BLUEBERRY INTEGRATED FRUIT PRODUCTION MANUAL

Blueberries New Zealand - Version 1. September 2019

Contents

1.0 INTRODUCTION

The following information supporting Integrated Pest Management (IPM) in the blueberry industry has been developed by Blueberries NZ. IPM is encouraged primarily with a view to support environmentally and economically sustainable production of blueberries for both local and export markets. It is also recognised there is increasing desire by consumers internationally for healthy and safe food that has been grown with minimal impact on the environment and known providence.

It is recognised that NZ blueberry growers are a low user of agrichemicals and applying no sprays remains a practice for a significant number of growers. However, this cannot always be the case when accessing export markets as there are key pests of concern that need to be more stringently controlled. Targeting pests of concern at appropriate times, minimising applications and using products with the least adverse impacts demonstrates a responsible approach to pest control via IPM.

While one of the focuses for implementing is ensuring access to export markets, Blueberries NZ encourages all growers to apply IPM principles.

2.0 IPM

The UN's Food and Agriculture Organization defines IPM as "the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimize risks to human health and the environment. IPM emphasizes the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms”

IPM principles can be broadly divided into 3 categories

- Prevention – understanding potential problems and what may increase or decrease the likelihood of occurrence and where possible using cultural and biological controls.
- Crop Monitoring/Decision Tools - Identifying when a problem is present.
- Intervention - Determining and applying the best course of action to deal with problems identified (cultural, biological, chemical).

As pest pressure varies from property to property and season to season, IPM is an approach to pest management that enables growers to apply the principles to their specific situation to avoid economic loss. IPM aims to use cultural, biological and chemical controls in a considered and targeted manner. It emphasizes cultural and biological control over chemical as well as prevention over cure. It aims to reduce the use of agrichemicals and improve safety to the grower and the environment.

3.0 IPM - TECHNIQUES USED IN BLUEBERRY PRODUCTION

Prevention strategies (including biological and cultural controls) will minimise infestations. Crop monitoring and decision-making tools in the form of thresh-holds and control options enable growers to make decisions regarding the most appropriate form on intervention. When chemical control is necessary IPM guidelines will recommend the use of selective chemicals with the least environmental impact.

3.1 PREVENTION

- **Use of resistant or tolerant cultivars** –
  - Using varieties and cultivars that are resistant to certain pests and diseases e.g. rust is the first step in avoiding the establishment of unwanted organisms . Using resistant varieties to replace older plantings is common practice. Appendix One provides collective industry knowledge from blueberry growers in NZ about the level of resistance of various blueberry varieties to rust during ripening.
  - Maintain healthy source blocks or ensure plants are healthy when sourced.
- **Orchard hygiene**
  - Using sterilisers such as Methylated spirits and Virkon for sanitising pruning equipment avoids transfer of fungal and bacterial diseases e.g. *Botryosphaeria.* Sterilisers must always be used according to manufacturer instructions.
  - Infected wood is pruned before fungal and bacterial diseases spread extensively. This also prevents spread between plants. Infected wood is pruned at least 15cm below a visible point of infection ensuring the full extent of the disease is captured. Any infected material (pruned) and debris is removed from the crop and burnt or removed from the property. This removes sources of inoculum that can cause new infections.
  - Remove alternate hosts for pests and diseases, such as stone fruit trees (a host for leafroller) in the immediate vicinity. *Tsuga sp* are an alternative host for rust so should also be removed, this may disrupt the life cycle of the rust.
  - Assisting the breakdown of overwintering leaf material that may harbour pests and diseases by applying 5% urea solution, Digester or such products assists with controlling diseases such as *Botrytis*.
- **Plant spacing and pruning**
  - Using appropriate plant spacings helps to create air flow and reduce humidity and drying times which creates an environment less conducive to pest and disease establishment such as Anthracnose and Botrytis.
  - Where possible, use drip irrigation instead of overhead irrigation. If overhead irrigation is used, apply when water will evaporate quickly so

plants are not wet for extended periods making the environment less conducive to for fungal growth.

