/ha	3055 g/ha	611 L/ha
3	Prosper 500EC Fungicide	244 ml/ha	407 L/ha	366 ml/ha	611 L/ha
4	Score Foliar Fungicide	204 ml/ha	407 L/ha	305 ml /ha	611 L/ha
5	Thiovit Jet Microgranule Fungicide / Miticide	814 g/ha	407 L/ha	1222 g/ha	611 L/ha
6	Walabi SC Fungicide	814 ml/ha	407 L/ha	1222 ml/ha	611 L/ha

Refer to Appendix 5. for Product Descriptions

Application Equipment

Treatments were applied to each side of the trellis panels using a trial hand-held, compressed gas vertical double boom. It incorporated three Allbuz TXVK Cone Jet No.12 Brown nozzles per boom. Walking speed was one metre per second. (Refer to Appendix 5.1)

Application Methods

A total of three spray applications were conducted. The first application used a lower water volume of 375L/ha when the plant height had reached the third trellis wire (Refer Table 2). The second and third applications progressed to a higher water volume of 611L/ha when the plant height had reached the fourth trellis wire, to allow for coverage of greater plant surface area. (Refer Table 2).

Table 2: Treatment dosages at each application

Product	**Aero**	**Score**	**Thiovit**	**Prosper**	**Walabi**
Label Rate	1.0 - 3.0 Kg / Ha	300 - 500 mls / Ha	200 grams / 100L water (to a maximum 2kg/ha)	60 mls / 100L water	2L / Ha
Trial Rate 1st application	2.035 Kg / Ha	203.5 mls / Ha	814 grams / Ha	244 mls / Ha	814 mls / Ha
Water Volume 1st application	407 L / Ha	407 L / Ha	407 L / Ha	407 L / Ha	407 L / Ha
Trial Rate 2nd & 3rd application	3.05 Kg / Ha	305 mls / Ha	1.2 Kg / Ha	366 mls / Ha	1.2 L / Ha
Water Volume 2nd & 3rd application	611 L / Ha	611 L / Ha	611 L / Ha	611 L / Ha	611 L / Ha
Trial rate per 2L Bottles	10 grams / 2 L	1 ml / 2 L	4 grams / 2L	1.2 mls / 2L	4mls / Ha

Table 3: Weather conditions during applications (Refer to Appendix 4)

Date	**Water volume (L/Ha)**	**Application Time (Hours)**		**Temperature (^{0}C)**	**Relative Humidity (%)**	**Wind (km per hour)**	**Wind direction**
9 February 2007	375 L/ha	7:00-12:00	Max	26.1	83	11.6	353
			Min	12.7	43	3.4	25
			Average	20.0	59	6.7	112
23 February 2007	611 L/ha	6:30-11:30	Max	28.7	93	10.0	356
			Min	17.0	45	1.6	5
			Average	22.7	66	5.0	91
1 March 2007	611 L/ha	7:00-12:00	Max	25.6	86	9.7	202
			Min	17.2	48	3.6	152
			Average	21.0	70	6.4	179

Assessment Methods

Field assessments

Four field assessments were conducted on 2 February 2007, 19 February 2007, 26 February 2007, and 5 March 2007. Levels of *Oidium lycopersici, Leveillula taurica,* plus any other major pests, diseases or environmental problems were recorded. The eastern side of the centre panel of each plot was evaluated.

Powdery mildew levels were recorded as plants reached each trellis wire height according to the following key: (Appendix 2)

Rank	Level	Percentage
0	Not present	No powdery mildew spores or discolouration visible
1	Low	Powdery mildew spores or discolouration visible on 1-25% of each leaf
2	Moderate	Powdery mildew spores or discolouration visible on 26-50% of each leaf
3	High	Powdery mildew spores or discolouration visible on 51-75% of each leaf
4	Severe	Powdery mildew spores or discolouration visible on 76-100% of each leaf

Where individual plants differed from the norm, the predominant and higher powdery mildew level was recorded. *Oidium* and *Leveillula* were evaluated separately.

Laboratory assessments

One laboratory assessment was conducted on 8 March 2007. A random sample of 10 leaves between the first and second wire, and 10 leaves between the third and fourth wire, were collected from the centre panel of each plot. Plot samples were collated into their treatment groups before being assessed according to the above key. These analyses were conducted visually and therefore statistical analysis could not be applied due to a minimal level of objectivity. To aid in the assessment process *Oidium* and *Leveillula* were evaluated collectively. (Refer to Appendix 2)

Fruit residue sampling

Ten fruit were randomly sampled from the middle panel of the most northerly Prosper and Aero treatment plots. Samples were taken on 5 March 2007 (9 days before first pick), 16 March 2007 (day of 1st pick), and 23 March 2007 (7 days after first pick). The first "clean-up pick" on 16th March was earlier than anticipated due to the extreme hot and dry seasonal conditions experienced. Due to these conditions the plants became stressed and early fruit ripening occurred. Fruit was submitted to the Agrifood Technology laboratory for residue analysis of Spiroxamine (active constituent in Prosper), and Metiram and Pyraclostrobin (active constituents in Aero).

Sap sampling

Sap samples were collected on a fortnightly basis for Sap Nutritional Analysis. Agvita NU-TEST sampling techniques for tomatoes were followed:

- Collect 1 leaf per plant
- Select the youngest fully expanded leaf, usually the third or forth leaf from the top from actively growing plants
- Sample 20-30 petioles
- Discard the leaflets and retain the petioles for analysis

Samples were collected at three growth stages:

29-1-07- Growth stage 3.2 Second inflorescence developed per stem
12-2-07- Growth stage 4.1 First inflorescence has set fruit with at least two fruit >1cm in diameter
26-2-07- Growth stage 4.5 Fifth inflorescence has set fruit with at least two fruit >1cm in diameter

Samples were analysed by Agvita in Devonport, Tasmania. Sap results and fertiliser management decisions were discussed with the grower throughout the trial period to understand the nutritional status of the crop during the duration of the trial.

Soil Moisture Monitoring

Soil moisture was measured at three locations within the trial plot, using C-Probes on TerraCom telemetry units, to determine any variations in soil moisture. The capacitance probes had sensors at 10, 20, 30, 40, and 50cm. These were installed within the same row at approximately one quarter, half and three quarters of the way down the length of the row. The weather station was positioned half way down the same row. (Refer to Appendix 4.6)

Weather Monitoring

A Visola weather station with a MetSpy Multi-sensor on a Terracom unit was installed at the trial site. This unit recorded rainfall, temperature, relative humidity, wind speed, wind direction, solar radiation, barometric pressure and leaf wetness. (Refer to Appendix 4.6)

7 RESULTS

Powdery Mildew Fungicide Trial Field Results

Results are summarised in Tables 4 and 5 and are presented in full in Appendices 3. The data was analysed using ANOVA and Least Significant Difference (LSD) techniques.

Table 4: Oidium lycopersici. - Mean Leaf Ratings

No.	Treatment (Amount/ha)	*Oidium lycopersici* Leaf Rating			
		Assessment 1 2/2/2007	**Assessment 2 19/2/2007**	**Assessment 3 26/2/2007**	**Assessment 4 5/3/2007**
1	Untreated Control	0	0.86	2.18	3.32
2	Aero (1875, 3055 g/ha)	0	0.66	1.18	2.54
3	Prosper (225, 366 ml/ha)	0	0.62	1.57	3.04
4	Score (187.5, 305 ml/ha)	0	0.62	1.57	3.11
5	Thiovit (750, 1222 g/ha)	0	1.14	1.68	3.43
6	Walabi (750, 1222 ml/ha)	0	0.76	1.57	3.11
p value		-	0.01	0.01	0.01
LSD (5% level)		Not applicable	0.29	0.49	0.45

Significant difference at 5% confidence level

Table 5: Leveillula taurica - Mean Leaf Ratings

No.	Treatment (Amount/ha)	*Leveillula taurica* - Leaf Rating			
		Assessment 1 2/2/2007	**Assessment 2 19/2/2007**	**Assessment 3 26/2/2007**	**Assessment 4 5/3/2007**
1	Untreated Control	0	0	0.64	2.89
2	Aero (1875, 3055 g/ha)	0	0	0.25	2.11
3	Prosper (225, 366 ml/ha)	0	0	0.25	2.46
4	Score (187.5, 305 ml/ha)	0	0	0.29	2.14
5	Thiovit (750, 1222 g/ha)	0	0	0.46	2.21
6	Walabi (750, 1222 ml/ha)	0	0	0.18	2.46
p value		-	-	0.63	0.25
LSD (5% level)		Not applicable	Not applicable	Not applicable	Not applicable

Sap Sampling Results

Table 6:. Sap Nutrient level results (ppm) at three growth stages.

	Sap Nutrient Levels (ppm)												
Growth Stage	**NO3**	**P**	**K**	**Ca**	**Mg**	**Zn**	**B**	**S**	**Cu**	**Fe**	**Mn**	**Na**	**Mo**
3.2 – Flowering	5040	266	4173	755	489	3.17	0.98	260	6.87	2.07	2.35	145	0.022
4.1 – Fruit Set & Growth	2678	249	3769	543	354	1.87	1.02	260	7.35	2.03	2.32	128	0.027
4.5 – Fruit Set & Growth	3331	213	6068	396	471	2.07	1.77	415	2.71	3.46	2.01	290	0.042

Chemical Residue Results

Table 7: Chemical residue levels for Aero and Prosper.

Product	**Aero**				**Prosper**	
Active constituent	**Metiram mg/kg**		**Pyraclostrobin mg/kg**		**Spiroxamine mg/kg**	
Sampling date	Limits of Recording	Residues detected	Limits of Recording	Residues detected	Limits of Recording	Residues detected
5 March 2007	<0.2	0.21	<0.02	<0.02	<0.1	<0.1
16 March 2007	<0.2	0.32	<0.02	0.02	<0.1	<0.1
23 March 2007	<0.2	<0.2	<0.02	<0.02	<0.1	<0.1

Powdery Mildew Lab Results

Refer to Appendix 3 for full tables of results

Table 8: Top wire assessments 25 days after initial application.

Treatment	**Plant height assessed**	**Percentage of leaf area showing Powdery Mildew infections**				
		Not Present 0%	**Low 1-25%**	**Moderate 26-50%**	**High 51-75%**	**Severe 76-100%**
Prosper	Top (Wires 3 to 4)	16%	51%	20%	13%	0%
Thiovit	Top (Wires 3 to 4)	10%	34%	24%	16%	16%
Walabi	Top (Wires 3 to 4)	13%	33%	31%	19%	4%
Aero	Top (Wires 3 to 4)	26%	53%	16%	3%	3%
Score	Top (Wires 3 to 4)	10%	46%	20%	16%	9%
Untreated	Top (Wires 3 to 4)	10%	30%	31%	23%	6%

Provided the most effective control for powdery mildew

Table 9: Bottom wire assessments 25 days after initial application.

Treatment	Plant height assessed	Percentage of leaf area with Powdery Mildew infections				
		Not Present 0% LA	**Low 1-25% LA**	**Moderate 26-50% LA**	**High 51-75% LA**	**Severe 76-100% LA**
Prosper	Bottom (Wires 1 to 2)	0%	6%	13%	34%	47%
Thiovit	Bottom (Wires 1 to 2)	0%	1%	7%	17%	74%
Walabi	Bottom (Wires 1 to 2)	0%	0%	3%	27%	70%
Aero	Bottom (Wires 1 to 2)	0%	7%	23%	17%	53%
Score	Bottom (Wires 1 to 2)	0%	1%	6%	16%	77%
Untreated	Bottom (Wires 1 to 2)	0%	0%	0%	13%	87%

Provided the most effective control for powdery mildew

PART B – SEASON 2008 – 2009

8 AIM

- To measure the difference in the level of powdery mildew disease between a best management practice program (Treated) against a standard grower program (Untreated).
- To determine any difference between treated and untreated blocks.
- To complete residual and phytotoxicity work on unregistered fungicides that aid in the control of powdery mildew.

9 METHOD

TRIAL SITES:

Site 1

Location:	Hooper Rd, Undera Victoria
Grower:	Gillieston Fresh Produce – Mr Alby Borzillo
Crop:	Rebel Tomatoes
Soil Types:	Heavy Loam
Site history:	Fresh tomato ground
Crop management:	Ground tomatoes
Irrigation:	Sub-surface tape irrigation
Planting Date:	30th of December 2008
1st Pick:	20th of March 2009
Seasonal conditions:	Hot and Dry

Site 2

Location:	Waugh Rd Toolamba, Victoria
Grower:	Toolamba Fresh Produce – Mr Daniel Tripoli
Crop:	Rebel Tomatoes
Soil Types:	Shepparton Fine Sandy Loam
Site history:	Fresh tomato ground
Crop management:	Ground tomatoes
Irrigation:	Sub-surface tape irrigation
Planting Date:	8th of January 2009
1st Pick:	15th of April 2009
Seasonal conditions:	Hot and Dry

Site 3

Location:	Hooper Rd, Undera Victoria
Grower:	Gillieston Fresh Produce – Mr Alby Borzillo
Crop:	Rebel Tomatoes
Soil Types:	Sandy Loam
Site history:	Fresh tomato ground
Crop management:	Ground tomatoes
Irrigation:	Sub-surface tape irrigation
Planting Date:	6th of April 2009
1st Pick:	18th of April 2009
Seasonal conditions:	Hot and Dry

EXPERIMENTAL DESIGN

The trial sites utilised four bays in late season plantings, for the two treated applications and two untreated at each site. The fungicide trial was conducted on a specifically planted small trial block. Products were incorporated into the existing spray program for each grower. Site 1 consisted of two bays with twelve rows in each and a length of 255 metres, therefore approximately 6,000 plants/ bay. (Refer to Appendix 8.1)

Site two was two bays with 9 rows in each of 185metres long, totalling 3,700 plants/ bay. Refer to Appendices 8.2 and 8.3 for trial site design.

Site 3 was five rows of plants, each row consisting of approximately 20 plants. The trial design layout was: row 1 – untreated, row 2 – Prosper, row 3 – untreated, row 4 – Systhane, row 5 – untreated. Refer to Appendix 8.4 for site layout.

TREATMENTS

The products were applied by each grower in conjunction with their regular spray program. Refer to Appendix 9 for product descriptions.

SITE 1 –Gillieston Fresh Produce

PRODUCT		APPLICATION	RATE	TIMES APPLIED
1	OFS MicroPlus	Foliar	125g/Ha	Once
2	OFS Super Kelp	Foliar	5L/ Ha	Three times
3	OFS Super Kelp	In planting water	2L/ 100L water	At planting
4	OFS Humus 26	Fertigated	5L/ Ha	Once
5	OFS Fish Emulsion	Fertigated	5L/Ha	Twice

SITE 2 – Toolamba Fresh Produce

PRODUCT		APPLICATION	RATE	TIMES APPLIED
1	OFS MicroPlus	Foliar	125g/Ha	Once
2	OFS Super Kelp	Foliar	5L/ Ha	Once
3	OFS Super Kelp	In planting water	2L/ 100L water	At planting
4	OFS Humus 26	Fertigated	5L/ Ha	Once
5	OFS Fish Emulsion	Fertigated	5L/Ha	Twice

SITE 3 – Gillieston Fresh Produce

PRODUCT		APPLICATION	RATE	TIMES APPLIED
1	Prosper	Foliar		Three
2	Systhane	Foliar		Three

ASSESSMENTS

The progression of powdery mildew at both sites was monitored throughout the growing cycle of the crops. The first sign of infection at Site 1 was detected on the 5th of February, while at Site 2 the first signs were on the 4th of March.

Site 1 was harvested on the 11th of March, a sample of twelve plants was taken from both the treated and untreated bays. The plants were selected using a systematic sampling technique, the first plant was selected at random and then a sampling interval was applied. Whole plants were removed from the field, all fruit was picked and weighed and the plant was bagged and labelled for visual rating of the level of powdery mildew. Site 2 was harvested on the 1st of April with a sample of fifteen plants from each of the treated and untreated bays. Plants were selected and assessed as per site 1. (Refer to Appendix 7 for assessment thresholds)

RESULTS

There were several components to the results of this trial, firstly the fruit was weighed with the results tabled below.

