Results Summary – NZ Walnut Blight Research 2004/5

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This report presents the results of experiments conducted in the 2004/2005 growing season. This was a year of high blight pressure largely related to the high rainfall and humidity levels in December 2004.

Objective 1 – Copper Spraying, Timing and Additives

Materials and Methods

This experiment investigated the effect of the timing of sprays and additions to copper and was conducted over three orchards. Four treatments and the control were trialed at Orchards A and B where there were eight replicate trees (per orchard) for each treatment. The treated trees at each orchard had been part of the trial of spray types in Objective 2 in the 2003/2004 experiments. In the previous years experiments there had been eight treatments with five replicates and no evidence of variation according to experimental block. Each of this years treatments then was applied to all eight of last years treatments to allow a comparison of the effect of last years treatments and last years blight scores with this years blight score over all the different treatments.

Most treatments were only piloted at Orchard C with a limited number of replicates so comparisons at this orchard were treated as indicative only. For each of the twelve treatments and control at Orchard C, there was only one replicate tree of each of Stans (B300) and Dublin's Glory cultivars and two replicates for each treatment for the cultivar Meyric.

Treatment descriptions for the current year are given in Table 3 and are further detailed in the Appendix (including climatic indices and spray dates).

Walnut blight was assessed at two times (early January and early March) by assessing the status of all nuts below 2.5 metres high on each tree. This allowed an assessment of loss from the tree (attributed to blight as a reasonable assumption based on observation of blighted nuts on orchard floors) between these two recording dates. Five randomly selected nuts per tree (still on the tree and below 2.5 m) were dissected at the March date to determine whether the kernel was affected by blight and then a figure for kernel affected by blight was corrected according to the proportion of fallen nuts (assumed to be kernel affected).

Results and Discussion

The results for Orchard A and B are presented in Tables 1 and 2

Table 1: ORCHARD A. Walnut Blight Recorded in January and Final Result

Treatment	Percentage Infected	Avge lesion size (% of fruit surface) out of Infected fruit	Avge lesion size (% of fruit surface) out of Total fruits	Proportion Apex/Total	Final % Kernels Blighted (March)
1 Control	78%[a]	11.2	8.7	83%	45[a]
4 Three Starter Sprays	66%[ab]	12.6	9.1	75%	32[ab]
5 Xanthocast	40%[bc]	10.5	4.9	76%	18[bc]
8 Full Spray Programme	15%[c]	5.7	0.9	65%	6[c]
11 Liquicop + Mancozeb	17%[c]	7.2	1.3	67%	7[c]

*** average results with the same letters are not statistically significantly different from each other at the 95% confidence level.**

Table 2: ORCHARD B. Walnut Blight Recorded in January and Final Result

Treatment	Percentage Infected	Avge lesion size (% of fruit surface) out of Infected fruit	Avge lesion size (% of fruit surface) out of Total fruits	Proportion Apex/Total	Final % Kernels Blighted (March)
1 Control	81%[a]	16.3	12.9	83%	58[a]
4 Three Starter Sprays	68%[abc]	12.8	9.6	79%	37[ab]
5 Xanthocast	49%[bcd]	7.3	3.8	66%	30[abc]
8 Full Spray Programme	39%[bcd]	4.1	1.7	49%	13[c]
11 Liquicop + Mancozeb	39%[cd]	4.8	2.0	52%	11[c]

*** average results with the same letters are not statistically significantly different from each other at the 95% confidence level.**

The results at Orchard A and B were broadly consistent with those found at Orchard C (see below) for the corresponding treatments, giving good evidence that the three weekly sprays at budburst had an effect on walnut blight level (using one-tailed paired sample t-test comparisons for the three orchards combined this difference from control is statistically significantly different, p=0.002). The Xanthocast based climate index also tended to reduce walnut blight level but this was only statistically significant at Orchard A (over all three orchards it was also statistically significantly different in one-tailed paired t-test comparison, p=0.04).

