Green14 Budrot / Fruitlet-drop Survey
Project PC1442

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Executive Summary

This project aimed to investigate orchard and management factors that may have been associated with the level of budrot experienced by kiwifruit growers, particularly growers of Green14, in the spring of 2012.

The investigation included an electronic survey of Green14 growers, field assessments of a range of orchards in winter to quantify the losses, a telephone survey of Green14 growers to gauge orchard characteristics and management, analysis of Zespri spray diary records, analysis of weather records from the various weather stations and analysis of the data collected in the Zespri crop estimate (Hayward IMOP) programme.

Data collected in the survey of Green14 growers and by analysing IMOP data indicates that budrot was significant in both cultivars with Green14 experiencing an average 29% loss (range 0 – 89%) and Hayward experiencing an average 23% loss (range 0 – 79%). There was no statistical difference in budrot loss as a result of the variety grown.

Budrot was more severe in areas where Psa is severe. There was also a higher level of budrot in Green14 orchards where secondary Psa symptoms were expressed in either or both the female and male vines. Despite this, it cannot be confirmed that Psa was the causal pathogen of the budrot experienced in 2012. The absence of laboratory analysis and the high level of budrot experienced by a Gisborne Hayward orchard, (not known to have Psa and with a history of budrot) in a KVH containment zone, mean that the traditional budrot cannot be ruled out as a causal agent.

Budrot was strongly associated with orchards that were cold and wet during flowering. This was the case in low elevation orchards in wider Te Puke and Whakatane areas and in high elevation orchards.

Canopy management activities that reduced the overlapping of female and male canopies around flowering time appear to have reduced the incidence of budrot. Strategies used to cut out symptoms of Psa were also important. Growers who saw secondary symptoms of Psa and cut them out and removed the diseased material from the orchard at least monthly had lower losses than those who did nothing or simply cut out diseased material and left it in the orchard. Other canopy management indices such as numbered winter buds, flower buds and wood type tied down were not associated with budrot.

There were many other factors that were found not to be statistically significant in relation to the losses suffered by growers. These include block size, shelter height, planting density, strategies implemented by the grower to reduce the risk of movement of Psa into or around the orchard, and the Crop Protection Programme (CPP) used.

Pre harvest fruit drop was not widespread at a significant level, and was not more severe where budrot was more severe. However, pre-harvest fruit drop cannot occur where the flower was lost in spring as budrot. That means there was limited data available this season, so this factor should have on-going monitoring and investigation.

As a result of the analysis undertaken there are a number of recommendations that could be made to growers to limit budrot in the future. Many of these strategies align with what is considered industry best practice recommendations for disease management. These are:

Variety Susceptibility

Hayward and Green14 growers should be aware that their vines are similarly susceptible to budrot.

Crop Protection Programme

Maintain a comprehensive spray programme – although locational factors overrode CPP impacts on budrot, and broadly growers' CPP were similar, microanalysis showed that few growers had CPP cover in place for most of the spring weather events.

Canopy Management

The data suggests that subtleties of canopy management such as early crush tipping and pre-flowering trimming of male vines that reduce canopy overlap and aid canopy drying may help to reduce budrot.

Management of overhead sprinkler systems

Minimising frosts is important but also sprinkler frost protection may favour budrot. Thus refining the operating strategy for overhead frost protection systems to reduce water applied may be beneficial.

Passive orchard warming

Passive frost prevention measures such as short grass, good weed control, open shelter bases may assist. Similarly, encouraging air movement with shelter management, including of under-vine shelters may help.

Wet Artificial Pollination

Given the data suggests wet pollination is associated with higher budrot, wet pollen is probably best applied when conditions favour rapid drying.

Psa Monitoringand Management

Closely monitor Psa symptoms on all vines, but particularly male vines, – M91 appeared more susceptible to Psa and was associated with more severe budrot and remove infected material from the orchard promptly.

Budbreak Sprays

Consider splitting timing of budbreak sprays on different blocks to manage risk of conditions favouring budrot occurring at the most sensitive time across the whole orchard.

Records of cultivars and their location

Many orchards had poor records or field-marking, particularly of male vine cultivars. It is recommended that growers keep track of the cultivars (including rootstocks) in their orchard.

1. Introduction

During the 2012/13 growing season there was considerable budrot in both the Green14 and Hayward varieties of kiwifruit, with Green14 particularly affected. At a Green14 discussion group some growers reported losing up to 80% of their flowers, although there was considerable variation in the budrot impact between orchards. A consensus at the discussion group was that *Pseudomonas syringae* pv *actinidiae* (Psa) or a complex of *Pseudomonas syringae* pv *syringae* (Pss) and other *Pseudomonas* sp. responsible for traditional budrot were likely to be factors in the budrot experienced in the spring of 2012.

Pre-harvest fruit-drop was also reported as a problem, particularly on Green14 orchards, and some analysis of this was included in the project.

2. Aims

The aims of this project were to identify environmental conditions and management practices related to either high or low levels of budrot, to make recommendations for the 2013/14 growing season and to help guide further research. Green14 was chosen as the focus of this work because of the extreme levels of budrot reported in spring 2012. Some analysis of budrot on Hayward was also specifically included and results are likely to be relevant to all kiwifruit cultivars.

Factors affecting pre-harvest fruit drop were also considered in the project.

A literature review or laboratory analysis were not part of this project.

3. Method

The project had four key components:

1. An on-line survey to identify Green14 growers affected by budrot, investigate factors growers considered impacted on their level of budrot and identify suitable orchards for further investigation.
2. Site visits to a subset of Bay Plenty orchards selected from the on-line survey to gather field information.
3. A telephone survey of willing growers who responded to the on-line survey. This included analysis of the orchard spray diary information and weather data.
4. Analysis of existing data on Hayward (IMOP) orchards to investigate relationships between budrot and other factors such as spray diary information and weather data.

Method used focused on site and management factors likely to affect disease.

3.1 On-line survey method – Green14

An on-line survey consisting of 8 questions was developed in conjunction with Zespri staff. An email inviting growers to complete the survey was distributed by Zespri to growers of Green14 kiwifruit with vines grafted in 2010 or earlier. Growers clicked on a link in the email which took them to the survey. The platform used for surveying was 'Survey Monkey'[1]. Growers were asked:

- the amount of budrot they experienced in spring 2012
- what site, climate or management factors they considered had influenced budrot
- what patterns of variability they had noticed about budrot
- whether they had flower and fruit counts and/or weather data for the orchard
- what other production issues they had experienced with their Green14 vines
- whether they were willing to participate further in the project.

The survey link was sent to 158 separate email addresses in May 2013, during the kiwifruit harvest period, and the survey was closed after 2½ weeks.

The survey questions are appendixed [Appendix 1].

3.2 Site visit method – Green14

Twelve sites in the Bay of Plenty were selected for field visits. These orchards were visited before pruning in winter 2013 to get an assessment of the amount of budrot, the canopy density and stage of canopy development. All the sites where a site visit was made were also included in the telephone survey. Ten areas on the orchard were assessed, choosing half that were likely to be slow drying areas or those in low spots and half that were in areas more likely to dry quickly. The number of winter buds, fruit stalks likely to have been from harvested fruit (all blocks had been harvested) and the number of withered flower stalks were counted. The number of pieces of fruiting wood one metre out from the leader wire were also counted and recorded as being either replacement cane (ie one-year-old), two-year-old wood or three year old wood. The length and width of the area counted was also measured, which in most instances was a quarter of a bay, as well as measuring the length and width of a full bay. The field recording sheet is appendixed [Appendix 2].

The field data was analysed in two ways:

1. Using Statistics Package for Social Sciences (SPSS) Statistics software.
2. Using simple spreadsheet regression analysis and graphs.

[1] http://www.surveymonkey.com/

3.3 Telephone Survey Method – Green14

3.3.1 Orchard maps and weather data

Maps of the Green14 orchards were obtained, with the grower's permission. These showed details of the Green14 areas of the orchard, in particular the area, block arrangement and elevation of the orchard. In a very few instances, the elevation was not shown on the map, so it was estimated from GoogleEarth, based on the orchard address and other locational details indicated by the orchard map.

Weather data was obtained from the site if one was specified by the grower in their on-line survey response. Otherwise, weather data was obtained from a site on www.harvest.com or www.metservice.co.nz known to be near the orchard or to have similar weather readings. Where the average daily temperature was calculated, in most instances it was based on the integrated average from the full number of readings over the 24-hour day. Otherwise, the simple average of the daily maximum and daily minimum was used in the few instances the integrated average was not available. Rainfall was recorded to 0.1mm and temperature to 0.1 degrees Celsius. Where a cluster of orchards was being more intensely analysed, a relevant weather site to the cluster was identified, often by viewing and comparing data from several sites known to be close to or relevant to the cluster. Weather was compared for the area or cluster.

3.3.2 Spray programme analysis

The spray programmes for each Green14 KPIN and block were analysed for the use of materials likely to affect expression of diseases. In particular, the use of copper, elicitors, antibiotic, fungicide, biological materials and materials applied to help prevent frost damage was noted. The number of sprays of each type of material and the dates of application were extracted from content of the electronic spray diary that had been formatted as a spreadsheet file. The 2011/12 and 2012/13 season spray diaries were analysed to identify the relevant materials applied from 1 January 2012 until the recorded fruitset date of that KPIN or orchard block and also whether an elicitor had been applied in 2011. In the few instances where no fruitset date was recorded, the end of November was used as the end date of recording the spray materials. This period of analysis allowed identification and analysis of sprays from the previous late summer, autumn and dormant periods as well as from the spring period leading up to the budrot-affected flowering of 2012.

There were 125 Green14 blocks across 39 KPINs. In instances where there were multiple blocks in the spray diary for one KPIN, analysis was done at KPIN level unless we had budrot losses for the individual blocks.

3.3.3 Telephone Survey Data Collection and Analysis

The blank telephone survey forms were pre-populated with any information we already had from either the on-line survey, maps, spray diary or field visit. The survey form is appended (Appendix 3 – Appendix Telephone Survey form). The grower was then phoned to arrange a time to do the telephone survey. As well as filling in the survey form, notes were made to elaborate on practices. Where additional information was to follow later, such as packhouse results, an arrangement was made for these to be emailed or mailed.

To analyse the survey data that was not already numerical, the responses were converted into a numerical scale from 1 to 5. The lower number 1, was used for features or practices least likely to favour budrot and 5 for those most likely to favour budrot. This method was used to numerically analyse Seasonal Events, Psa Risk, Site Frost Factors, Irrigation Strategy, Psa Hygiene Strategy, summer pruning and Winter Pruning Strategy. The table detailing how these were classified is appendixed (Appendix 4 - Green14 Budrot Coding).

Once survey data was expressed numerically, it was tested against the level of budrot by regression analysis and graphing. Where stronger relationships were found, further analysis was done to help to determine whether there was a direct or indirect relationship between the factor and budrot. From this, growing area emerged as a significant association with budrot and further analysis of clusters of orchards in different areas, and area characteristics like weather were also investigated further.

3.4 Hayward Data Analysis Method

Zespri collects data on Hayward kiwifruit vines across a wide range of supply areas as part of the annual crop forecasting programme called 'IMOP'. Around 180 orchards are included in this programme. Some of this data was able to be analysed with respect to budrot. The IMOP data was sorted to identify orchards with both flower and fruit counts. This was available for 63 orchards. These were in-season counts, with the flower counts having been made between 16 October and 21 November 2012 and fruit counts being made between 11 December 2012 and 17 January 2013.

3.4.1 Orchard maps and weather data

Orchard maps and weather data were collected in the same way as for the Green14 orchards, except that as Hayward is an unlicensed variety, fewer orchard maps were available.

For weather analysis, temperatures and rainfall from a weather site selected as relevant for the area were personalised to the individual orchard flowering and pre-flowering periods. The flowering period used was the 10 days before fruit set and the pre-flowering period used was from 10-20 days before fruit set.

3.4.2 Hayward spray programme analysis

The spray programmes were also obtained for the 63 orchards with both flower and fruit counts. The spray programmes for each Hayward KPIN and block were analysed in the same way as those for the Green14 variety, except that only the 2012/13 season spray programme was analysed. This meant the period for spray analysis was from the beginning of the spray diary following harvest in 2012 until the fruitset date of each individual KPIN or orchard block. This covered the late-autumn, dormant and spring period leading up to the budrot-affected flowering time in 2012.

There were 103 Hayward blocks across the 63 KPINs. Where there were multiple blocks in the spray diary for one KPIN, analysis was done at KPIN level as only one budrot figure was available for the KPIN.

Analysis was done using simple spreadsheet analysis and graphs and manually to compare spray programmes of orchards or groups of orchards with contrasting budrot levels.

A first analysis of the data was made using SPSS Statistics software. Further analysis was done using simple spreadsheet analysis and graphs and manually to compare management practices and spray programmes of orchards or groups of orchards with contrasting budrot levels.

3.5 Comparison of Hayward and Green14 Data

Results for the Green14 and Hayward data sets were compared where there was a valid basis for comparison, such as CPP, orchard location and elevation.

3.6 Data Quality

The quality of data varied according to the way it was collected. For example, the Hayward in-season flower and fruitlet counts, the Green14 field counts, the weather data, elevations gained from GPS maps and the spray diary data were all accurate data.

The level of accuracy reduces with data collected from dispersed sources or where assumptions had to be made. For example, growers own assessment of budrot losses were used from the Green14 orchards that were not sites for field visits.

The third issue with data is applicability. For example, data from a weather station data near an orchard is accurate data but only representative of conditions at orchards in the locale. Also, temperature at a single site can vary by a significant amount (eg 0.5-1°C) depending on the sensor location.

Also, the difference between flower and fruitlet counts may have been due to factors other than budrot in Hayward orchards. Furthermore, the methodology for counting used in the IMOP programme is to count only "king" flowers whereas all fruit are counted, including side fruit. This has at times resulted in more fruit than flowers being counted.

To maintain consistency for non-numerical data, a limited number of people did the telephone surveys, and in-person interviews were used in some instances; all telephone survey data classification was done by one person on a consistent basis according to criteria determined by a broader discussion among the project technical team.

For analysis, all the data is treated as accurate and applicable, and then anomalous results identified and re-investigated.

Statistical analysis used a 95% confidence level, shown as error bars on graphs, that is, relationships were considered statistically significant when there is a 95% likelihood that the differences are not due to chance, shown by error bars not overlapping.

This mix of broad data-analysis and artisan individual analysis was used to identify spurious relationships suggested by statistical analysis of the data alone.

4. Results

4.1 On-line survey

60 responses were received from 64 KPINS, a 38% response rate from the 158 growers emailed. Growers replied for all the KPIN's using the same contact email address, which ranged from 1-4 KPINs per survey response.

Two responses were manually entered after growers reported they had been unable to complete the survey on-line, although one of these was later identified as a duplicate response.

For twelve orchards, the vines were too young to flower so these orchards were excluded from further analysis of factors relating specifically to budrot, flowering and fruit.

From orchards old enough to flower, there were 45 responses representing 50 KPIN's.

Most growers assessed their level of budrot in the lower severity category, as shown in figure 1.

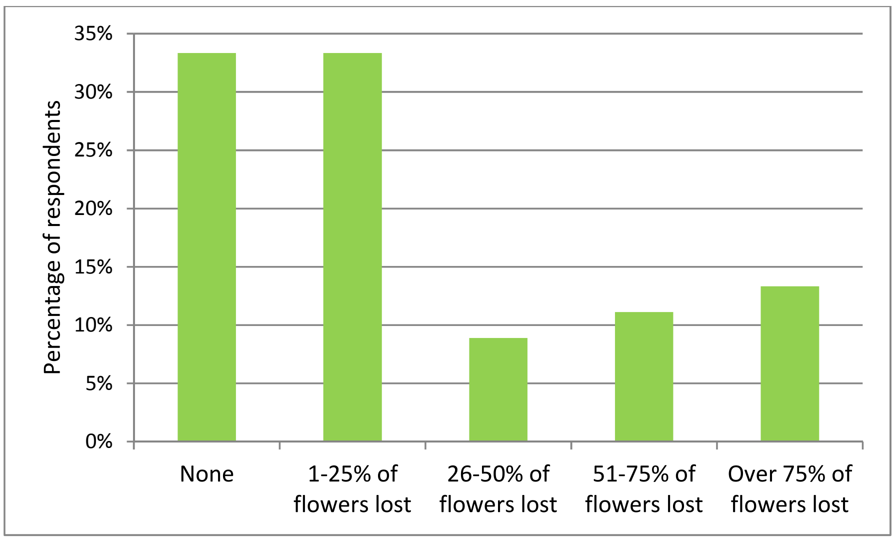

Figure 1 Green14 grower assessment of losses to budrot in spring 2012

To analyse the importance growers associated with factors potentially affecting budrot, a rating was assigned to each factor with 'Very important' rating 5; 'Important' rating 3; 'Not important' rating 1 and 'Not applicable' rating 0. This enabled the average rating for each factor to be graphed, with a higher number or bar indicating a greater perceived importance of that factor.

The most significant site or climate factors growers identified as influencing budrot were Psa and climate/weather (figure 2). Other factors noted as influencing budrot were frost, shelter, elevation, flowering date and disease history. Factors considered less important were soil conditions, undulating terrain, vine spacing and vine age.

Comments growers made included that 'budrot' had occurred as loss of already-opened flowers or young fruitlets rather than flowers dropping off as buds. Growers also suggested that flowers were damaged by frost around the time of budbreak, leading to problems later in the season.

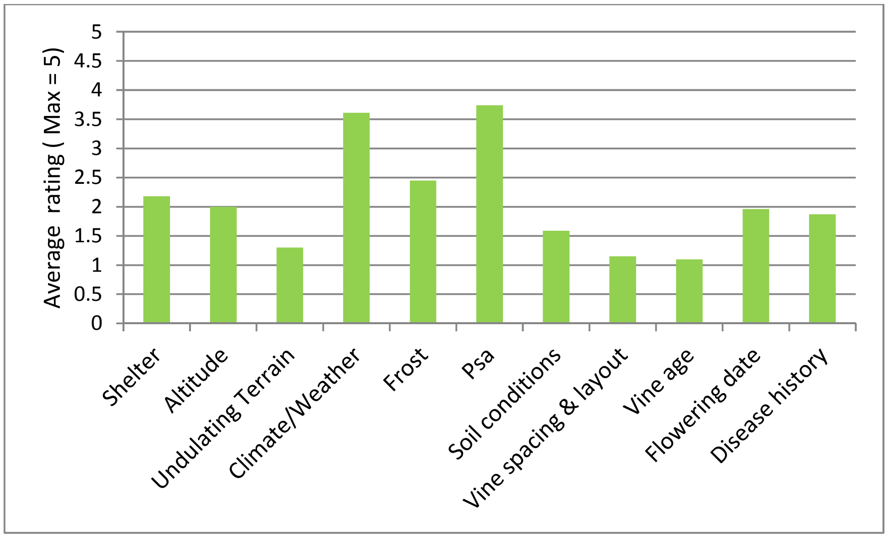

Figure 2 Green14 grower assessment of site or climate factors influencing budrot

The main management factors growers identified as influencing budrot were the crop protection programme, particularly in spring 2012, then in the previous autumn (2012) and the winter dormant period just prior to spring. This was closely followed by the influence of frost protection and orchard hygiene practices. Lower rated management factors were canopy density, quality of fruiting wood and vine nutrition. This is shown in figure 3, with the same format as figure 2. Note that 'CPP' is an abbreviation of Crop Protection Programme.

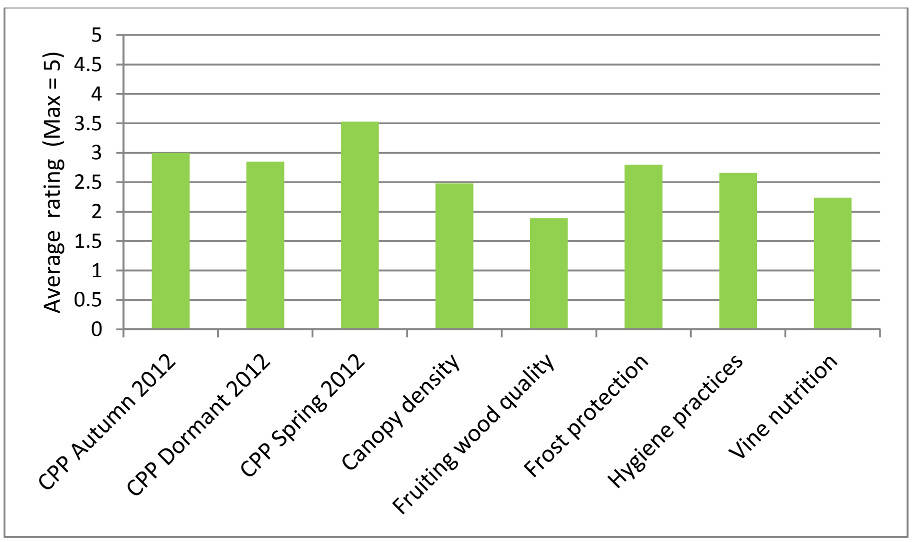

Figure 3 Green14 grower assessment of management factors influencing budrot

Few growers had comprehensive counts of flowers and early-season fruit counts that would validate their estimate of losses to budrot. Fifteen nominated a weather station on or relevant to their orchard.

Analysis of distribution of budrot within the orchard was analysed for those reporting budrot (figure 4). The most common response was 'not applicable' indicating no clear pattern of budrot distribution, which accounted for 50-85% of responses to each location listed. However, worse budrot was found in areas where the canopy was slow to dry, in areas of denser canopy, frost prone parts of the orchard and close to shelter trees. Less budrot was found under artificial shelter and in areas of poor soil. For areas near under-vine shelters there was little data, and conflicting reports of both more and less budrot near under-vine shelters.

Comments in response to this question included high variability in the incidence of budrot between bays; less budrot close to the western-side shelter; worse budrot in areas where there was Psa leaf spotting or fungal infections and in colder parts of the orchard.

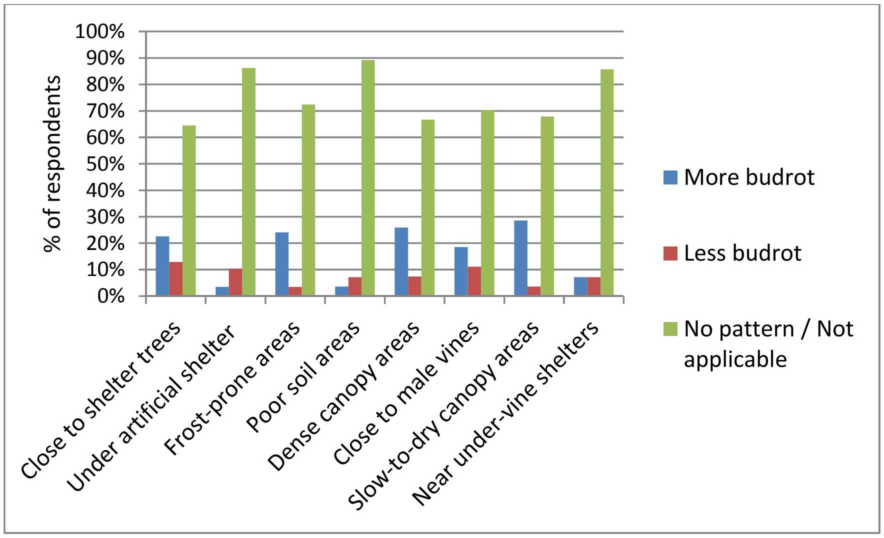

Figure 4 Patterns of budrot variability observed by growers

Growers were also canvassed about what issues other than budrot they had encountered with their Green14 vines. Those with vines too young to flower were added back into analysis for this question (figure 5). The most common issue was small fruit size in 2013 with 70% of those responding selecting this as a problem. The next most frequently mentioned problems were Psa symptoms in 2012/13 and pre-harvest fruit drop in 2013. Poor fruit shape in 2012/13 recorded 19% response. More problems were encountered in 2012/13 than in 2011/12. Small fruit size, pre-harvest fruit drop, poor fruit shape, Psa symptoms and spring budrot were all worse in the 2012/13 season than in 2011/12. However, these blocks may not all have been producing in 2012 so the differences may be to do with the orchard age as well as to seasonal differences.