Table 10: Gillieston Fresh Produce – Yield Comparison Data

TREATED				
Row Number	Plant Number	Number of fruit	Total Fruit Weight (kg)	Average fruit weight (gm)
1	10	140	5.9	42.14
2	385	160	5.4	33.75
3	316	105	5.9	56.19
4	304	129	5.1	39.53
5	24	144	7.6	52.78
6	436	105	4.1	39.05
7	243	257	9.7	37.74
8	506	93	3.3	35.48
9	271	81	5.2	64.20
10	65	77	2.7	35.06
11	387	67	3.2	47.76
12	161	127	3.5	27.56
TOTAL		**1485**	**61.6**	**511.25**
AVERAGE		**123.8**	**5.1**	**42.60**

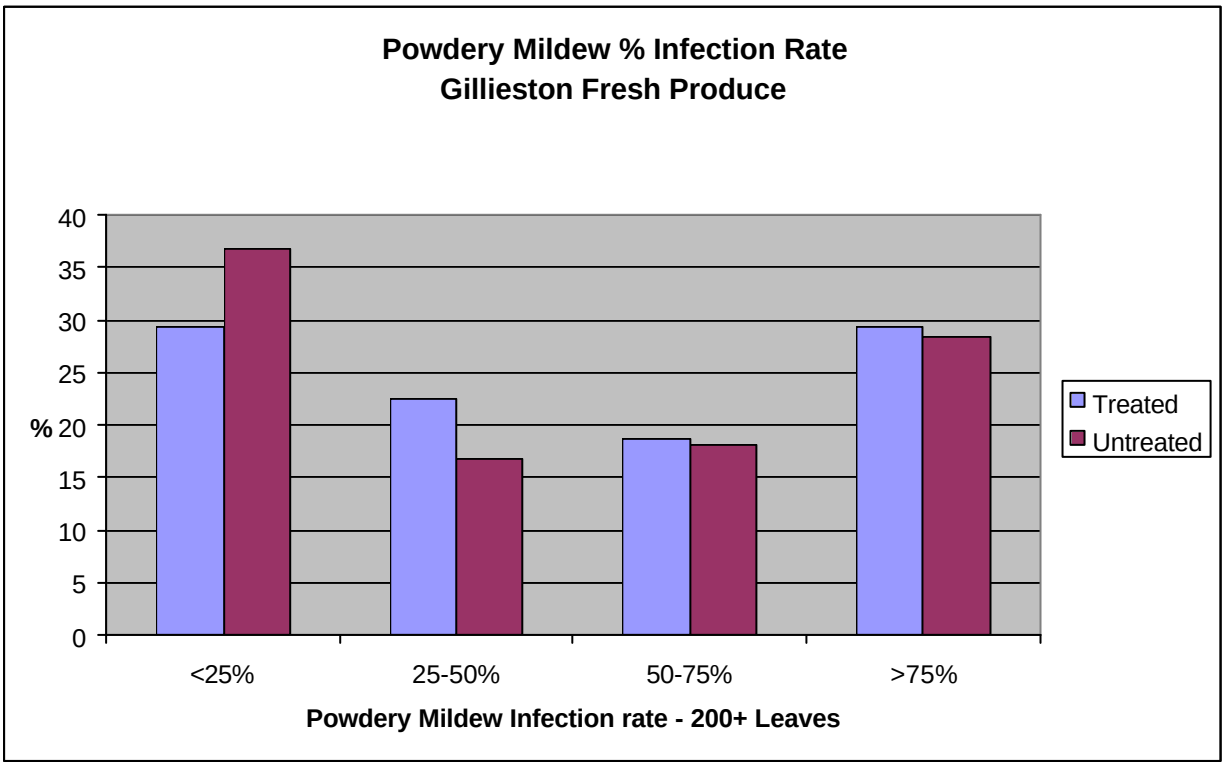
UNTREATED				
Row Number	Plant Number	Number of fruit	Total Fruit Weight (kg)	Average fruit weight (gm)
1	10	105	5.2	49.52
2	385	123	3.7	30.08
3	316	148	6.3	42.57
4	304	121	4.5	37.19
5	24	117	4.9	41.88
6	436	77	2.8	36.36
7	243	220	7.5	34.09
8	506	127	3.6	28.35
9	271	74	2.7	36.49
10	65	96	3.9	40.63
11	387	160	4.8	30.00
12	161	69	3.5	50.72
TOTAL		**1437**	**53.4**	**457.88**
AVERAGE		**119.8**	**4.5**	**38.16**

Table 11: Site 2: Toolamba Fresh Produce – Yield Comparison Data

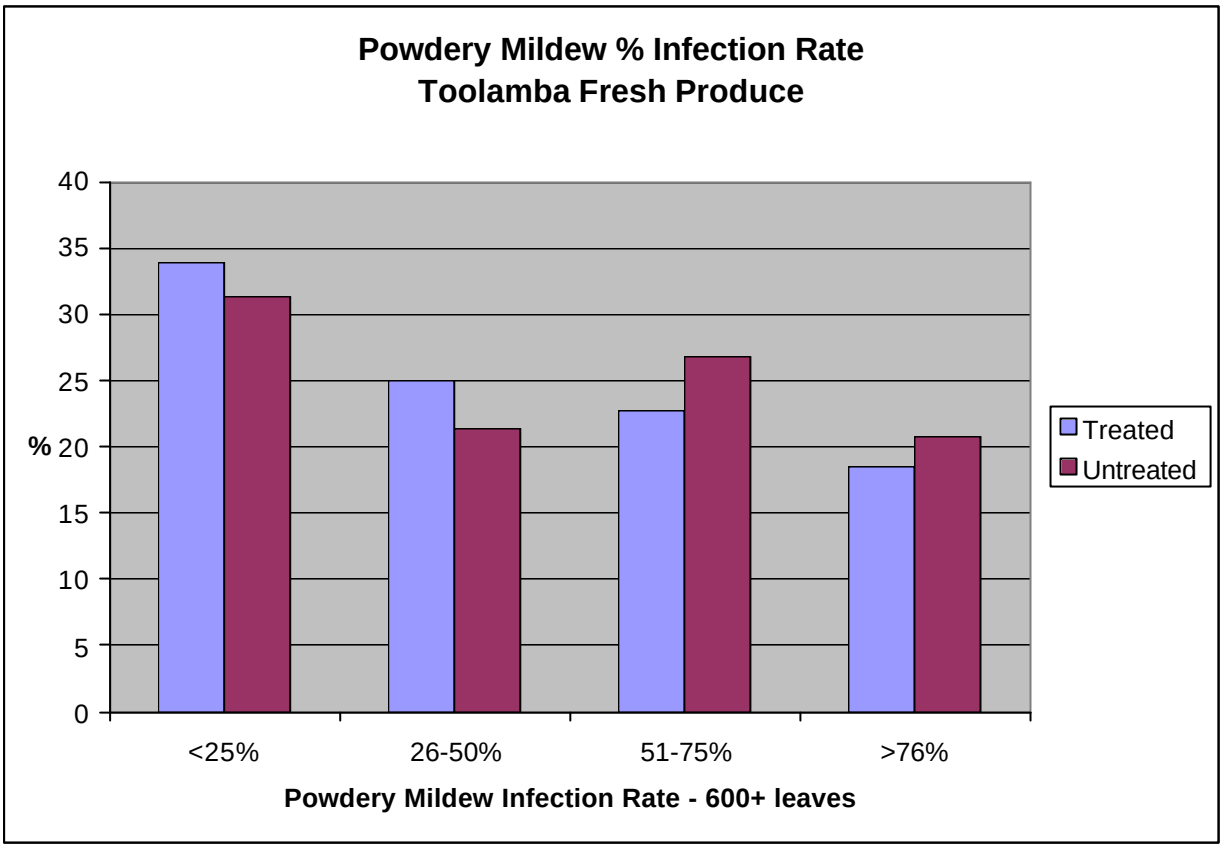
TREATED				
Row Number	Plant Number	Number of fruit	Total Fruit Weight (Kg)	Average fruit weight (gm)
1	1	111	4	36.04
1	2	135	5	37.04
2	1	137	4.5	32.85
2	2	149	5.5	36.91
3	1	109	4	36.70
3	2	115	6.5	56.52
4	1	136	6	44.12
5	1	159	6.5	40.88
5	2	71	3	42.25
6	1	172	6.5	37.79
7	1	95	4	42.11
8	1	198	8	40.40
8	2	83	3.5	42.17
9	1	135	5.5	40.74
9	2	48	1.5	31.25
TOTAL		**1853**	**74**	**597.76**
AVERAGE		**124**	**5**	**39.85**

UNTREATED				
Row Number	Plant Number	Number of fruit	Total Fruit Weight (Kg)	Average fruit weight (gm)
1	1	128	4.2	32.81
1	2	117	4	34.19
2	1	114	4.3	37.72
3	1	130	3.6	27.69
4	1	139	3.9	28.06
5	1	142	4.3	30.28
5	2	135	6.2	45.93
6	1	127	5	39.37
6	2	116	5.4	46.55
7	1	144	4.3	29.86
7	2	123	4.6	37.40
8	1	131	5.8	44.27
8	2	150	5.5	36.67
9	1	144	5.6	38.89
9	2	94	4.6	48.94
TOTAL		**1934**	**71.3**	**558.63**
AVERAGE		**129**	**5**	**37.24**

Graph 1: Site 1 Powdery mildew percentage Infection Rate – Gillieston Fresh Produce

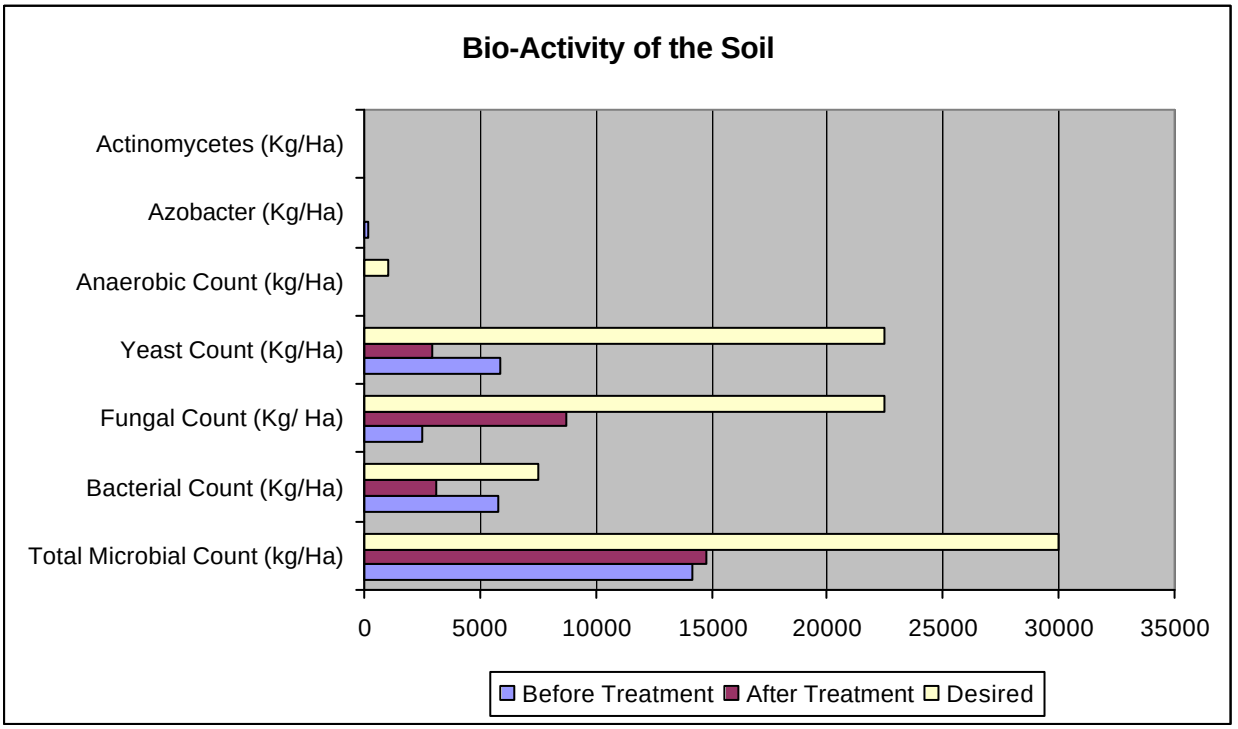


Graph 2: Site 2 Powdery mildew percentage Infection Rate – Toolamba Fresh Produce

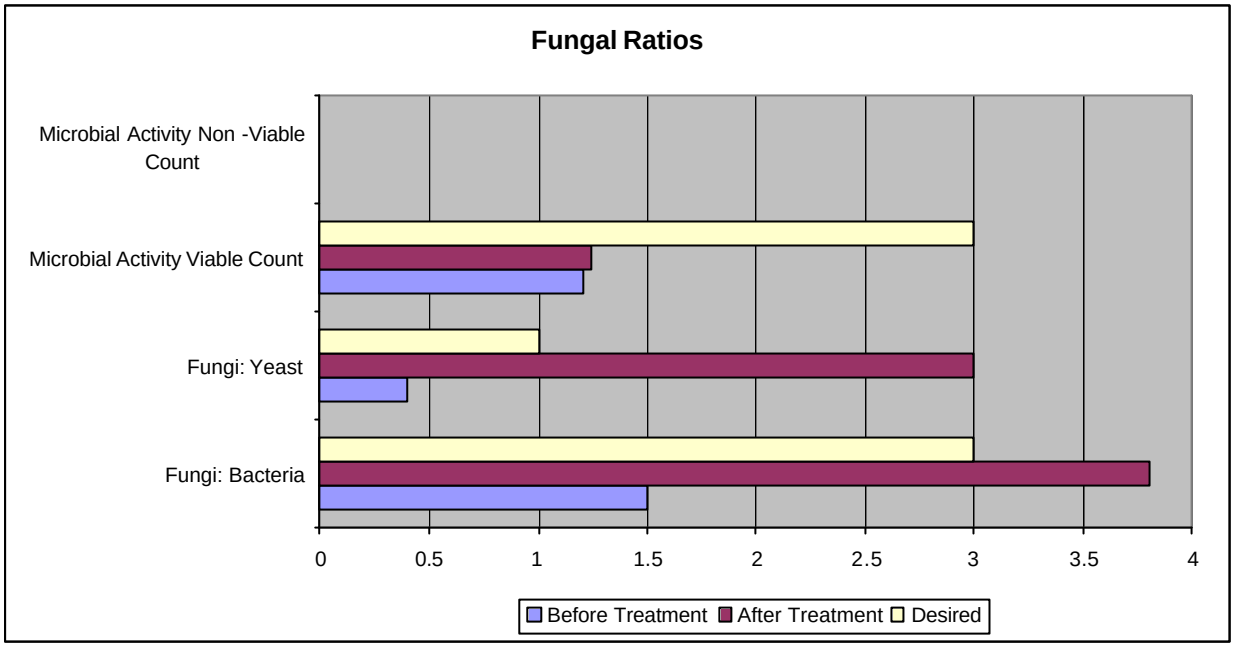


SOIL HEALTH TESTING

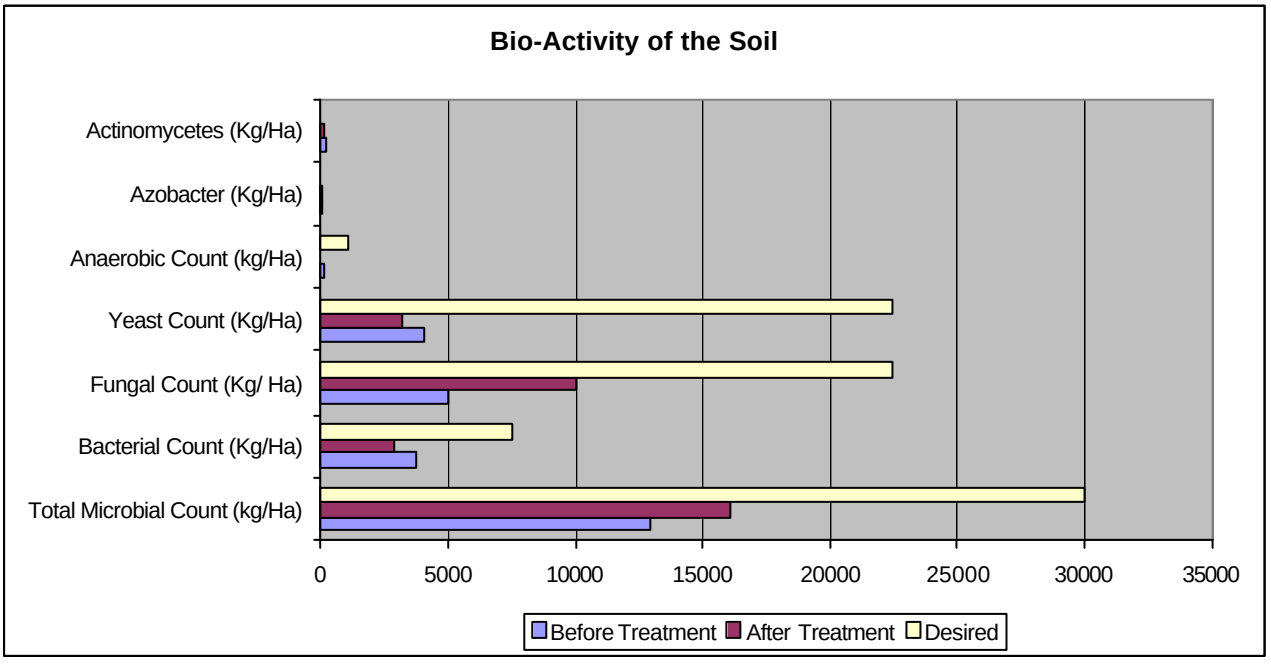
Graph 3: Site 1 Gillieston Fresh Produce – `Soil microbial indicator testing'



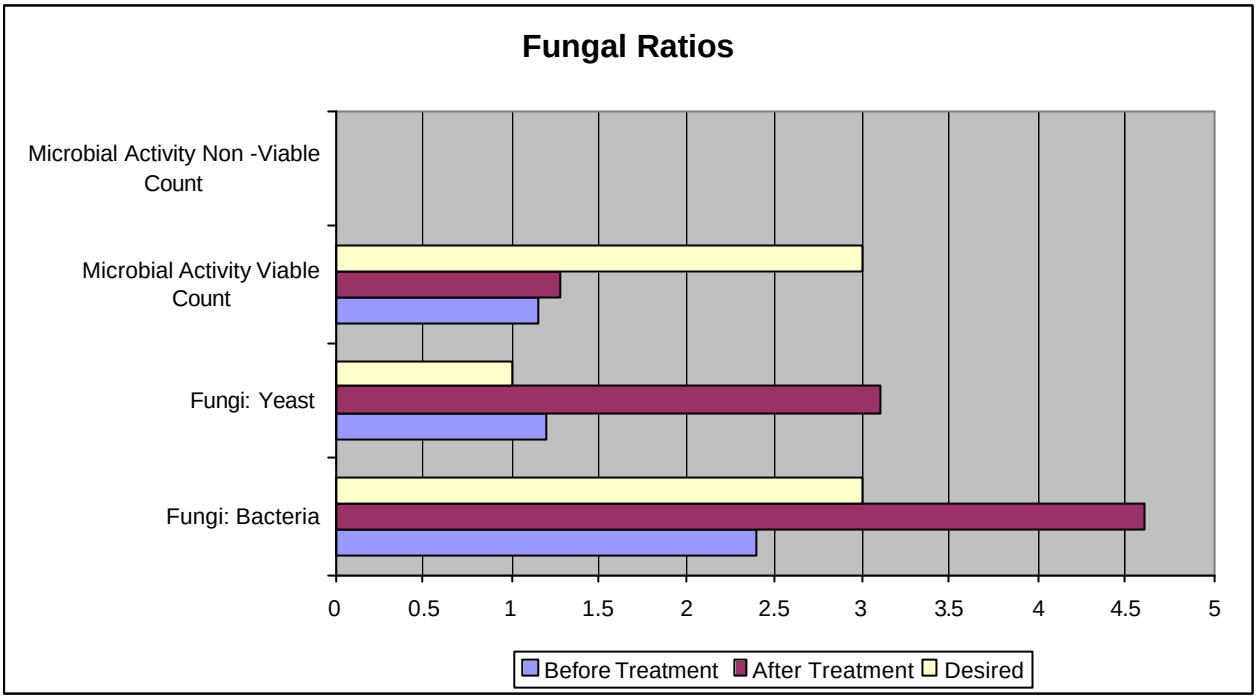
Graph 4: Site 2 Toolamba Fresh Produce – `Fungal Ratios'



Graph 5: Site 2 Toolamba Fresh Produce – `Soil microbial indicator testing'



Graph 6: Site 2 Toolamba Fresh Produce – `Fungal Ratios'



FUNGICIDE RESIDUAL AND PHYTOTOXICITY

Site 3: Fruit residue tests conducted by Agrifood Technology.