The Liquicop plus mancozeb treatments performed similarly to the full rate of Mankocide despite the reduced rate of copper. Given, however, the fact that the rate of copper application may have been greater than required (based on tendency of results at Orchard C – Treatment 10 cf. Treatment 8), this does not yet prove conclusively that Liquicop is superior to Kocide (copper hydroxide) as a form of copper for combination with mancozeb and subsequent control of walnut blight. It was however easy to work with the liquid Liquicop product and it is efficacious without leaving the mixture of Liquicop and mancozeb for an extended period of time (the two were mixed and applied immediately).

Orchard A and B trees included in the 2004/2005 experiment were part of the previous years experiment on spray type testing. This allowed the testing of an effect from the previous year from either recorded blight level or treatment type. Interestingly, there was no trend apparent in relation to either factor. This has positive implications given a restricted number of suitable trees for experimentation in Canterbury; i.e. that trees treated in a previous growing seasons experiment may not overly increase the amount of variation expected in a subsequent experiment.

There was an apparent clear order of effectiveness of spray programme with full spray programme > climate based timing > bud burst only > control. With similar results to last growing season experiments, there is a significant difference between orchards in the level of blight found indicating between orchard differences that may be due to management history or other factors. Determining the factors involved will require the benchmarking approach already commenced to check a large number of factors over several orchards.

At Orchard C it should again be noted that there was only one replicate of each of Stans (B300) and Dublin's Glory cultivars and two replicates for each treatment for cultivar Meyric – so this part of the experiment was only treated as a pilot study into the treatments represented. The January and March (the latter representing final harvest)

results are presented in Table 3. The January results gave greatest statistical significance between treatments but there was a generally similar trend between treatements over the two assessment dates.

Table 3: Orchard C. Effect of Copper Type, Additives and Timing on Walnut Blight Levels (January % Fruit Infected – figures in brackets are March % Fruit Infected / March % Kernels Affected)

	Treatment	Meyric	Stans B300	Dublin's Glory	Average *	Average Without D. Glory
1	Control: not sprayed	86% (82/59)	93% (84/60)	87% (80/65)	89^{a}% (82/62)	90%^{a} (83/60)
2	Mankocide: Single spray at bud burst	43% (41/25)	100% (95/73)	74% (63/40)	72^{a}% (66/46)	72%^{a} (68/49)
3	Mankocide: First spray at bud burst then sprayed one week after that	69% (53/35)	60% (54/34)	100% (94/57)	76^{a}% (67/42)	65%^{ab} (54/35)
4	Mankocide: First spray at bud burst then sprayed two consecutive weeks after that	71% (50/28)	68% (61/46)	92% (86/70)	77^{a}% (66/48)	70%^{a} (56/37)
5	Mankocide: First spray at bud burst then sprayed two consecutive weeks after that THEN Climate Index 1 based Sprays (based on Xanthocast)	49% (33/21)	51% (35/23)	80% (65/42)	60^{ab}% (44/29)	50%^{ab} (34/22)
6	Mankocide: First spray at bud burst then sprayed two consecutive weeks after that THEN Climate Index 2 based Sprays	25% (21/16)	29% (18/12)	88% (70/53)	47^{b}% (36/27)	27%^{bc} (20/14)
7	Mankocide: First spray at bud burst then sprayed two consecutive weeks after that THEN just a single Climate Index 2 based Spraying early to mid November	48% (32/20)	71% (57/41)	72% (59/41)	64^{ab}% (49/34)	60%^{ab} (45/30)
8	Mankocide: First spray at bud burst then sprayed weekly until November then fortnightly	3% (2.3/1.4)	7% (4.8/3)	10% (6.7/5.2)	7^{d}% (4.6/3.2)	5%^{c} (3.6/2.3)
9	Mankocide plus AminoFit: First spray at bud burst then sprayed weekly until November then fortnightly	2% (2.1/1.3)	0% (0/0)	38% (29/23)	13^{cd}% (10/8.1)	1%^{c} (1.1/0.6)
10	Mankocide reduced rate (equivalent to last seasons): First spray at bud burst then sprayed weekly until November then fortnightly	3% (1.7/1.3)	4% (2.1/1.3)	33% (24/13)	13^{cd}% (9.3/5.4)	4%^{c} (1.9/1.3)
11	Liquicop (equivalent to Treatment 10 copper level) and Mancozeb: First spray at bud burst then sprayed weekly until November then fortnightly	12% (9.4/5.6)	6% (3.3/2.4)	37% (22/14)	18^{cd}% (12/7.4)	9%^{c} (6.4/4.0)
12	Kocide (equivalent copper rate to Treatment 8): First spray at bud burst then sprayed weekly until November then fortnightly	2% (3.4/2.4)	11% (7.4/5.3)	12% (8.3/5.4)	8^{cd}% (6.3/4.4)	7%^{c} (5.4/3.9)
13	Kocide (equivalent to Treatment 8) with Nu-Film as spray additive: First spray at bud burst then sprayed weekly until November then fortnightly	36% (26/16)	14% (10.4/6.9)	29% (26/15)	26^{bcd}% (21/13)	25%^{bc} (18/11)
	Average	**35% (27/18)**	**40% (33/24)**	**58% (49/34)**		