The 'Other' issues were individually reviewed and many were fairly able to be reclassified as comments or elaborations rather than specific additional issues with Green14. Of those not reclassified as comments, slow growth and low production was the most common additional issue, with one record each of fungal infections, wind vulnerability of the variety and low 2012-crop fruit dry matter.

Comments included fruit being of good size but low weight at harvest in 2013; fruit size being adversely affected by use of the same fruit weight bands as for Hayward variety fruit; and a suggestion that pre-harvest fruit drop started when the irrigation use was stopped.

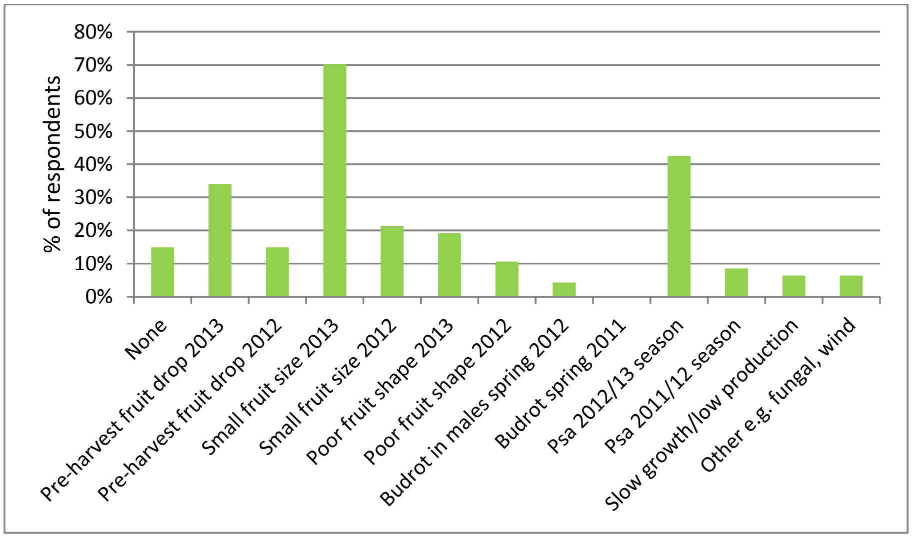

Figure 5 Other issues growers reported with their Green14 vines

Most growers were willing to participate further in the project with 39 specifically giving permission to obtain their spray diary, orchard map, Psa status and offering to participate in a more detailed telephone survey.

From those willing to participate further, all were targeted for following up with a telephone survey and analysis of their spray diary and orchard map. Twelve Bay of Plenty sites were selected for field visits to represent orchards in different locations and with experience of low, medium and high levels of budrot.

4.2 Site Visit Results

In total, there were 120 orchard plots from the 12 orchards, across six western Bay of Plenty supply areas. The fruit stalks and withered flower stalks were used to estimate the individual level of budrot. One low-budrot orchard had done a significant amount of flower thinning so the withered flower stalks were not attributed to budrot.

Budrot occurs over flowering, in November, and the field work for this project was carried out in June the following year, after harvest but before winter pruning had been done. The amount of budrot was calculated as the proportion of withered flower stalks over the total of withered flower stalks and 'sound' fruit stalks. To assess the validity of assessing the amount of budrot this way, 6 months after the occurrence of budrot, a comparison was made of losses of flowers over the flowering period from orchards where we had both after-harvest field data and in-season counts of flowers and fruitlets. These were not from the same individual bays in the orchard as the after-harvest counts.

This comparison (figure 6) showed a strong correlation (R^2 = 0.79) between the two methods of counting, indicating the counts made after harvest were a good assessment of the in-season flower loss. At 2 of the 5 sites with both in-season and winter data, the winter counts underestimated the losses estimated from in-season counts. This could be due to variability between bays or the loss of flower stalks between flowering and harvest. In-season flowers and early fruitlets are typically the most difficult counts to make accurately, which may also be a factor which could over-estimate losses from the in-season counts.

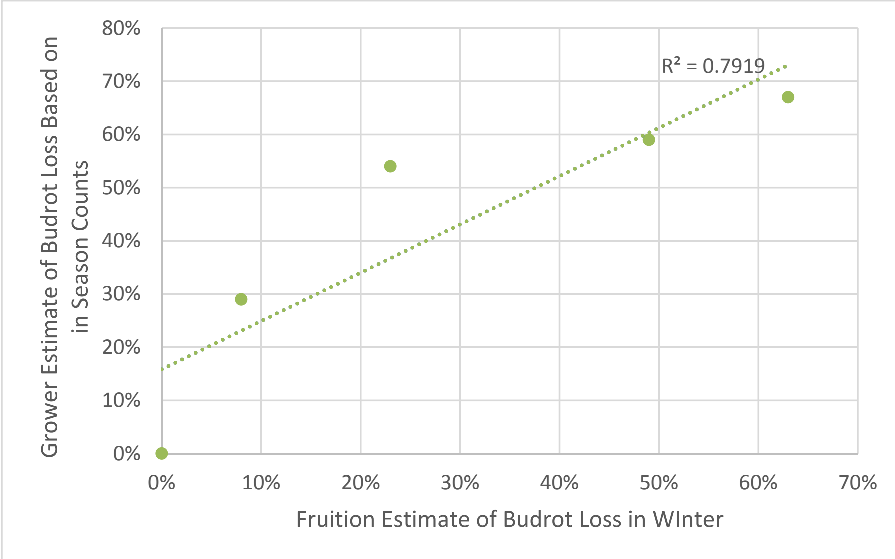

Figure 6 Green14 Site-visit orchards –Budrot winter assessment compared to in-season counts

At many of the field sites, some of the budrot-affected flowers were still present, as 'mummified' flowers, on the end of their withered flower stalk (figure 7).

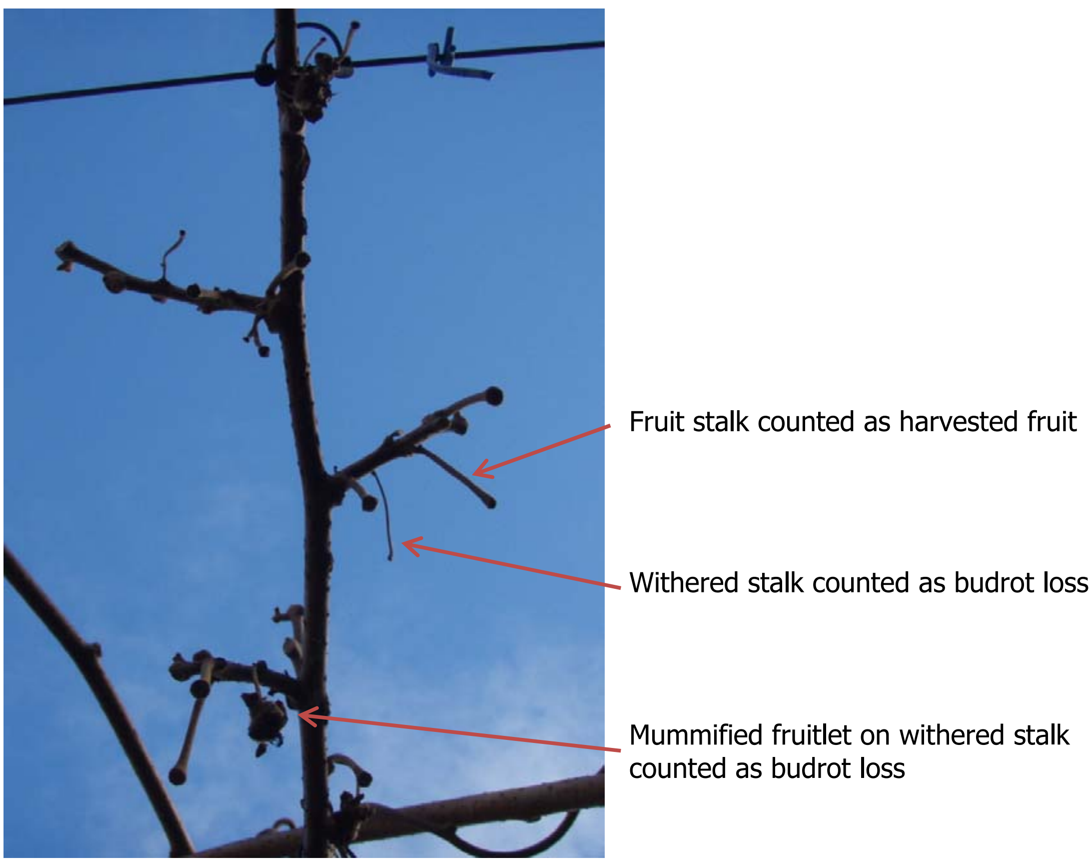

Figure 7 Green14 withered flower stalks, mummified fruitlet and sound fruit stalks at site-visit

Zespri supply area had the strongest relationship to the level of budrot, and there was also a relationship with elevation. Plots in Paengaroa, Te Puke-mid, Pukehina and Tauranga had more budrot than those in Katikati (figure 8). However, the small number of orchards in each area and the variation in budrot between sample bays influenced these results with differences falling into four statistically-separable groups, listed in order of increasing severity of budrot:

1. Katikati (2 orchards) - low budrot;
2. Pukehina (2 orchards) – more budrot but not as high as other supply areas;
3. Te Puke-mid (1 orchard), Maketu (4 orchards), and Tauranga (2 orchards) – more budrot;
4. Paengaroa (2 orchards) – even more budrot than Maketu and Tauranga but not Te Puke - mid.

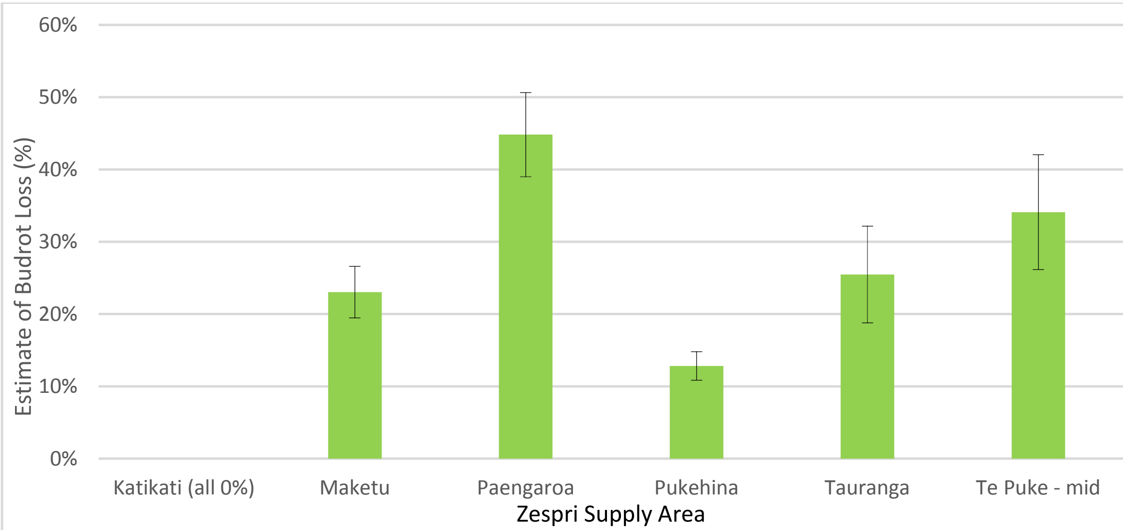

Figure 8 Green14 Site-visit orchards – Budrot by supply area

Plots had 0.27% more budrot with each metre above sea level when analysed at block level using SPSS. The relationship with elevation was tested excluding the highest elevation orchard and found to hold. However, the R^2 for this relationship was weak when the data was reviewed at orchard level with simple spreadsheet analysis, at only 0.18 (figure 9). Plots located in a cold dip also had more budrot, by 16%.

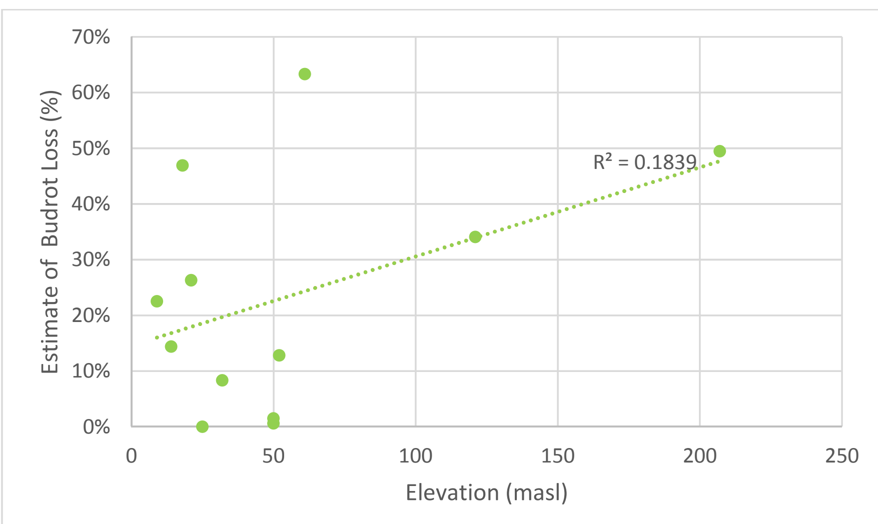

Figure 9 Green14 Site-visit orchards – Budrot variation with orchard elevation

The number of winter buds per square metre varied from 20 to 45, with most orchards between 25 and 35 winter buds per square metre. This range is similar to that in mature Hayward kiwifruit canopies, perhaps slightly lower. The number of flowers initially present ranged between 20 and about 55 per square metre, with most orchards recording between 30 and 40 flowers per square metre. Again, this range is similar or slightly lower than typical for mature Hayward canopies. Neither the number of winter buds (R^2 = 0.0052), nor the number of initial flowers (R^2 = 0.0011), had a significant relationship to the incidence of budrot. This suggests that canopy density was not closely related to severity of budrot at these densities.

The type of wood tied down in the 2012 winter was also noted during the field assessment. Records were kept of the number of replacement canes, canes that were two years old and those three years or older. From the 120 vines assessed there was a range of fruiting wood arrangements from 100% of the wood being one year old replacement cane to 100% of the wood being two years or older. There was no difference in the losses assessed and the age of the fruiting cane tied down (R^2=0.004).

4.3 Telephone Survey Analysis

A total of 37 growers from throughout the North Island were telephoned to gain more detail about their Green14 orchard and the management of the orchard. The telephone survey relates to 75 hectares of Green14. Of these 37 growers the majority were in the wider Te Puke area (n=16). Only four orchards were outside the Bay of Plenty, one of them in a recovery region, one in a containment zone and two in exclusion zones.

Initial analysis of the data was done using SPSS at orchard block level and a summary of spray materials applied, orchard location and elevation. The budrot level used was either that derived from the field assessment (where this was available) or a grower estimate of budrot loss. There were 125 blocks across 37 orchards. Location was simplified into Katikati, Tauranga, Te Puke, Eastern Bay of Plenty and outside the Bay of Plenty. The analysis using SPSS found the most significant factor to be the region, with Katikati and outside the Bay of Plenty having lower budrot than the other regions. Of the sprays applied, only the number of sprays used to reduce the effect of frost appeared to have a significant association with budrot, although usage was low and mostly on orchards with low frost risk.

4.3.1 Orchard Location and Psa Zone Classification

A table of the locations and the average estimated budrot losses is provided below.

Orchard Location	Number of Orchards	Average Estimated Budrot (%)	Range of estimated budrot (%)	KVH Zone Classification
Franklin	1	0%	n/a	Recovery
Gisborne	1	0%	n/a	Containment
Whanganui	1	0%	n/a	Exclusion
Whangarei	1	0%	n/a	Exclusion
Katikati	5	2%	0-5%	Recovery
Pukehina	2	7%	1-13%	Recovery
Waihi	1	7%	n/a	Recovery
Opotiki	2	18%	0-35%	Recovery
Tauranga	3	25%	1-49%	Recovery
Te Puke	5	36%	2-75%	Recovery
Whakatane	5	49%	2-75%	Recovery
Paengaroa	4	45%	8-82%	Recovery
Maketu	5	50%	14-89%	Recovery
Te Teko	1	75%	n/a	Recovery
Overall	**37**	**29%**	**0 - 89%**	

Table 1 Green14 orchard budrot regional summary and KVH Psa Zone

Overall, the estimated Green14 budrot loss within the surveyed growers was 29% for the Green14 and ranged from no loss to as high as 89% loss.

The highest budrot losses occurred in those orchards that have a high risk rating in terms of Psa. Those orchards with no known Psa in their region suffered almost no losses to budrot this season. A graph showing budrot by Psa risk category is provided below.

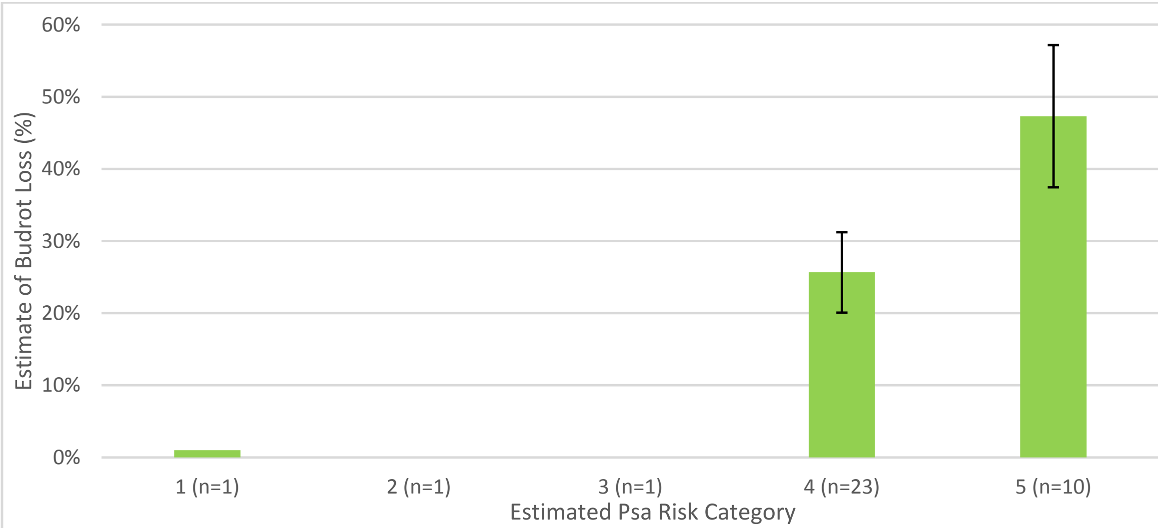

Figure 10 Green14 budrot losses and Psa risk category; 1 = low Psa risk; 5 = high Psa risk

This graph shows a statistically significant difference in the orchards that are within a KVH recovery zone and with Psa susceptible cultivars within their orchard or neighbouring their property expressing secondary Psa symptoms (risk categories 4 & 5) and those orchards not expressing symptoms on their's or their neighbours' orchards and those orchards in other KVH zones (risk categories 1-3). There is a also a significant difference in the losses experienced by growers who have vines expressing secondary symptoms of Psa (category 5) and those who have no symptom expression (category 4). Only three orchards (8%) were in categories 1-3.

Only four of the growers interviewed reported that they had had a previous problem, albeit minor, with budrot prior to 2010 when Psa was first detected in New Zealand. The traditional budrot experienced by kiwifruit growers was strongly associated with elevation and high rainfall during flowering.

Three groups of growers were also investigated as a cluster. These were Whakatane and Maketu, selected for having high average losses but a range around the average in a compact geographical area; and Katikati selected for having low average losses in a fairly compact geographical area. The Katikati orchards were more spread out than the other two clusters. Specific analysis of these clusters is appendixed (Appendix 5) and key comments incorporated into the narrative for this section.

The growers with low budrot losses compared to their area average were specifically investigated, which found:

- The low-budrot Whakatane orchard (2% budrot) has low frost risk, had no frosts in spring 2012 and has no frost protection system. This low frost risk is unusual for the area and is probably because their orchard bounds the Rangitaiki River which provides drainage of cold air and so prevents most frosts.
- The low-budrot Te Puke orchard (2% budrot) is at a higher elevation, had no frost, had low rainfall over flowering and used a comprehensive crop protection programme.

- The low-budrot orchard in the Maketu cluster (8% budrot) used windmill or helicopter frost protection 5 times, used a comprehensive crop protection programme and had no M91 male vines.
- The low-budrot Maketu orchard (14% budrot) used windmill frost protection 10 times, used a comprehensive crop protection programme and had cut out their M91 male vines before flowering due to severe Psa symptoms occurring on them.

4.3.2 Orchard Psa symptoms

Expression of Psa in the orchard is statistically significant when related to budrot expression in the female vines (figure 11). Growers who observed no expression of disease (n=12) had the lowest level of budrot (6%). Those who witnessed severe expression (n=8) experienced the highest level of budrot (65%).

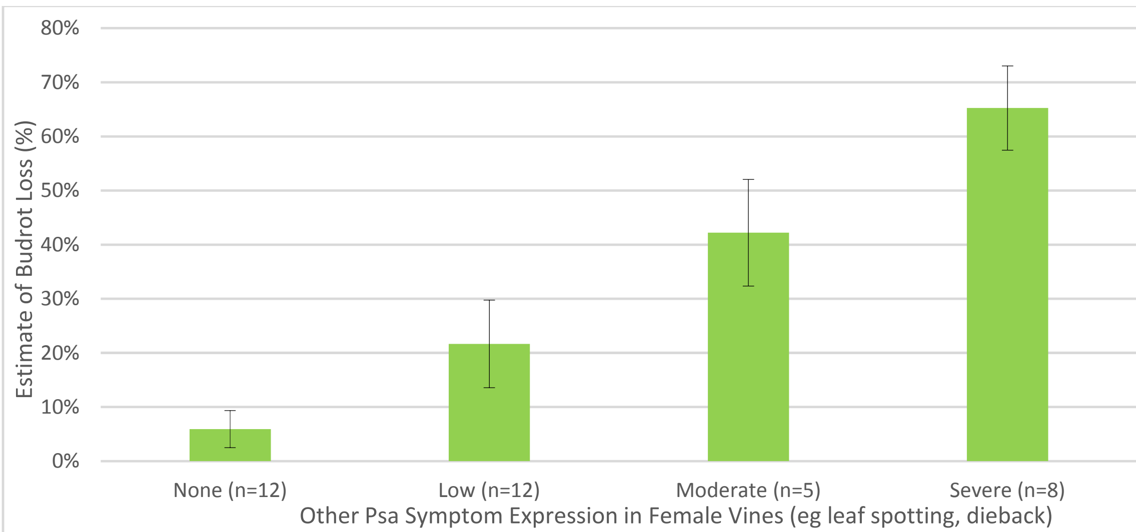

Figure 11 Green14 orchards: relationship between Psa symptom expression and budrot

A similar relationship is shown when looking at the expression of Psa symptoms in male vines (figure 12) with growers observing a moderate to severe level of expression of Psa in their males having significantly higher observed losses to budrot.