Prosper – Active Constituent Spiroxamine

	MRL APVMA	**Limit Of Recording**	**RESULT**
Spiroxamine		<0.1	<0.1

Systhane – Active Constituent Myclobutanil

	MRL APVMA	**Limit Of Recording**	**RESULT**
Myclobutanil	NA	<0.05	<0.05

10 DISCUSSION

11 PART A – Season 2006 - 2007

Stable temperatures and ideal relative humidity provided favourable conditions for the development of powdery mildew on tomatoes planted late in the season (see Appendix 4 for weather station data), in season 2006-2007. The trial site had been used to grow tomatoes in the previous season, which had displayed symptoms of powdery mildew and so provided ideal conditions for re-infection in the subsequent crop due to the possible spore carryover on host plants.

The first field assessment prior to any treatments showed no symptoms of the disease in the trial. The second assessment (10 days after the 1st treatments) showed Powdery Mildew symptoms (*Oidium lycopersici*) on all treatments and the untreated control. There was no significant difference found between the treatments or untreated replications at LSD 5%. The first symptoms of Powdery Mildew became evident when the tomato plants were in the process of fruit set and sizing. Additional stress on tomato plants seems to aid in the development of the powdery mildew disease.

The third field assessment was 3 days after the second application of the powdery mildew treatments. This assessment found that both types of powdery mildew (*Oidium lycopersici* and *Leveillula taurica*) were active and spreading. Aero was the only treatment that showed significant difference between the untreated control and other treatments for powdery mildew (*Oidium lycopersici* only. (See Table 4).

The fourth assessment conducted four days after the third treatments were applied also resulted in Aero being the only product that was significantly different (5% LSD) from the untreated control and other treatments. Even though the plants treated with Aero visually had less powdery mildew (*Oidium lycopersici*) than the untreated control and other treatments, the disease was present in levels high enough to impact on yield and quality.

An unfortunate miscalculation when determining rates per 2 litres of water resulted in two of the trial products being under-dosed as per their label rates. Score was under-dosed for its first application whilst Walabi was under-dosed for all three applications (Refer to Table 2).

Aero gave some level of control, but evaluation between treatments was difficult to assess accurately due to the miscalculation of rates for two of the products. This unfortunately means that comparisons between treatments are not conclusive. This highlights the importance of ensuring correct dosage and water volumes.

The final assessment in the lab could not be statistically analysed due to all the replicates for each product being combined when assessed, although Aero and Prosper showed less signs of Powdery Mildew as a percentage than the untreated control using the field assessment key (See Appendix 2, Figures 1 - 3).

Soil moisture measured during the trial at 3 locations showed that the South end probe was different to the central and north probes. The South end probe indicated an inability of water to penetrate deep into the soil profile. This was also visually noticeable with excessive water in the rows at the South end probe. The impact of the water logging was demonstrated by poor plant health and growth. When tomato plants ability to function normally is impeded, the development of diseases such as Powdery Mildew can be more prevalent. In this trial, due to the ideal conditions for the disease across the whole trial site there was no obvious difference in Powdery Mildew pressure, but there was a difference in general plant health. (Refer to Soil and Weather data Appendix 4)

The weather was conducive to the development of powdery mildew during the period of the trial (See Appendix 4.2) Ideal weather conditions mean that protectant fungicides must be applied at every fruit set to minimise potential impact of powdery mildew. General plant health is important as the powdery mildew disease tends to develop more rapidly when plants are under stress.

Samples taken from the trial site and sent to the Department of Primary Industries Knoxfield (Crop Health Services) for diagnosis found only *Leveillula taurica* species of powdery mildew. James Cunnington a diagnostician from Crop Health Services states that *"Oidium lycopersici* often forms very few fungal spores on infected leaves, thus it may not be detected even though it is present", this may be the reason that the majority of samples tested positive only for *Leveillula taurica*, despite apparent visual symptoms of *Oidium lycopersici.*

The nutritional status of the tomato plants was within acceptable ranges when sap testing was conducted throughout the season. Sodium levels were slightly high towards the end of the crop. This is often associated with longer and more frequent irrigations to fill fruit, higher sodium levels can impact on the availability of Calcium to the plant. Calcium is important for cell wall strength in plants and fruit. Deficiencies can lead to Blossom End Rot. Blossom End Rot was not noted during assessments.

Residue testing was conducted on Aero and Prosper to provide an indication of likely withholding periods that will need to be observed if these products are to be used if registered. Aero is due to be released next season on Tomatoes for the control of Alternaria, whilst Prosper is currently registered on Grapes and will not be registered on Tomatoes. The residue results (Table 7) found some residues for Aero but not Prosper. An original concern with Prosper was the potential of phytotoxicity damage to the tomato fruit. This was not observed on any of the replicated treatments.

The leaf ratings were assessed from the ground to the first wire, between the first and second wires, between the second and third wires and between the third and fourth wires. The mean value for each treatment has been used for the purposes of these summaries.

The nutritional balance of the tomatoes sampled during the trial was overall in balance. The only concern found was at growth stage 4.5 where the Sodium (Na) levels increased significantly, whilst Calcium levels decreased. High Sodium levels can "lock up" available Calcium which is critical for firm fruit.

12 PART B – Season 2008 - 2009

The weather between October 2008 and March 2009 provided ideal conditions for the development of powdery mildew. (Appendix 12 and 13). An extreme heat event in mid to late January dropped flowers and stopped further plant and fruit growth for two weeks, this event also halted the further development of powdery mildew. As the plants recovered from the extreme heat the reserved nutrients that had built up in the plants system resulted in a flush of new growth that once again kick started powdery mildew.

The four growers who took part in the project did so with the understanding that the best management program would be followed as closely as possible. Unfortunately, due to the nature of growing trellis tomatoes this was not always possible. As a result, a final assessment on the two trellis tomato sites was not conducted.

Final yield assessments at Site one and Site two found a slight increase in fruit weight in both sites. The results were tested statistically and at the five percent level there was no significant difference between the treated and untreated blocks for either site (Appendix 10.1 and 10.2). However, all the fruit on each plant was harvested when the first fruit set was greater than 1cm in diameter, consequently the fruit was at varying stages of maturity. Fruit tends to gain weight more rapidly from this growth stage onward and to obtain a true indication of increased yield the fruit could have been harvested as each fruit set reached maturity.

From the growers perspective, they believed the treated fruit to be "firmer, larger and had more shine". This was an observation of the fruit in the bin at the time of harvest.

Plants were assessed for the level of control of powdery mildew. The leaves of plants were identified as being affected by powdery mildew and then rated according to the percentage of infection on each leaf. Thresholds were established with examples for each group. (Refer to Appendix 7, figures 1 – 4).
Results show that there were no discernable differences in the rates of powdery mildew infection at either site between the treated and untreated bays. (Appendix 6) This element of the trial was not tested statistically as the classification process was conducted visually and the leaves were collated to aid in the evaluation process.

The lack of significant difference between the treated and untreated blocks highlights the nature of powdery mildew and the lack of adequate control measures available once infection has occurred. It is extremely difficult to eradicate powdery mildew and the focus becomes the level of control that is achievable with the products available. Timing and application is critical. Complete coverage of the foliage is essential to ensure a level of control with the fungicide options available.

As part of the project, random samples of leaves showing symptoms of powdery mildew were taken from various tomato blocks. These samples were sent to Crop Health Services at the Department of Primary Industries – Knoxfield to determine powdery mildew species. (Appendix 11). Over the last three seasons Crop Health Services has diagnosed a total of thirty two samples as predominantly infected with *Leveillula taurica*, with only one sample showing symptoms of *Oidium lycopersici*. A reason for the low level of *Oidium lycopersici* may be that the tomato is not the preferred host plant and subsequently the disease produces very few spores that are not detected although they may be present.

Prosper and Systhane are fungicides that are registered for the control of powdery mildew on other crops in Victoria, these fungicides have been used successfully in small plot demonstrations to provide a level of control of tomato powdery mildew. The purpose of this trial was to help determine if these chemicals can be used on tomatoes without recording a residue at the limit of recording (LOR). The results show that neither product was detected at the LOR levels, after three applications and tested ten days after the last application. Phytotoxicity was not observed for either product. (Refer to Table 12)

It is well known that a healthy plant, not under stress has a greater ability to fight the impact of powdery mildew disease. The addition of organic products early at the seedling stage and throughout the life of the plant was done with the aim of reducing the impact of stress. Soil microbial indicator testing was conducted to ascertain the soil health before and after treatment with Micro Plus, Super Kelp, Humus 26 and Fish Emulsion.

The results show an improvement in fungal, microbial counts whilst a decrease in yeast and bacteria counts. The levels are below those desired, but with continued use of the products, improvement in the microbe levels can be achieved. A more nutritionally balanced plant is less likely to be under stress and more likely to protect itself against the impact of powdery mildew.

13 TECHNOLOGY TRANSFER

Over the last six years, the Northern Victorian fresh tomato industry has made significant improvements on how to manage powdery mildew. This in part is due to the small number of growers that make up the Northern Victoria fresh tomato industry. The size of the industry allowed the project team to disseminate information quickly and assist growers through one to one contact. Minutes from group meetings and trial summaries were both emailed and posted

A proactive growing program is required that concentrates not only on available and new fungicide chemistry, but what agronomic actions are required depending upon the number and timing of plantings (early season compared to late season). Effective application of sprays is an issue of great importance, maintenance and correct calibration of equipment is crucial. New ground is always preferable when planting tomatoes but not always an option due to limited sites for rotation. A crop rotation regime that restores the health of the soil whilst reducing potential carryover of disease on host material would benefit growers.

14 RECOMMENDATIONS

Powdery mildew continues to be a major factor decreasing the ability of growers to successfully and economically grow tomatoes later in the season. These trials successfully demonstrated that product choice, correct dosage and spray coverage are critical in providing a level of control for Powdery Mildew.

Powdery mildew will continue to be a major problem for tomato growers as our climatic conditions favour the development of this disease. Continuing to grow tomato crops on ground that has a history of powdery mildew will provide ongoing challenges. These challenges can be minimised by following sound best management practices to reduce the impact of this disease from season to season.

This project has demonstrated that when the correct fungicide dose, timing and spray volumes are used in a trial situation, a significant reduction in powdery mildew can be achieved. Given that this was not achieved in the grower managed programs, it suggests that more work with growers on spray application and equipment setup is required.

In addition a crop rotation regime to reduce potential carryover of disease, improvement of soil health and a shortening of rotations would bring economic benefits through a reduction in the acreage growers would need to lease.

The Northern Victorian Fresh Tomato Industry needs to continue to be proactive with regard to chemical use, changing legislation will require a responsible approach to the use of chemicals that are currently not registered on tomatoes, and trial work needs to continue to aid in the registration of new chemicals. In addition a best management strategy with growers setting internal benchmarking parameters would allow clear identification of areas of their business that are effective or requiring improvement.

15 ACKNOWLEDGEMENTS

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Fresh Tomato Industry Development Committee

Jo Vraca, Fresh tomato grower

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16 REFERENCES

Anon. 2004, California PestCast Disease Model Database, University of California, Davis, USA, update May 2005. (www.ipm.ucdavis.edu/DISEASE/DATABASE/tomatopowderymildew)

Anon. 2005, Interactive Tools and Models: About the Spray Forecast for Tomato Powdery Mildew, Statewide IPM Program, Agriculture and Natural Resources, University of California, Davis, USA, update May 2005. (www.ipm.ucdavis.edu/MODELS/TOMPM/abouttomatopm.html)

Anon. 2005, Interactive Tools and Models: Tomato Powdery Mildew Spray Forecast, Statewide IPM Program, Agriculture and Natural Resources, University of California, Davis, USA, update May 2005. (www.ipm.ucdavis.edu/calludtw.cgi/TOMPMSTART.html)

Anon. 2007, Tomato: Powdery Mildew on Field Grown Tomatoes, Statewide IPM Program, Agriculture and Natural Resources, University of California, Davis, USA, update Jan 2007. (www.ipm.ucdavis.edu/calludtw.cgi/TOMPMSTART.html)

Cerkauskas, R. 2005, Powdery Mildew Fact Sheet, AVRDC- The World Vegetable Centre, Shanhua, Taiwan. www.avrdc.org/pdf/tomato/powdery.pdf

Jones, H., Whipps, J. and Gurr, S. 2001. 'The tomato powdery mildew fungus *Oidium neolycopersici'*, *Molecular Plant Pathology*, vol. 2. no. 6, pp. 303-309.

LaMondia, J.A., Smith, V.L. and Douglas, S. M. 1999. 'Host range of *Oidium lycopersicum* on selected solanaceous species in Connecticut', *Plant Disease*, vol.83, pp. 341-344.

Paulus, A. and Correll, J. 1993, 'Powdery Mildew', in *Compendium of Tomato Diseases*, The American Phytophathological Society ed. Jones, J., Stall, R., and Zitter,T., APS Press, USA.

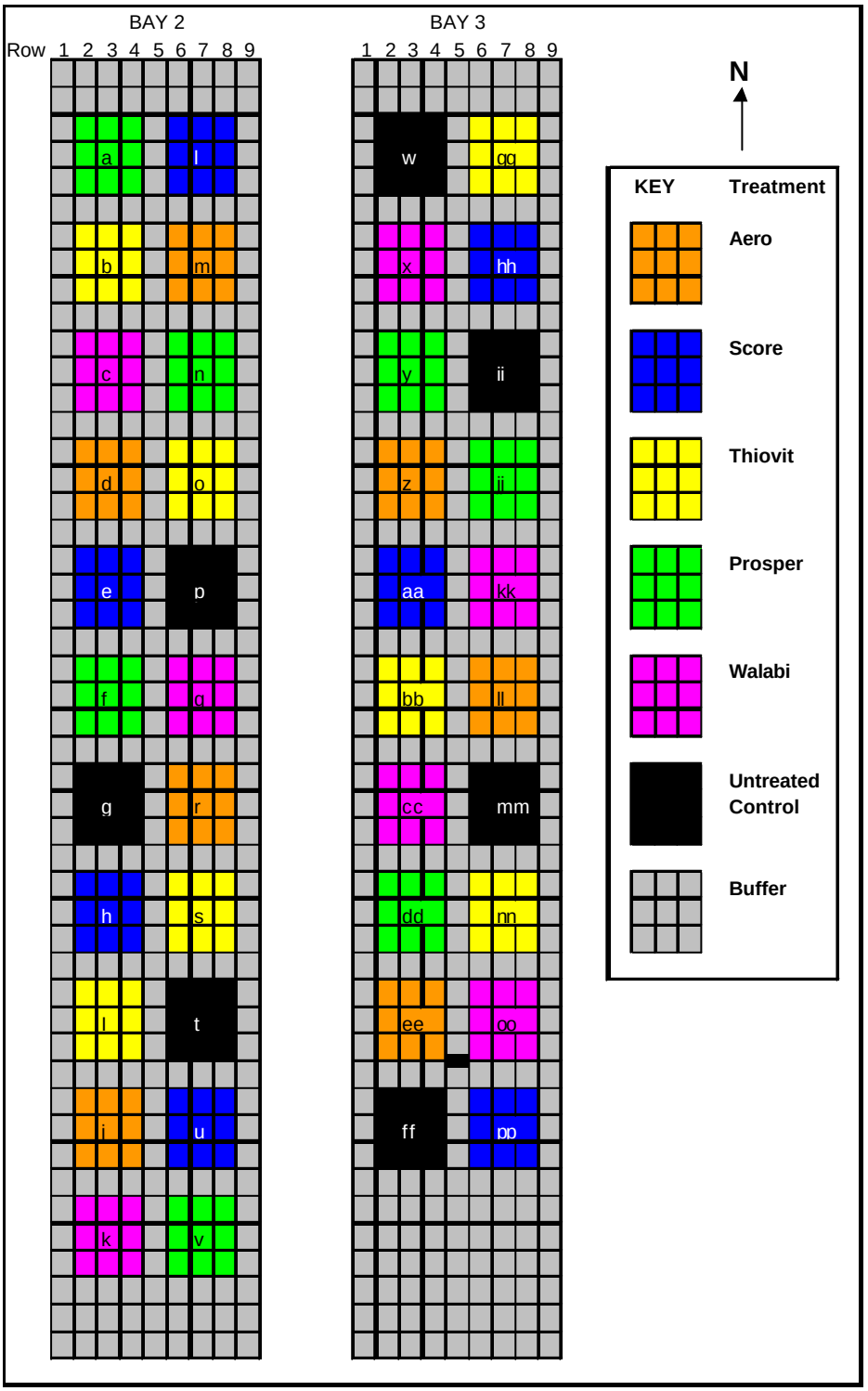
Serve-Ag, 2006, NU-TEST Guidelines for Tomatoes, Serve-Ag, Launceston, Tasmania.

University of California,1998, Integrated Pest Management for Tomatoes, 4th edn, Publication 3274, University of California, USA.

Watterson, J.C. 1985, Tomato Diseases: A Practical Guide for Seedsmen, Growers & Agricultural Advisors, Petoseed Co. Inc. California, U.S.A.