*** average results with the same letters are not statistically significantly different from each other at the 95% confidence level.**

Overall the Dublin's Glory results appeared to give the most spurious results (so averages are also presented without the Dublin's Glory results included) and generally yielded

higher blight levels than the other treatments (this may be related to an earlier budburst timing and that spraying did not commence early enough for this cultivar).Generally the requirement for extra replicates to be sure of differences is shown in the difficulty in seeing statistically significant differences. In concentrating on the Meyric and Stans (B300) results, the addition of AminoFit (see treatment 9) and the use of Liquicop as the source of copper (see treatment 11) are worthy of further investigation. It should be noted that the reduced copper rate (equivalent to last year's New Zealand experimental use) gave similar results to the high rate in these two cultivars – though the result in Dublin's Glory appears quite different.

Given the wet December period and therefore constantly high disease potential, it is not surprising that the reduced amounts of sprays in the climate based models (including one based on the Xanthocast Californian model – referred to here as Climate Index 1) and the starter sprays only were not sufficient to give good control. The Climate Index 2 treatment (the NZ prototype model) seemed to provide greater protection. This could be related to an actual improved timing effect or simply to the increased number of sprays (including the consequently higher total level of copper applied).

Xanthocast, in terms of how it has been applied here does not appear to be suitable for New Zealand conditions. Trigger events for accumulation of points to indicate time for spraying were too far in between largely due to most leaf wetness occurring during low air temperatures. A new, more responsive model is to be developed for trialing in the next season. Major features will include more responsiveness to differing lengths of time of leaf wetness and a more continuous relationship with temperature rather than discrete cut off points for disease response.

Spraying at budburst once, twice or three times at weekly intervals tended to show protection compared to control though this was not statistically significant at Orchard C.

The treatment with the lowest level of walnut blight incidence was regular spraying with the full dose of Mankocide with an average recording of blight well into the single figures.

The difference between Kocide and Kocide with Nu-Film showed no evidence in this pilot trial of increasing walnut blight control and in fact the trend (though not statistically significant) was quite the opposite. It remains possible that there was a true depression in blight control due to the Nu-Film treatment (e.g. could possibly be through complexing of copper away from active toxicity to bacteria or prevention of entry into buds or plant tissue) but this is by no means proven.

Recommendations

The overall preliminary recommendations are the use of Mankocide or Liquicop plus mancozeb at the reduced rates applied in this experiment. Best practice based on the trade off between level of blight control and the amount of copper applied appears to lie between bud burst only spraying (three sprays at weekly intervals) and the full spray programme. It is therefore recommended that orchard spraying include the bud burst sprays plus one, two or in some seasons more subsequent sprays related to environmental conditions (leaf wetness – and/or relative humidity – and temperature combined ideally, but there is probably some value in simply spraying just prior to an expected prolonged

rainfall event). Future research will focus on pinning down the environmental triggers and climate indices suitable for determining spray timing. Spraying does not appear to be required after mid January for a current season's harvest given the good level of control achieved when ceasing spraying on 6 January.