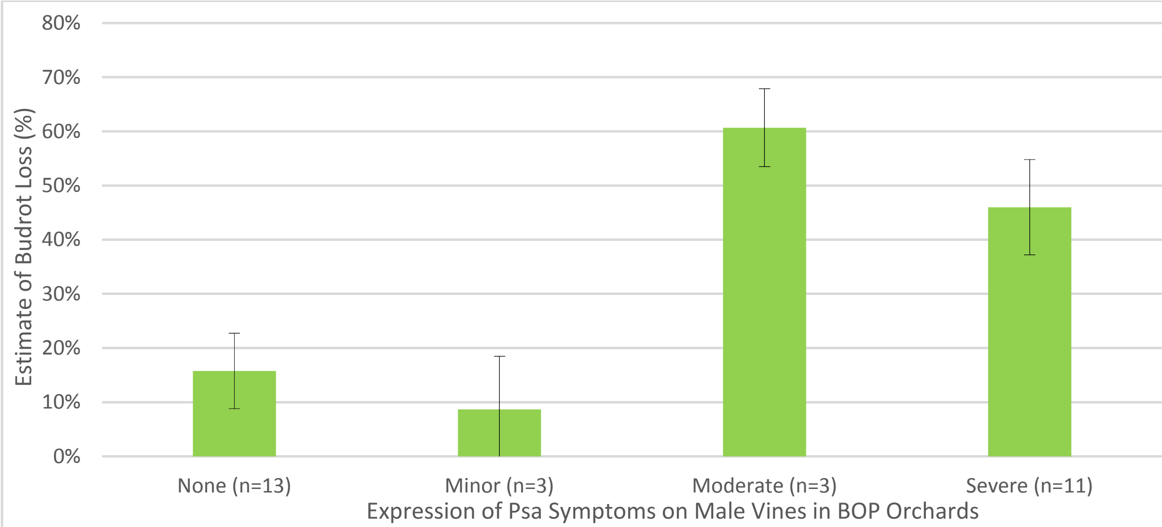

Figure 12 Green14 orchard relationship between male vine Psa symptom expression and budrot

The strategy used by growers to cut out any syptoms of Psa (figure 13) was found to be statistically significant. Four growers in the Bay of Plenty undertook either no cutout of Psa secondary symptoms or they cut diseased wood and left it in the orchard. One of these four growers described their Psa symptoms in their females as severe whereas another commented that they only had low symptom expression. The other two orchards were sold during the year and attention to detail on canopy management did not appear to be a priority for the vendors. The balance (n=25) cut out and removed any secondary symptoms from the orchard. Eight growers were recorded as n/a as they had no symptoms to cut out.

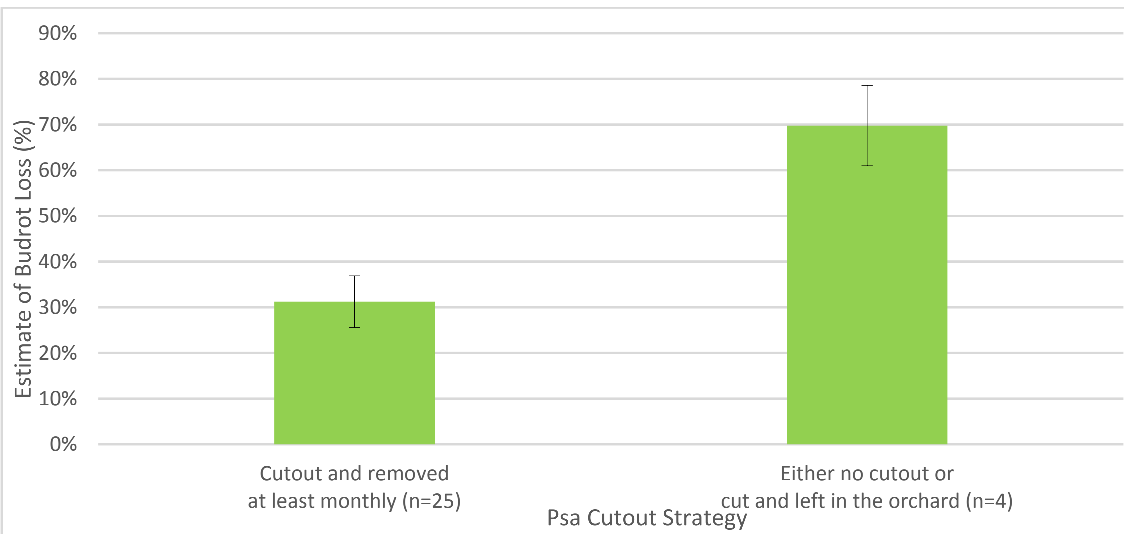

Figure 13 Green14 orchards: relationship between Psa cut-out strategy and budrot

Growers who were in the orchard, constantly looking out for symptoms of Psa (Category 1; n=10) suffered significantly lower losses (10%) than other growers (figure 14).

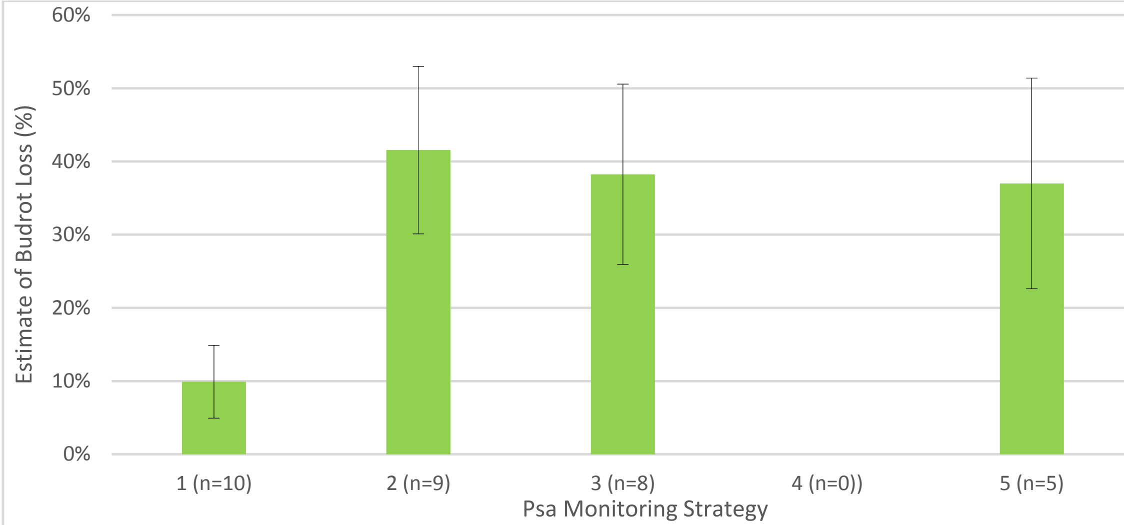

Figure 14 Green14 orchards: relationship between Psa monitoring strategy and budrot 1 = intensive Psa monitoring; 5 = little Psa monitoring

4.3.3 Orchard hygiene

Only one grower used no form of orchard hygiene. This grower, in an exclusion zone, did nothing specific to prevent Psa entering their property or spreading within it. Other growers used various strategies to stop Psa entering their property and then stop the transfer of Psa within their property. None of these appear to have had a significant impact on the losses to budrot.

4.3.4 Orchard Set up

Of the 75 ha encompassed in the surveyed population, orchards ranged in size from 0.26 ha to 8.05 ha. All but two of the orchards were planted on Bruno rootstock. One orchard had some Kaimai rootstock and one still had some *Actinidia chinensis* rootstock amongst their block. All the blocks were conventionally grown on pergola structures. There is a mix of single and double planting but this did not appear to impact significantly on budrot loss.

4.3.5 Elevation

The orchards ranged in elevation from 6 metres above sea level (masl) to 207 masl. Various analysis done shows a slight correlation between budrot loss and elevation. The 'noise' around this statistic is likely to be due to many low elevation orchards around Te Puke and Whakatane suffering high losses. This trend is confirmed with the fitting of a quadratic trend line (figure 15), though the trend is weak (R^2 = 0.08).

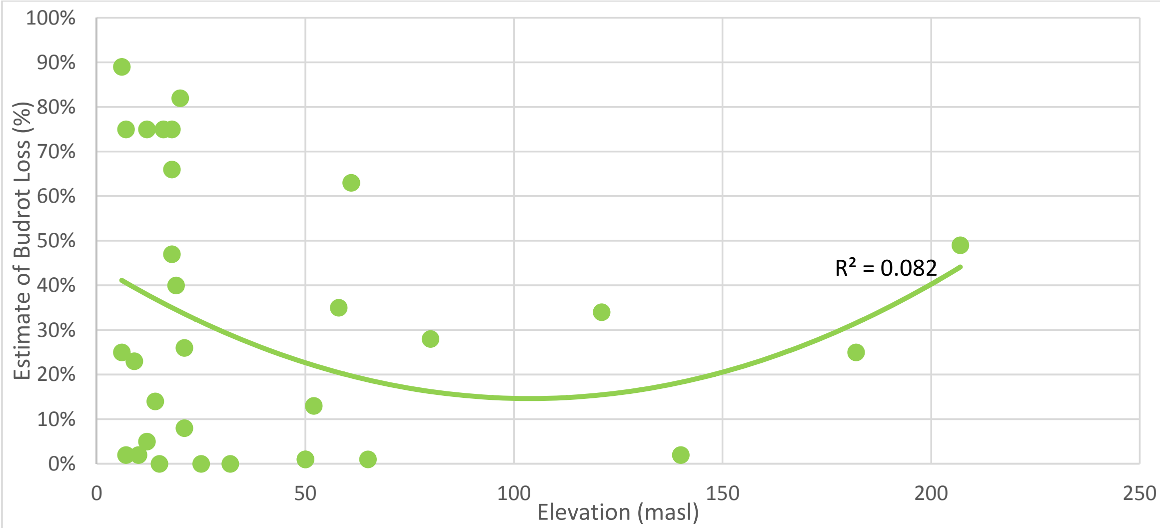

Figure 15 Green14 orchards: relationship between elevation and budrot

The Whakatane and Maketu clusters both had low elevations and generally high losses to budrot; the Katikati cluster had moderate elevation and low losses to budrot.

4.3.6 Orchard topography

Topography was described by the growers to be either flat, sloping or undulating (figure 16). The topography did appear to impact on the level of budrot experienced. Bay of Plenty growers with undulating blocks (n=8) appear to have experienced more budrot than others with 52% loss, while growers on land described as flat (n=19) experienced 32% loss. Growers with sloping land (n=5) experienced a significantly lower loss than those on undulating land at only 7%. The difference between undulating and flat land was also statistically significant.

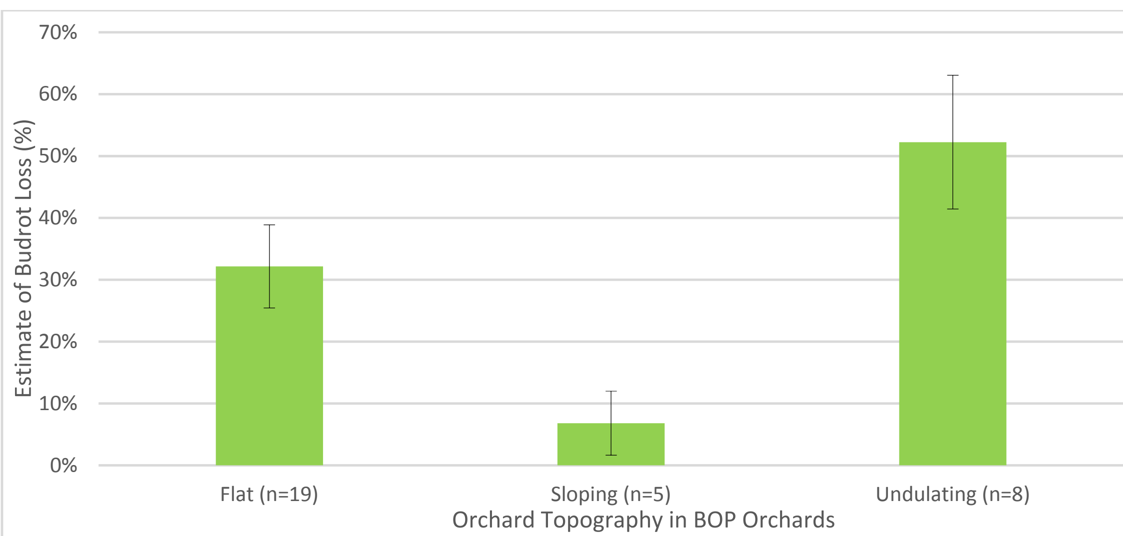

Figure 16 Green14 orchard relationship between orchard topography and budrot in the Bay of Plenty

4.3.7 Frost risk and frost protection system

Growers were asked about the level of frost risk that they identify on their orchard. Nine growers stated that their orchard was not exposed to risk at all (category 1); 7 indicated that there were pockets on their orchard affected by frost (category 3 and 4); while 21 indicated that frost was an issue for their entire block (category 5). The frost risk of the block has impacted on losses to budrot in Bay of Plenty orchards (figure 17). Those who indicated their block was all at risk of frost (category 5) suffered on average 45% budrot loss, significantly more than those with just pockets of frosty areas (15%) and those with no frost risk (10%).

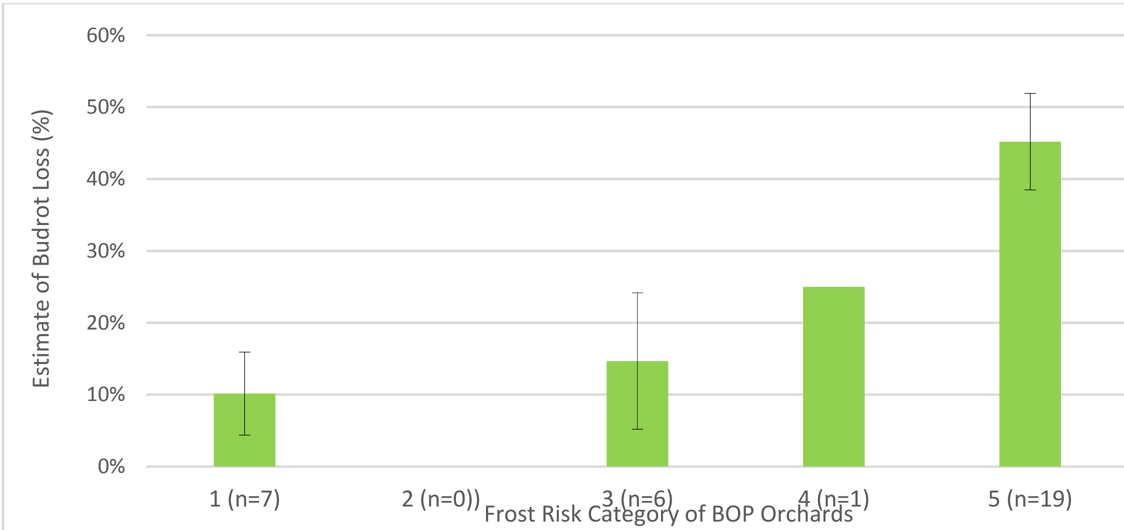

Figure 17 Green14 orchard relationship between frost risk category and budrot in the Bay of Plenty

There is also a relationship between the number of times that growers used their frost protection system over the spring of 2012 in the Bay of Plenty and the level of budrot experienced (R^2 = 0.24; figure 18). Ten growers used no frost protection, 18 growers used overhead sprinklers and five used wind (either fans and/or helicopters), and another four growers used other strategies such as spraying low biuret urea when frost was imminent. When the use of overhead sprinklers is analysed separately from other frost protection systems the relationship between the number of times the system was used and estimate of budrot became stronger (R^2 = 0.33). It seems more likely that this is because of the use of the overhead sprinklers in locations where frost is an identified issue. It is likely that growers who have invested in overhead sprinklers have done so because of the high risk of frost damage to their orchard because of their location and climatic characteristics.

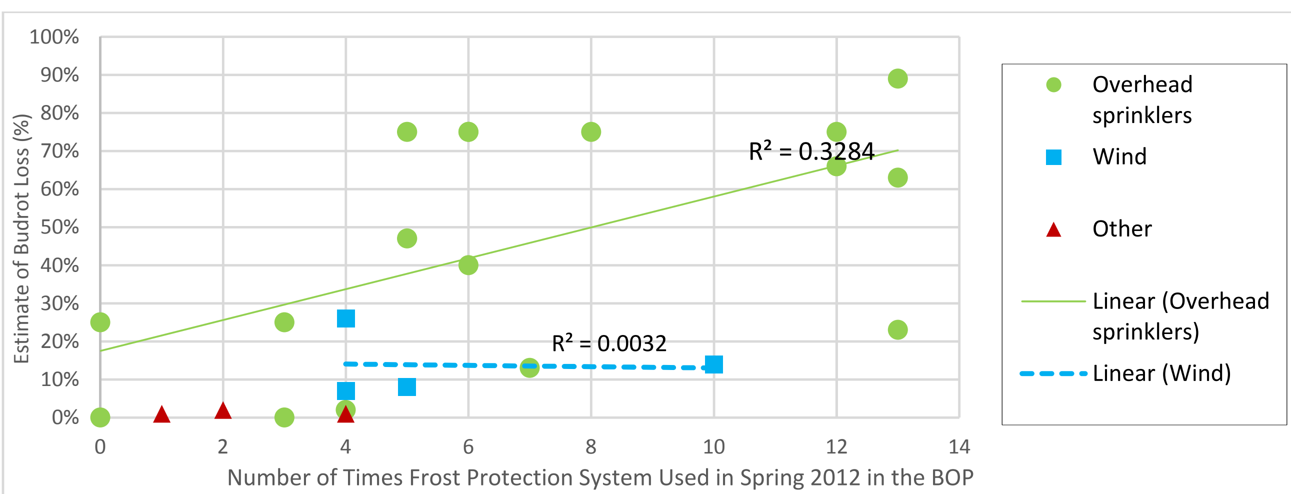

Figure 18 Green14 orchard relationship between type of frost protection, frost protection usage and budrot in the Bay of Plenty

Growers who used no frost protection had significantly less budrot loss than those who used overhead sprinklers but not significantly less than those who used wind. Those who used other strategies experienced lower losses still. Growers using these other strategies were outside the high risk/high loss areas of wider Te Puke and Whakatane. Again, the issue is probably more frost risk rather than frost protection used.

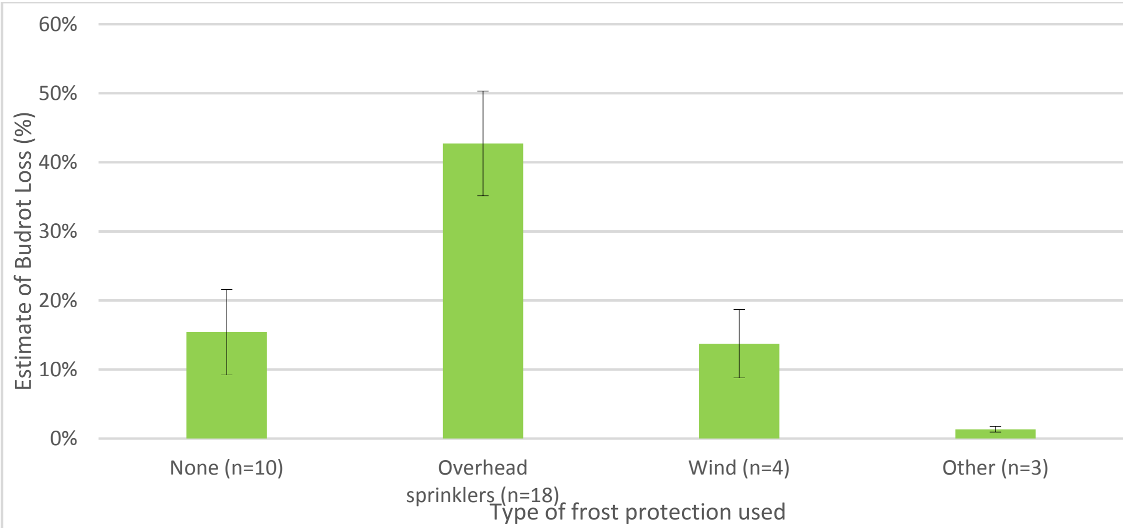

Figure 19 Green14 orchard relationship between type of frost protection and budrot

The Whakatane and Maketu clusters are very different to the Katikati cluster with respect to frost. In the Whakatane cluster, 5 of the 6 orchards have frost protection systems, operated between 2 and 12 times in spring 2012 and in Maketu all have frost protection, operated between 4 and 13 times in spring 2012. In contrast, in Katikati, half of the growers have frost protection which was operated between 0 and 3 times in spring 2012.

4.3.8 Pollination and male vine cultivar

The male layout on the blocks varied with some growers having "patch" males (n=12), some with a strip of male running parallel to their female vines "strip" (n=16) while others running their strip of male perpendicular to the females "east-west" (n=7). Two growers had a mix. Analysis shows no significant difference in the budrot suffered as a result of the male layout.

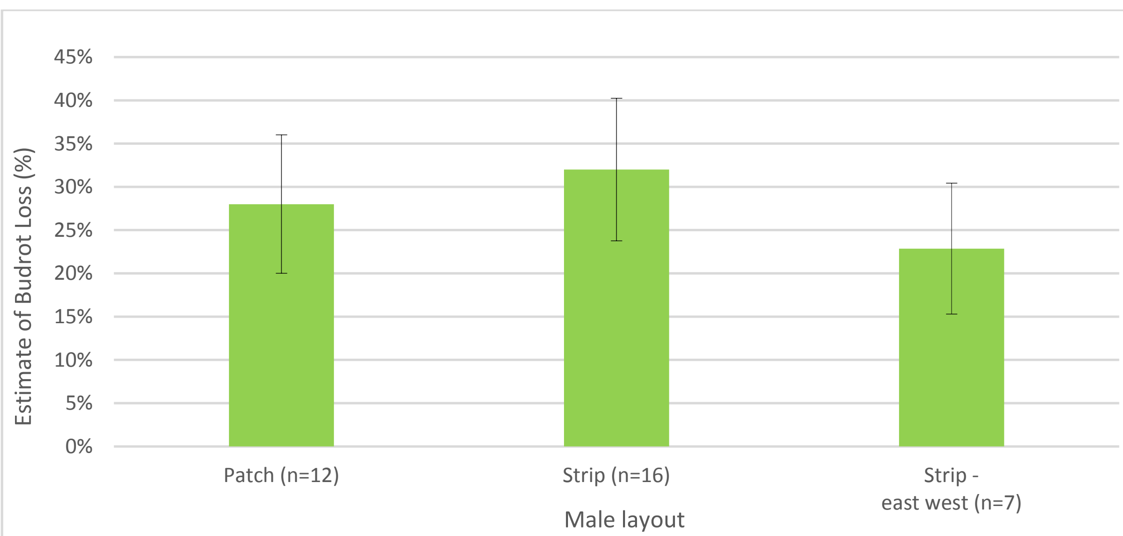

Figure 20 Green14 orchard relationship between male vine layout and budrot

The mix of male cultivars growers have in their orchards varies greatly. Many of the combinations occur only on one orchard making analysis of impact of male cultivar mix difficult as other factors, such as property location, influence the results. As discussed in the section on the Maketu cluster (Appendix 5), there was one grower who had no M91 on their block. Amongst the larger group this grower remains the only grower with no M91. This limited data implied that M91 was associated with higher budrot.