- **Weed control**
  - Mulching and synthetic weeds mats are used to prevent weeds emerging. Weeds are manually removed via mowers, hand weeding and line trimmers. When herbicides are used, they are targeted for the weed species.
- **Preservation of habitats for beneficial insects**
  - Promote natural predators by planting insectaries in headlands. Plants such as Alyssum greatly extend in the lifespan of hoverfly adults, resulting in more eggs laid and more hunting juveniles in the field. Maintaining lacewings and ladybird populations can control aphids. Avoid use of broad-spectrum agrichemicals.
- **Monitor weather conditions, environment and use historical knowledge to make decisions regarding the application of protectant crop protection products**
  - At times, crop protection products will be applied to prevent development of a pest avoiding higher numbers of applications once the pest has established. For example, there are only two materials available in New Zealand that are active against bacterial diseases. Both these products are only effective in protecting against the disease becoming established, so they need to be applied after events creating disease entry points, such as hail storms and in the autumn at early leaf fall to protect leaf scars. Certain weather conditions are conducive to pest population growth e.g. fungal diseases will develop during wet and warm conditions.
  - All protectants need to be applied before the disease becomes established e.g. anthracnose. Where historical knowledge demonstrates the disease has been a problem before, spraying should start in early spring and continue over flowering at 7 to 10-day intervals, especially in wet springs.

3.2 SCOUTING

Undertaking crop scouting is with the intent of identifying all pests and diseases present and determining appropriate action, not just those with specific IPM interventions associated with them. Monitoring to identify problems in early stages of development by regular scouting and accurate pest identification allows for early detection and decisions as to the most appropriate action to take.

Although less structured in terms of timing, monitoring environmental and weather conditions is an important part of IPM monitoring with regard to pest and disease management. Following the principles of IPM any treatment of pests and diseases must be justified. At times, weather and environmental conditions are justification for intervention.

a) Training of Crop Scouts

Prior to undertaking any crop monitoring the scout must understand sample selection, sampling frequency, inspection technique, pest identification and how to record results. Section 3.2 provides guidance on how each of these should be approached. However, dependent on experience on crop monitors/scouts additional training may be beneficial.

Correct identification of a pest or disease is important for determining the most appropriate approach to treating the issue. It allows investigation of cultural controls options and/or the selection of an appropriate biological or crop protection control. It facilitates the selection of targeted chemistries that have the least impact on other insect populations and the orchard eco-system as a whole. The intention is to where ever possible use a crop protection product that targets the specific insect population.

Growers and their scouts should have on hand a copy of 'Identification of insects, diseases and disorders in New Zealand Blueberries' (Appendix 1). This provides a comprehensive list and description of the most common pest and disease issues for blueberries in New Zealand. Pests and diseases can also be sent for sampling when they are unable to be identified.

b) Number of blueberry bushes to be inspected during scouting

When determining the number of plants to be inspected during monitoring, the production area covered by the monitoring must first be defined. For the purposes of sampling a 'block' is defined as below.

Block: An area of land where the management practices and pest control regime are the same. This may be an entire property or the property may be split into more than one block.

Once the production area the block covers has been defined, establish the size of the block and using the table below determine how many plants must be inspected during scouting.

Size of scouted area	# of plants to be inspected
Up to 2 ha	20
Up to 3 ha	30
Up to 4 ha	40
Up to 5 ha	50

Table 1: minimum numbers of plants to be inspected when undertaking crop scouting.

For each plant selected five branches (either leaf or fruiting) must be thoroughly inspected from base to tip. These branches must be

selected from a range of places on the plant. See Section 3.2e for more detail on inspection technique.

c) Selection of blueberry plants to scout *(Sampling)*

Plants within a block must be selected to give confidence to the grower that they provide an accurate picture of what is happening in the field. There are two approaches to select plants for scouting, the marked tree and the repeat random methods. Either method is valid, but a grower must stick with a sampling method once established.

The following sampling patterns should be followed unless there are specific requirements for a pest in Section 5.

i) Marked tree method

The required number of plants per hectare are randomly selected and tagged. These plants are then marked on a farm plan and are inspected each time crop scouting is carried out i.e. use the same plants each time scouting is undertaken.

ii) Repeat Random method

The required number of bushes are randomly selected each time scouting is done. Different, randomly selected trees are inspected each time crop scouting is carried out.