The recommended chemical for best control remains as Mankocide with at this stage no clear evidence for benefit of additives though there is some indication that the inclusion of AminoFit can be beneficial (this will be investigated further). From previous research in Tasmania and France it would appear that Bordeaux mixture gives best results for organically allowable sprays.

The rates used in the walnut blight experiments to achieve leaf coverage were comparatively low due to the efficiency of the mist blower sprayer. The spray rate for full foliage was around 2.4 litres per tree (depending on tree size) which translates to roughly 840 L per hectare equivalent (depending on density of planting). Rates of around double this amount per canopy hectare may be required to achieve adequate leaf coverage using tractor based spraying.

Early January is a key time to assess the level of walnut blight present and will be useful in making comparisons between orchards as part of the walnut benchmarking project. The method recommended is to assess five nuts closest to an imaginary line drawn at each north, south, east and west point of the tree (detailed instructions are available from annual WIG workshops). The proportion of nuts with obvious blight symptoms at this stage is roughly double the eventual loss of saleable walnuts from blight (this will vary markedly but the January measurement remains the easiest and most reliable comparison between orchards).

Environmental Sustainability

The primary environmental aim of the walnut blight research is to elucidate methods of applying lower amounts of copper (atomic symbol Cu) per hectare on walnut orchards with minimal reduction in the level of blight control. The amount of copper applied per hectare equivalent for each treatment is given in the Appendix section A (far right hand column of table). The definition of sustainable copper application differs according to sources including 2 kg/ha for conservative assessments, 3 kg/ha for some organic certification authorities and sometimes 4 kg/ha.

The amounts of copper applied on a per hectare equivalent in this experiment were sustainably low for Treatments 2 (0.63 kg Cu / ha, single spray at budburst), 3 (1.3, two weekly sprays at budburst), 4 (1.9, three weekly sprays at budburst), 7 (2.8, three weekly sprays at budburst plus a single spray at the end of October related to an NZ climate index trigger) (all of these treatments had poor levels of control) and marginally sustainable for Treatments 10 and 11 (both 5.3 kg Cu / ha for these reduced rate applications of mankocide and liquicop + mancozeb respectively giving good control). The full spray programme represented an unsustainable application of 13.3 kg Cu / ha. It is important to note that the spray rates utilized are roughly half those expected to be required by tractor based application per hectare to achieve sufficient leaf coverage so there is still a research requirement to seek to significantly lower spray rates and still achieve adequate control.

Objective 2 – Walnut Cultivar Susceptibility to Blight

The level of blight recorded in January is presented in Table 5 with results for 2003/2004 growing season compared with 2004/2005 for the same trees in an unsprayed area. Blight was assessed from an assessment of all accessible (by ladder or climbing) up to a maximum of 100 randomly selected nuts per tree.

Table 5: Lincoln University Walnut Trial Block – Unsprayed Area. Level of Walnut Blight Infection

Cultivar	% Infected (2003/4)	% Infected (2004/5)
Esterhazy	71%	76%
Meyric	68%	86%
G120	63%	72%
G139	61%	78%
Tehama	49%	68%
Chico	46%	82%
Vina	45%	79%
W148	40%	66%
Hartley	36%	42%
McKinster	34%	62%
Franquette	29%	51%
B300	25%	62%
G026	6%	39%
AVERAGE	44%	66%

There was overall a 50% increase in the level of blight recorded in this unsprayed area of trees. There was still a similar trend in the level of blight according to cultivar, which appears to be largely related to timing of budburst (later budburst cultivars generally showing less blight percentage).