Fifteen growers did not artificially pollinate their female flowers whereas 18 growers indicated that they did. Those who did not artificially pollinate their orchard experienced 19% losses and those who did suffered 38%. When analysis was done on the type of artificial pollination, nine growers indicated that they used wet pollen while the others used dry. While there was a difference in the losses experienced that was deemed significant this is more likely to be a location factor than as a result of the use of wet pollen as four of the orchards using wet pollen were in the high budrot Te Puke area.

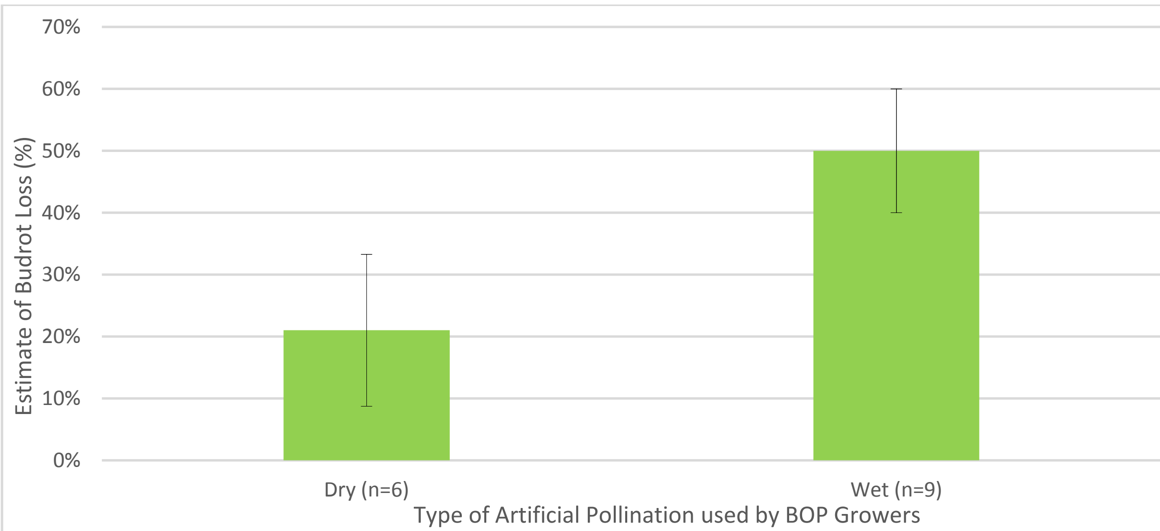

Figure 21 Green14 orchard relationship between type of artificial pollination and budrot

4.3.9 Fruitset Date

There was no consistent relationship between the date of fruitset and budrot across the Green14 orchard group as a whole (R^2=0.05; figure 22). However, a strong relationship was found in the Whakatane cluster (R^2=0.84) and a weaker relationship (R^2=0.29) was found in the Maketu cluster with later fruitset associated with lower budrot. In the Katikati cluster there was a relationship in the opposite direction (R^2=0.66) with later fruitset date having higher budrot, however all budrot in the Katikati cluster was low when compared with Whakatane and Maketu. These differences suggest that location-related events leading up to fruitset, which differ from location to location, may affect budrot.

Figure 22 Relationship between budrot and fruit set date at various locations

3.4.10 Size of orchard blocks and shelter

The type of shelter on the block and the average size of the block does not appear to impact on the losses to budrot. The blocks averaged 0.80 ha in size ranging between 0.17 ha and 2.42 ha. Shelter typically averaged in height between 6 and 10 m but one block had a large Northern shelter of around 30 m in height. This orchard did suffer high budrot but the location of this orchard in Maketu was possibly the overriding factor in this. Many of the blocks had undervine shelter (n=19). There was a slight reduction (R^2 = 0.24) in budrot as the distance between these shelters increased in the Bay of Plenty orchards.

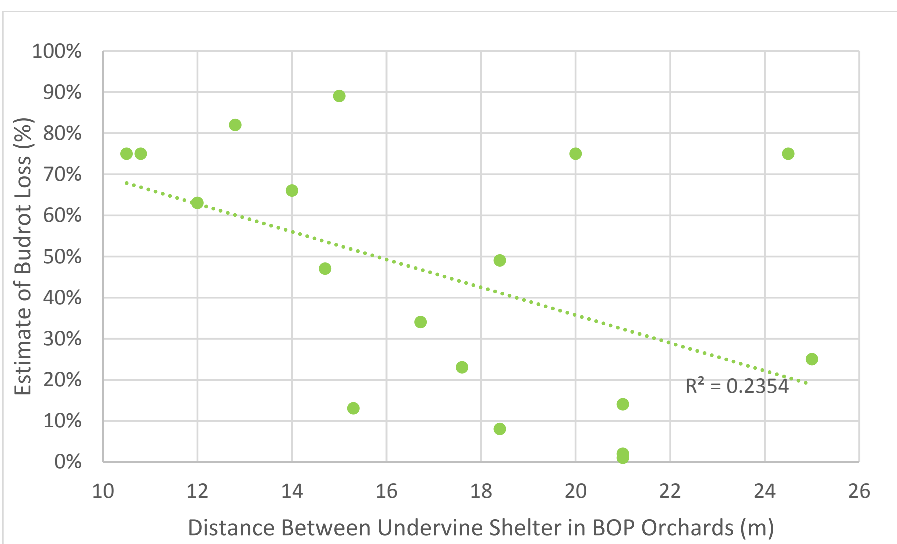

Figure 23 Green14 orchard relationship between undervine shelter spacing and budrot in the Bay of Plenty

4.3.11 Irrigation

There appears to be no relationship between the use of irrigation and budrot. Those who used no irrigation (n=9) suffered less losses, but not significantly less than those that did (n=28). As most irrigation was used after the period when budrot occurred, this fits with it not being a significant factor in budrot.

4.3.12 Pruning strategy

Winter pruning strategy

Growers winter pruning strategy has not impacted on budrot. Twenty eight growers described their pruning as "tying everything in" whereas five growers were more selective in what they tied down trying to achieve a certain spacing or density of winter buds.

Summer pruning strategy

Summer canopy work undertaken on the female vines prior to fruitset has impacted on the level of budrot loss. Three growers reported that they did nothing in the canopy prior to flowering. These growers suffered higher losses than those that did "a bit of crush tipping" (n=14; category 3) to those who undertook quite intensive canopy management (n=4; category 1).

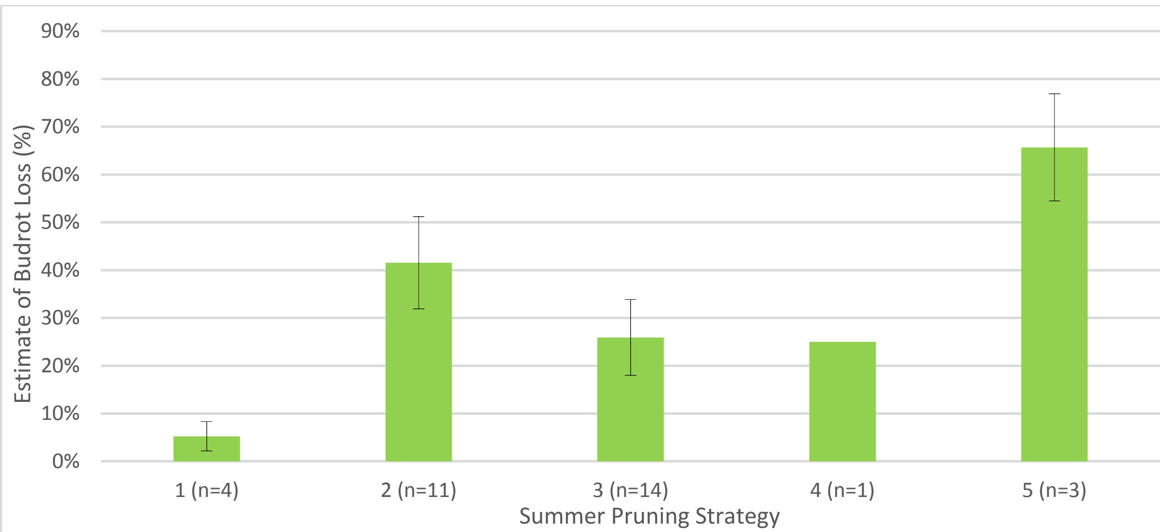

Figure 24 Green14 orchard relationship between summer pruning strategy and budrot. 1 = intensive pruning 5 = no pruning

Male vine pruning strategy

The strategy with respect to male pruning has impacted on the losses suffered by growers (figure 25). Those growers who intensively managed their males by pruning them prior to and immediately after flowering (n=15; categories 1 & 2) suffered significantly lower losses than those who pruned their males only once after flowering and sometimes were a bit late with this activity for reasons such as wet weather (n=20; categories 3, 4 & 5).

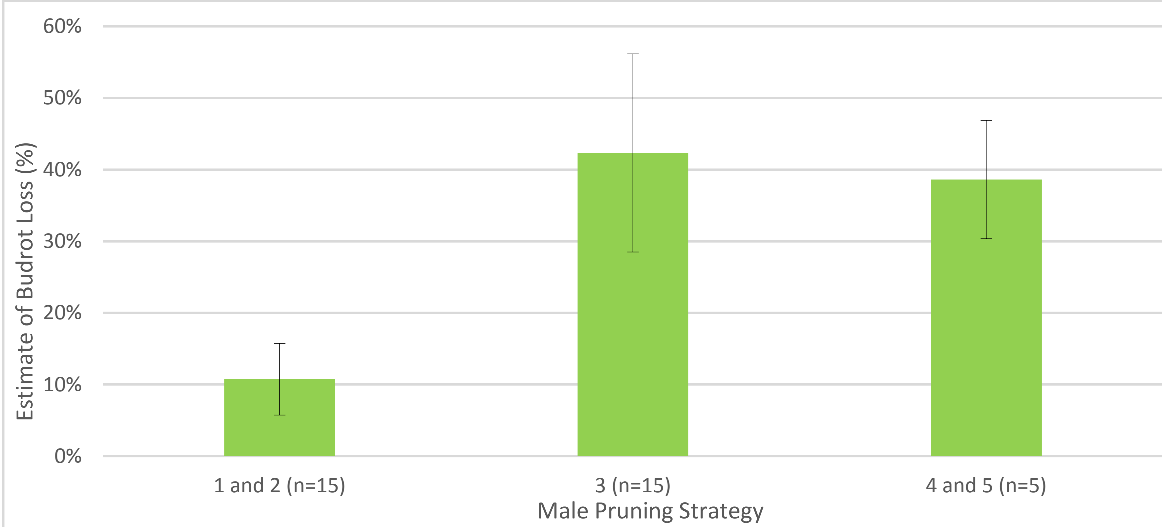

Figure 25 Green14 orchard relationship between male vine pruning strategy and budrot

4.3.13 Fruit thinning

Though there was a statistically significant difference between intensive pre-flowering thinning and other thinning strategies, the one orchard that thinned pre-flowering was in Katikati with little disease pressure around it. We are confident in stating that there is no difference in budrot as a result of pre-flower thinning undertaken.

4.3.14 Green14 Crop protection programme

The crop protection programme applied to the Green14 vines is summarised in the table below for the materials likely to affect disease.

G14 Spray Practices	Number of sprays applied from January 2012 spray diary to 2012 fruit set date								Days between last copper and fruitset
	copper	antibiotic	Actigard elicitor	non-ACVM protectants	BioAlexin elicitor	biological	fungicide	frost protection	
Average:	4.8	1.0	0.6	0.2	0.0	1.0	0.3	0.2	20.5
% using:	95%	44%	54%	18%	3%	38%	33%	13%	n/a
Highest #:	10	2	3	3	1	7	1	2	65
Lowest #:	0	0	0	0	0	0	0	0	2
Average # for users	5.2	1.7	1.3	1.3	1.0	2.8	1.0	1.0	n/a
R^2 with budrot[2]	0.0032	0.0294	0.0015	0.0049	0.0031	0.1185	0.007	0.041	0.026
	None of these are statistically significant								

Table 2 Summary of CPP for Green14 Growers

[2] This is the R^2 from the regression analysis to establish whether the data supports a relationship between the factor and the level of budrot for the data set. R^2 = 0.8-1 is a strong relationship. All these relationships are weak to non-existent.

None of the spray relationships tested had a significant relationship with the amount of budrot in the Green14 orchards. As well as those recorded in the table above, the relationship between the date of the first copper protectant applied in 2012 and whether Actigard was used in spring 2011 were also tested and found to be not significant.

The low correlation between crop protection product and the level of budrot does not mean the crop protection materials did not influence budrot, more that there were other more significant relationships such as with occurrence of frosts. The low usage of non-ACVM protectants, BioAlexin and frost protection materials means this data set does not adequately test their association with budrot. The SPSS initial analysis had implied frost protection sprays reduced budrot but this was found to be a weak relationship when the regression data between these two factors was specifically investigated.

Investigation of the relationship between timing of sprays applied and the recommended crop protection programme for Psa indicated that none of the orchards followed best practice of maintaining a protective copper cover. In particular, cover was low during the autumn of 2012 (leading up to the 2012 harvest). Clusters were analysed for maintenance of a protective cover before weather events in spring 2012 which found that in Maketu there were 15 weather events and in Whakatane 10 events. Katikati could not be separated into area-wide weather events in the same manner. The best crop protection programme coverage of weather events in Maketu covered 10 of the 15 events by a grower who had a low level of budrot. However, the grower with the lowest budrot had cover in place for only 1/3 of the events. In Whakatane, the grower with the highest coverage had cover for 9 of the 10 events but still a high level of budrot.

The only CPP material sufficiently numerous for further analysis was copper. When analysed in separate three week intervals leading up to flowering, there was no significant relationship between copper application and budrot. However, the similarity between different growers CPP made it unlikely that a difference would emerge. For example on average 76% of Green14 growers had a copper spray in each interval with the range from 61 – 89%.

More extensive narrative about the crop protection programme is in Appendix 7 for the clusters and overall for the Green14 orchards surveyed.

4.4 Green14 Pre-harvest fruit drop

Most of the growers interviewed (n = 22) had no issue with pre-harvest fruit drop, whereas 15 did, with four of these describing it as minimal. There was no statistically significant relationship between budrot and experience of pre-harvest fruit drop. One grower had quantified their pre-harvest fruit drop at 8% of their crop. They were located in Katikati, not affected by budrot, had a comprehensive crop protection programme and had not operated their spring frost protection system in spring 2012.

4.5 Weather

The weather between budburst and flowering in the spring of 2012 (analysed from 1 September until fruitset) differed between various locations where Green14 is grown and also from the previous season. Of significance was the difference in the temperatures. In 2012 Whakatane had 12 days where temperatures dropped below 1^{o}C, Maketu 8 days and Katikati 4 days. In the spring of 2011 there were considerably fewer cold days in Whaktane with only 4 days when temperatures dropped below 1^{o}C and the only frost recorded was on the 3rd of September, possibly before there was any leaf, let alone flower buds on the Green14 vines. Appendix 6 provides a pictogram of these weather events.

The table following summarises rainfall, temperature and weather events for Maketu, Katikati and Whakatane in spring 2012 and Whakatane in 2011. Key differences are highlighted.

Weather Feature	**Maketu 2012**	**Katikati 2012**	**Whakatane 2012**	**Whakatane 2011**
September Rainfall (mm)	42 - 75 mm	135 mm	118 mm	46.4 mm
October Rainfall (mm)	54 – 70 mm	106 mm	110 mm	235.4 mm
November Rainfall (mm)	11 – 16 mm	29 mm	16 mm	45 mm
Total Spring Rainfall (mm)	**107 – 161 mm**	**270 mm**	**244 mm**	**326.8 mm**
Number of Rain Days (>1.0 mm)	20 days	38 days	44 days	59 days
Number of Heavy Rain Days (>30 mm)	1 day	2 days	3 days	4 days
Number of Days with minimum temperatures Between 1 – 2 °C	0 days	1 day	0 days	5 days
Number of Days with minimum temperatures Between 0 – 1 °C	6 days	3 days	7 days	3 days
Number of Days with minimum temperatures Between 0 – -1 °C	2 days	1 day	4 days	1 day (on the 3rd of September)
Number of Days with minimum temperatures less than - 1 °C	0 days	0 days	1 day (on the 13th of September)	0 days
Fruit Set Dates	9 – 19 November	11 – 22 November	12 – 28 November	12 – 18 November
Weather events during pre-flowering (estimated to be 20-10 days prior to fruit set)				
Event 1	2 days of temperatures below 1°C	1 day of rain < 1 mm and 1 day of temperatures below 1°C	2 days of temperatures below 1°C and 2 days of rain < 1 mm	1 day of rain < 1mm
Event 2	1 day of rain between 1 and 10 mm	1 day of rain between 11 and 30 mm	1 day of temperatures below 1°C followed by 2 days of temperatures below 0°C	5 days of rain totalling 39 mm
Weather events during flowering (estimated to be 10 days prior to fruit set)				
Event 1	A period of wet then cold then wet from the 3rd of November to the 8th.	1 – 10 mm of rain on the 3rd of November	A period of wet then cold then wet from the 1st of November to the 8th.	1 day of rain on the 4th of November
Event 2	10 – 30 mm of rain on the 12th of November	7 rain days from the 12th to the 18th of November	3 rain days from the 11th – 13th of November	2 days rain on the 6th and 7th of November
Event 3	10 – 30 mm of rain on the 17th of November		2 days rain from the 17th – 18th November	1 day of rain on the 10th of November
Event 4			2 rain days from the 22nd and 23rd of November	4 days of rain from the 14th to the 17th of November.

Table 3 Weather comparison between Green14 clusters in spring 2012 and comparison to Whakatane in 2011. Key differences are lightly shaded (see appendix 6 for more details)

Records of weather events over the spring of 2012 show that the period around fruit set was different in various locations. Fruit set is recorded as having occurred between the 3rd and the 30th of November for the entire population but was more condensed in the locations. Table 3 shows the weather events that occurred during spring, particularly the pre-flowering and flowering periods. Both Maketu and Whakatane had events of wet and cold temperatures during the period when flowering was occurring in 2012. In Katikati in 2012 there were no cold events during flowering. Whakatane in 2011 had far fewer of these events of both wet and cold during the spring period.

Figure 26 shows the relationship between the periods of cold in the spring of 2012 and budrot by location, with a comparison to Whakatane in 2011.

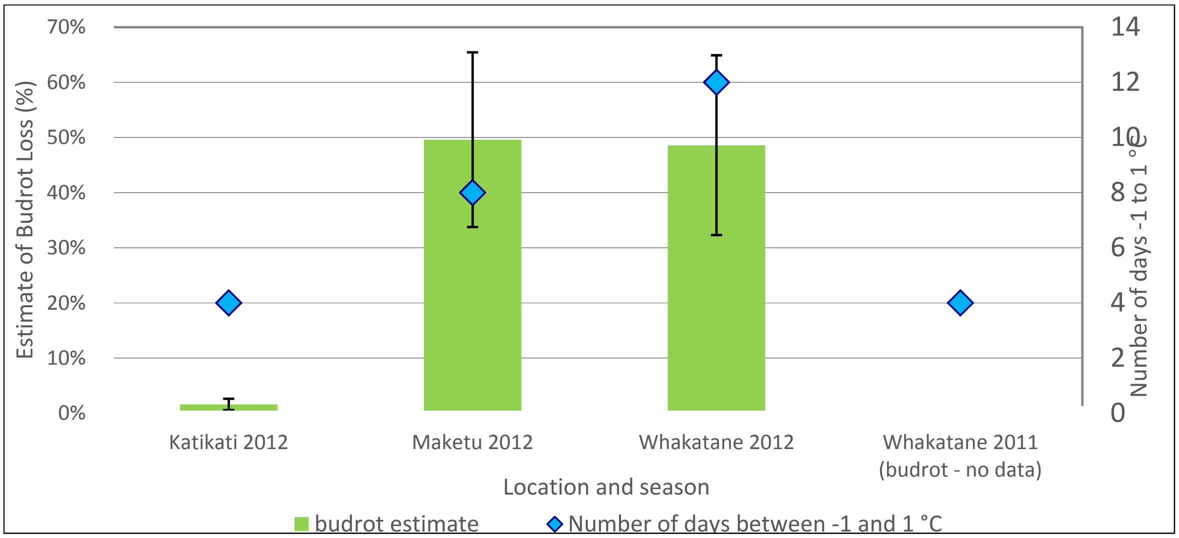

Figure 26 Key weather events related to budrot in various locations

The analysis and comparison to spring 2011 implies the occurrence of budrot in 2012 and the relationship between budrot and region in 2012 is more related to low temperatures than rainfall. Detail of the weather in the Whakatane, Katikati and Maketu clusters is appendixed (Appendix 6).

4.6 Hayward IMOP Data Analysis

A total of 63 Hayward orchards were in the data set extracted from IMOP. Most were in the North Island, predominantly the wider Bay of Plenty. None of the orchards were also orchards involved in the Green14 part of this project. Budrot was calculated from the difference between the number of flowers counted and the number of fruitlets counted, which gives a % flower retention. The percent flower retention was converted to a '% flower loss', with the assumption that the losses were due to 'budrot'. In a few instances, the number of fruitlets was higher than the number of flowers counted. All these instances were re-checked and found to be 'correct'. This is shown as a negative amount of budrot e.g. -10%, and reflects counting methodology. We do not know if any of the losses were as a result of early flower bud or fruitlet thinning.

4.6.1 Orchard Location

A table of the orchard location and the average estimated budrot losses is provided below, with the Kiwifruit Vine Health (KVH) Psa Zone Classification for the area. The orchard location is based on the spray diary 'supply area' but with some further subdivision such as into a higher-elevation area of Tauranga, whereas the spray diary has Tauranga as a single area. The IMOP programme uses more sub-regions in the Bay of Plenty than are presented here.

Orchard Location	Number of Orchards	Average Estimated Budrot (%)	Range of Estimated Budrot (%)	KVH Psa Zone Classification
Kerikeri	1	3%	n/a	Containment
Whangarei	1	-10%[1]	n/a	Exclusion
Auckland (North-west)	1	5%	n/a	Exclusion
Waikato	5	5%	-6% -18%	Recovery
Katikati[2]	7	15%	-4% -39%	Recovery
Tauranga	8	13%	-10% - 48%	Recovery
Tauranga – high elevation	9	29%	2% - 75%	Recovery
Te Puke – low elevation	4	28%	6% - 43%	Recovery
Te Puke – mid elevation	7	23%	-4% - 45%	Recovery
Te Puke – high elevation	4	43%	12% - 79%	Recovery
Paengaroa/Maniatutu	3	25%	24% - 26%	Recovery
Maketu	5	21%	10% - 48%	Recovery
Whakatane	4	64%	53% - 76%	Recovery
Opotiki	2	10%	7% - 12%	Recovery
Gisborne	1	45%	n/a	Containment
Motueka	1	6%	n/a	Exclusion
Overall	**63**	**23%**	**-10% - 79%**	

Table 4: Hayward orchard budrot regional summary and KVH Psa Zone Classification.

[1] In some instances, fruitlet counts were higher than flower counts for the same orchard bays. This reflects counting methodology, and is not considered 'material' to the data analysis overall from the instances it was found.
[2] One orchard in Waihi is included in the Katikati group.