When selecting random plants it is important to select numbers randomly from both the numbers of rows within a block and the number of plants within the row.

c) How often to inspect blueberry bushes. *(Sampling Frequency)*

Selected trees (using either the marked tree method or repeat random method) are scouted at the frequency specified in the table below. If pest pressure and weather conditions dictate, scouting can be undertaken more frequently but not less frequently. The continued monitoring not only enables identification of any issues but also means the effectiveness of any treatments used can be evaluated.

SCOUTING FREQUENCY BASED ON PRODUCTION STAGE				
Pest	**Dormancy to bloom**	**Bloom to fruit set**	**Fruit Set to Harvest**	**Postharvest to Dormancy**
Scale	**4 – 6 weeks**	**Weekly**	**Weekly**	**6 weeks**
Thrips		**Weekly**	***Weekly**	***6 weeks**
Leaf rollers (traps)		**Weekly**	**Weekly**	
Leaf rollers (field)		**Weekly**	**Weekly**	
Mealy bug	**4 – 6 weeks**	**Weekly**	**Weekly**	**6 weeks**
Rust		**Weekly**	**Weekly**	
Botrytis		**Weekly**		
Botryosphaeria	**4 – 6 weeks**	**Weekly**	**Weekly**	**6 weeks**

Table 2 – Scouting frequency

** Scouting for thrips after fruit set does not require tapping of fruiting spurs. Looking for signs and symptoms such as bronzing, leaf curling and frass are more relevant during periods other than flowering.*

d) Equipment needed

10 - 30 x lens with backlight if possible
Recording sheet or electronic device
Clip board
Camera
Jars, Vials, Ampules, small bag (or something to collect insect pests)
Pest identification manual

e) Inspection Technique for Crop Scouting

The following inspection technique should be followed unless there are specific requirements for a pest in Section 5.

Generally carrying out crop scouting in the morning when it is cooler is recommended as some adult insects e.g. thrips may fly away more quickly when disturbed when is it warmer. Although, wet/dewy conditions may make scouting more difficult.

For each plant selected five branches (either leaf or fruiting) must be thoroughly inspected from base to tip including flowers and stems. These branches must be selected from a range of places on the plant.

Examine selected branches starting at the shoot tips. Typically, this is where there would see aphids and tip dieback caused by botrytis. Moving down the bush the older leaves and stems are to be examined for damage or signs of disease and the presence of pests or diseases.

Examine the whole plant for flagging caused by *Botrysophaeria* (See Blueberry Pest and Disease Manual) and general vigour.

Particular note should be made for the presence of ants on plants. An indication of a pest issue like mealy bugs, scale or aphids is the presence of ants on plants. Ants feed on the honeydew left by various pests and often the first sign a grower will see of those pests.

Signs and symptoms associated with specific pests are detailed in Section 5. The following are inspection techniques specific to individual pests.

Thrips: *During flowering* - For each plant selected, select 5 flowering stems and gently tap all the flower clusters of each flowering stem onto a white or black surface. This will dislodge thrips and make them visible. *During other growth periods* – look for typical signs and symptoms as specified in Section 5.3b.

Botrytis: For each plant selected, select 5 flowering stems and examine flowers for botrytis.

Mealy Bugs: *During fruiting* – Look under leaves and the calyx end of berries. *During other growth periods* - Ensuring to look under loose bark and in crevices will assist in finding any mealy bug present.

Leafrollers: *During overwintering* - Rabbiteye varieties often harbour overwintering populations on leaves that don't drop, and particular attention should be paid to these varieties when looking for signs and symptoms of leafroller.

During other growth periods - Checking the tips of new shoots for rolled leave assist in finding leafroller.

Rust: When looking for rust it is important to turn over leaves over and look for orange pustules on the underneath of the leave.

f) Recording Crop Monitoring/Scouting Results

Recording crop monitoring/scouting results in a consistent method enables easy review for decision making and review. This will enable growers to identify movement in pest populations and to make decisions as to appropriate actions to take. Consistent records may also be used to review any historical patterns.