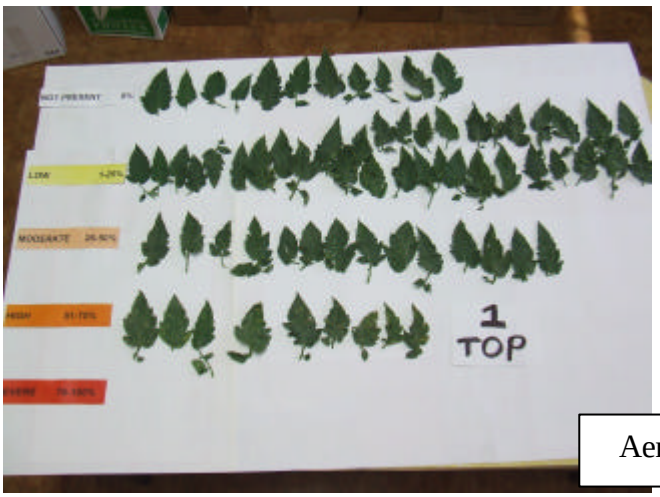
17 APPENDICES

Appendix 1. Completely Randomised Trial Design Layout



Appendix 2: Laboratory Assessments

Figure 1: At wires 3-4 (top), only 6% of Aero leaves had High to Severe mildew infections.
At wires 1-2 (bottom), 70% of Aero leaves had High to Severe Powdery Mildew damage.



Aero

Figure 2. At wires 3-4 (top), only 13% of Prosper leaves had High to Severe mildew infections.
At wires 1-2 (bottom), 81% of Prosper leaves had High to Severe mildew infections.

Prosper

Figure 3. At wires 3-4 (top), only 29% of Untreated leaves had High to Severe mildew infections.
At wires 1-2 (bottom), 100% of Untreated leaves had High to Severe mildew infections.

Untreated Control

Appendix 3. Field Assessment Data

Appendix 3.1: First field assessment, 2 February 2007- Seven days after first spray application

Assessment 1		Powdery Mildew									
2/02/2007		Oidium lycopersici				Plot	Leveillula taurica				Plot
Plot	Treatment	Wires 0-1	Wires 1-2	Wires 2-3	Wires 3-4	mean	Wires 0-1	Wires 1-2	Wires 2-3	Wires 3-4	mean
d	Aero	0	0			0	0	0			0
j	Aero	0	0			0	0	0			0
m	Aero	0	0			0	0	0			0
r	Aero	0	0			0	0	0			0
z	Aero	0	0			0	0	0			0
ee	Aero	0	0			0	0	0			0
ll	Aero	0	0			0	0	0			0
a	Prosper	0	0			0	0	0			0
f	Prosper	0	0			0	0	0			0
n	Prosper	0	0			0	0	0			0
v	Prosper	0	0			0	0	0			0
y	Prosper	0	0			0	0	0			0
dd	Prosper	0	0			0	0	0			0
jj	Prosper	0	0			0	0	0			0
e	Score	0	0			0	0	0			0
h	Score	0	0			0	0	0			0
l	Score	0	0			0	0	0			0
u	Score	0	0			0	0	0			0
aa	Score	0	0			0	0	0			0
hh	Score	0	0			0	0	0			0
pp	Score	0	0			0	0	0			0
b	Thiovit	0	0			0	0	0			0
l	Thiovit	0	0			0	0	0			0
o	Thiovit	0	0			0	0	0			0
s	Thiovit	0	0			0	0	0			0
bb	Thiovit	0	0			0	0	0			0
gg	Thiovit	0	0			0	0	0			0
nn	Thiovit	0	0			0	0	0			0
g	Untreated	0	0			0	0	0			0
p	Untreated	0	0			0	0	0			0
t	Untreated	0	0			0	0	0			0
w	Untreated	0	0			0	0	0			0
ff	Untreated	0	0			0	0	0			0
ii	Untreated	0	0			0	0	0			0
mm	Untreated	0	0			0	0	0			0
c	Walabi	0	0			0	0	0			0
k	Walabi	0	0			0	0	0			0
q	Walabi	0	0			0	0	0			0
x	Walabi	0	0			0	0	0			0
cc	Walabi	0	0			0	0	0			0
kk	Walabi	0	0			0	0	0			0
oo	Walabi	0	0			0	0	0			0

Not Present Low Moderate High Severe

Appendix 3.2: Second field assessment, 19 February 2007 – Ten days after first spray application.

Assessment 2		Powdery Mildew									
19/02/2007		Oidium lycopersici				Plot	Leveillula taurica				Plot
Plot	Treatment	Wires 0-1	Wires 1-2	Wires 2-3	Wires 3-4	Mean	Wires 0-1	Wires 1-2	Wires 2-3	Wires 3-4	Mean
d	Aero	1	1	0		0.667	0	0	0		0.000
j	Aero	1	0	0		0.333	0	0	0		0.000
m	Aero	1	0	0		0.333	0	0	0		0.000
r	Aero	1	1	0		0.667	0	0	0		0.000
z	Aero	2	2	0		1.333	0	0	0		0.000
ee	Aero	1	1	0		0.667	0	0	0		0.000
ll	Aero	1	1	0		0.667	0	0	0		0.000
a	Prosper	1	1	0		0.667	0	0	0		0.000
f	Prosper	1	1	0		0.667	0	0	0		0.000
n	Prosper	1	1	0		0.667	0	0	0		0.000
v	Prosper	1	0	0		0.333	1	1	0		0.667
y	Prosper	1	1	0		0.667	0	0	0		0.000
dd	Prosper	1	1	0		0.667	0	0	0		0.000
jj	Prosper	1	1	0		0.667	0	0	0		0.000
e	Score	1	1	0		0.667	0	0	0		0.000
h	Score	1	1	0		0.667	0	0	0		0.000
l	Score	1	1	0		0.667	0	0	0		0.000
u	Score	1	0	0		0.333	0	0	0		0.000
aa	Score	1	1	0		0.667	0	0	0		0.000
hh	Score	1	1	0		0.667	0	0	0		0.000
pp	Score	1	1	0		0.667	0	0	0		0.000
b	Thiovit	1	1	1		1.000	0	0	0		0.000
l	Thiovit	1	1	1		1.000	0	0	0		0.000
o	Thiovit	1	1	1		1.000	0	0	0		0.000
s	Thiovit	2	2	0		1.333	0	0	0		0.000
bb	Thiovit	2	2	0		1.333	0	0	0		0.000
gg	Thiovit	1	1	0		0.667	0	0	0		0.000
nn	Thiovit	2	2	1		1.667	0	0	0		0.000
g	Untreated	1	1	0		0.667	0	0	0		0.000
p	Untreated	1	1	0		0.667	0	0	0		0.000
t	Untreated	1	1	0		0.667	0	0	0		0.000
w	Untreated	1	1	0		0.667	0	0	0		0.000
ff	Untreated	1	1	0		0.667	0	0	0		0.000
ii	Untreated	1	1	1		1.000	0	0	0		0.000
mm	Untreated	2	2	1		1.667	0	0	0		0.000
c	Walabi	1	1	0		0.667	0	0	0		0.000
k	Walabi	1	1	0		0.667	0	0	0		0.000
q	Walabi	2	2	0		1.333	0	0	0		0.000
x	Walabi	1	1	0		0.667	0	0	0		0.000
cc	Walabi	1	1	0		0.667	0	0	0		0.000
kk	Walabi	1	1	0		0.667	0	0	0		0.000
oo	Walabi	1	1	0		0.667	0	0	0		0.000

Not Present Low Moderate High Severe

Appendix 3.3: Third field assessment, 26 February 2007 – Three days after second spray application.

Assessment 3		Powdery Mildew									
26/02/2007		Oidium lycopersici				Plot	Leveillula taurica				Plot
Plot	Treatment	Wires 0-1	Wires 1-2	Wires 2-3	Wires 3-4	Mean	Wires 0-1	Wires 1-2	Wires 2-3	Wires 3-4	Mean
d	Aero	3	1	0	0	1.00	1	0	0	0	0.25
j	Aero	1	1	0	0	0.50	1	0	0	0	0.25
m	Aero	3	3	0	0	1.50	1	0	0	0	0.25
r	Aero	3	3	0	0	1.50	3	0	0	0	0.75
z	Aero	4	2	0	0	1.50	0	0	0	0	0.00
ee	Aero	2	2	0	0	1.00	1	0	0	0	0.25
ll	Aero	2	2	1	0	1.25	0	0	0	0	0.00
a	Prosper	2	2	1	0	1.25	1	1	0	0	0.50
f	Prosper	2	2	1	0	1.25	0	0	0	0	0.00
n	Prosper	4	4	0	0	2.00	0	0	0	0	0.00
v	Prosper	2	2	0	0	1.00	2	2	0	0	1.00
y	Prosper	4	2	0	0	1.50	0	0	0	0	0.00
dd	Prosper	4	2	0	0	1.50	1	0	0	0	0.25
jj	Prosper	4	4	2	0	2.50	0	0	0	0	0.00
e	Score	2	1	1	0	1.00	1	0	0	0	0.25
h	Score	3	3	1	0	1.75	0	0	0	0	0.00
l	Score	4	3	0	0	1.75	1	0	0	0	0.25
u	Score	3	3	0	0	1.50	3	3	0	0	1.50
aa	Score	3	2	0	0	1.25	0	0	0	0	0.00
hh	Score	4	2	1	1	2.00	0	0	0	0	0.00
pp	Score	4	1	1	1	1.75	0	0	0	0	0.00
b	Thiovit	2	1	0	0	0.75	0	0	0	0	0.00
l	Thiovit	2	1	1	0	1.00	2	2	0	0	1.00
o	Thiovit	2	2	0	0	1.00	4	4	0	0	2.00
s	Thiovit	4	4	0	0	2.00	0	0	0	0	0.00
bb	Thiovit	3	2	0	0	1.25	0	0	0	0	0.00
gg	Thiovit	4	4	4	1	3.25	0	0	0	0	0.00
nn	Thiovit	4	4	1	1	2.50	1	0	0	0	0.25
g	Untreated	2	2	1	0	1.25	2	0	0	0	0.50
p	Untreated	4	2	0	0	1.50	4	0	0	0	1.00
t	Untreated	4	4	3	0	2.75	4	3	3	0	2.50
w	Untreated	4	4	2	0	2.50	0	0	0	0	0.00
ff	Untreated	4	4	0	0	2.00	0	0	0	0	0.00
ii	Untreated	4	4	2	0	2.50	0	0	0	0	0.00
mm	Untreated	4	4	2	1	2.75	2	0	0	0	0.50
c	Walabi	2	2	1	0	1.25	0	0	0	0	0.00
k	Walabi	1	1	0	0	0.50	1	0	0	0	0.25
q	Walabi	4	3	0	0	1.75	0	0	0	0	0.00
x	Walabi	4	2	0	0	1.50	0	0	0	0	0.00
cc	Walabi	3	3	0	0	1.50	1	1	0	0	0.50
kk	Walabi	4	4	2	0	2.50	2	0	0	0	0.50
oo	Walabi	4	2	1	1	2.00	0	0	0	0	0.00

Not Present Low Moderate High Severe

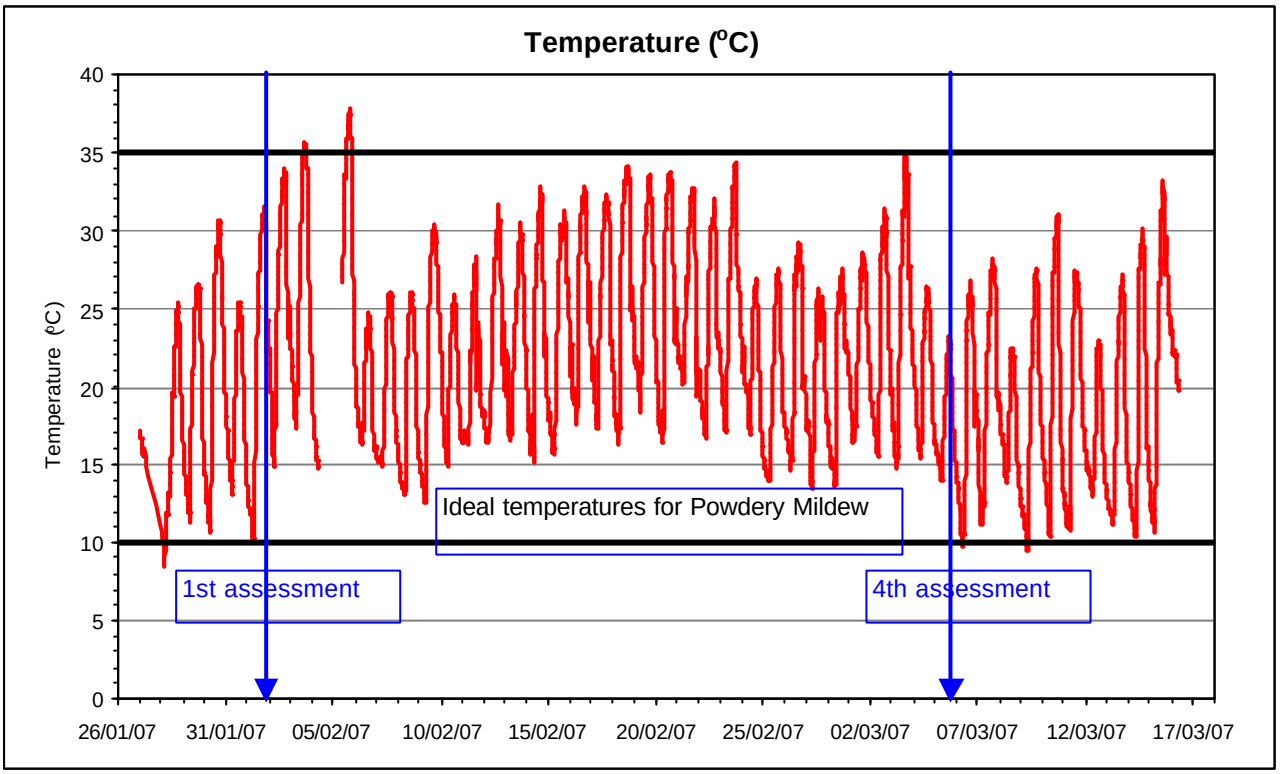
Appendix 3.4: Final field assessment, 5 March 2007- Four days after third spray application.

Assessment 4		Powdery Mildew									
5/03/2007		Oidium lycopersici				Plot	Leveillula taurica				Plot
Plot	Treatment	Wires 0-1	Wires 1-2	Wires 2-3	Wires 3-4	Mean	Wires 0-1	Wires 1-2	Wires 2-3	Wires 3-4	Mean
d	Aero	3	3	1	0	1.75	3	1	0	0	1.00
j	Aero	3	3	3	1	2.50	4	3	3	2	3.00
m	Aero	4	4	3	0	2.75	4	4	0	0	2.00
r	Aero	4	4	3	0	2.75	3	3	0	0	1.50
z	Aero	4	4	0	0	2.00	4	4	0	0	2.00
ee	Aero	4	4	4	0	3.00	4	4	3	0	2.75
ll	Aero	4	4	3	1	3.00	4	4	2	0	2.50
a	Prosper	4	4	3	2	3.25	3	3	2	1	2.25
f	Prosper	3	3	2	1	2.25	4	3	1	0	2.00
n	Prosper	4	4	3	0	2.75	4	4	0	0	2.00
v	Prosper	4	4	4	3	3.75	4	4	4	3	3.75
y	Prosper	4	4	3	0	2.75	4	4	0	0	2.00
dd	Prosper	4	4	4	2	3.50	4	4	4	0	3.00
jj	Prosper	4	4	3	1	3.00	4	4	1	0	2.25
e	Score	4	3	2	1	2.50	4	3	1	0	2.00
h	Score	4	4	3	1	3.00	3	2	0	0	1.25
l	Score	4	4	4	3	3.75	4	4	0	0	2.00
u	Score	4	4	4	0	3.00	4	4	4	0	3.00
aa	Score	4	4	3	0	2.75	4	4	0	0	2.00
hh	Score	4	4	4	3	3.75	4	4	2	2	3.00
pp	Score	4	4	3	1	3.00	4	3	0	0	1.75
b	Thiovit	4	3	3	2	3.00	2	1	1	0	1.00
l	Thiovit	4	3	3	1	2.75	4	1	1	1	1.75
o	Thiovit	4	4	4	3	3.75	4	4	0	0	2.00
s	Thiovit	4	4	4	3	3.75	4	4	0	0	2.00
bb	Thiovit	4	4	3	2	3.25	4	4	3	0	2.75
gg	Thiovit	4	4	4	4	4.00	4	4	2	2	3.00
nn	Thiovit	4	4	4	2	3.50	4	4	2	2	3.00
g	Untreated	3	3	2	1	2.25	3	2	0	0	1.25
p	Untreated	4	4	4	3	3.75	3	3	0	0	1.50
t	Untreated	4	4	4	3	3.75	4	4	4	3	3.75
w	Untreated	4	4	4	0	3.00	4	4	4	4	4.00
ff	Untreated	4	4	4	2	3.50	4	4	3	3	3.50
ii	Untreated	4	4	4	2	3.50	4	4	3	1	3.00
mm	Untreated	4	4	4	2	3.50	4	4	4	1	3.25
c	Walabi	4	3	3	2	3.00	3	2	1	0	1.50
k	Walabi	3	2	2	1	2.00	4	4	2	3	3.25
q	Walabi	4	4	3	0	2.75	4	4	3	0	2.75
x	Walabi	4	4	3	3	3.50	4	4	0	0	2.00
cc	Walabi	4	4	3	3	3.50	4	4	0	0	2.00
kk	Walabi	4	4	4	2	3.50	4	4	4	1	3.25
oo	Walabi	4	4	4	2	3.50	4	4	1	1	2.50