Objective 3 - Mankocide Spraying versus Copper Spraying and Effect of Penetrant

The experiment focussed on the effect of organo-silicone penetrant (no Pulse, Pulse at standard rate and Pulse at double rate) and copper spray type on walnut blight and predatory mite / mite populations. No mites were observed so the intention is to make mite observations next season. There were low numbers of fruit present on most trees and many trees did not produce fruit at all. Fortunately there were several trees (minimum of 4) in each replicate but only the January results were collated due to insufficient accuracy of counts and availability of nuts for the destructive final harvest assessment. The walnut blight results are presented Table 6.

In both cultivar Meyric and Rex, Mankocide tended to give more control than Liquicop (without mancozeb) for the same amount of copper applied though this was only weakly statistically significant (p=0.07). No trend was seen for the use of Pulse penetrant.

Table 6: Orchard D. Effect of Copper Type and Use of Pulse Penetrant on Walnut Blight Level

	Spray Type	Pulse	Jan Reading of % Infected	Average for Spray Type
Meyric	Control	-	46.7	46.7
	Liquicop	No Pulse	46.7	
	Liquicop	Pulse	34.0	
	Liquicop	2 X Pulse	51.3	44.0
	Mankocide	No Pulse	32.5	
	Mankocide	Pulse	45.6	
	Mankocide	2 X Pulse	34.0	37.3
Rex	Control	-	41.4	41.4
	Liquicop	No Pulse	26.1	
	Liquicop	Pulse	28.9	
	Liquicop	2 X Pulse	38.5	31.2
	Mankocide	No Pulse	22.7	
	Mankocide	Pulse	21.6	
	Mankocide	2 X Pulse	22.3	22.2

Appendix: Treatment Details for Objective 1

A) Treatment Descriptions and Rates of Copper (Cu)

TREATMENT	Spray Rate (amount product per 100 L water)	Mancozeb per litre (g)	Copper per litre (g Cu)	Number of Sprays (total litres sprayed per tree in brackets)	Total kg Cu applied per hectare equivalent
1 Control: not sprayed					
2 Mankocide: Single spray at bud burst*	500 g Mankocide	0.75	1.5	1 (1.2)	0.63
3 Mankocide: First spray at bud burst then sprayed one week after that*	500 g Mankocide	0.75	1.5	2 (2.4)	1.3
4 Mankocide: First spray at bud burst then sprayed two consecutive weeks after that*	500 g Mankocide	0.75	1.5	3 (3.6)	1.9
5 Mankocide: First spray at bud burst then sprayed two consecutive weeks after that THEN Climate Index 1 based Sprays (based on Xanthocast)*	500 g Mankocide	0.75	1.5	8 (15.0)	7.9
6 Mankocide: First spray at bud burst then sprayed two consecutive weeks after that THEN Climate Index 2 based Sprays*	500 g Mankocide	0.75	1.5	10 (19.8)	10.4
7 Mankocide: First spray at bud burst then sprayed two consecutive weeks after that THEN just a single Climate Index 2 based Spraying early to mid November*	500 g Mankocide	0.75	1.5	4 (5.4)	2.8
8 Mankocide: First spray at bud burst then sprayed weekly until November then fortnightly*	500 g Mankocide	0.75	1.5	13 (25.4)	13.3
9 Mankocide plus AminoFit: First spray at bud burst then sprayed weekly until November then fortnightly*	500 g Mankocide 250 mL AminoFit	0.75	1.5	13 (25.4)	13.3
10 Mankocide reduced rate (equivalent to last seasons): First spray at bud burst then sprayed weekly until November then fortnightly*	195 g Mankocide	0.29	0.6	13 (25.4)	5.3
11 Liquicop (equivalent to Treatment 10 copper level) and Mancozeb: First spray at bud burst then sprayed weekly until November then fortnightly*	630 mL Liquicop 60 mL Kotec	0.29	0.6	13 (25.4)	5.3
12 Kocide (equivalent copper rate to Treatment 8): First spray at bud burst then sprayed weekly until November then fortnightly*	412 mL Kocide Liquid Form	0	1.5	13 (25.4)	13.3
13 Kocide (equivalent to Treatment 8) with Nu-Film as spray additive: First spray at bud burst then sprayed weekly until November then fortnightly*	412 mL Kocide Liquid Form 45 mL Nu-Film	0	1.5	13 (25.4)	13.3

B) General Spray Dates

Spray dates are given here for most treatments with the exception of Climate Index Sprayed treatments.