An example of a form to be used for recording crop scouting results is included in Appendix 4.

3.3 INTERVENTION

a) General

Specific cultural, biological and chemical options are detailed under each of the pests covered in the Section 5 of this IPM Manual . In all instances cultural and biological controls will be considered in preference to using crop protection products.

Crop protection products will be used when deemed necessary based on monitoring and other factors. They will always be used in a considered manner. Action should be indicated and justified by a combination of field data and the grower's knowledge. For example, the Botrytis count may be low, but historical disease pressure and a forecast rain event would indicate that a preventive spray before the rain comes would be beneficial. Alternatively, the threshold may have been exceeded but a forecast of hot, dry weather and the growers understanding of their farm and cultivars may indicate only continued monitoring.

Considered use also involves avoiding spraying while bees are active. This is usually achieved by night spraying or organising with the bee keeper to remove the hive for the day of spraying. This is good practise for both insecticide and fungicide use as some fungicides have been shown to affect hive health.

In addition, considered use prioritises 'soft', narrow-spectrum insecticides over broad-spectrum ones. This helps maintain predator and pollinator levels in the field.

When crop protection products are used it is important to

- ensure the most appropriate pesticide is selected,
- use agrichemicals at the optimum time (when pest is most vulnerable),
- used a targeted pesticide rather than broad spectrum,
- use at recommended rates,
- ensure equipment is calibrated.
- rotate chemicals as much as possible to avoid resistance
- ensure your spray applicators is trained e.g. Growsafe certificate

b) Intervention thresh-holds during different production stages

Intervention thresh-holds are based on whether or not a pest/disease is present on any individual branch or flowering stem (whichever is appropriate). While total numbers of pests/diseases can be recorded, the thresh-holds for intervention are based on the total percentage of branches or flowering stems that have any number of the pest being scouted. e.g. if 40 trees are inspected on a 4 ha block and 6 canes are found to have scale present – this will equate to 15% so will initiate intervention appropriate to the market being supplied.

INTERVENTION THRESH-HOLDS				
Pest	**Dormancy to bloom**	**Bloom to fruit set**	**Fruit Set to Harvest**	**Postharvest to Dormancy**
Scale	**10%**	**5%**	**5%**	**10%**
Thrips		**5%**	**5%**	**10%**
Leaf rollers (traps		***10 or more moths in a trap**	***10 or more moths in a trap**	
Leaf rollers (field)		**10%**	**10%**	
Mealy bug	**10%**	**5%**	**5%**	**10%**
Rust		**See 5.5c**	**See 5.5c**	
Botrytis		**See 5.6c**		
Botryosphaeria	**0%** Presence = Hygiene Prune	**0%** Presence = Hygiene Prune	**0%** Presence = Hygiene Prune	**0%** Presence = Hygiene Prune

Table 2 *– Intervention Thresh-holds*
**where mating disruption is used this figure may trigger field inspection to determine whether intervention is required (see 5.1e)*

5.0 IPM GUIDELINES FOR INDIVIDUAL PESTS

The following section provides guidance on monitoring and treatment for specific pests of concern. Unless otherwise specified the sampling pattern, sampling frequency and inspection technique to follow will be as specified in Sections 3.2b, c, d and e.

5.1 Leafrollers including Light Brown Apple Moth

There are several species of leafroller caterpillars including including Light Brown Apple Moth *(Epiphyas postvittana),* Greenheaded Leafroller *(Planotortrix excessana)* and Brownheaded Leafroller *(Ctenopseustis obliquana)* that can damage blueberries. Trapping numbers in recent years have identified that Light brown Apple Moth (LBAM) is by far the most common of the leafroller species found in blueberries in the main growing regions. While the damage overall is slight, the contamination of leafrollers in export consignments can lead to total rejection of the consignment and the problem can therefore be very serious.