Overall, the estimated budrot loss was 23%, which is slightly lower than the 29% estimated for the Green14. Overall, Hayward flower losses ranged from no loss to as high as 79%, slightly less than the range for the Green14 telephone survey orchard sample. The highest losses occurred in the Whakatane orchards, followed by Gisborne (1 orchard) and the high-elevation Te Puke orchards.

A graph showing the budrot loss by orchard location is provided below (figure 27), with non-Bay of Plenty orchards grouped as a single 'region'.

When comparing level of budrot to regional Psa zone classification, Gisborne is an anomaly, being the only containment or exclusion zone with high budrot losses. However, this was from a single orchard, so limited conclusions can be drawn. This particular orchard is not known to have Psa and has a previous history of budrot losses.

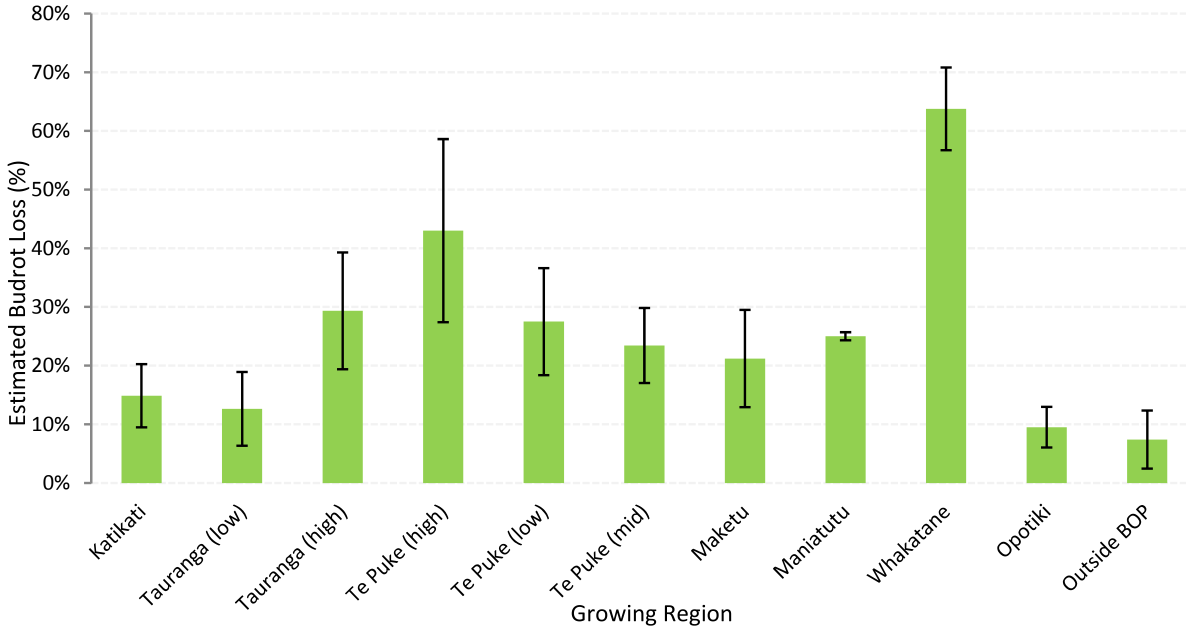

Figure 27 Hayward budrot by growing region

4.6.2 Elevation

The relationship between elevation and budrot losses was investigated for the 63 Hayward orchards (figure 28). The trendline shows more budrot both at lower and at higher elevations. This could be explained by the effect of cold and/or frost, which is more prevalent at low elevations, and of higher rainfall and cooler temperatures which are more prevalent at higher elevations. There is still considerable variation in this relationship, with the R^2 only 0.4. This can be expected for this data set as, for example, we have no knowledge of other factors that could affect budrot such as orchard topography or frost protection other than by using materials recorded in the orchard spray diary.

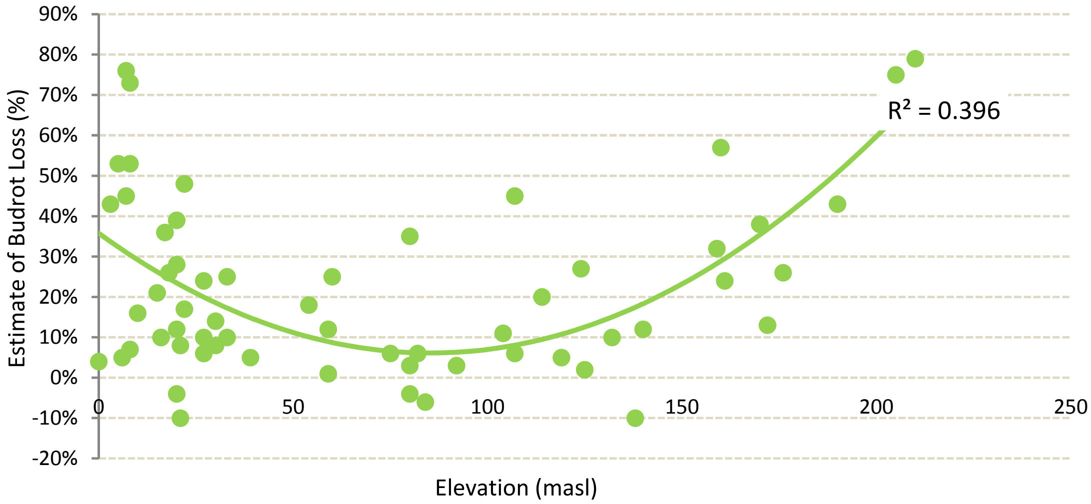

Figure 28 Hayward orchards relationship between elevation and budrot losses

Of the 8 orchards with budrot over 50%, all were in the Bay of Plenty either at high elevations (n=4; masl >160m) or at low elevations in Whakatane (n=4; masl <10m).

Of the 5 highest-elevation orchards with budrot under 15%, four were located in high-elevation Tauranga over 100 masl. Three were under organic and 2 under conventional management. Four of the 5 applied copper, with 16-26 days between the closest copper spray and fruit set date; fruitset dates were late November or early December. The orchard that applied no copper records no pre-flowering sprays of any type at all, so is possibly anomolous for some other reason.

The five highest elevation orchards were all in the Bay of Plenty and averaged 60% budrot. The elevation was at 175-210 masl.

There were seven orchards with low elevation and low budrot but only one of these had a GPS elevation reading. These orchards were in Opotiki, Katikati, Tauranga and Maketu.

4.6.3 Growing Method

In the Hayward data set, 14 of the 63 orchards (22%) were growing using organic production methods. The orchards under organic production had lower budrot at 20% on average compared to 24% for the orchards under conventional management. However, this is not necessarily a significant difference given the locations of the organic orchards and the different size of the data sets. The organically-managed orchards recorded typical budrot losses for their region and those worst affected by budrot tended to be at high elevations or at low elevations as for the conventionally-managed orchards. The organic orchards tended to have a later fruitset date, but only by one day on average, and more of the group had anomalous counts, that is, higher numbers of fruit set than flowers present, suggesting more side flowers as a result of not using budbreak chemicals. This comparison suggests that the drivers of budrot in Hayward orchards in spring 2012 affected both organic and conventionally-managed orchards.

4.6.4 Hayward spray programme

The spray programme applied to the Hayward orchards is summarised in the table 5 for the materials likely to affect disease.

Hayward IMOP Spray Practices	Number of sprays applied from start of 2012/13 season spray diary to fruit set date								Days between last copper and fruitset
	copper	antibiotic	Actigard elicitor	non-ACVM protectants	BioAlexin elicitor	biological	fungicide	frost protection	
Average # used:	3.3	0.3	0.7	0	0.05	0.0	0.3	0.0	25
% using:	90%	19%	59%	0%	3%	2%	25%	3%	n/a
Highest #:	9	2	2	0	2	1	1	1	62
Lowest #:	0	0	0	0	0	0	0	0	7
Average # for users	3.7	1.3	1.2	0	1.5	1.0	1.0	1.0	n/a
R^2 with budrot[1]	0.009	0.005	0.062	n/a	n/a	n/a	0.007	n/a	0.009
	None of these are statistically significant								

Table 5 Summary of CPP for Hayward Growers in 2013 Harvest

[1] This is the R^2 from the regression analysis to establish whether the data supports a relationship between the factor and the level of budrot for the data set. R^2 = 0.8-1 is a strong relationship. All these relationships are weak to non-existent.

None of the spray relationships tested had a significant relationship with the amount of budrot on the orchard. This doesn't necessarily mean that the sprays do not work, but they have not been shown to have a strong relationship with budrot in 2012. This can be to do with the variation between orchards and the relatively small amount of data for some relationships. For example, 4 orchards applied 2 antibiotics, averaging 15% budrot but with a range of 1-26% budrot. For orchards applying 1 antibiotic, budrot averaged 26% with a range from 10-43% and some results not characteristic of the orchard location.

Low use of BioAlexin, biological and frost protection sprays mean little conclusion can be drawn about the relationship between these materials and budrot. For example, the single orchard that used a biological spray had low budrot but also applied two antibiotic sprays, one fungicide, 5-6 copper sprays, the last being 22 days before fruitset, had a relatively late fruit set date, and was in low-elevation (~60 masl) Tauranga.

Application of copper

There is interaction with factors, which is difficult to statistically validate as the numbers of orchards becomes small. An example of this is that of the 6 orchards applying no copper sprays, 4 had very low budrot. However, these also all had a late fruit set date (Dec 2nd-7th) and 3 of the 4 are outside the Bay of Plenty. The other two orchards applying no copper had high budrot loss, with the highest of the two being located in Whakatane.

Again, the only CPP material sufficiently numerous for further analysis was copper. When analysed in separate three week intervals leading up to flowering, there was no significant relationship between copper application and budrot. However, as for Green14 the similarity between different growers CPP made it unlikely that a difference would emerge. For example on average 63% of Hayward growers had a spray in each interval with the range from 59 – 70%.

Duration between last copper and fruit set date

The 7 orchards that applied their closest copper 50 or more days before fruit set averaged 29% budrot with a range from 10% to 53%; all were in the Bay of Plenty with the worst budrot at a Whakatane orchard and the least at an orchard in Tauranga and in Maketu. The 8 orchards whose closest copper before fruitset was applied less than 14 days before fruit set averaged

30% budrot, range -4% to 76%. The two worst-affected orchards were at high elevation or in Whakatane; the two least-affected orchards were in Tauranga and in mid-elevation Te Puke, one under organic management.

Other materials applied

Over 30 different foliar fertilisers had been applied to this group which prevented any meaningful extraction of data relating to budrot.

4.6.7 Weather

The relationship between the level of budrot on each orchard was compared to the temperature over flowering and over the period leading up to flowering personalised to each orchards fruit set date. There was no significant relationship found for either time period, using the following factors:

1. Average temperature
2. Average minimum temperature
3. Lowest minimum temperature
4. Total rainfall for the period.

Nor was there a relationship between the date of fruit set and the level of budrot.

While it was disappointing to find no relationship between budrot and rainfall or temperature data representative of individual orchard sites during the flowering and pre-flowering periods, the confounding aspects to this kind of analysis are applicability of the temperature sites used, given individual orchard site and management factors such as topography and frost management. For example, at one orchard weather station site, temperatures may vary by 1°C at any particular time, depending on the sensor location.

4.7 Comparison of Hayward and Green14 Budrot Losses

Analysis of the losses suffered by the growers of Green14 and Hayward enables a comparison to be done of the losses between these two cultivars. Obviously there are limitations in that the data sets and methods of calculation of the losses are different.

Overall, during the season of 2012/13 both Hayward and Green14 suffered significant losses to budrot in the spring of 2012. It is calculated that losses in Hayward amounted to an average 23% losses whereas Green14 losses averaged 29%. These loss levels are similar and have been shown to not be statistically significantly different.

When the analysis is broken down by region the similarities continue. Where data is available for the two cultivars in the regions they have been compared. Figure 29 presents this data.

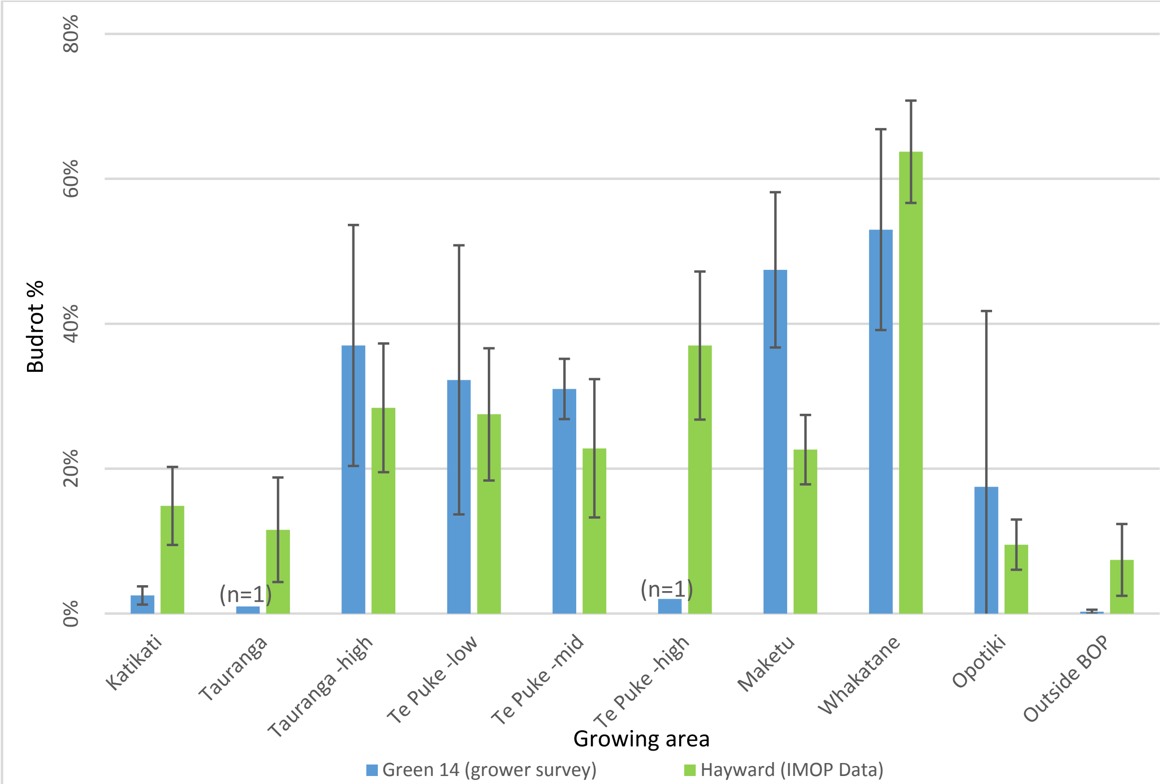

Figure 29 Comparison of Losses in Hayward and Green14

This shows that the losses in Hayward and Green14 were significantly different only in Katikati, Maketu and outside of the Bay of Plenty. Losses were similar between the two varieties in other growing areas.

The losses outside of the Bay of Plenty include one Gisborne orchard that suffered losses of 45% in their Hayward. This orchardist has recorded the 23rd of November as their fruit set date. The spring in Gisborne was particularly wet. In the 11 days preceding this recorded fruit set date 107 mm of rain[3] was recorded to have fallen in Gisborne. Such extensive rain is the type of event that would have triggered the budrot experienced by growers in high elevation orchards in wet springs in the Bay of Plenty prior to the incursion of Psa. That is, traditional budrot. The single Green14 orchard in Gisborne had an early November fruit set date (3rd November) and no budrot.

None of the orchards in the Hayward IMOP database were also in the Green14 dataset so cannot be directly compared in terms of budrot losses between the cultivars. Work undertaken by Fruition, independent to this research, includes vine monitoring counts in two orchards where growers have both Hayward and Green14 varieties in neighbouring blocks. The data collected shows that both cultivars experienced losses in the spring of 2012. The grower data is presented in Table 6. The data shows that the Tauranga – High orchard suffered high losses for both varieties. Interestingly this grower's average losses are very close to those estimated for this location in the IMOP data. The losses for the grower in Paengaroa are lower than those averaged by others in the location as calculated from the IMOP data and the telephone survey. In both these instances, the Green14 variety had higher budrot than the Hayward variety.

[3] AH Geuze Harvest.com weather station

Location	Cultivar	Flower Counts (flowers/bay)	Fruit Counts (fruit/bay)	Estimated Budrot (%)	Orchard Average Budrot Loss for both cultivars
Tauranga - high	Hayward	1,058	760	28.1%	43.45%
	Green14	1,005	414	58.8%	
Paengaroa	Hayward	1,159	1,107	4.4%	16.7%
	Green14	442	314	29.0%	

Table 6 Comparison of Green14 and Hayward budrot losses in two specific orchards.

Another client reported low levels of budrot in both Hayward and Green14 on neighbouring blocks in their Katikati orchard, based on their in-season counts.

Our key findings that the relationships between location and budrot and between elevation and budrot persist in the combined data set, as shown in Figure 30.

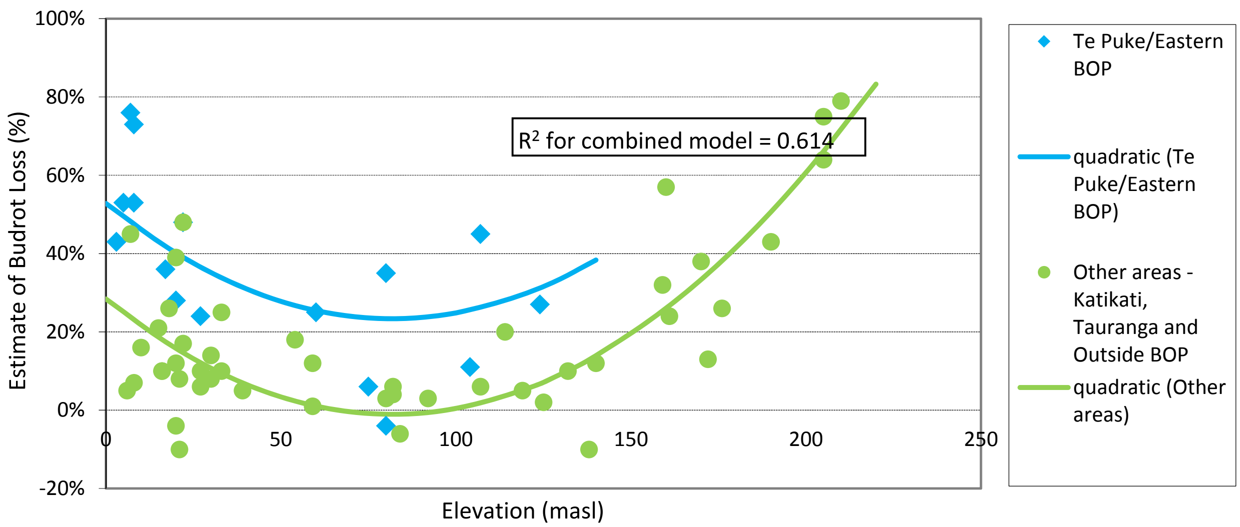

Figure 30 Combined dataset effect of elevation and location

5. Discussion

This project indicates that the environmental factors were the primary issue with budrot in spring 2012 in both Green14 and Hayward variety orchards. Budrot was also more severe in areas with more severe Psa disease status or where more severe Psa symptoms were present on the orchard, on male or female vines.

At the regional level, the weather relationship was compelling, with low temperature events particularly implicated. Furthermore, orchards that are known to be at risk of frost events suffered a higher level of budrot loss. At a regional level, the timing of flowering in relation to cold and wet weather events was strongly correlated to budrot loss in Katikati and Whakatane, the relationship was less strong for the Maketu cluster.

There was limited association between different orchard crop protection programmes and the level of budrot. This may be more as a result of the similar use of key copper containing crop protection materials at key times. There is insufficient data to draw conclusions on other crop protection materials.

5.1 Budrot General Conclusions

Budrot was widespread and severe in spring 2012, particularly in areas where frosts or low temperatures approaching frosts (temperature ≤ -1-1°C) were experienced during spring 2012 between budbreak and flowering (Green14 and IMOP data).

Budrot was more severe in areas where Psa is more severe (Green14 and IMOP data). There was also a higher level of budrot loss in Green14 orchards where secondary Psa symptoms were expressed in either or both the female and male vines. Despite this, it cannot be categorically stated that Psa was the causal pathogen in the budrot experienced in 2012. The absence of laboratory analysis and the high level of budrot experienced by the one Gisborne Hayward orchard, in a KVH containment zone, mean that the traditional budrot cannot be ruled out as a causal agent in the disease experienced in 2012. Growers who were regularly monitoring for Psa and removing symptomatic wood experienced a lower level of loss (Green14 data).

Budrot in spring 2012 was generally more severe in low and high elevation areas, with the low-lying Whakatane-area particularly severely affected (Green14 and IMOP data).

Budrot expression was also higher in flat or undulating orchards when compared with those described as sloping or gently sloping (Green14 data).

Budrot severity was not statistically different between Green14 and Hayward orchards (Green14 and IMOP data), although on the small amount of data for both varieties on the same orchard Green14 budrot was higher than Hayward except where neither were bad. If Green14 was more susceptible than Hayward – one factor could be flowers borne more compactly on shoots in Green14, which could be a factor in budrot pathogen transfer from flower to flower.

Organic and conventionally-managed Hayward orchards experienced similar patterns relating to severity of budrot (IMOP data).

Canopy density, either of winter buds or initial flowers was not a significant impact on the level of budrot, at the range in the orchards assessed, which reflects typical variation in industry practice (Green14 field assessment).

Wood type did not have a significant impact on the level of budrot (Green14 field assessment).

Winter assessment of budrot losses, although not ideal, was a fair assessment when compared to in-season counts of flowers and fruitlets (Green14 field assessment).

Individual components of the crop protection programme are not closely related to the occurrence of budrot (Green14 and IMOP data). The crop protection approach was not hugely different between orchards, particularly the use of copper during the key pre-flowering period.

Canopy management, both in the female and the male Green14 vines, prior to flowering appears to have impacted on the level of losses experienced. Growers who more intensively managed their vines, resulting in a separation of the male and female canopies experienced lower levels of budrot. This is likely to be related to increased air movement and/or reduced opportunity for inoculum movement (Green14 data).

There was a significant increase in budrot suffered by those growers who used wet artificial pollination though this may be a location factor as four of these orchards were in an area with high budrot (Green14 data).

There were many factors that were not found to be statistically significant in relation to the losses suffered by growers. These include block size, shelter height, planting density, strategies used to cut out symptoms of Psa, Psa hygiene strategies implemented by the grower, and the CPP used by the grower.

5.2 Green14 pre-harvest fruit drop

Pre harvest fruit drop was not widespread at a significant level, and was not higher where budrot was higher. However, pre-harvest fruit drop cannot occur where the flower was lost in spring as budrot. That means there was limited data available this season, so this factor should have on-going monitoring and investigation.

5.3 Grower Strategies

As an output from this project, Fruition was asked to identify any recommendations for grower strategies to manage budrot in the future. Based on our analysis and our experience we have these recommendations.