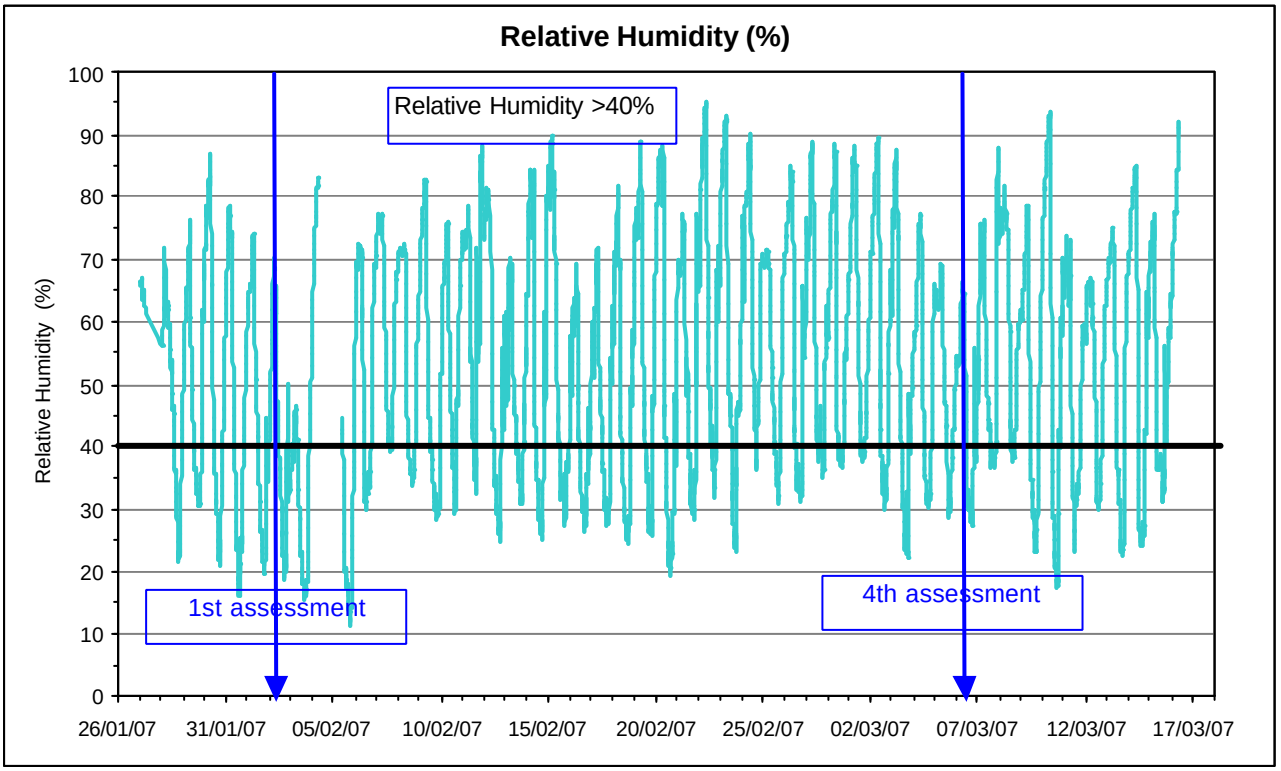
Not Present Low Moderate High Severe

Appendix 4. Weather Station Graphs

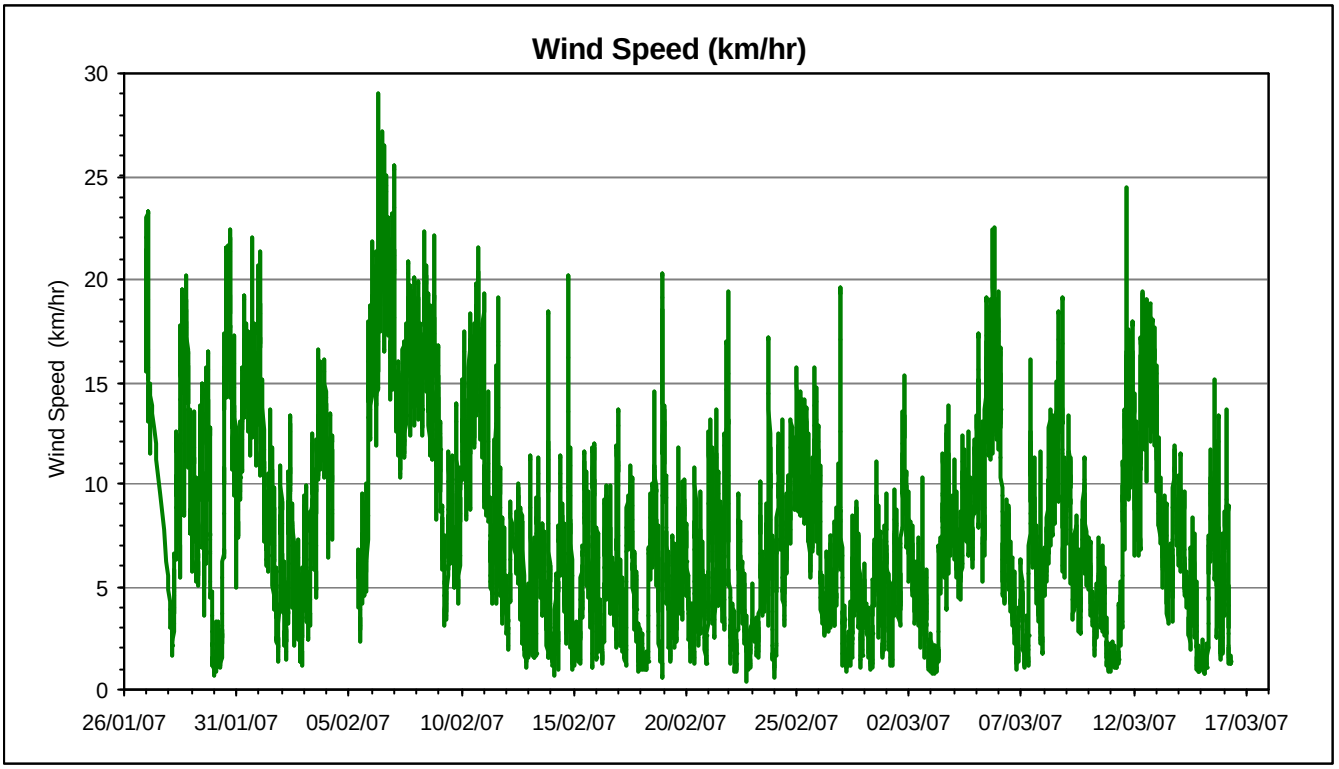
Appendix 4.1: Ideal temperatures for Powdery Mildew growth (10 to 35 degrees C) recorded between the first and fourth assessments.



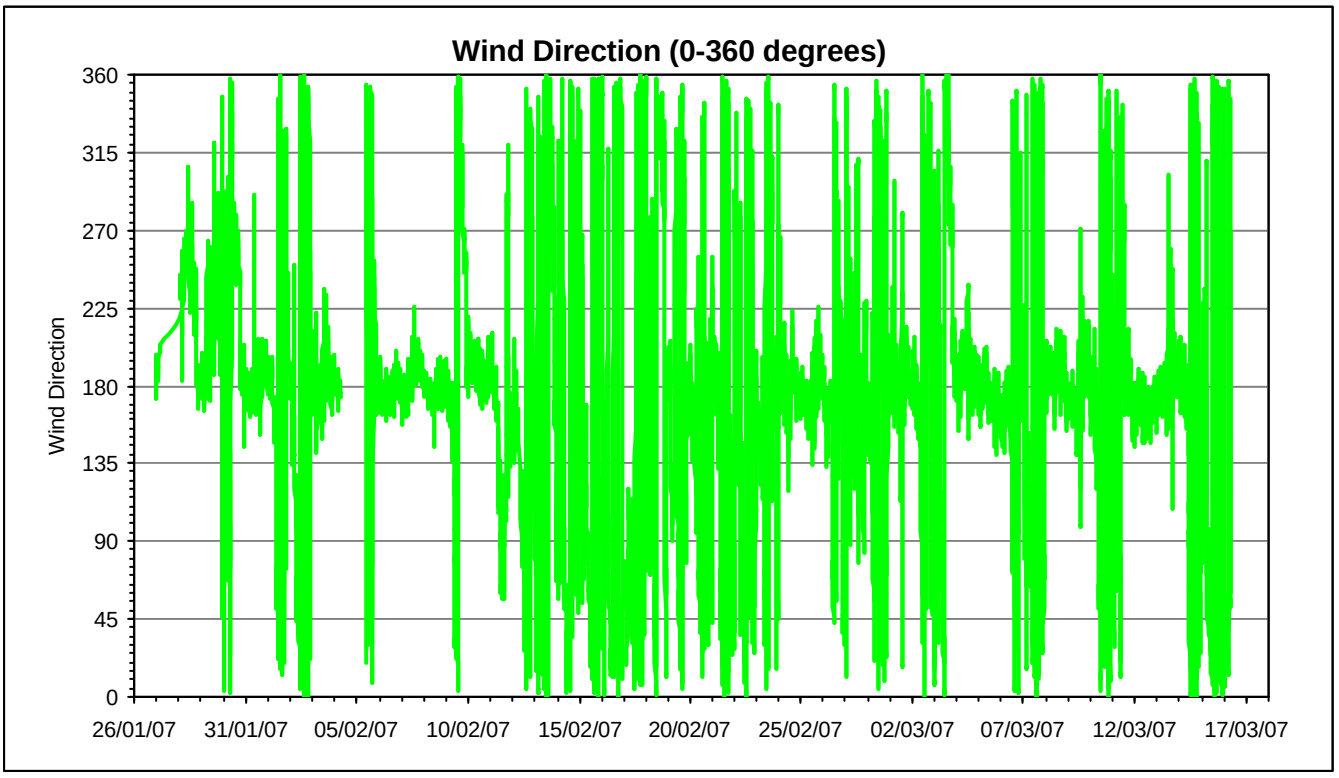
Appendix 4.2: Relative humidity generally >40% throughout trial.



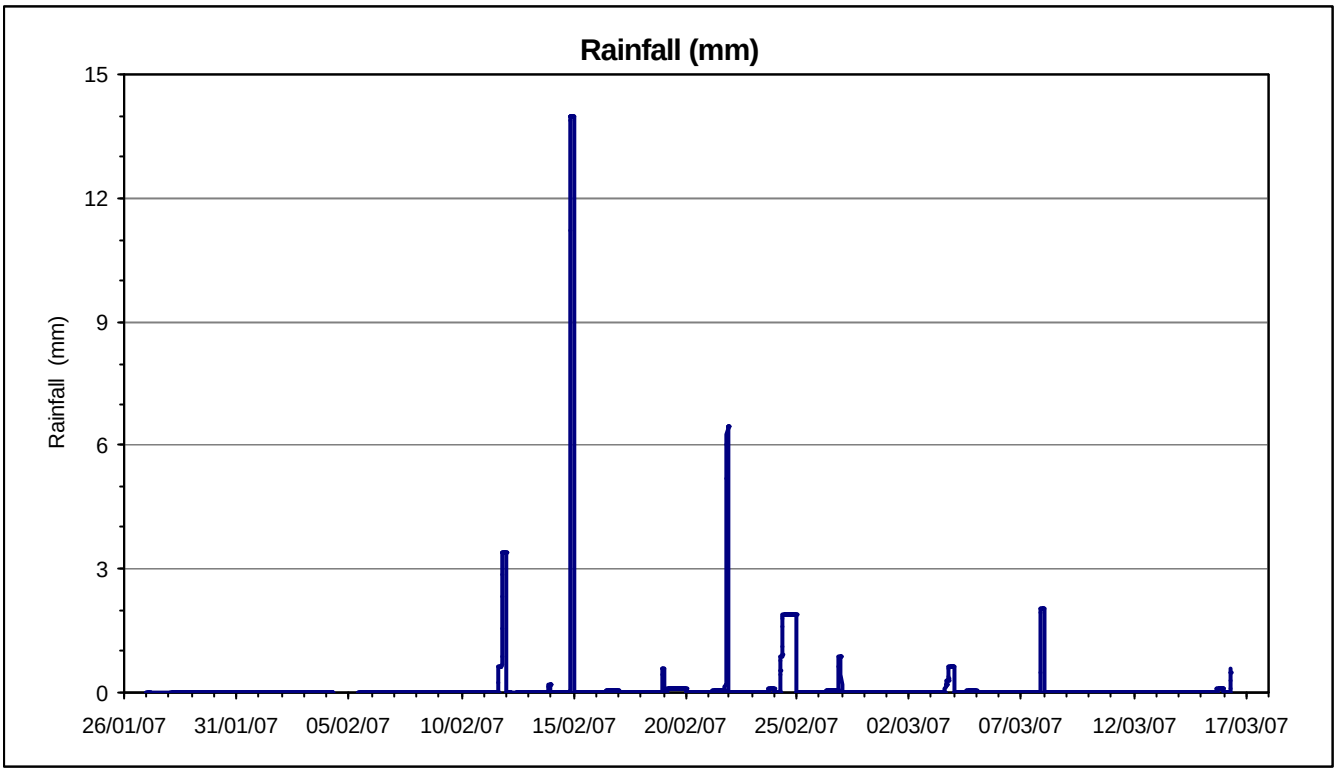
Appendix 4.3: Wind speed recorded at trial site.



Appendix 4.4: Wind direction recorded at trial site.



Appendix 4.5: Rainfall recorded at trial site.



Appendix 4.6: Weather Station

Appendix 5: Treatment Details

Aero Fungicide

Formulation:	Water dispersible granule
Active ingredients:	550g/kg Metiram and 50g/kg Pyraclostrobin
Group:	Group K and Y Fungicide
Label Use:	For the control of early and late (Irish) blight in potatoes. To be registered on Tomatoes in 2007 for the control of Alternaria
Withholding Period:	Not yet available
Marketed by:	Nufarm Australia Limited

Prosper 500ec Fungicide

Formulation:	Emulsifiable concentrate liquid
Active ingredients:	500g/L Spiroxamine
Group:	Group E Fungicide
Label Use:	For control of powdery mildew on grapevines.
Withholding Period:	Grapes: Do not harvest for 4 weeks after application
Marketed by:	Bayer CropScience Pty Ltd

Score Foliar Fungicide

Formulation:	Emulsifiable concentrate
Active ingredients:	250g/L Difenconazole
Group:	Group C Fungicide
Label Use:	Controls Target Spot of Potatoes and Tomatoes, Leaf Blight of Carrots, Leaf Spot Diseases of Bananas, Husk Spot on Macadamias
Withholding Period:	Tomatoes: Do not harvest for 3 days after application
Marketed by:	Syngenta Crop Protection Pty Limited

Thiovit Jet Microgranule Fungicide / Miticide

Formulation:	Water dispersible granule
Active ingredients:	800g/kg Sulphur (S)
Group:	Group Y Fungicide
Label Use:	For the control of Powdery Mildew, Rust and Mites in Pome and Stone fruit, Citrus, Grapevines, Kiwifruit, Mangosteens, Rambutans, Strawberries, Tomatoes, Ornamentals and some vegetables
Withholding Period:	Not required when used as directed
Marketed by:	Syngenta Crop Protection Pty Limited

Walabi SC Fungicide

Formulation:	Suspension concentrate
Active ingredients:	375g/L Chlorothalonil and 150g Pyrimethanil
Group:	Group Y and I Fungicide
Label Use:	For the control of target spot (early blight) in potatoes and tomatoes
Withholding Period:	Tomatoes: Do not harvest for 1 day after application
Marketed by:	Bayer CropScience Pty Ltd

Appendix 5.1: Trial Spray Application Equipment

Appendix 6: Rates of Leaf Infection

Figure 6.1: Gillieston Fresh Produce – Rate of Leaf Infection

Treated/ Untreated	Row Number	Plant Number	Number of Leaves Affected				Total leaf number	% of Leaves Affected			
			<25%	25-50%	50-75%	>75%		<25%	25-50%	50-75%	>75%
Treated	1	10	15	14	10	5	44	34	32	23	11
Treated	1	260	20	12	4	16	52	38	23	8	31
Treated	3	316	15	16	9	19	59	25	27	15	32
Treated	4	304	9	7	13	21	50	18	14	26	42
Treated	7	243	13	6	10	11	40	33	15	25	28
			72	55	46	72	245	**29**	**22**	**19**	**29**
Untreated	2	100	19	10	11	11	51	37	20	22	22
Untreated	4	304	17	6	8	6	37	46	16	22	16
Untreated	7	243	9	7	12	13	41	22	17	29	32
Untreated	9	271	22	9	2	20	53	42	17	4	38
Untreated	12	161	19	7	9	16	51	37	14	18	31
			86	39	42	66	233	**37**	**17**	**18**	**28**

Figure 6.2: Toolamba Fresh Produce– Rate of Leaf Infection

Treated/ Untreated	Row Number	Plant Number	Number of Leaves Affected				Total leaf number	% of Leaves Affected			
			<25%	25-50%	50-75%	>75%		<25%	25-50%	50-75%	>75%
Treated	2	1	58	32	38	30	158	37	20	24	19
Treated	2	2	46	44	36	34	160	29	28	23	21
Treated	3	2	56	45	50	39	190	29	24	26	21
Treated	5	2	56	33	26	12	127	44	26	20	9
Treated	7	1	36	32	20	23	111	32	29	18	21
			252	186	170	138	746	**34**	**25**	**23**	**18**
Untreated	1	2	40	31	28	32	131	31	24	21	24
Untreated	4	1	49	37	26	29	141	35	26	18	21
Untreated	5	1	35	25	36	22	118	30	21	31	19
Untreated	5	2	48	22	41	30	141	34	16	29	21
Untreated	7	2	35	26	46	25	132	27	20	35	19
			207	141	177	138	663	**31**	**21**	**27**	**21**