a) Introduction

There are several species of leafroller caterpillars including *Epiphyas postvittana* (Light Brown Apple Moth) that can damage blueberries. Trapping numbers in recent years have identified that Light brown Apple Moth (LBAM) is by far the most common of the leafroller species found in blueberries in the Waikato. While the damage overall is slight, the contamination of leafrollers in export consignments can lead to total rejection of the consignment and the problem can therefore be very serious.

b) Signs and Symptoms

Look for webbing and 'rolled' leaves. In spring, they often feed on new buds so look for rolled leaves and feeding damage on new growth. Later generations feed on ripened fruit. They may construct typical leaf rolls (nests) by webbing together leaves, a bud and one or more leaves, leaves to a fruit, or by folding and webbing individual mature leaves. During the fruiting season, they also make nests among clusters of fruits, damaging the surface and sometimes tunnelling into fruit. Eggs are flat and oval and laid in rafts. They are initially pale green but change to pale yellow prior to hatching.

Signs and Symptoms of leafroller		
 **Pupa - Light Brown Apple Moth (*Epiphyas postvittana)*** *Image: Todd M. Gilligan and Marc E. Epstein, TortAI: Tortricids of Agricultural Importance, USDA APHIS PPQ, Bugwood.org*	 **Moth (*Epiphyas postvittana)*** *Image: Blueberry Pest and Disease Manual 2018*	 **Leafroller webbing on fruit** *Image: Supplied by Blueberry Industry*
 **Leafroller webbing on blueberry leaves – note spots of black frass at bottom or photo** I*mage: Supplied by Blueberry Industry*	 **Leafroller webbing on blueberry leaves** I*mage: Blueberry Pest and Disease Manual 2018*	 **Eggs - Light Brown Apple** *Image: Department of Primary Industries and Water, Tasmania, Bugwood.org*

c) Sampling pattern if using pheromone traps

Pheromone traps

Pheromone lures are used to attract male moth to sticky traps. Traps are to be placed in the middle of a block with one trap per two hectares.

d) Inspection if using pheromone traps

Pheromone traps

The surface of the sticky traps are inspected for leaf-roller and light brown apple moth and the number of moths trapped is recorded. Visually breaking down the sticky trap makes it easier to count the number of moths.

e) Thresh-holds

i) Pheromone traps (without mating disruption)

If there are more than 10 moths per trap per week, control action is required.

Ii) Pheromone traps (with mating disruption)

The thresh-hold is different when mating disruption is used.

When mating disruption is used trap counts can overestimate the actual numbers of caterpillars in the field. In this situation, when 10 or more moths are found in a trap, signs of leaf roller as should be looked for by scouts and the decision to control will be based on field inspections. The threshold to trigger action from inspection is as below for visual signs and symptoms.

ii) Visual signs and symptoms

Thresh-hold for action is 10% i.e. presence of one or more on a cane.

f) Control Options

i) Cultural

There are currently no commercially available biological controls for mealybug in New Zealand.

ii) Biological

Mating disruption using pheromone dispensers can be used for management of leafrollers. Determine the number of dispensers used based on historical pest pressure and manufacturer's recommendations. Dispensers should be tied around a shoot near the top of the plant early in the season before the first flights of moths. Dispensers will normally last a full season. Dispensers should also be placed in surrounding areas and higher numbers should be placed

on the side of blocks from where the prevailing winds come, but otherwise distributed evenly throughout the block. This technique works best when large areas are treated, or in enclosed areas like tunnel houses. Refer to table Appendix 2.

iii) Chemical

Refer to table in Appendix 3.

5.2 MEALY BUGS

a) Introduction

This is a relatively rare pest of blueberries. Mealybugs overwinter in crevices beneath loose bark, emerging in spring. Generation time is about 8 weeks in mid-season and it may have three generations per year. It can cause quarantine issues by hiding in the calyx end of fruit, so early season control is important. The insect sucks sap and excretes honey dew on which sooty mould can grow. Heavy infestations can cause stunting of growth.

b) Signs and Symptoms

Heavy infestations of mealy bug can cause stunting, chlorosis, defoliation and wilting. Adults suck sap and excrete honey dew on which can cause the growth of sooty mould. Mealy bugs often produce a powdery white wax present in the leaf axils or other sheltered places on the plant. Eggs are laid and covered in cottony looking secretions except in the case of the long tailed mealy bug when live nymphs are born. The presence of ants around a blueberry plant's root system can be an indication that mealybugs may be present on blueberry roots.