> *Crop Protection programme*
>
> Keep up the crop protection programme – although locational factors overrode CPP impacts on budrot, and broadly growers' CPP were similar, microanalysis showed that few growers had CPP cover in place for most of the spring weather events (Green14 data).
>
> *Canopy Management*
>
> The data suggests that subtleties of canopy management such as early crush tipping and pre-flowering trimming of male vines that reduce canopy overlap and aid canopy drying may help to reduce budrot.
>
> *Management of overhead sprinkler systems*
>
> The data suggests that minimising frosts is important but also that sprinkler frost protection may favour budrot. Thus refining the operating strategy for the overhead frost protection system to reduce water applied may be beneficial.
>
> *Passive orchard warming measures*
>
> Passive frost prevention measures such as short grass, good weed control, open shelter bases will help. Similarly, encouraging air movement with shelter management, including of under-vine shelters may assist. Frost protection using low biuret urea and biological sprays could merit further investigation.

Use of Wet Artificial Pollination

Given the data suggests wet pollination is associated with higher budrot, wet pollen is probably best applied when conditions are not favourable to budrot.

Psa Monitoring

Closely monitor Psa symptoms on all vines, particularly male vines and take appropriate cut out action. It appears M91 is more susceptible to Psa and was associated with more severe budrot.

Budbreak Sprays

Consider splitting timing of budbreak sprays on different blocks to manage risk of conditions favouring budrot occurring at the most sensitive time.

Variety Susceptibility

Hayward and Green14 growers should be aware that their vines are similarly susceptible to budrot.

Records of cultivars and their location

Many orchards had poor records or field-marking, particularly of male vine cultivars. It is recommended that growers keep track of the cultivars in their orchard.

6. Acknowledgements

Sincere thanks to the many growers involved in this project who gave their time and orchard management information to help investigate factors affecting budrot on Green14.

Thanks to the Zespri team for extracting data for analysis and reviewing drafts.

Thanks to the rest of the team at Fruition for their assistance in gathering, summarising and interpreting data and to Robert de Kock for his specialist statistical analysis.

Appendix 1 Questionnaire for On-line Survey

1. **Please enter the KPIN or KPINs of the GREEN14 kiwifruit orchard(s) that you are referring to in this survey** (just the numbers eg '1234' not 'KPIN 1234'):

2. **What level of budrot did you experience on your GREEN14 vines in spring 2012 (tick one; if your vines are too young to flower, move on to questions 7 & 8 by clicking the 'Next' buttons):**

- Not applicable - vines too young to flower
- None
- 1-25% of flowers lost to budrot
- 26-50% of flowers lost to budrot
- 51-75% of flowers lost to budrot
- Over 75% of flowers lost to budrot
- Comments: e.g. not yet producing

3. **What site or climate factors do you consider influenced budrot on your GREEN14 vines in spring 2012** (each factor was rated either Not important, Important, Very important or Not applicable):
    - Shelter
    - Elevation
    - Undulating terrain
    - Climate / Weather
    - Frost
    - Psa
    - Soil conditions
    - Vine spacing and layout
    - Vine age
    - Flowering date
    - Disease history e.g. previous sclerotinia %/or 'classic' budrot
    - Comments on site and climate factors; Psa status and severity: ____

4. **What orchard management factors do you consider influenced budrot on your GREEN14 vines in spring 2012** (each factor was rated either Not important, Important, Very important or Not applicable):
    - Crop protection programme in autumn 2012
    - Dormant crop protection programme (winter 2012)
    - Crop protection programme in spring 2012
    - Canopy density
    - Quality of fruiting wood
    - Frost protection
    - Orchard hygiene practices
    - Vine nutrition
    - Comments on management factors: ______________________________

5. **Do you have flower and/or fruit counts for your GREEN14 vines** (tick all that apply):
    - Spring flower counts
    - Early season fruit counts
    - Pre-harvest fruit counts
    - Harvest data 2013
    - Winter bud counts (2012)

- Weather data (local)
- Name of nearest weather station and other relevant comments: ______________________________

6. **What patterns of variability did you notice about budrot on your GREEN14 vines?** Each location was marked as either 'More budrot in these areas' or 'Less budrot in these areas' or 'Not applicable':
   - Close to shelter trees
   - Under artificial shelter cloth
   - Frost-prone parts of the orchard
   - Areas of poor soil
   - Areas of denser canopy
   - Close to male vines
   - Areas where the canopy is slow to dry
   - Areas near under-vine shelters
   - Comments on budrot variation: ______________________________

7. **What other issues have you experienced with your GREEN14 vines?** (tick all that apply):
   - None in 2012/13
   - Pre-harvest fruit drop 2013
   - Pre-harvest fruit drop 2012
   - Small fruit size 2013
   - Small fruit size 2012
   - Poor fruit shape 2013
   - Poor fruit shape 2012
   - Budrot in males in spring 2012
   - Budrot in spring 2011 (2011/12 season)
   - Psa symptoms in 2012/13 season
   - Psa symptoms in 2011/12 season
   - Others: ______________________________

8. **Are you willing to participate further in this project? May we** (tick all that apply)**:**
   - Telephone you for a follow-up survey
   - Access your Psa status via KVH or your packhouse
   - Access your GREEN14 spray diary via Zespri
   - Access a map of your GREEN14 licenced area via Zespri
   - Best contact phone number & time to ring: ______________________________

Appendix 2 Field Data Collection Sheet

Budrot Survey Vine Monitoring Data										
Grower Name					KPIN	Assessed by			Date	
Description of Area						Pieces of wood 1m from leader wire				
	Leader Length	Bay Width	Winter Buds	Fruit Stalks	Withered Stalks or Mummified Flowers	3 year	2-year	Replmnt cane	% canopy cover	Notes
Vine 1										
Vine 2										
Vine 3										
Vine 4										
Vine 5										
Vine 6										
Vine 7										
Vine 8										
Vine 9										
Vine 10										
Average										

Appendix 3 Telephone Survey Sheet
(note sheet was for Fruition staff to talk through and therefore not in a format that was sent to growers)

G14 KIWIFRUIT BUDROT – TELEPHONE SURVEY
ORCHARD ASSESSMENT

Surveyed by: __________________ Data entry by: ________________
Date: ______________ Data entry date: ____________

KPIN: ______ Grower name: ________________________

Orchard Name: ______________________________ Phone: __________
Best time to call:
____

Email address:
____

Orchard Location: ____________________ Elevation: (from map?) ___________

Budrot group: None / Low / Moderate / High Amount of budrot: ___________%

____

History of Budrot in Hayward pre 2010:______________________________
History of other diseases (eg Sclerotinia):____________________________
____

Weather station name / How similar?:
____
____

Own weather records? e.g. rain, frost
____
____

Key seasonal weather events on this orchard: e.g. Frost / wind / rain / wet-spots / dry
____

2011/12 Season:
____

2010/11 Season:
____
____

ORCHARD (map will provide some of these details)
Other varieties on orchard:

Block name / #	**Area (ha)**	**Variety**	**Mature?**	**Close to G14?**	**Psa symptoms** (type / severity)		**Budrot** (occurrence / severity)	
					2011/12 season	**2012/13 season**	**2011/12 season**	**2012/13 season**

Comments:

____
____
____
____

Neighbouring orchards:
Comments on Psa, varieties, proximity etc.

____
____
____
____
____
____
____

FOR THE G14 SPECIFICALLY:

Total G14 Area:_________canopy hectares   Growing method: ___________________

G14 Age details:

Block name / #	Area (ha)	Rootstock type / 'interstock'	Year(s) grafted to G14	Block Aspect / Slope	Production (trays; size)				% of full canopy at harvest 2013
					2010	2011	2012	2013	

Notes: e.g. block shape(s):

____
____
____

Structure: T Bar/Pergola (delete one)   Comments e.g. edge row has T-bar wing:

____

Vines/Bay ___________________________   Vine spacing in row: ________________________

Row spacing ___________________________   Post Spacing _______________________
Bay size: (m2): ___________________________

Male Vine Set-up – Uniform across different G14 blocks? If not, repeat table for multiple blocks

Male layout	e.g. strip, patch, overhead
Area of male vine	e.g. ¼ bay
Male cultivar / pattern	e.g. x, y, and z males, randomly
Male pruning strategy e.g.: tip / leader zone /	

current-season growth / older growth	
Male pruning date(s)	

Male pruning – cultivar differences:

____

Any other comments on male pruning:

____

____

Male cultivar:				
Budrot symptoms?				
Psa symptoms?				
Comments				

Shelter around G14 block(s): height, type: [artificial, natural – species], thickness / when trimmed

North end:

____

South end:

____

West side: ____

East side:

____

Within block: artificial under vine [details]

____

artificial above vines [details]

____

Frost & Frost Protection in G14 Block(s)

Site frost factors e.g. low spots ____

Frost events 2012 spring: ____

Frost protection type: None / None required / Overhead sprinklers / Windmill / Other (specify)

____

Basis of frost protection use: e.g. temperature to switch on / off

____

____

____

Number of times frost protection operated in spring 2012:

____

____

____

Irrigation in G14 Block(s):

Type: e.g. none / drip / undervine sprinklers etc.

____

Strategy 2012/13 season:

____

Usage 2012/13 season:

How assess irrigation requirement?

Hicane use in G14 Block(s): (check spray diary)

Rates: Chemical: __________ Water volume: _________a.i?: __________ Date: _________
Comments on Hicane:

Block Hicane differences:

CANOPY MANAGEMENT

Pruning hygiene / Psa measures?: ____

Hygiene measures applied to: e.g. All vines for all activities / pruning only / all female vines

Summer / Autumn 2011/12:
Girdling strategy?

Winter pruning 2012:
Strategy: e.g.: x canes per side per bay / retain everything

Male pruning in winter / strategy?

Winter pruning dates:

How were winter prunings handled: e.g. mulched____

Any other comments on winter pruning?:

Pre-flowering (spring) pruning 2012:
Strategy: e.g.: crush tip / leader zone / fruiting zone / cane girdling

Spring pruning dates:

Spring pruning hygiene / Psa measures?:

Male pruning also in spring?

Comments on Spring pruning:

Flower and fruit thinning

Crop load strategy: ____

Flower thinning: Dates or crop stage / how much removed / what removed / purpose

Record of flower and fruit counts – please provide, with dates and/or crop stage at counting time

Pre-harvest Fruit Drop

When occurred?	
Quantity / Counts	
Blocks / areas worst & best	
Results of fruit maturity samples around then?	
Comments:	

Budbreak / Flowering Dates (Check spray diary)

Date(s) of G14 budbreak in 2012: ______________________________________

Block budbreak differences / comments?: __________________________________

Date(s) of male vine flowering in 2012: ___________________________________

Comments on male cultivar flowering dates in 2012: __________________________

Date(s) of beehive introductions in 2012: _________________________________

Date(s) of beehive removals in 2012: _____________________________________

Fruit set date 2012: ______________ ____________________________________

Detail(s) of artificial pollination in 2012: __________________________________

CROP PROTECTION PROGRAMME (Strategy **-** e.g. timing re weather events)
After 2012-harvest (Autumn 2012) Strategy:

Winter 2012 Strategy: Note whether sprays were applied pre and/or post pruning

Spring 2012 Strategy:

Summer 2012/13 – Autumn (pre-harvest) 2013 Strategy:

Comments on crop protection strategy:

Comments on general pest / disease issues for G14 in this orchard:

Psa symptoms & treatments:
Psa severity: none / low / moderate / severe

Leaf spotting: **female vines** autumn 2012 / spring 2012 / summer 2012/13 / autumn 2013
Distribution in block(s)?:

Dieback / cankers: female vines autumn 2012 / spring 2012 / summer 2012/13 / autumn 2013
Distribution in block(s)?:

Psa cutting strategy:

Psa checking / cutting frequency:
____

2013 HARVEST DETAILS:
Are you able to send us your packhouse details of harvest date, trays, size, reject rate etc. by G14 block?
Send to our email address or get their postal address and we mail out a reply-paid envelope.

~~Proposed 2013 G14 pruning date:~~ N/A now field work done

Known challenges for this orchard:

General Comments on G14 and G14 budrot:

THANK YOU!

Follow-up notes:
e.g. to email harvest results

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Appendix 4 – Green14 Budrot Coding

Categories listed were coded on a 1 – 5 scale with 1 'least favourable to budrot' and 5 'most favourable to budrot'.

	Code				
Category	**1**	**2**	**3**	**4**	**5**
Seasonal Events	No event noted that may have created bud rot risk		An event noted that may have created bud rot risk		An event noted that is strongly linked to creating a bud rot risk
Psa Risk	Orchard in an Exclusion Region	Orchard in a Containment Region No expression of Psa symptoms in orchard or with neighbouring orchards	Orchard in a Containment Region Orchard has tested Psa positive	Orchard in Recovery Region Orchard contains other susceptible cultivars	Orchard in Recovery Region Vines expressing secondary symptoms within the orchard or in immediate neighbour's orchard
Site Frost Factors	The site is not at risk of frost at all		Pockets of the orchard are at risk of frost		The entire site is at risk of frost damage
Irrigation Strategy	No irrigation used		Irrigation used on the basis of measurable decision criteria around flowering 2012		Irrigation run irrespective of decision criteria around flowering 2012
Psa Hygiene Strategy	Best practice is in place to reduce risk of Psa entering the property on tools, people and vehicles Best practice is in place to reduce the transfer of Psa between vines	Measures are taken to reduce risk of Psa entering the property on tools, people and vehicles Measures are in place to reduce the transfer of Psa between vines	Measures are taken to reduce risk of Psa entering the property on tools, people and vehicles		No measures have been taken to protect the orchard from Psa
Winter Pruning Strategy	Canes spaced at more than 40cm and only replacement cane	Canes spaced at more than 40 cm	Everything available was tied down		Winter buds were crammed in

	used				
Pre-flowering pruning	Leader ripped and crush tipped prior to flowering in 2012		Some crush tipping done		Nothing was done in the canopy prior to flowering in 2012
Male Vine Pruning	Males pruned back prior to flowering and again after flowering. Males maintained as a spur structure		Males maintained as a spur structure after flowering		Males pruned to replacement canes once after flowering
Summer pruning	Vines crush tipped and zero leafed prior to flowering		No summer pruning required		No summer pruning done despite dense canopy growth
Flower thinning	Flowers were thinned to remove side flowers and thin down dense shoots		No thinning was needed		No thinning was done despite high flower load
Psa cutting strategy	Cut any symptoms of Psa out as soon as it was noticed, bagged and/or collected the infected wood and buried it or removed it from the property Sterilised equipment between vines		Cut out any symptoms of Psa at least monthly	Cut out monthly and left prunings on the ground to be mulched	No cut out strategy
Psa monitoring strategy	In the orchard constantly monitoring Make a point of walking the entire block at least weekly		Make the point of walking the block at least monthly		No formal monitoring strategy

Appendix 5 – Green14 Cluster Write-up

Maketu Cluster

Description

This cluster consisted of nine orchards concentrated around the Maketu, Paengaroa, lower Te Puke area. Budrot losses ranged from 8% to 89% and averaged 49%. None of these orchards have previously had problems with budrot prior to Psa being found in New Zealand in 2010.

All of the orchards are at elevations of 21 masl or below – although one orchard's GPS map has it at 32m which does not appear to be correct given its proximity to other orchards and our knowledge of the topography.

All of the orchards, by virtue of their location are considered to be "High Risk" in terms of Psa infection. That is, these orchards are in a KVH recovery zone and they have Psa susceptible vines either within their orchard or neighbouring their orchard.

Seven of the 9 growers identified either cold or frost as a seasonal weather event that impacted on their orchard during the 2012/13 growing season.

All the orchards are conventional blocks grafted onto Bruno rootstock.

The orchards are described as having either flat (3) or undulating (9) topography. There appears to be no statistical significance in the amount of budrot loss experienced as a result of topography.

Male vines and pollination

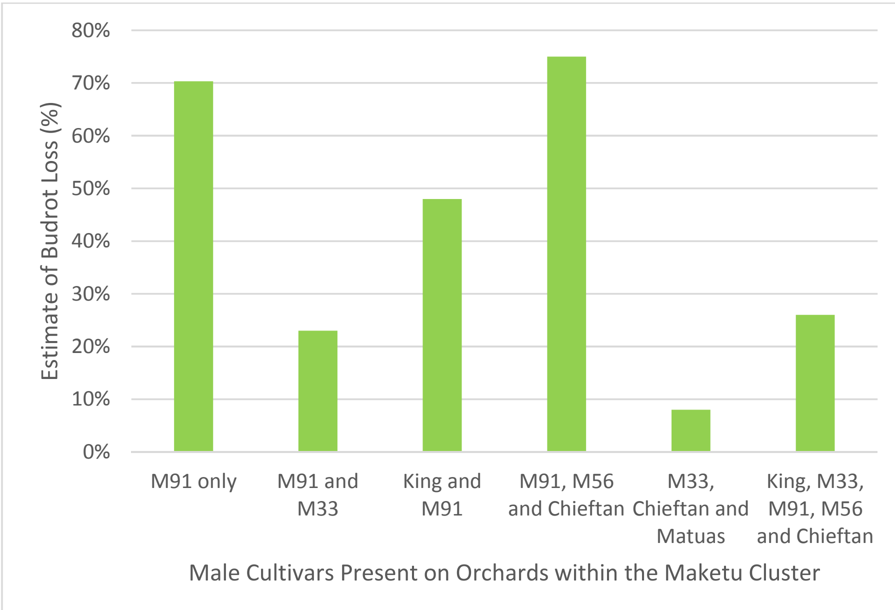
Five of the orchards have males planted in a patch arrangement, 2 have strip males in the typical North-South orientation and 2 have strip males running East-West. It appears that there is a higher level of budrot in the orchards that are planted in the standard strip male arrangement but this is not supported by the analysis of the wider group of orchards and so is probably chance due to the lack of replicates within this sample.

There was one orchard within the cluster that does not have M91 as a male cultivar. Another orchard removed the M91 prior to flowering in 2012 as they were expressing severe symptoms of Psa. Interestingly, these two orchards experienced the lowest level of budrot at 11%. All the growers with M91 commented that their M91 vines suffered from Psa with symptoms ranging from dieback, to oozing to death. The mix of male cultivars on the properties is presented in the table below:

Male Cultivar Mix	Number of Orchards (total = 9)	Average Budrot Loss (%)
M91 only	3	70%
M91 and M33	1	23%
King and M91 (one of these cut their M91 back before flowering to be regrafted)	2	48%
M91, M56 and Chieftan	1	75%

M33, Chieftan and Matuas	1	8%
King, M33, M91, M56 and Chieftan	1	26%

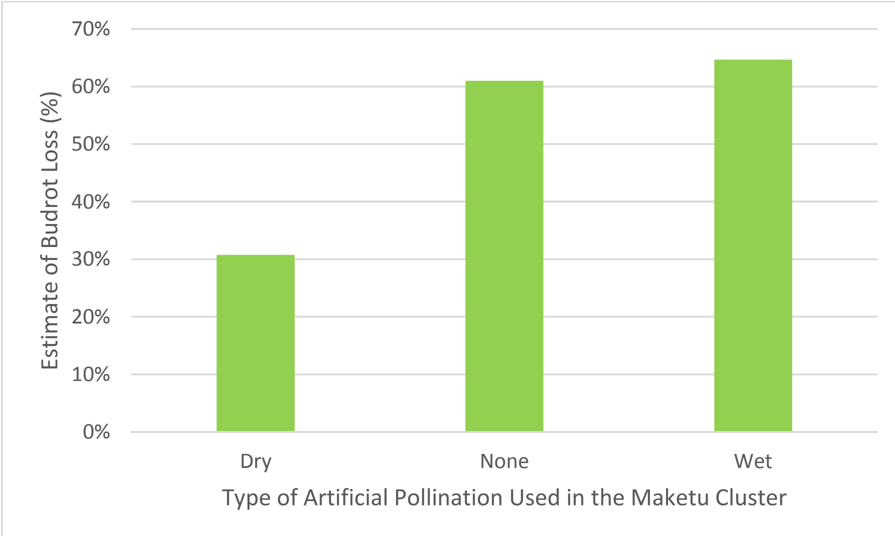
Green14 Maketu cluster male mix.



Green14 Maketu cluster male varieties

Growers within the cluster typically pruned their males once after flowering. There were two orchards where the males were not well pruned after flowering as this activity coincided with a change in ownership. There appears to be no statistical difference between different male pruning practices between either of these groups of orchards.

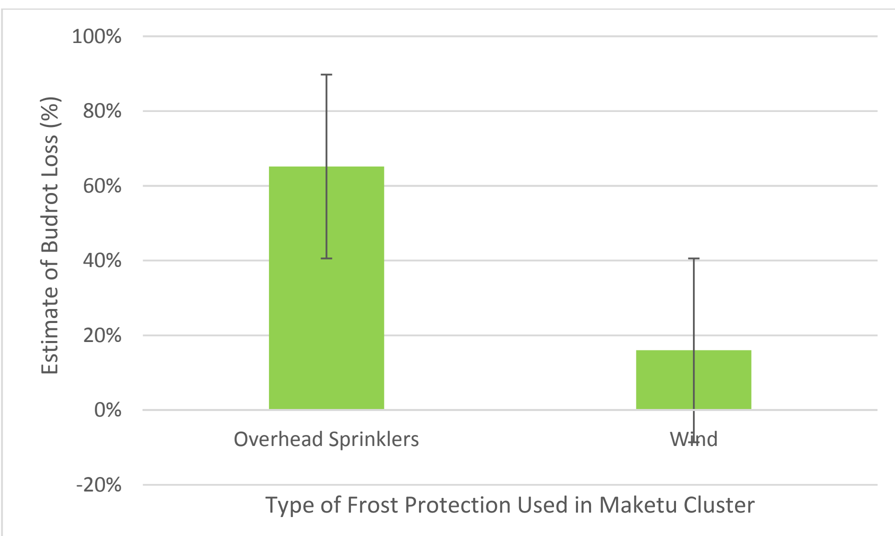
Seven of these growers used artificial pollination, 3 applying wet pollen (one of these using both wet and dry) and 4 applying dry pollen. Those applying wet pollen had significantly higher losses (65%) than those applying dry pollen (31%) but confusingly, there was no significant difference in the losses suffered by those applying wet pollen and those not using artificial pollination.



Green14 Maketu cluster methods of artificial pollination.

Frost and frost protection

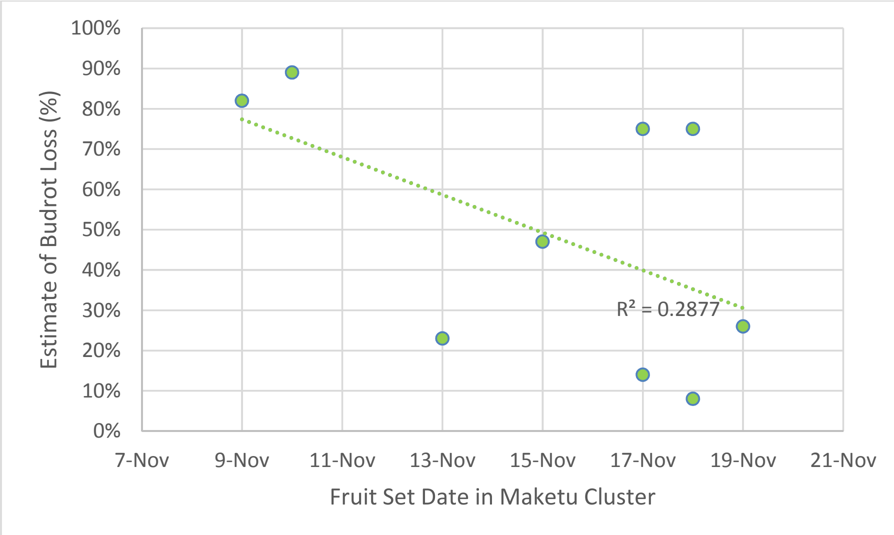
All of the orchards in the cluster are considered to be at risk of frost damage. All have frost protection, which was used between 4 and 13 times during the spring of 2012. Six of the orchards have overhead sprinklers for frost protection and three use wind (either helicopters, a windmill or both). There was a difference in the budrot loss suffered by those using wind (16%) or using water (65%) for frost protection but this difference was not shown to be statistically significant.