Percentage for each rate of infection, for treated and untreated

Appendix 7: Thresholds for Rate of Powdery Mildew Infection Analysis

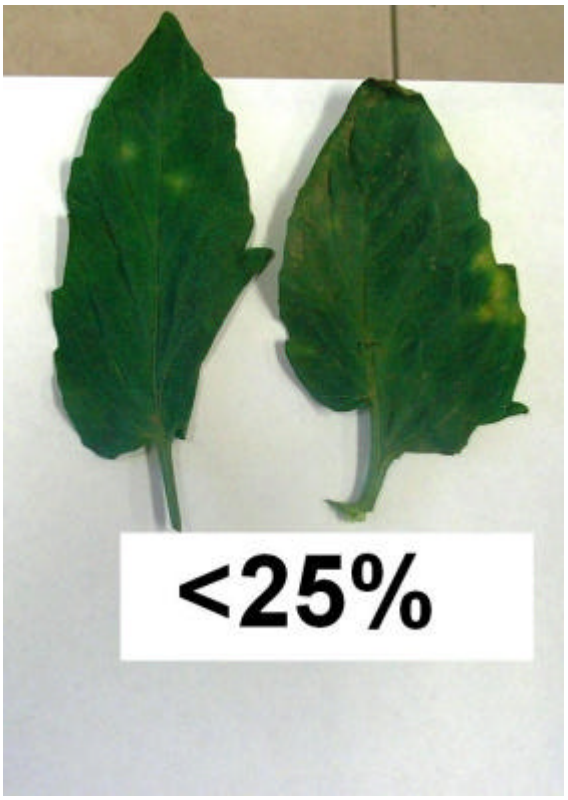


Figure 1

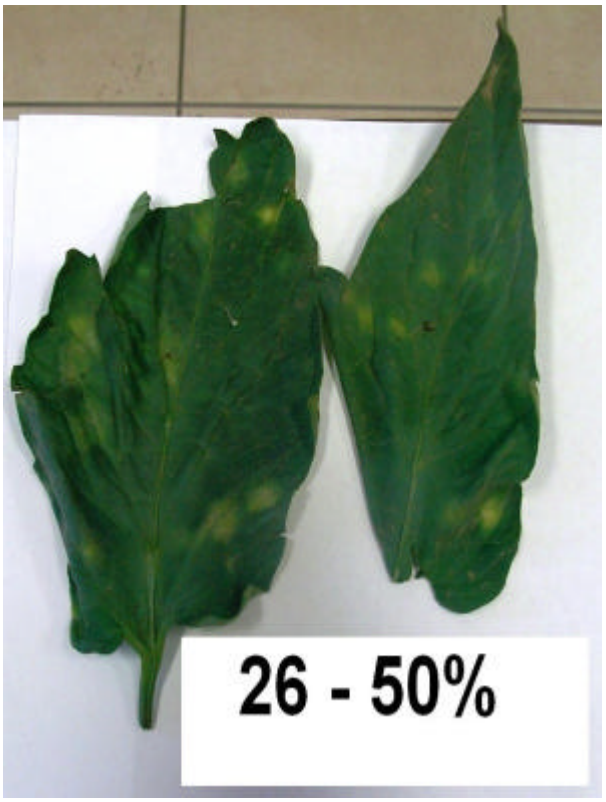


Figure 2

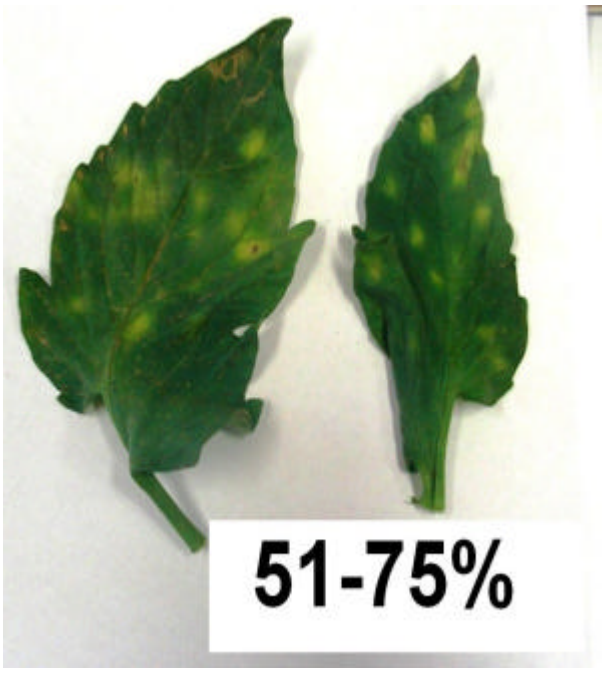


Figure 3

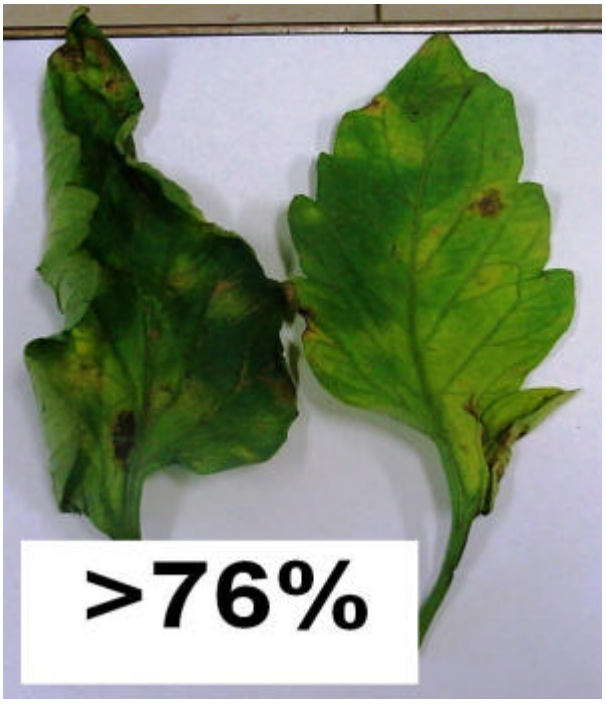
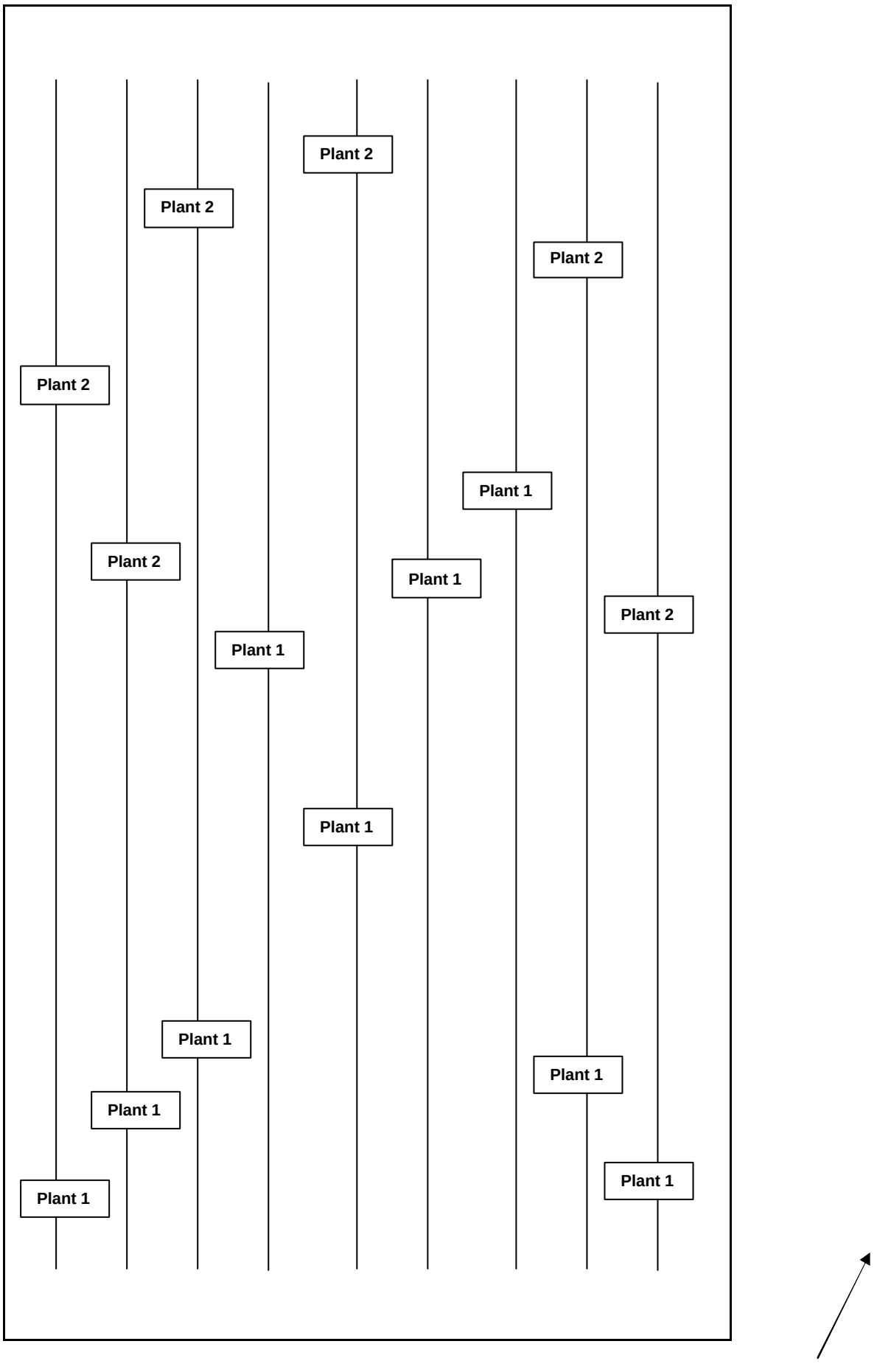


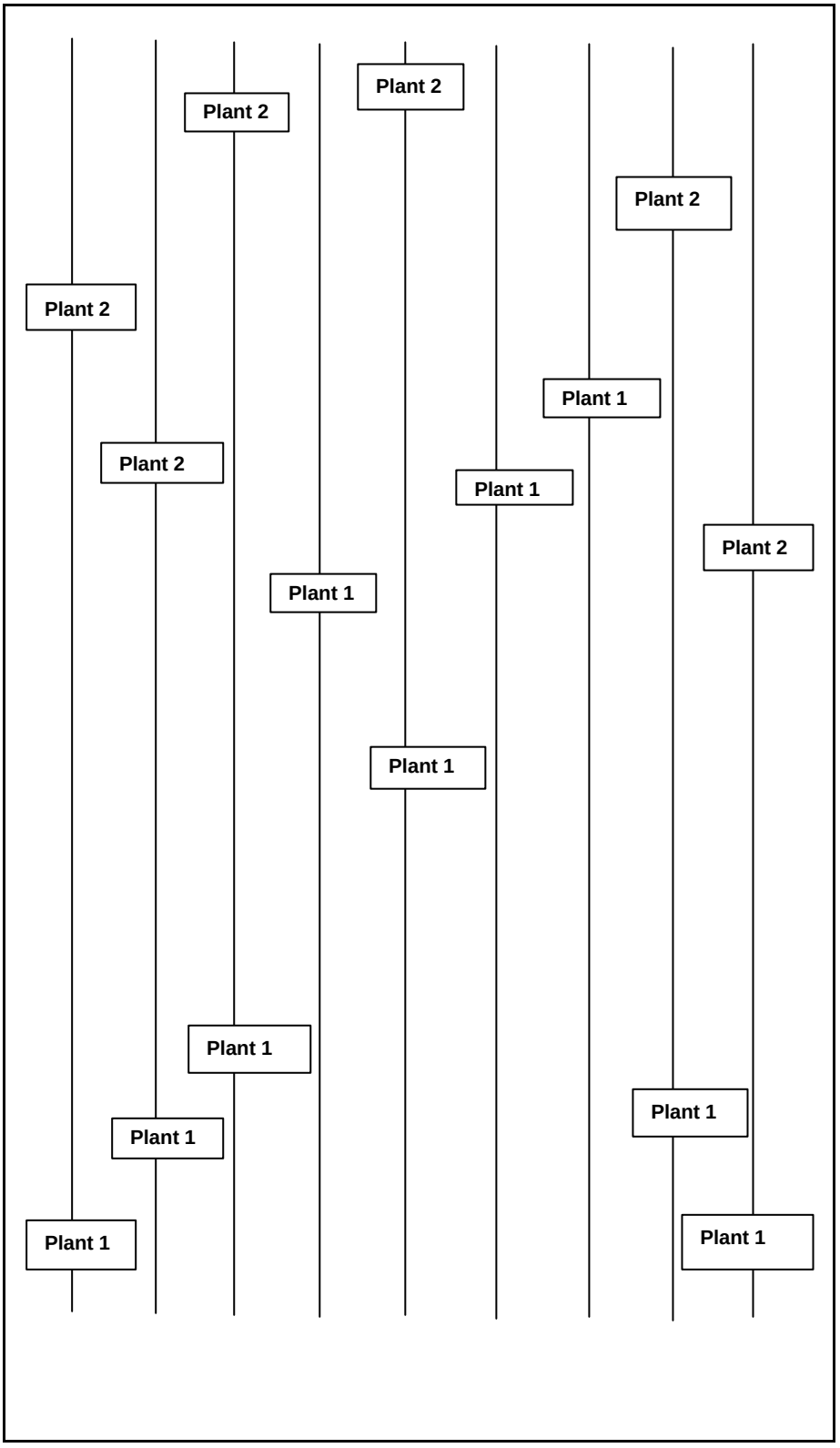
Figure 4

Appendix 8: Trial Site Layout

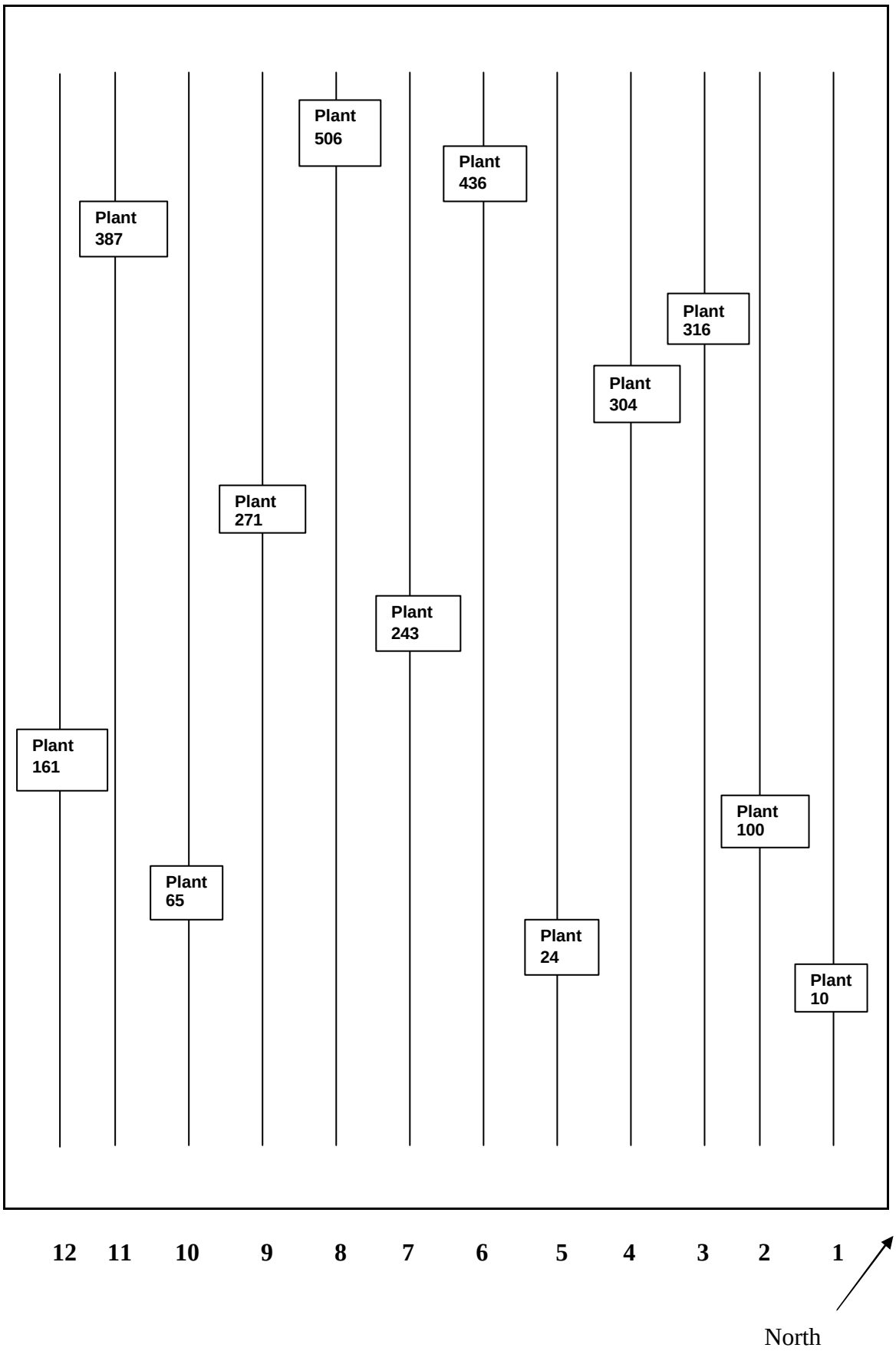
Appendix 8.1: Toolamba Fresh Produce - Untreated



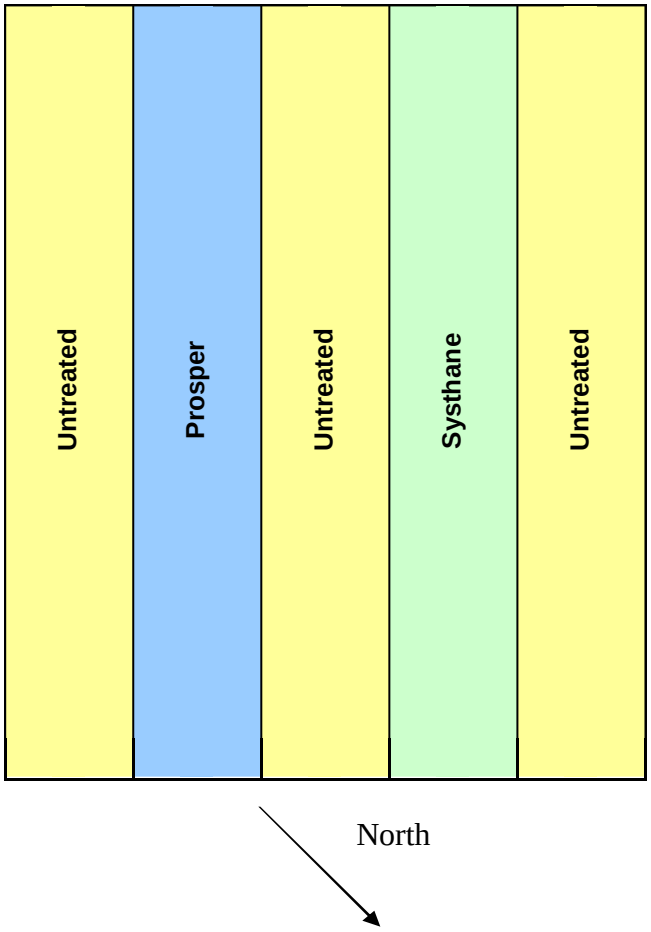
Appendix 8.2: Toolamba Fresh Produce - Treated