Signs and Symptoms of Mealy Bug	
 **Mealy Bug on Blueberry** *Image: Blueberry Pest and Disease Manual 2018*	 **Adult Mealy Bug** *Image: Supplied by Blueberry Industry*

c) Thresh-holds

Time of year	Thresh-hold
Dormancy to bloom	10% or more of branches inspected have mealy bug present
Bloom to fruit set	5% or more of branches inspected have mealy bug present
Fruit set to harvest	5% or more of branches inspected have mealy bug present
Postharvest to dormancy	10% or more of branches inspected have mealy bug present

d) Control Options and Recommendations - Cultural/biological/chemical

i) Cultural

Where mealy bugs are present in small numbers, they can be squashed – other than that there are no cultural controls.

ii) Biological

There are currently no commercially available biological controls for mealybug in New Zealand.

iii) Chemical

It has been documented that after the use of broad spectrum chemicals a mealy bug infestation can get worse due to the predator populations being affected. Targeted chemistries can be found in Appendix 3. As with all crop protection products they should be used at recommended concentrations and frequencies.

5.3 THRIPS

a) Introduction

Thrips are found on blueberry leaves and flowers. They damage leaves, flowers and fruit through feeding and egg laying, creating wounds that are susceptible to fungal disease. They can also be seen on new flowers, feeding on the petals and especially pollen and flower structures. Flower thrips may feed on pollen, which can lead to fruit abortion. These types of feeding injuries can initiate major yield losses. Additionally, females lay eggs within various flower tissues and the scars from this egg laying activity can cause mature fruit to be unmarketable.

b) Signs and Symptoms

Thrips are often concealed inside flowers making them difficult to see. Adult thrips are minute (generally less than 2 mm long) insects with slender body and are usually pale yellow to light or dark brown in colour. Thrips sucks sap and excrete honey dew on which sooty mould can grow. Heavy infestations can cause stunting of growth and can result in distortion in young leaves. Heavy infestation many also result in discolouration on younger leaves (bronzing) and a silvered appearance on older leaves. Black spots of frass may also be seen.

Signs and Symptoms of Thrips

Thrips damage on blueberry fruit
I*mage: Blueberry Pest and Disease Manual 2018*

Citrus thrips damage on leaves to two different blueberry varieties
Image: Copyright (c) 2019 Regents of the University of California.

Thrips damage on fruit
I*mage: Supplied by Blueberry Industry*

Thrips – Adult (Right) and larval stages
I*mage: Blueberry Pest and Disease Manual 2018*

c) Inspection

For each plant selected select 5 flowering stems and gently tap all the flower clusters of each flowering stem onto a white or black surface. This will dislodge thrips and make them visible. Record the number of flowering stems that have thrips present.

d) Thresh-holds

Time of year	Thresh-hold
Bloom to fruit set	5% or more of branches inspected have thrips present
Fruit set to harvest	5% or more of branches inspected have thrips present
Postharvest to dormancy	10% or more of branches inspected have thrips present

e) Control Options and Recommendations

i) **Cultural –** No cultural controls

ii) **Biological -** Biological controls can be seen in Appendix 2. Biological controls are best used in a preventative manner as opposed to a curative manner meaning they should be applied to the crop prior to establishment in thrips populations throughout the season.

iii) **Chemical** Agrichemical controls can be seen in Appendix 3.

5.4 SCALE

a) Introduction

There are several species of scale that affect blueberries in New Zealand and these can be seen in the Pest and disease manual. Scales are sucking insects that insert tiny, sucking mouthparts into bark, fruit, or leaves, mostly on trees and shrubs and other perennial plants. The presence of scales can be easily overlooked, in part because they do not resemble most other insects.

b) Signs and symptoms

Adult female scales and nymphs lack a separate head or other easily recognizable body parts. Newly hatched greedy scale has legs for crawling. Once they have found a favourable site the legs are shed and a protective hard-shell forms and the adult scale does not move. Black and greedy scale do not change greatly in appearance as they grow other than in size and colour. Scales sucks sap and excrete honey dew on which sooty mould can grow. The presence of ants may indicate the presence of scale.