Green14 Maketu cluster methods of frost protection.

Date of fruit set

Fruit set occurred between the 9th and the 22nd of November 2012. There is a slight relationship (R^2 = 0.29) between earlier fruit set date and a higher level of budrot loss. This may be because the earlier flowering dates coincided with a period of cold, wet weather in early November 2012.



Green14 Maketu cluster relationship between budrot and fruit set date.

Crop protection programme

The crop protection programme used by the growers varied. A summary of the products applied from 1 January 2012 to harvest 2013 is presented in a table at the end of this section. As occurred for the whole Green14 group, there was no significant relationship between specific sprays applied in the crop protection programme and the level of budrot experienced.

Relationship between crop protection and weather events

None of the orchards in the cluster are considered to have followed the recommended programme for protecting their orchards from Psa. In particular, there was no copper cover in place, on any of these orchards, from January 2012 through to the 2012 harvest.
For the growers within this cluster who have kept records, budburst occurred in late August, early September. From budburst until flowering, the time when budrot occurred, this location experienced 19 rain days (rainfall >1mm) and 8 periods when temperatures fell below 1°C. Both low temperature and rainfall are considered to be risk factors with respect to Psa infection and therefore the protective cover that growers have on their vines prior to these events is considered to be important. These rain days and periods of cold have been grouped into 15 weather events that could have impacted on vine health.

Spray diaries have been analysed in relation to these key events to determine whether growers within the Maketu cluster had Psa protectant cover in place for the event. The length of time a product will provide protective cover is unknown. Factors such as the product type, the use of surfactants, spray application, the weather and also crop growth all impact. For the purposes of this analysis we have taken a proxy for "appropriate cover" during this period of fast leaf expansion as a copper product applied within 2 weeks of a rainfall or frost event. Ideally, cover should also be in place following vine management activities. Grower records (or survey tedium) of timing of these activities were insufficient to undertake this analysis.

There was no grower who maintained 100% cover for these weather events. The nearest result was a grower who had cover in place for 10 of the 15 events. This grower had a low level of budrot loss but the grower with the lowest level of loss only had cover in place for 1/3 of the events. There was no statistical relationship found between number of times that a grower had cover in place for these weather events and budrot loss.

Specific sprays – Copper

Amongst this cluster the first copper was applied on the 29th of April 2012, that is, from 1 January 2012 through the autumn of 2012 there was no copper protective cover on any orchard. There is no statistical significance however between the number of copper sprays applied or the date of the first copper spray and budrot loss.

Specific sprays – Actigard

Five of the orchards had Actigard applied in the spring of 2011. There was no difference in the budrot loss between these orchards and those that did not apply Actigard. During the spring of 2012 again five growers applied Actigard, one applying it twice. There is again no difference in the level of budrot loss suffered as a result of this application. Only two growers applied Actigard in both years, again, this did not have a significant impact on budrot loss either way.

Specific sprays – Antibiotic

Five growers applied an antibiotic in the spring of 2012, again there is no statistically significant reduction in budrot as a result.

Specific sprays – Biologicals

Three growers applied biologicals to protect against Psa by applying Plant Shield and TripleX. These growers had a slightly higher, though not significantly higher level of budrot loss.

Specific sprays – Fungicides

Three of the growers applied a fungicide around fruit set. This did not impact on the level of budrot experienced.

Specific sprays – Other materials

Other products applied included ExStinkt, Spotless and Sporekill. The grower who applied the ExStinkt (3 applications) experienced the lowest level of budrot amongst this cluster. This grower also applied 7 coppers, 1 antibiotic and 2 Actigard sprays as protection against Psa.

Pre-harvest fruit drop

Only 2 of the 9 growers reported pre-harvest fruit drop and both described it as minimal.

Budrot %	Fruitset Date	# copper sprays 1 Jan 2012 - Fruitset Date in Nov 2012	Date of copper spray 1	# Antibiotic sprays 1 Jan 2012 - Fruitset Date	# Elicitor sprays Actigard 1 Jan 2012 - Fruitset Date	Date of Actigard spray 1	# of non ACVM protectants 1 Jan 2012- fruitset date	Name of non ACVM protectant	# Biological sprays 1 Jan 2012 - Fruitset Date	Name of biological sprays 1 Jan 2012 - Fruitset Date	# Fungicide sprays 1 Jan 2012 - Fruitset Date	Name of fungicide sprays 1 Jan 2012 - Fruitset Date	# of frost protection sprays	Actigard Applied in the Previous Spring
8	18-Nov	7	20-Jul	1	2	30-Oct	3	ExStinkt	0		0		0	No
14	17-Nov	5	24-Aug	0	1	19-Oct	0		0		0		0	Yes
23	13-Nov	6	9-Jun	0	1	23-Oct	1	Spotless	3	Plant Shield	1	Flint	0	No
26	19-Nov	2	13-Sep	1	0		0		0		0		0	Yes
47	15-Nov	4	29-Apr	1	0		0		0		1	Flint	0	Yes
75	18-Nov	5	29-Apr	2	0		1	Sporekill	1	TripleX	0		0	Yes
75	17-Nov	3	1-Sep	0	1	5-Nov	0		0		0		0	No
82	9-Nov	4	22-Aug	0	0		0		0		0		0	No
89	10-Nov	7	26-May	1	1	20-Oct	1	spotless	6	Plant Shield	1	Flint	0	Yes

Green14 Maketu cluster summary of crop protection programme.

Whakatane Cluster

Description

This cluster consisted of 6 orchards concentrated around the Edgecumbe and Te Teko. The area in Green14 on these orchards is 13.18 hectares.

Budrot losses ranged from 2% to greater than 75% and averaged 53%. The orchard suffering the low level of 2% loss was an outlier statistically. Two of these orchards have previously had problems with budrot prior to Psa being found in New Zealand in 2010. All of the orchards are at elevations of 18 masl or below.

All of the orchards, by virtue of their location are considered to be "High Risk" in terms of Psa infection. That is, these orchards are in a KVH recovery zone and they have Psa susceptible vines either within their orchard or neighbouring their orchard.

Five of the orchards are conventional blocks grafted onto Bruno rootstock and trained on Pergola structures. One grower was unaware of what rootstock they had. All orchards are described as having a flat topography.

Four of the 6 growers identified either cold or frost as a seasonal weather event that impacted on their orchard during the 2012/13 growing season. One grower recalled a -5^{o}C frost.

Male vines and pollination

Four of the orchards have a strip male arrangement, one of these a strip male running East-West and the others two orchards had either patch males or a mix of both arrangements. This does not appear to have impacted on budrot losses.

Three orchards contained a mix of three male cultivars, King, M91 and M33. These orchards suffered on average 72% loss to budrot. This level of loss was significantly different from the one orchard with a mix of M91 and M56. There was no difference between either of these male mixtures and the average of the two growers who had a mix of M91 and M33. The mix of male cultivars on the properties is presented in the below:

Male Cultivar Mix	Number of Orchards (total = 6)	Average Budrot Loss (%)
King, M91 and M33	3	72%
M33 and M91	2	38.5%
M91 and M56	1	25%

Green14 Whakatane cluster male mix.

Growers within the cluster typically pruned their males once after flowering. There were two orchards where the males pruned more intensively. There appears to be no statistical difference between different male pruning practices between either of these groups of orchards.

The one grower who suffered the lowest level of budrot loss witnessed no Psa symptoms in their males during the season. Other growers observed symptoms ranging from leaf spotting to death. Two of the growers with high levels of loss (75%+) observed oozing in their M91.

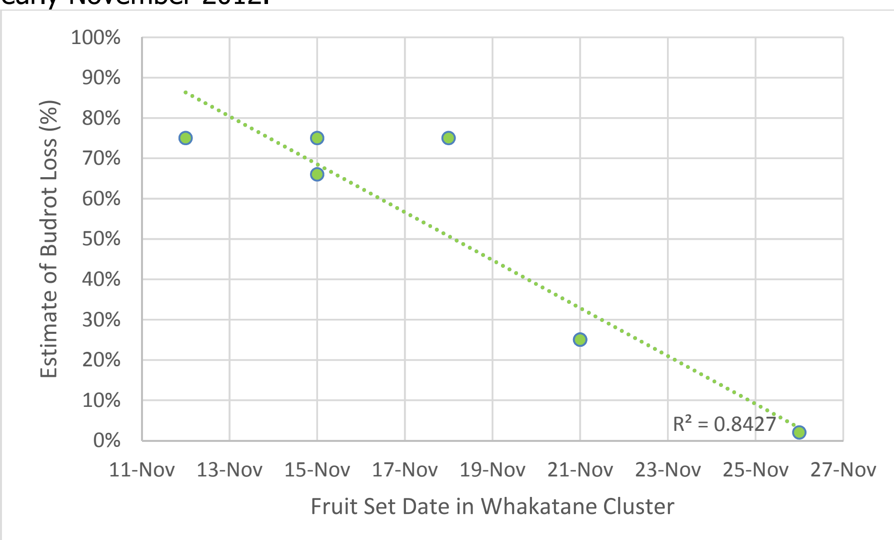
Half of these growers used artificial pollination, 1 applying wet pollen and the others applying dry pollen. There was no significant difference in the losses suffered by those applying pollen and those not using artificial pollination.

Frost and frost protection

All but one of the orchards in the cluster are considered to be at risk of frost damage. The one grower who suffered the least loss (2%) doesn't identify frost as an issue at all, has no frost protection and recalled no frost events on their orchard during the spring of 2012. Their orchard bounds the Rangitaiki River and may benefit from the river draining the frost from the orchard. Other growers within this cluster operated their frost protection systems (all overhead sprinklers) on between 2 and 12 times. One of these growers also applied Thermomax as they were concerned about the amount of water being applied to already waterlogged soils.

Date of fruit set

Fruit set occurred between the 12th and the 26nd of November 2012. There is a significant relationship (R^2 = 0.84) between earlier fruit set date and a higher level of budrot loss. This may be because the earlier flowering dates coincided with a period of cold wet weather in early November 2012.



Green14 Whakatane cluster relationship between budrot and fruit set date.

Crop protection programme

The crop protection programme used by the growers varied. A summary of the products applied from 1 January 2012 to harvest 2013 is presented at the end of this section. As occurred for the whole Green14 group, there was no significant relationship between specific sprays applied in the crop protection programme and the level of budrot experienced.

Relationship between crop protection and weather events

None of the orchards in the cluster are considered to have followed the recommended programme for protecting their orchards from Psa. For example only one grower had a no copper cover in place, from February 2012 through to the 2012 harvest.

For the growers within this cluster who have kept records, budburst occurred between the 9th and the 15th of September. From budburst until flowering, the time when budrot occurred, this location experienced 41 rain days (rainfall >1mm) and 12 periods when temperatures fell below 1°C. Both low temperature and rainfall are considered to be risk factors with respect to Psa infection and therefore the protective cover that growers have on their vines prior to these events is considered to be important. These periods of cold and wet have been grouped into 10 weather events.

Spray diaries have been analysed in relation to these key events to determine whether growers within the Whakatane cluster had Psa protectant cover in place for the event. The length of time a product will provide protective cover is unknown. Factors such as the product type, the use of surfactants, spray application, the weather and also crop growth all impact. For the purposes of this analysis we have taken a proxy for "appropriate cover" during this period of fast leaf expansion as a copper product applied within 2 weeks of a rainfall or frost event. Ideally, cover should also be in place following vine management activities. Grower records of timing of these activities were insufficient to undertake this analysis.

There was no grower who maintained 100% cover for these weather events. The nearest result was a grower who had cover in place for all but one of the events. This grower still had a high level of budrot loss. There was no statistical relationship found between number of times that a grower had cover in place for these weather events and budrot loss.

Specific sprays – Copper

Amongst this cluster the first copper was applied on the 28th of February 2012, on all other orchards, from 1 January 2012 through the autumn of 2012 there was no copper protective cover on any orchard. There is a trend (R^2 = 0.3) showing an increase in budrot loss with increasing number of copper sprays.

Specific sprays – Actigard

Two of the orchards had Actigard applied in the spring of 2011. There was no difference in the budrot loss between these orchards and those that did not apply Actigard. During the spring of 2012 three growers applied Actigard, one applying it twice. There is again no difference in the level of budrot loss suffered as a result of this application. Only one growers applied Actigard in both years to one, not all of their blocks, again, this did not have a significant impact on budrot loss either way.

Specific sprays – Antibiotic

Two growers applied an antibiotic in the spring of 2012, again there is no statistically significant reduction in budrot as a result.

Specific sprays – Biologicals

Four growers applied biologicals to protect against Psa by applying TripleX. There was no significant difference in the level of budrot between those orchards that did or did not use biologicals.

Specific sprays – Fungicides

None of the growers applied a fungicide around fruit set.

Specific sprays – Other materials

Other products applied included Thermomax. One grower applied this twice in mid-September and early October to coincide with two periods of cold temperatures. One applied Sporekill in a mix with a Liquicop spray on the 22nd of September. There was no significant difference in the level of budrot suffered by these or other growers.

Pre-harvest fruit drop

None of these growers reported pre-harvest fruit drop.

Budrot %	Fruitset Date	# copper sprays 1 Jan 2012 - Fruitset Date in Nov 2012	Date of copper spray 1	# Antibiotic sprays 1 Jan 2012 - Fruitset Date	Date of antibiotic spray 1	# Elicitor sprays Actigard 1 Jan 2012 - Fruitset Date	Date of Actigard spray 1	# of non ACVM protectants 1 Jan 2012-fruitset date	# Elicitor sprays BioAlexin 1 Jan 2012 - Fruitset Date	# Biological sprays 1 Jan 2012 - Fruitset Date	Biological sprays 1 Jan 2012 - Fruitset Date	# Fungicide sprays 1 Jan 2012 - Fruitset Date	Notes e.g. thermomax spray	Date applied 1	Date applied 2
75	12-Nov	9	28-Feb	0		1	28-Oct	0	0	1	Triple X	0			
75	12-Nov	8	12-Aug	0		1	28-Oct	0	0	0		0			
66	15-Nov	3	11-Sep	1	3-Oct	0		0	0	0		0			
66	15-Nov	3	11-Sep	1	3-Oct	0		0	0	0		0			
66	15-Nov	4	11-Sep	1	3-Oct	0		0	0	0		0			
66	15-Nov	4	11-Sep	1	4-Oct	1	12-Jan	0	0	1	Triplex	0			
66	15-Nov	5	11-Sep	1	3-Oct	2	12-Jan	0	0	2	Triplex	0			
2	26-Nov	2	7-Sep	0		0		0	0	0		0			
25	21-Nov	3	11-May	0		0		0	0	2	TripleX	0	Thermomax	13/09/2012	2/10/2012
75	18-Nov	5	4-Sep	1	12-Oct	1	5-Oct	0	0	2	TripleX	0			
75	15-Nov	7	20-Jul	0		0		0	0	0		0			

Green14 Whakatane cluster summary of crop protection programme.

Katikati Cluster

Description
This cluster consisted of six orchards concentrated around Katikati and into Waihi. Budrot losses ranged from 0% to 7% and averaged 3%. One of these orchards previously had problems with budrot prior to Psa being found in New Zealand in 2010.

All of the Katikati orchards are at elevations between 10 and 50 masl, while the Waihi orchard is relatively high elevation at 128 masl.

All of the orchards, by virtue of their location are considered to be either "Moderately High" or "High Risk" in terms of Psa infection. That is, these orchards are in a KVH recovery zone and they have Psa susceptible vines either within their orchard or neighbouring their orchard.

4 of the 6 growers identify either cold or frost as having been a seasonal weather event that impacted on their orchard during last growing season.

All the orchards are conventional blocks and 5 are grafted onto Bruno rootstock. One orchardist believes that they have some *Actinidia chinensis* rootstock still in their block, however this has not impacted on budrot loss suffered by this grower.

Half the orchards are described as being flat and half as having gently sloping topography. There appears to be no statistical significance in the amount of budrot loss experienced as a result of topography.

Male vines and pollination
Four of the orchards have males planted in a patch arrangement, one has typical North-South strip males and one has strip males running East-West. It appears that there is a higher level of budrot in the orchards that are planted in the patch male arrangement. This is similar to the analysis of the wider population but differs for the result from the Maketu cluster.

All of the orchards had M91 males. One orchard did have some Bruce males in their orchard that they removed in 2012 but these males do not appear to have impacted on budrot loss.

Male Cultivar Mix	**Number of Orchards (total = 6)**	**Average Budrot Loss (%)**
M91 only	1	7%
King, M91 and M56	3	2%
CK2, King, M91, M56 and Chieftan	1	0%
M33, M91, M56 and Bruce (removed during 2012)	1	2%

Green14 Katikati cluster male mix.

Only one of the growers witnessed any symptoms of Psa in their male vines. This grower noted oozing on their M91 vines, possibly vines that are on Chinensis rootstock. This grower experienced 7% budrot loss which is the highest in the Katikati cluster, although is not high when compared to the whole Green14 data set.

All but one of the growers pruned their males relatively intensively. These growers pruned their males during winter, just prior to flowering and then straight after flowering. One grower pruned their males only the once with a hard prune straight after flowering. Neither strategy impacted on budrot loss.

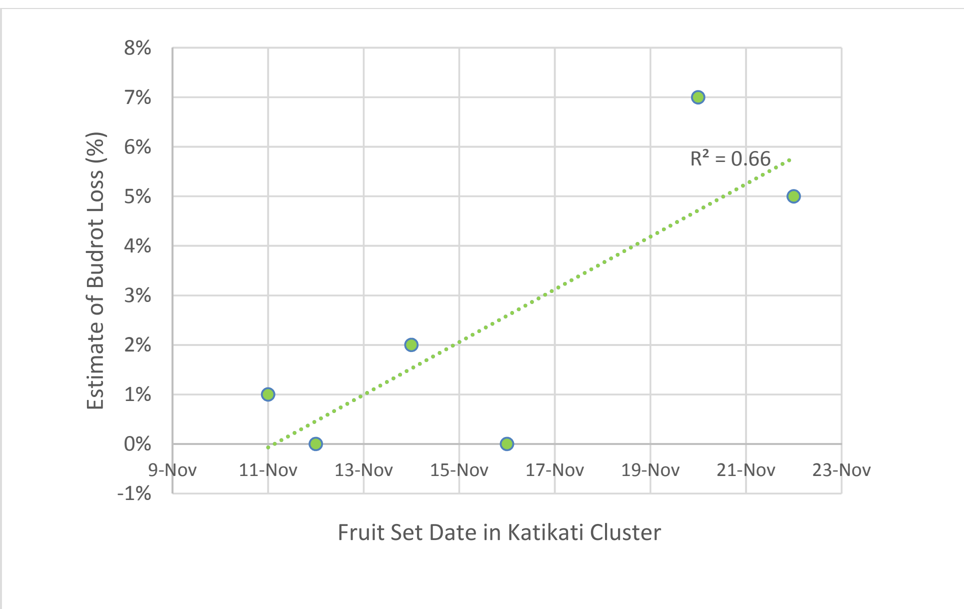
Artificial pollination was used by only two of the growers in this cluster. One grower used wet pollen while the other used dry pollen. The grower using the wet pollen experienced the highest level of budrot.

Frost and frost protection

Four of the orchardists within the cluster comment that they have pockets on their orchard that are prone to frost damage with the Waihi orchard being slightly more prone. Two of the growers commented that the G14 blocks are not at risk of frost at all. One grower used their overhead frost protection three times during the spring of 2012. One grower used their windmill four times and another applied low biuret urea and used their diesel burners six times. None of these frost protection strategies have impacted on budrot losses.

Date of fruit set

Fruit set occurred between the 11th of November and the 22nd of November. There is a relationship (R^2 = 0.66) between fruit set date and level of budrot loss. The two growers with the higher levels of budrot loss set fruit during an extended period of rain. On the 12th of November a period of 5 or 7 rain days occurred, depending on the weather station, which resulted in between 28 and 40 mm of rainfall.



Green14 Katikati cluster relationship between budrot and fruit set date.

Crop protection programme

The crop protection programme used by the growers varied. A summary of the products applied from 1 January 2012 to harvest 2013 is presented at the end of this section. As occurred for the whole Green14 group, there was no significant relationship between specific sprays applied in the crop protection programme and the level of budrot experienced.

Relationship between crop protection and weather events

None of the orchards in the cluster are considered to have followed the recommended programme for protecting their orchards from Psa. In particular, only one grower applied a copper in January of 2012 but then applied no further coppers until September. Other growers within the cluster applied between 2 and 7 coppers but these were not applied until, at the earliest 15 June 2012, and at the latest, 24 September. One of these orchards that did not have a 2011/12 spray diary, so records only start from after the 2012 harvest. For the growers within this cluster who have kept records, budburst occurred in early September. From budburst until flowering, the time when budrot occurred, this location experienced 39 rain days (rainfall >1mm) and 4 periods when temperatures fell below 1°C. Both low temperature and rainfall are considered to be risk factors with respect to budrot infection and therefore the protective cover that growers have on their vines prior to these events is considered to be important. These rain days and periods of cold occurred intermittently and cannot be grouped into weather events as clearly as those affecting the Maketu Cluster.

Spray diaries have been analysed in relation to these key events to determine whether growers within the Katikati cluster had Psa protectant cover in place for the event. There was no grower who maintained 100% cover for these weather events.

Specific sprays – Copper

Amongst this cluster the first copper was applied on the 7th of January 2012 on one orchard. For all but this orchard, from 1 January 2012 through the autumn of 2012 there was no copper protective cover. However, there is no statistical significance between the number of copper sprays applied or the date of the first copper spray and budrot loss.

Specific sprays – Actigard

Three of the orchards had Actigard applied in the spring of 2011. There was no difference in the budrot loss between these orchards and those that did not apply Actigard. During the spring of 2012 four growers applied Actigard, three applying it twice. There is again no difference in the level of budrot loss suffered as a result of these applications.

Specific sprays – Antibiotic

Three growers applied an antibiotic in the spring of 2012, again there is no statistically significant reduction in budrot as a result.

Specific sprays – Biologicals

One grower applied biologicals to protect against Psa by applying Blossom Bless over flowering. This did not impact on budrot losses.

Specific sprays – Fungicides

Two of the growers applied a fungicide around fruit set. This did not impact on the level of budrot experienced.

Specific sprays – Other materials

The only other product applied was Spotless which was applied by one grower. This application did not impact on budrot levels.

Points to follow up
Key recommendations

Pre-harvest fruit drop

All of the growers reported pre-harvest fruit drop but described it as minimal except for one who quantified the loss to be around 1,200 trays per hectare.