Appendix 8.3: Gillieston Fresh Produce – Treated and Untreated



Appendix 8.4: Fungicide Trial Layout 2009 – Gillieston Fresh Produce



Appendix 9: Treatment Details

OFS MicroPlus

Formulation:	
Active ingredients:	Streptomyces lydicus (1 x 10^7 cfu/ml)
Marketed by:	Organic Farming Systems

OFS Super Kelp

Formulation:	Liquid Concentrate
Typical Analysis:	100% seaweed extract
Marketed by:	Organic Farming Systems

OFS Humus 26

Formulation:	Liquid Concentrate	
Typical Analysis	Total water soluble humate and fulvate	26%
	Organic Carbon as humic acids	15%
	Potassium as organic humate	4.8%
	Nitrogen as organic humate	0.2%
	Calcium as organic humate	0.1%
	Sulphur as organic humate	0.1%
	Iron as organic humate	0.5%
Marketed by:	Organic Farming Systems	

OFS Fish Emulsion

Formulation:	Liquid Concentrate	
Typical Analysis	Nitrogen	2.5%
	Phosphorus	0.3%
	Potassium	0.25%
	Calcium	0.5%
	Oil Content	3.0%
Marketed by:	Organic Farming Systems	

Prosper 500 EC

Formulation:	Emulsifiable Concentrate
Active ingredients:	500g/L Spiroxamine
Group:	Group E Fungicide
Label Use:	For the control of Powdery Mildew on grapevines
Withholding Period:	Do not harvest for four weeks after application
Marketed by:	Bayer CropScience

Systhane 400 WP

Formulation:	Wettable Powder
Active ingredients:	400g/kg Myclobutanil
Group:	Group C Fungicide
Label Use:	For the control of black spot on apples and pears and powdery mildew on apples and strawberries as per the directions for use table
Withholding Period:	Apples and Pears – Do not apply later than twenty one days before harvest. Strawberries - Not required when used as directed
Marketed by:	Dow AgroSciences

Appendix 10: Statistical analysis for yield data

Appendix 10.1: Gillieston Fresh Produce

$\overline{X}_1 = 4.45$ $\overline{X}_2 = 5.13$

$\sigma_1 = 1.4$ $\sigma_2 = 2.02$

$\sigma^2_1 = 1.96$ $\sigma^2_2 = 4.08$

$$\sigma^2_d = \frac{1.96}{12} + \frac{4.08}{12}$$

$= 0.16 + 0.34$

$= 0.5$

$\sigma_d = \sqrt{0.5}$

$= 0.71$

$$t = \frac{5.13 - 4.45}{0.71}$$

$$t = \frac{0.68}{0.71}$$

$t = 0.96$

df = 22 p = 2.07 at 5%

Appendix 10.2: Toolamba Fresh Produce

$\overline{X}_1 = 5$ $\overline{X}_2 = 4.75$

$\sigma_1 = 2$ $\sigma_2 = 1$

$\sigma_1^2 = 4$ $\sigma_2^2 = 1$

$$\sigma_d^2 = \frac{4}{15} + \frac{1}{15}$$

$= 0.27 + 0.07$

$= 0.34$

$\sigma_d = \sqrt{0.34}$

$= 0.58$

$$t = \frac{5 - 4.75}{0.58}$$

$$t = \frac{0.25}{0.58}$$

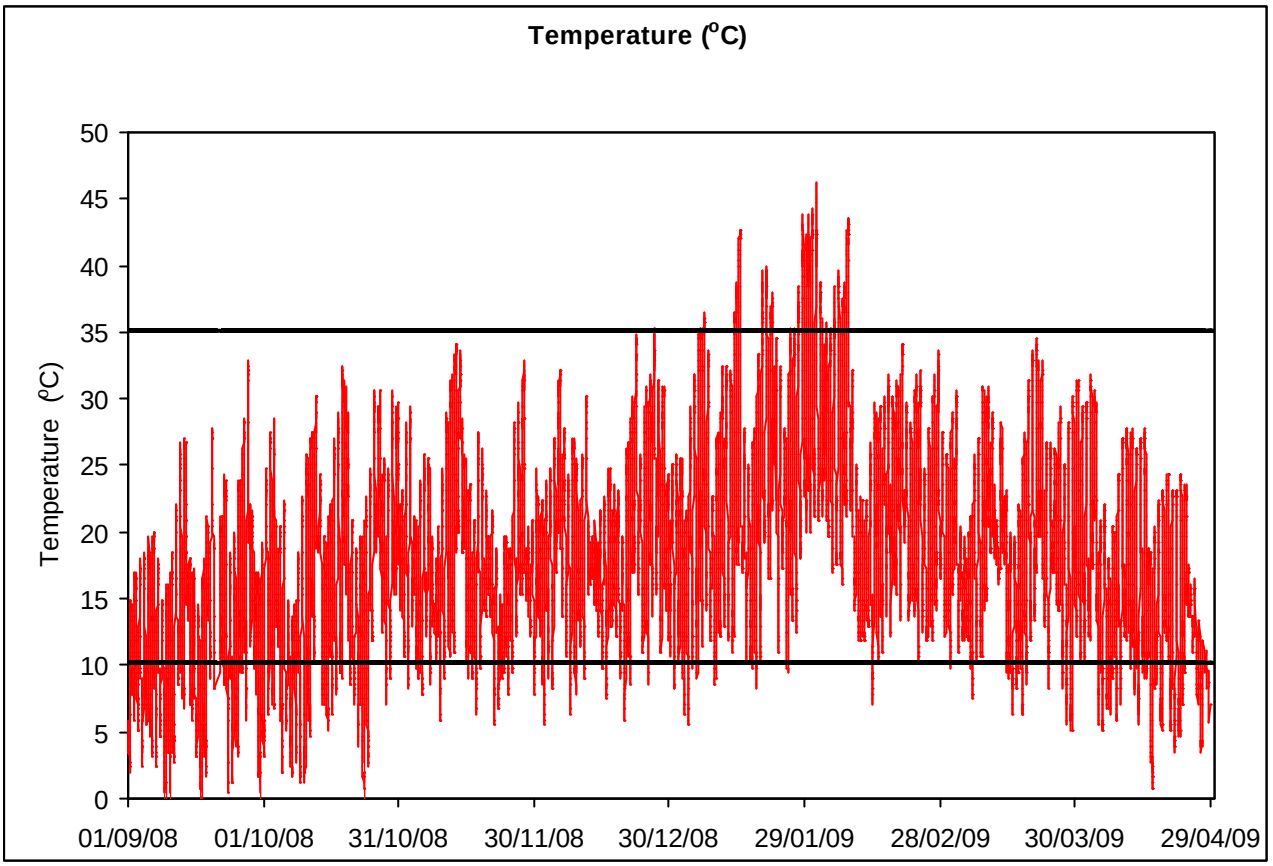
$t = 0.43$

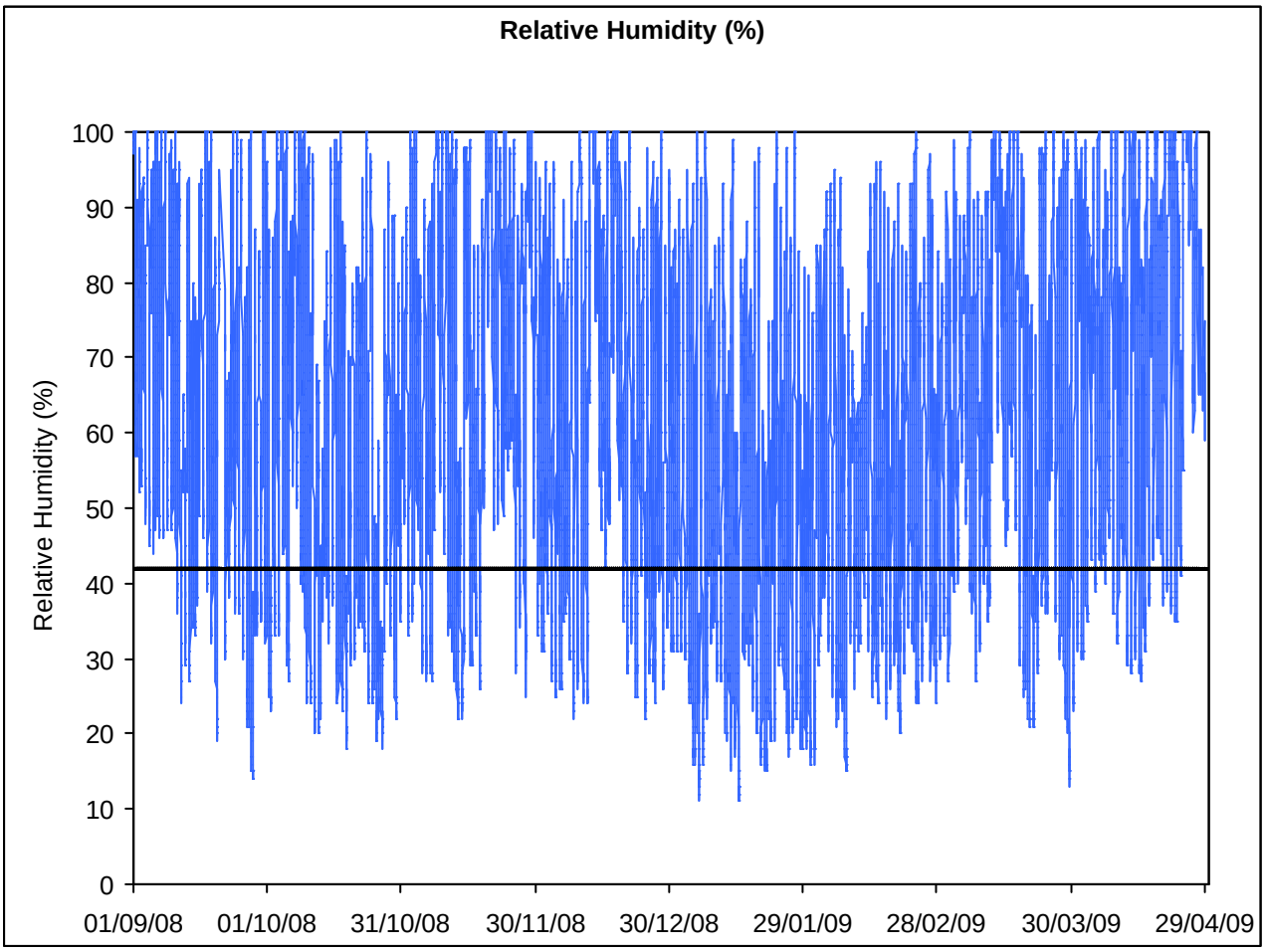
df = 28 p = 2.05 at 5%

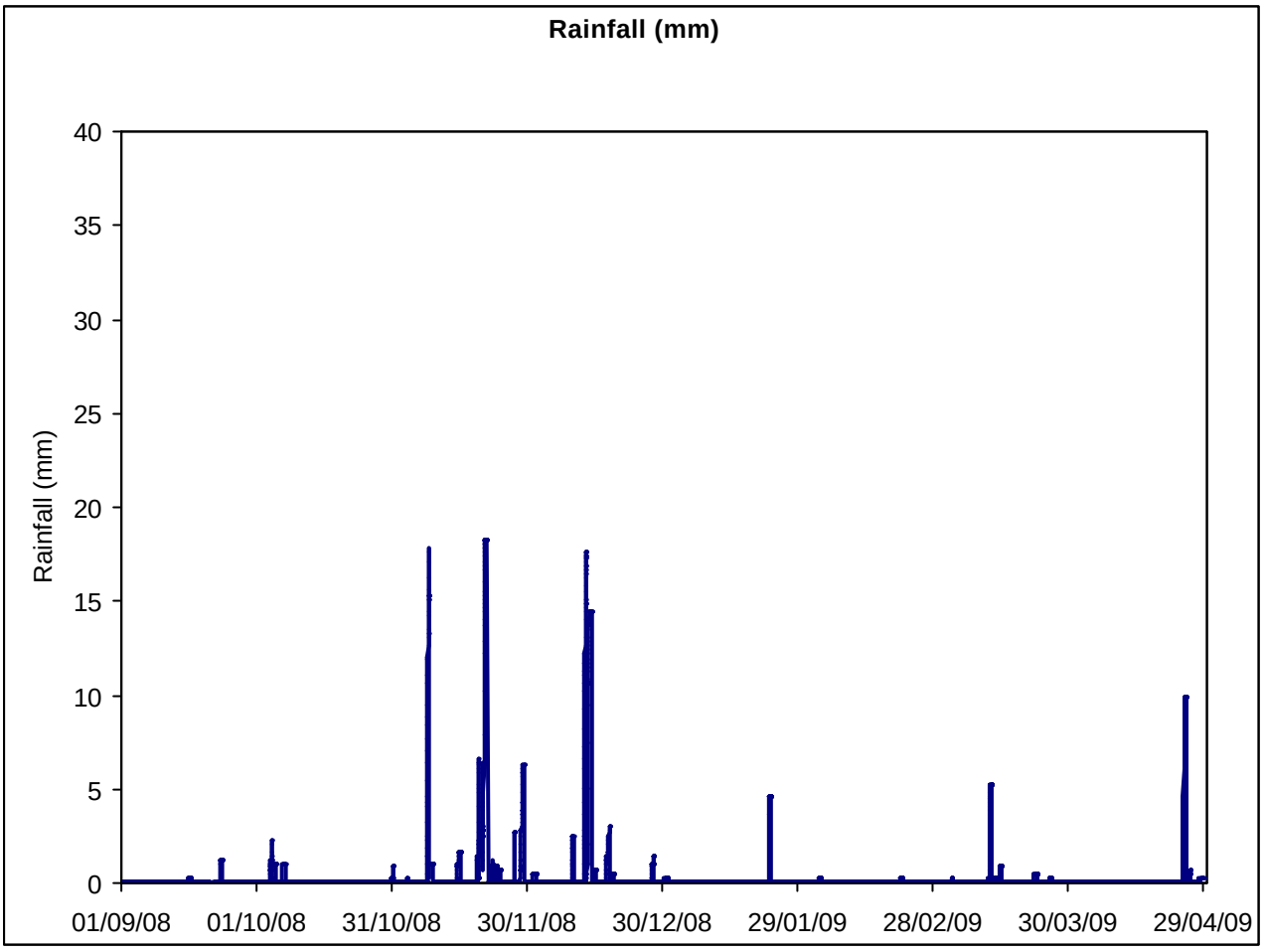
Appendix 11: Crop Health Services – Services Report

DATE	SAMPLE NAME	*Leveillula Taurica*	*Oidium lycopersici*
20-Feb-08	1	Present	Not Present
20-Feb-08	2	Present	Not Present
20-Feb-08	3	Present	Not Present
20-Feb-08	4	Present	Not Present
20-Feb-08	5	Present	Not Present
20-Feb-08	6	Present	Not Present
20-Feb-08	7	Present	Not Present
14-Mar-08	N30	Present	Not Present
14-Mar-08	N41	Present	Not Present
14-Mar-08	N50	Present	Not Present
5-Mar-09	Block 1	Present	Not Present
5-Mar-09	Block 2	Present	Not Present
13-Mar-09	1	Present	Present
13-Mar-09	2	Present	Not Present
13-Mar-09	3	Not Present	Not Present
13-Mar-09	4	Not Present	Not Present
13-Mar-09	5	Not Present	Not Present
26-Mar-09	Costa Vraca-Smiths	Present	Not Present
26-Mar-09	A&F&D Mercuri-Ryans	Present	Not Present
26-Mar-09	NVFTIDC Shepparton	Present	Not Present
8-Apr-09	1	Present	Not Present
8-Apr-09	2	Present	Not Present
8-Apr-09	3	Present	Not Present
8-Apr-09	4	Present	Not Present
8-Apr-09	5	Present	Not Present
8-Apr-09	6	Present	Not Present
8-Apr-09	7	Present	Not Present
8-Apr-09	8	Present	Not Present
8-Apr-09	9	Not Present	Not Present
8-Apr-09	10	Present	Not Present
8-Apr-09	11	Present	Not Present
8-Apr-09	12	Not Present	Not Present