Spraying commenced on 25 September (Orchard C) and 26 September (Orchards B and C) this being interpreted as early bud burst time.

Spraying was thereafter weekly on appropriate treatments until a final weekly spray on November and then fortnightly until 6 January. (The next scheduled fortnightly spray of 20 January was considered beyond necessary spraying time with walnut shells already developed).

Treatments that were sprayed weekly from budburst till November 2004 and then fortnightly until 6 January 2005 thus received 13 sprays.

Appendix Table: Spray Schedule for Weekly and Fortnightly Sprays

Spray Schedule Number	Orchard A and B	Orchard C
1	26 September	25 September
2	3 October	3 October
3	8 October	7 October
4	15 October	14 October
5	22 October	21 October
6	29 October	28 October
7	5 November	4 November
8	12 November	10 November
9	18 November	17 November
10	26 November	25 November
11	10 December	9 December
12	24 December	24 December
13	6 January	6 January

C) Climate Based Spray Indices

A Climate Station was set up at Orchard C and included measurements of air temperature and relative humidity within the walnut canopy and leaf wetness (through an artificial leaf wetness sensor) at the edge of the canopy.

Climate Index 1: Proactive. Based on Xanthocast cumulative forecasting.

Xanthocast details as interpreted by K. Evans 23/10/03 and utilized in the Experiment
Temperature-mediated wetness accumulation model:
A. Each day, determine the number of hours in each of three temperature ranges
B. Each day, determine the number of hours leaves are wet (this was based on 60% or higher leaf wetness as measured by climate station Orchard C) for each temperature range
Temperature Ranges recorded were
>=6^{o}C but <12 ^{o}C Threshold Value 8 hours leaf wetness
>=12 ^{o}C but <17 ^{o}C Threshold Value 4 hours leaf wetness
>=17 ^{o}C Threshold value 1 hour leaf wetness
C. Each day, add one 'point' if the duration of leaf wetness reaches the predetermined threshold level for each temperature category. Threshold levels for a low acceptance of risk were used.
D. Multiply the points for the 12-17 C category by 3, and then sum the point across each category to get the daily disease index
E. Sum each daily index until a threshold of 5 is reached. Apply a bactericide as soon as possible
F. Seven days after applying the bactericide begin cumulating the daily disease index again, until a threshold of 5 is reached

Climate Index 2: Reactive. NZ model developed for testing.

When mean daily temperature is > 12 C for at least 2 successive days (using rolling 48 hour average i.e. any 48 hour period could be counted) AND RH>70% (at 2pm) or there has been a 10mm rainfall event within the last 2 days. Sprayed immediately (e.g. within 12 hours of rainfall event).

D) Climate Based Spray Dates

In addition to the standard budburst sprays
Climate Based Index 1 (Xanthocast based) had triggered spray events on 5 occasions.
Climate Based Index 2 (NZ model) had triggered spray events on 7 occasions.

Appendix Table: Climate Based Spray Dates

DATE	INDEX TRIGGERED
30 October	Both Index 1 (Xanthocast) and 2 (NZ)
12 November NZ	Index 2 (NZ)
16 November XA	Index 1 (Xanthocast)
25 November NZ	Index 2 (NZ)
5 December NZ	Index 2 (NZ)
17 December NZ	Index 2 (NZ)
21 December XA	Index 1 (Xanthocast)
28 December NZ	Index 2 (NZ)
31 December XA	Index 1 (Xanthocast)
7 January NZ	Index 2 (NZ)
9 January XA	Index 1 (Xanthocast)