Budrot %	Fruitset Date	# copper sprays 1 Jan 2012 - Fruitset Date in Nov 2012	Date of copper spray 1	# Antibiotic sprays 1 Jan 2012 - Fruitset Date	Date of antibiotic spray 1	# Elicitor sprays Actigard 1 Jan 2012 - Fruitset Date	Date of Actigard spray 1	# of non ACVM protectants 1 Jan 2012- fruitset date	Name of non ACVM protectant	# Elicitor sprays BioAlexin 1 Jan 2012 - Fruitset Date	Date of BioAlexin spray 1	# Biological sprays 1 Jan 2012 - Fruitset Date	Name of biological sprays 1 Jan 2012 - Fruitset Date	Date of biological spray 1	# Fungicide sprays 1 Jan 2012 Fruitset Date
0	12-Nov	3	7-Jan	0		0		0		0		0			
0	16-Nov	7	17-Aug	2	11-Oct	1	27-Oct	0		0		0			
1	11-Nov	6	1-Jul	2	24-Sep	2	3-Oct	0		0		1	Blossom Bless	2-Nov	
2	14-Nov	3	15-Jun	0		2	21-May	1	Spotless	0		0			
5	22-Nov	4	24-Sep	1	24-Oct	0		0		0		0			
7	20-Nov	4	26-Aug	0		2	24-Sep	0		1	7-Nov	0			

Green14 Katikati cluster summary of crop protection programme from 1 January 2012 to fruit set date 2012.

Appendix 6 Pictogram of Weather Events in Key Locations

Legend

Rain		Minimum Temperature
< 1mm		1 to 2
1mm-10mm		0 to 1
11mm- 30mm		- 1 to 0
31m +		< -1.0

	Maketu 2012		**Katikati 2012**		**Whakatane 2012**	
Date	rainfall	temp	rainfall	temp	rainfall	temp
1-Sep						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
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21						
22						
23						
24						
25						
26						
27						
28						
29						
30						

	Maketu 2012		Katikati 2012		Whakatane 2012	
Date	rainfall	temp	rainfall	temp	rainfall	temp
1-Oct						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
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23						
24						
25						
26						
27						
28						
29						
30						

	Maketu 2012		Katikati 2012		Whakatane 2012	
Date	rainfall	temp	rainfall	temp	rainfall	temp
1-Nov						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
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Appendix 7 Green14 Crop Protection Programme

The Psa protection programme used by the growers varied with a range of products being used, from KeyStrepto, Actigard, various copper products to Blossom Bless.

A summary of the products applied from 1 January 2012 to harvest 2013 and whether a spring Actigard in late 2011 was part of the growers vine protection programme is presented at the end of this narrative.

Varied Approaches

Growers also appear to have had informal trials of their own going with different levels of protection apparent between blocks on the same orchard. For example three growers applied a spring Actigard in late 2011 to blocks that they also applied copper to over January/February 2012. On each orchard, G14 blocks that they did not apply Actigard to in spring received no copper until September 2012. A marked difference in treatment. No differentiation of level of budrot to those blocks was reported by the growers though all were in the 0-2% range. One orchard was located in Mid Te Puke where maximum budrot levels in G14 were 34%, the other two were in Katikati and Pukehina where budrot levels were below 5%.

Actigard

Actigard was applied to about half of our participating orchards/blocks over November/December 2011. There was no significant difference in budrot between the groups with levels of budrot ranging from zero to over 80% for both groups.
In 2012 Actigard application began in January with four blocks receiving Actigard in that month. There was then a break in Actigard application to after harvest with four blocks receiving Actigard in May and June. The main Actigard application season ran from late September to early November. Almost half the blocks received at least one Actigard. Application of Actigard at anytime over any number of applications had no impact on the level of budrot with all groups showing both high and low levels of budrot. NB only two blocks made three Actigard applications we only had a budrot record for one which was 49%.

Copper

Copper application also varied. Only outside of the Bay of Plenty, in Whangarei and Wanganui, were no copper sprays applied. One grower in Te Puke applied just one copper spray in mid-October to one block, which appears to be the only protection applied to the block between 1 January and fruit set 2012. It seems that block missed out on an earlier spray applied to the growers other blocks in mid-August. Budrot on that orchard was 34%. Ten blocks began their copper spray programme over January/February 2012. Of those ten blocks five blocks from two orchards did second copper spray before the end of February. The remaining orchards that applied copper began their copper programme after harvest with the first copper spray being applied on or after 29 April 2012. The number of copper sprays applied bore no relation to the level of budrot experienced on the block. Many of the early starters had low bud rot, but two did not. The blocks both with 75% bud rot are in the Whakatane supply area, one applied 5 copper sprays the other 10 sprays before fruit set 2012. It is noticeable that those who started early then stopped spraying after April. They did not re-start their copper spraying until August or September, after which seven of the ten applied 7-10 sprays over the total period.

Antibiotic

31 blocks had two antibiotic applications, 22 blocks had one antibiotic application and the remaining 48 blocks were not sprayed with antibiotics. Again there is no correlation between antibiotic sprays and incidence of budrot with high budrot blocks featuring in all groups.

Growers are innovative people who will try different things to solve a problem, so there was some use of products not intended for Psa protection but which growers felt it was worth applying in the hope that it might make a difference. Those products may have made some difference to overall Psa inoculum levels or vine infection status, but none made any difference to budrot on the blocks we looked at. In this group of products we found Spotless, Sporekill and Extinkt being used by growers. These products were used on 19 blocks across 6 KPIN'S. 1 grower used Spotless in January over 9 of his G14 blocks all were recorded as 28% budrot, including 2 blocks that were not sprayed with Spotless. One grower used Sporekill as a single application in September 2012 on two blocks, and had 75% budrot. Extinkt was used by one grower, three applications, each one week apart, in February on two blocks and recorded 8% budrot. Other growers using spotless recorded budrot levels between 0% and 89% from applications in either September or November, with a maximum of two applications on just one property.

Biologicals

Four biological sprays were used by growers for the purpose of Psa protection from 1 January to fruit set. They were, TripleX, Plant Shield, Serenade Max and Blossom Bless. Serenade Max is a strain of Bacillus Subtillus manufactured by Bayer. Blossom Bless is a bacterium (*Pantoea agglomerans* P10c) preparation for foliar application to pipfruit flowers for use as protection against fire blight, TripleX is based on *Bacillus Amyloliquefaciens* and Plant Shield utilises the hybrid fungus *Trichoderma harzianum*, strain T-22.

Growers largely either applied biologicals in January/February or September to November. Ten KPIN's applied either TripleX or Plant Shield in either January or February. One of those growers continued with approximately monthly applications of Plant Shield through to early April. Applications over January/February ranged from one to four. For six of those ten growers that was the extent of their application of biological products to their vines. Later in the year in a further four growers took up biological sprays to try to protect their vines, making a total of eight growers using the full range of biological products. The maximum number of biological sprays applied over this end of year period was three, but including early year applications on one property vines on two properties were sprayed six or seven times. Both of these orchards are part of multi-block properties and in both cases only one block received the full number of applications. We do not know if this was in response to observed conditions in the orchard or part of an organised trial of products by the grower.

All of those growers who are in a Psa area and for whom we have a budrot estimate and who applied biological products early in the year had budrot between 28 and 89%. Growers who only applied biologicals later in the year experienced bud rot between 0 and 63%. In the light of these results it appears that none of the biological products being used by growers during 2012 was effective in controlling budrot in G14 kiwifruit.

Fungicide

Would a fungicide assist in controlling budrot in G14 kiwifruit? 14 growers applied a fungicide between 2 and 28 November to 35 blocks. All but two of these were Flint. Ippon was used by the other two growers. Whether a fungicide was used or not made no difference to the incidence of budrot on the blocks we have information for. There was high and low budrot for both groups.

Frost Protection Sprays

Chemical frost mitigation agents, low biuret urea and Thermomax, a bio-dynamic preparation, were used by four growers on 10 blocks of G14 kiwifruit from 12 September to 2 October. On these blocks the maximum budrot was 25%. Low biuret urea was also used in April by one grower. It appears to have been utilised as a foliar fertiliser (34% budrot). Statistical analysis indicates that the chemical frost protectants were effective in controlling budrot and there is evidence for cold as a predictor of budrot in Hayward, (Everett K and W Henshall, Plant and Food Research in a presentation to the Research Update Meeting 21 August 2013). It is however a very small sample group, 4 growers, 10 blocks, and the work done on Hayward indicated low temperatures in the 10 days before flowering. The dates of the frost protectant applications on the G14 orchards indicates protection of new vegetative buds at bud burst not flower buds later in the season.

As individual agents, only the frost mitigants were statistically significant in reducing budrot, but the sample group is very small and the spray application would appear to have been applied too early in the season to assist with flower budrot.

Would a combination of products assist in reducing budrot on G14 orchards?

As already noted growers vine protection programmes from block to block varied considerably, but the recorded level of budrot did not. For example one grower had a light programme on one block of two coppers a Plant Shield and a Flint, in Te Puke, and recorded 63% budrot alongside blocks with 8-10 copper sprays, Streptomycin and Actigard. Another grower in Te Puke recorded one block with just three copper sprays through the season and no other spray applications alongside blocks with up to 10 copper sprays, streptomycin and Actigard and 2% budrot. The pattern of no pattern continues between orchards with some with high inputs having high or low budrot (1-63%) and orchards with low inputs having up to 34% budrot.

In conclusion our data indicates that there is no one chemical or combination of chemicals that will assist growers in controlling budrot in G14 orchards.

Supply Area	Budrot %	Block(s)	Fruitset Date	# copper sprays 1 Jan 2012 - Fruitset Date in Nov 2012	Date of copper spray 1	# Antibiotic sprays 1 Jan 2012 - Fruitset Date	Spring 2011 Actiguard Applied	# Elicitor sprays Actigard 1 Jan 2012 - Fruitset Date	Date of Actigard spray 1	# of non ACVM protectants 1 Jan 2012- fruitset date	Name of non ACVM protectant	# Biological sprays 1 Jan 2012 - Fruitset Date	Biological sprays 1 Jan 2012 - Fruitset Date	# Fungicide sprays 1 Jan 2012 - Fruitset Date	Fungicide sprays 1 Jan 2012 - Fruitset Date	# of thermomax spray
Katikati	0	3A	12-Nov	3	7-Jan	0	Yes	0		0		0		0		0
Katikati	0	3	12-Nov	2	7-Sep	0		0		0		0		0		0
Katikati	0	5	14-Nov	3	15-Jun	0	Yes	2	21-May	1	Spotless	0		0		2
Katikati	0	6	14-Nov	2	31-Aug	0	Yes	2	21-May	1	Spotless	0		0		2
Whakatane	75	5	12-Nov	9	28-Feb	0		1	28-Oct	0		1	TripleX	0		0
Whakatane	75	7	12-Nov	8	12-Aug	0		1	28-Oct	0		0		0		0
Te Puke-Mid	2	A1	25-Nov	8	6-Sep	2	Yes	1	19-Oct	0		0		0		0
Te Puke-Mid	2	A2	25-Nov	10	24-Aug	2	Yes	1	19-Oct	0		0		0		0
Te Puke-Mid	2	B1	25-Nov	7	24-Aug	2		1	19-Oct	0		0		0		0
Te Puke-Mid	2	B2	25-Nov	7	24-Aug	2		1	19-Oct	0		0		0		0
Te Puke-Mid	2	C1	25-Nov	7	24-Aug	2		1	19-Oct	0		0		0		0
Te Puke-Mid	2	D	25-Nov	6	6-Sep	2		1	18-Oct	0		0		0		0
Te Puke-Mid	2	D1	25-Nov	3	6-Jan	0	Yes	0		0		0		0		0
Te Puke-Mid	2	E1	25-Nov	10	6-Sep	2	Yes	1	18-Oct	0		0		0		0
Te Puke-Mid	2	E2	25-Nov	9	6-Sep	2	Yes	1	18-Oct	0		0		0		0
Te Puke-Mid	2	J	25-Nov	6	28-Aug	1		0		0		0		0		0
Te Puke-Mid	2	L1	25-Nov	7	28-Aug	2		1	19-Oct	0		0		0		0
Te Puke-Mid	2	L2	25-Nov	6	28-Aug	2		1	19-Oct	0		0		0		0
Te Puke-Mid	2	M2B	25-Nov	9	6-Sep	2	Yes	1	17-Oct	0		0		0		0
Te Puke-Mid	2	M3	25-Nov	8	6-Sep	2	Yes	1	17-Oct	0		0		0		0
Paengaroa	82	13	9-Nov	4	22-Aug	0		0		0		0		0		0
Paengaroa	82	14	9-Nov	4	22-Aug	0		0		0		0		0		0
Paengaroa	82	16	9-Nov	4	22-Aug	0		0		0		0		0		0
Paengaroa	82	17	9-Nov	4	22-Aug	0		0		0		0		0		0
Paengaroa	82	14A	9-Nov	4	22-Aug	0		0		0		0		0		0
Waikato	0	4	23-Nov	5	15-Jun	0		0		0		0		0		0
Waikato	0	2a	23-Nov	8	15-Jun	1		1	5-Oct	0		0		0		0
Waikato	0	4a	23-Nov	1	21-Sep	0		0		0		0		0		0
Waikato	0	6	23-Nov	10	15-Jun	1		1	5-Oct	0		0		0		0

Supply Area	Budrot %	Block(s)	Fruitset Date	# copper sprays 1 Jan 2012 - Fruitset Date in Nov 2012	Date of copper spray 1	# Antibiotic sprays 1 Jan 2012 - Fruitset Date	Spring 2011 Actiguard Applied	# Elicitor sprays Actigard 1 Jan 2012 - Fruitset Date	Date of Actigard spray 1	# of non ACVM protectants 1 Jan 2012- fruitset date	Name of non ACVM protectant	# Biological sprays 1 Jan 2012 - Fruitset Date	Biological sprays 1 Jan 2012 - Fruitset Date	# Fungicide sprays 1 Jan 2012 - Fruitset Date	Fungicide sprays 1 Jan 2012 - Fruitset Date	# of thermomax spray
Whakatane	25	1	21-Nov	3	11-May	0	Yes	0		0		2	TripleX	0		2
Whakatane	25	2	21-Nov	3	11-May	0	Yes	0		0		2	TripleX	0		2
Whakatane	25	3	21-Nov	3	11-May	0	Yes	0		0		2	TripleX	0		2
Whakatane	25	4	21-Nov	3	11-May	0	Yes	0		0		2	TripleX	0		2
Maketu	23	1	12-Nov	6	26-May	2		0		0		6	Plant Shield	1	Flint	0
Maketu	23	2	13-Nov	6	9-Jun	0		1	23-Oct	1	Spotless	3	Plant Shield	1	Flint	0
Opotiki		26	22-Nov	6	21-Jul	1	Yes	0		0		4	Plant Shield	0		0
Opotiki		27	22-Nov	6	21-Jul	1	Yes	0		0		0		0		0
Opotiki		28	22-Nov	6	21-Jul	1		0		0		0		0		0
Opotiki		29	22-Nov	6	21-Jul	1	Yes	0		0		0		0		0
Pukehina	1	Purple	15-Nov	10	10-Feb	0	Yes	1	17-Oct	0		0		1	Flint	0
Pukehina	1	Orange	1-Dec	5	25-Sep	0		1	22-Oct	0		0		0		0
Tauranga	49	6	30-Nov	3	20-Aug	0	Yes	3	20-Jan	0		0		1	Flint	0
Tauranga	49	7	30-Nov	3	20-Aug	0	Yes	2	6-Jun	0		0		1	Flint	0
Whangarei	0	4C	17-Nov	0		0		2	24-Oct	0		1	Serenade Max	0		0
Whangarei	0	4D	17-Nov	0		0		2	24-Oct	0		1	Serenade Max	0		0
Whangarei	0	4E	17-Nov	0		0		2	24-Oct	0		1	Serenade Max	0		0
Whakatane	0	3	15-Nov	7	20-Jul	0		0		0		0		0		0
Paengaroa	26	G14	19-Nov	2	13-Sep	1	Yes	0		0		0		0		0
Tauranga	1	3A	15-Nov	2	13-Sep	0		2	5-Oct	0		0		1	Flint	1
Tauranga	1	3B	15-Nov	2	13-Sep	0		2	5-Oct	0		0		1	Flint	1
Tauranga	25	B2	22-Nov	4	4-Jun	0	Yes	1	2-Oct	0		0		0		0
Te Puke-Mid	34	A2b	15-Nov	1	19-Oct	0		0		0		0		0		0
Te Puke-Mid	34	B1	15-Nov	2	15-Aug	0		0		0		0		1	Flint	1
Te Puke-Mid	34	B2	15-Nov	2	15-Aug	0		0		0		0		1	Flint	1
Te Puke-Mid	34	B3	15-Nov	2	15-Aug	0		0		0		0		1	Flint	1
Paengaroa	63	2NP	17-Nov	10	23-May	2	Yes	1	20-Oct	0		7	Plant Shield	1	Flint	0
Paengaroa	63	3	17-Nov	2	25-Oct	0		0		0		1	Plant Shield	1	Flint	0
Paengaroa	63	4	17-Nov	8	8-Jun	2		1	20-Oct	0		3	Plant Shield	1	Flint	0
Paengaroa	63	5	17-Nov	10	23-May	2		1	20-Oct	0		3	Plant Shield	1	Flint	0

Supply Area	Budrot %	Block(s)	Fruitset Date	# copper sprays 1 Jan 2012 - Fruitset Date in Nov 2012	Date of copper spray 1	# Antibiotic sprays 1 Jan 2012 - Fruitset Date	Spring 2011 Actiguard Applied	# Elicitor sprays Actigard 1 Jan 2012 - Fruitset Date	Date of Actigard spray 1	# of non ACVM protectants 1 Jan 2012-fruitset date	Name of non ACVM protectant	# Biological sprays 1 Jan 2012 - Fruitset Date	Biological sprays 1 Jan 2012 - Fruitset Date	# Fungicide sprays 1 Jan 2012 - Fruitset Date	Fungicide sprays 1 Jan 2012 - Fruitset Date	# of thermomax spray
Paengaroa	63	8	17-Nov	8	23-May	0		1	20-Oct	0		3	Plant Shield	1	Flint	0
Katikati	5	3	22-Nov	4	24-Sep	1		0		0		0		0		0
Maketu	47	H1	15-Nov	4	29-Apr	1	Yes	0		0		0		1	Flint	0
Whakatane	66	1	15-Nov	3	11-Sep	1	Yes	0		0		0		0		0
Whakatane	66	4	15-Nov	3	11-Sep	1	Yes	0		0		0		0		0
Whakatane	66	5	15-Nov	4	11-Sep	1	Yes	0		0		0		0		0
Whakatane	66	10	15-Nov	4	11-Sep	1	Yes	1	12-Jan	0		1	TripleX	0		0
Whakatane	66	15	15-Nov	5	11-Sep	1	Yes	2	12-Jan	0		2	TripleX	0		0
Maketu	75	2	17-Nov	3	1-Sep	0		1	5-Nov	0		0		0		0
Maketu	75	3	17-Nov	3	1-Sep	0		1	5-Nov	0		0		0		0
Opotiki	0	1	20-Nov	2	18-Aug	0		0		0		1	Serenade Max	0		0
Opotiki	0	2	20-Nov	2	18-Aug	0		0		0		2	TripleX	0		0
Maketu	14	1	17-Nov	5	24-Aug	0	Yes	1	19-Oct	0		0		0		0
Maketu	14	2	17-Nov	5	24-Aug	0	Yes	1	19-Oct	0		0		0		0
Katikati	1	BB1	11-Nov	6	1-Jul	2		2	3-Oct	0		1	Blossom Bless	1	Flint	0
Katikati	1	BB2	11-Nov	7	1-Jul	2		2	3-Oct	0		1	Blossom Bless	1	Flint	0
Te Puke-Mid	28	A	17-Nov	4	24-May	2	Yes	1	26-Oct	1	Spotless	3	Plant Shield	1	Flint	0
Te Puke-Mid	28	AB	17-Nov	4	24-May	2	Yes	1	26-Oct	1	Spotless	4	Plant Shield	1	Flint	0
Te Puke-Mid	28	B	17-Nov	4	24-May	2	Yes	1	26-Oct	2	Spotless	4	Plant Shield	1	Flint	0
Te Puke-Mid	28	C	17-Nov	4	24-May	2	Yes	1	26-Oct	1	Spotless	4	Plant Shield	1	Flint	0
Te Puke-Mid	28	D	17-Nov	2	24-May	1		0		0		2	Plant Shield	0		0
Te Puke-Mid	28	E	17-Nov	4	24-May	2	Yes	0		1	Spotless	3	Plant Shield	1	Flint	0
Te Puke-Mid	28	FA	17-Nov	4	24-May	2	Yes	1	26-Oct	1	Spotless	4	Plant Shield	1	Flint	0
Te Puke-Mid	28	FB	17-Nov	4	24-May	2	Yes	1	26-Oct	1	Spotless	4	Plant Shield	1	Flint	0
Te Puke-Mid	28	G	17-Nov	4	24-May	2	Yes	1	26-Oct	1	Spotless	4	Plant Shield	1	Flint	0
Te Puke-Mid	28	H	17-Nov	4	24-May	2	Yes	1	26-Oct	1	Spotless	4	Plant Shield	1	Flint	0
Te Puke-Mid	28	J	17-Nov	4	24-May	2	Yes	1	27-Oct	0		6	Plant Shield	1	Flint	0
Maketu	89	1	10-Nov	7	26-May	1	Yes	1	20-Oct	1	Spotless	6	Plant Shield	1	Flint	0
Maketu	89	2	10-Nov	6	8-Jun	1	Yes	1	20-Oct	1	Spotless	6	Plant Shield	1	Flint	0
Maketu	75	3	13-Nov	6	26-May	1	Yes	1	20-Oct	1	Spotless	6	Plant Shield	1	Flint	0

Supply Area	Budrot %	Block(s)	Fruitset Date	# copper sprays 1 Jan 2012 - Fruitset Date in Nov 2012	Date of copper spray 1	# Antibiotic sprays 1 Jan 2012 - Fruitset Date	Spring 2011 Actiguard Applied	# Elicitor sprays Actigard 1 Jan 2012 - Fruitset Date	Date of Actigard spray 1	# of non ACVM protectants 1 Jan 2012- fruitset date	Name of non ACVM protectant	# Biological sprays 1 Jan 2012 - Fruitset Date	Biological sprays 1 Jan 2012 - Fruitset Date	# Fungicide sprays 1 Jan 2012 - Fruitset Date	Fungicide sprays 1 Jan 2012 - Fruitset Date	# of thermomax spray
Maketu	75	L1	18-Nov	5	29-Apr	2	Yes	0		1	Sporekill	1	TripleX	0		0
Maketu	75	L2	18-Nov	5	29-Apr	2	Yes	0		1	Sporekill	1	TripleX	0		0
Pukehina	13	1B	20-Nov	2	7-Sep	0	Yes	0		0		0		1	Flint	0
Waihi		3	20-Nov	4	26-Aug	0	Yes	2	24-Sep	0		0		0		1
Waihi		4	20-Nov	4	26-Aug	0	Yes	2	24-Sep	0		0		0		1
Poverty Bay	0	West	3-Nov	2	7-Sep	0	Yes	0		0		1	Plant Shield	1	Ippon	0
Katikati	0	10	16-Nov	7	17-Aug	2		1	27-Oct	0		0		1	Flint	0
Wanganui	1	C	25-Nov	0		0		0		0		0		0		0
Te Puke-low		4B	8-Nov	8	13-Jul	0	Yes	3	5-Oct	0		0		1	Ippon	0
Whakatane	75	4	18-Nov	5	4-Sep	1		1	5-Oct	0		2	TripleX	0		0
Whakatane	2	4A	26-Nov	2	7-Sep	0		0		0		0		0		0
Maketu	8	1a	18-Nov	7	20-Jul	1		2	30-Oct	3	ExStinkt	0		0		0
Maketu	8	1b	18-Nov		20-Jul	1		2	30-Oct	3	ExStinkt	0		0		0