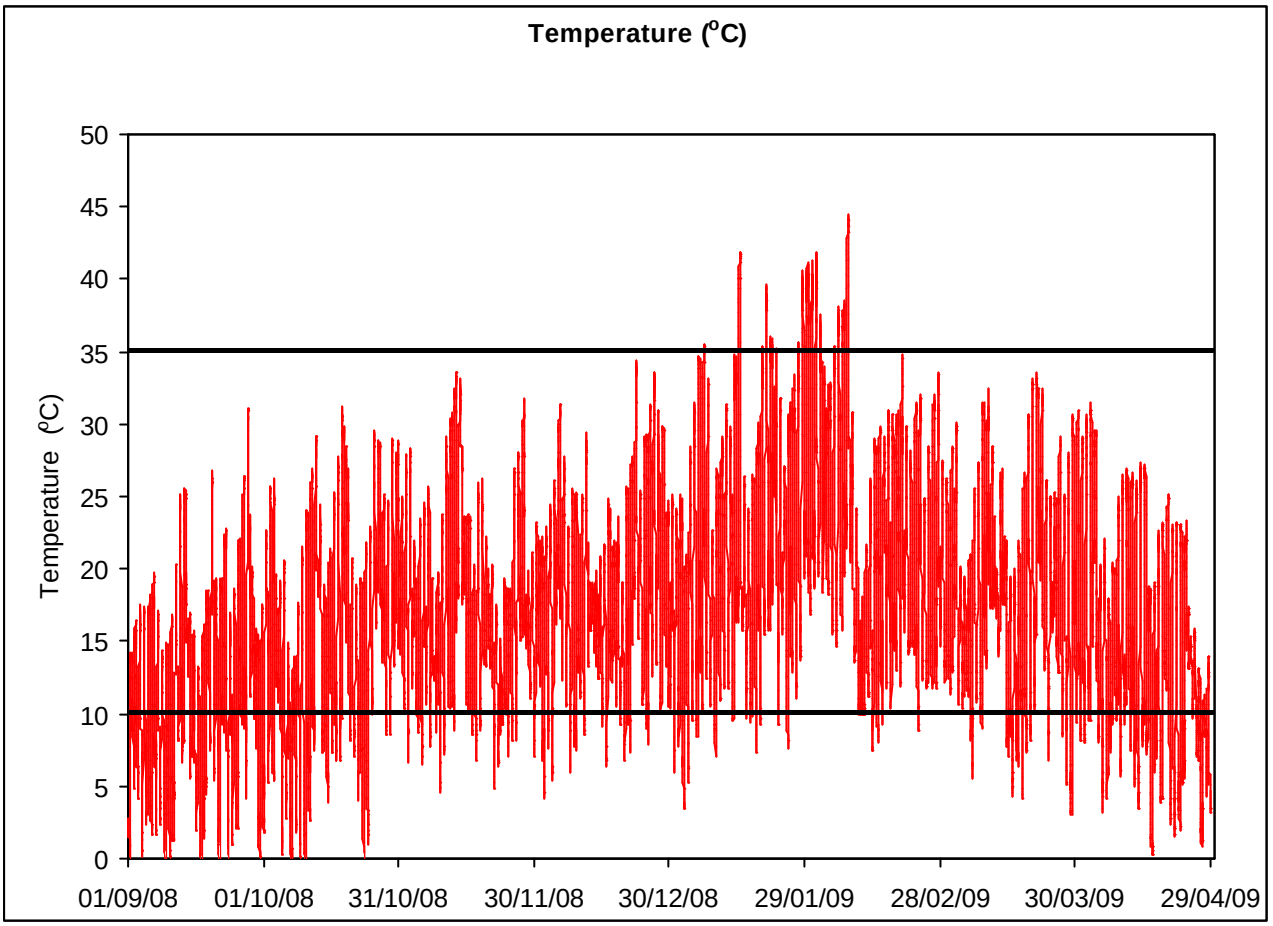
Appendix 12: IK Caldwell Weather Station Data - Ardmona

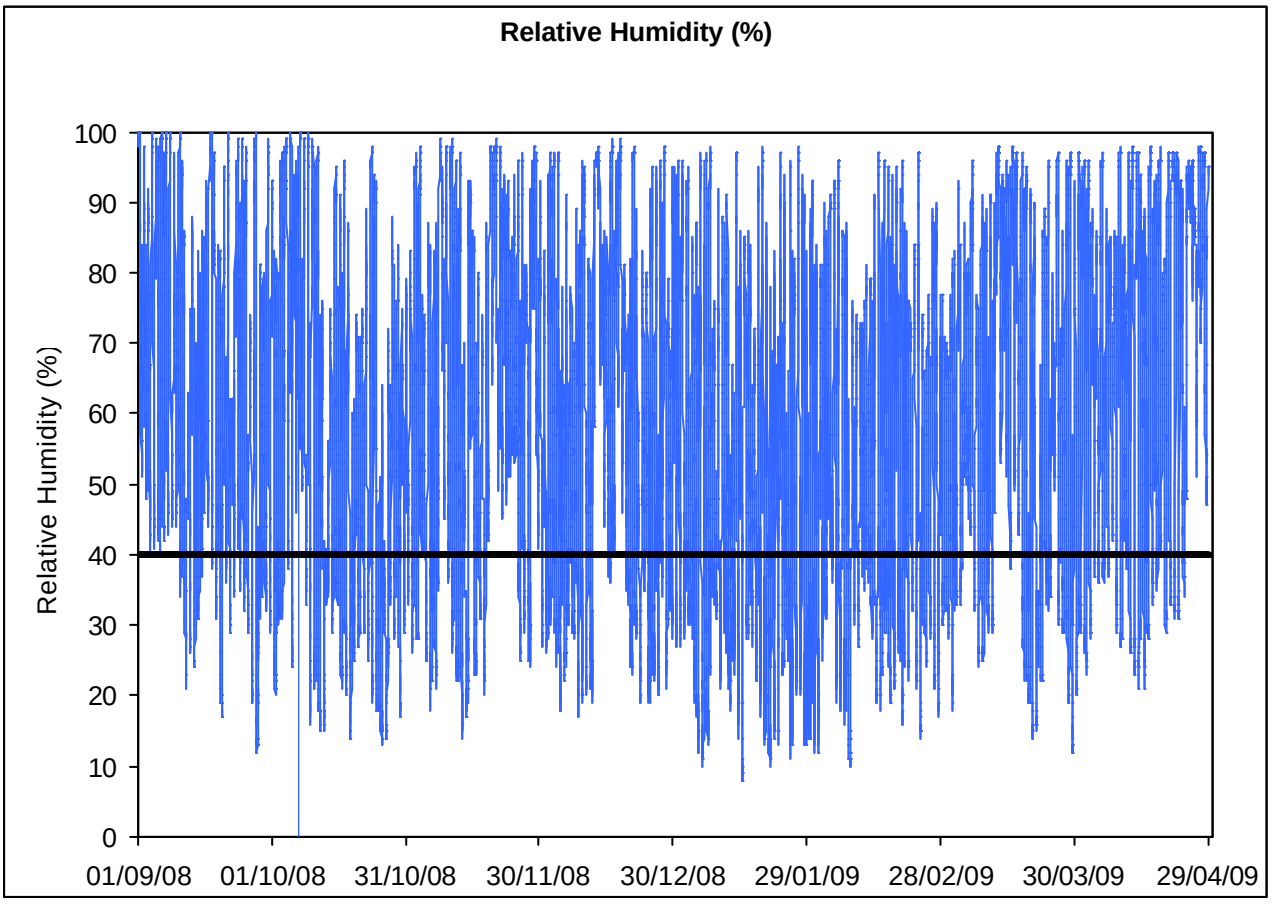


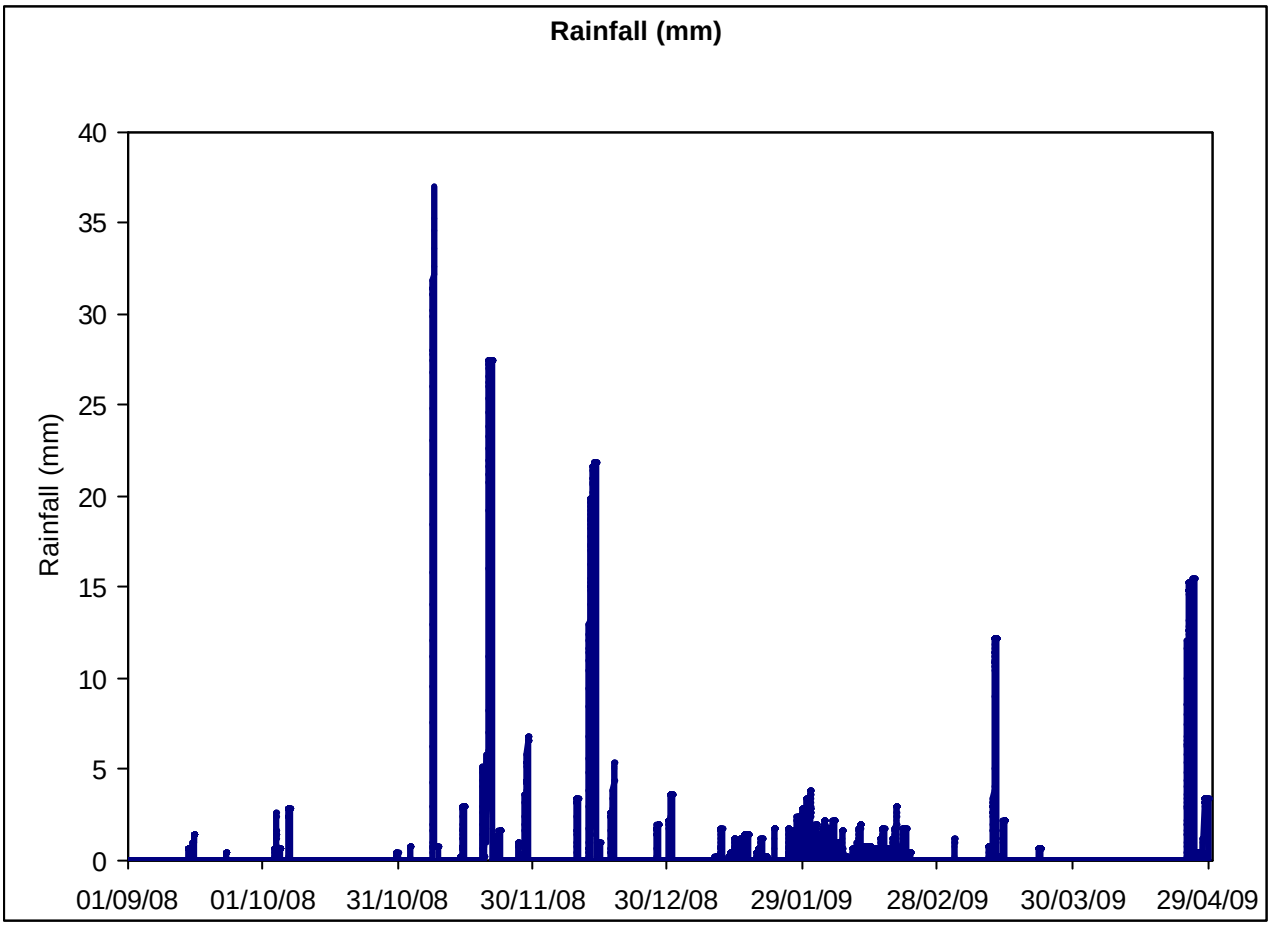


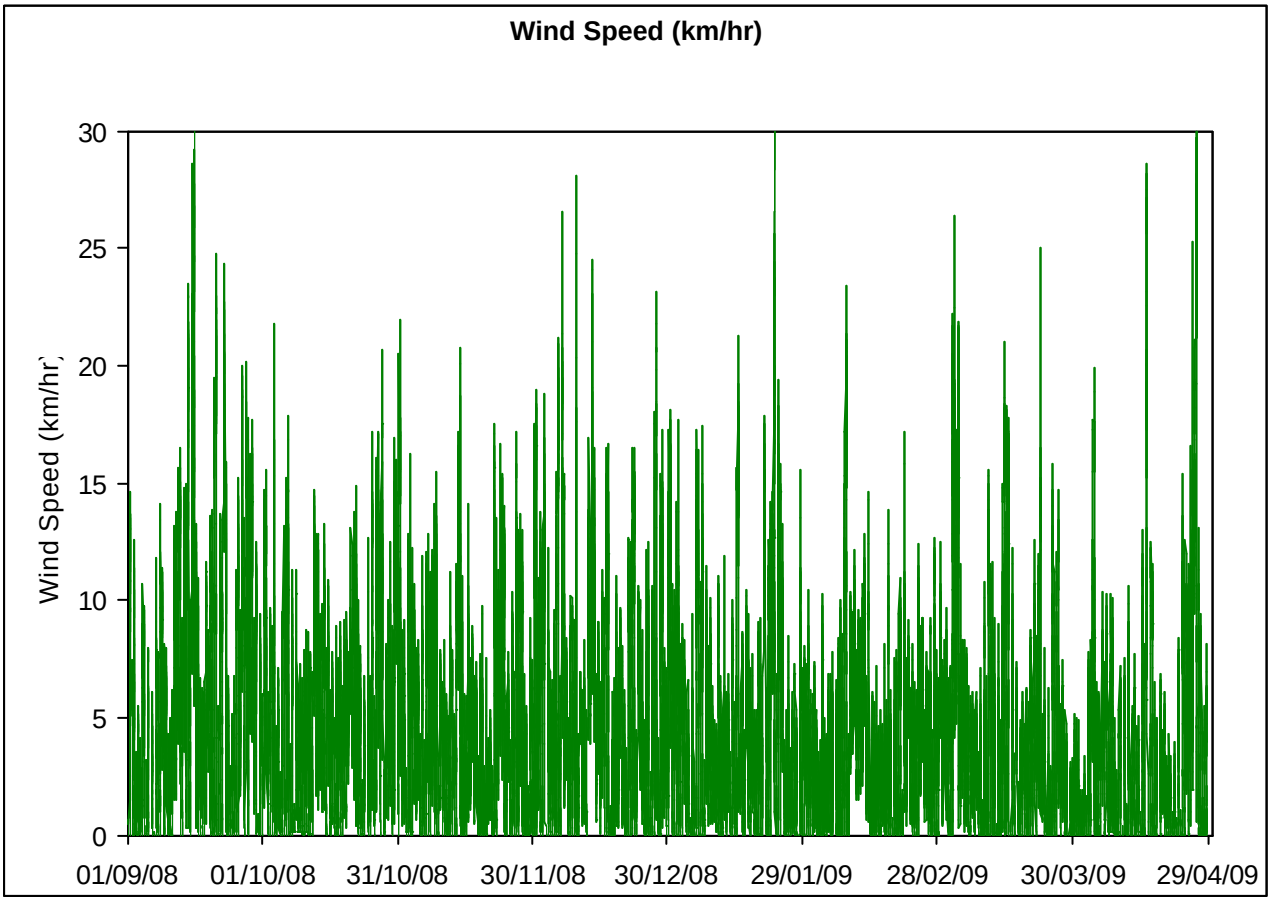

Rainfall (mm)
Rainfall (mm)
40
35
30
25
20
15
10
5
0
01/09/08
01/10/08
31/10/08
30/11/08
30/12/08
29/01/09
28/02/09
30/03/09
29/04/09

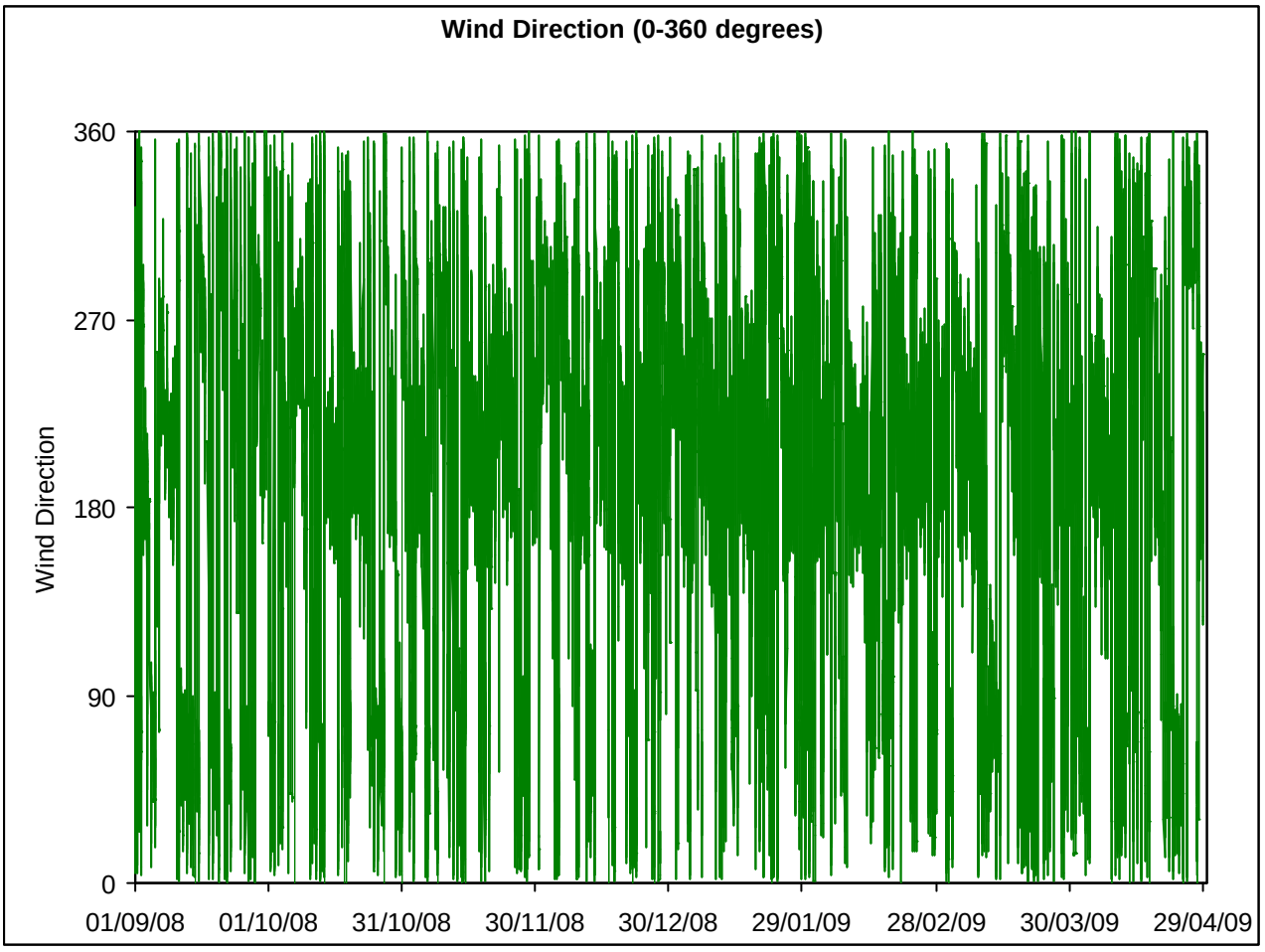
Appendix 13: IK Caldwell Weather Station Data - Toolamba






Rainfall (mm)
Rainfall (mm)
40
35
30
25
20
15
10
5
0
01/09/08
01/10/08
31/10/08
30/11/08
30/12/08
29/01/09
28/02/09
30/03/09
29/04/09


Wind Speed (km/hr)
Wind Speed (km/hr)
30
25
20
15
10
5
0
01/09/08
01/10/08
31/10/08
30/11/08
30/12/08
29/01/09
28/02/09
30/03/09
29/04/09


Wind Direction (0-360 degrees)
Wind Direction
360
270
180
90
0
01/09/08
01/10/08
31/10/08
30/11/08
30/12/08
29/01/09
28/02/09
30/03/09
29/04/09