Signs and Symptoms of Scale

Greedy scale *(Hemiberlesia rapax)* adult(s)
Image: United States National Collection of Scale Insects Photographs , USDA Agricultural Research Service, Bugwood.org

Lantania scale *(Hemiberlesia lataniae)* adult
Image: *Blueberry Pest and Disease Manual 2018*

 **Black/Olive Scale *(Sassetia oleae)*** *Image: Blueberry Pest and Disease Manual 2018*	 **Black /Olive Scale *(Sassetia oleae)*** *Image: Blueberry Pest and Disease Manual 2018*

c) Thresh-holds

Time of year	Thresh-hold
Dormancy to bloom	10% or more of branches inspected have scale present
Bloom to fruit set	5% or more of branches inspected have scale present
Fruit set to harvest	5% or more of branches inspected have scale present
Postharvest to dormancy	10% or more of branches inspected have scale present

If scales are detected, the best option for control is to identify the timing of the crawlers emerging from under the protected waxy covering. This can be done using double-sided tape or some other adhesive around a branch above and below the adult scale infestations (checking weekly) to 'catch' crawlers as they migrate to identify the most effective timing for a scale control product to be used.

d) Control Options and Recommendations

i) **Cultural** – No cultural controls

ii) **Biological** – The are no current biological controls

iii) **Chemical** - Crop protection products can be seen in Appendix 3. If scales are detected, the best option for control is to identify the timing of the crawlers emerging from under the protected waxy covering. This can

be done using double-sided tape checked each week, and this can identify when an in-season scale control product could be used.

5.5 RUST

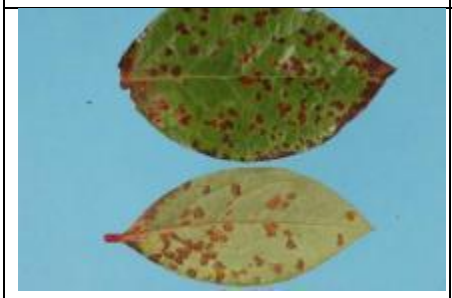
a) Introduction

Rust can become an issue late in the season and can reduce bud-set for the following season through defoliation.

b) Signs and Symptoms

Symptoms start as reddish spots on the upper surface. Affected areas turn reddish brown and become visible on the lower surface. These lower spots later become covered by masses of orange-yellow spores. Severely affected leaves may develop autumn colourations and are

Affected areas turn reddish brown and become visible on the lower surface. These lower spots later become covered by masses of orange-yellow spores. Severely affected leaves may develop autumn colourations and are commonly shed.

Signs and Symptoms - Blueberry Leaf Rust		
 **Blueberry Leaf Rust** **Image:** Bruce Watt, University of Maine	 **Blueberry Leaf Rust** **Image:** Bruce Watt, University of Maine	 **Blueberry Leaf Rust** **Image:** Bruce Watt, University of Maine
 **Rust (*Naohidimyces vacinii)*** **Image:** *Blueberry Pest and Disease Manual 2018*	 **Rust (*Naohidimyces vacinii)*** **Image:** *Blueberry Pest and Disease Manual 2018*	 **Rust (*Naohidimyces vacinii)*** **Image:** *Blueberry Pest and Disease Manual 2018*

c) Thresh-holds

When inspecting for rust score each branch inspected using the following:

0 = No rust

1 = Presence of rust

2 = 50% of leaves have rust

3 = 100% of leaves have rust

Time of year	Thresh-hold
Bloom to fruit set	Average score is greater than 2 (Add all scores then divide by number of branches inspected)
Fruit set to harvest	Average score is greater than 2 (Add all scores then divide by number of branches inspected)

NB: If blueberries are intended to be exported to Australia there is a requirement for a field clearance for rust. Therefore, any presence of rust would most likely trigger a treatment for product destined to Australia.

d) Control Options and Recommendations

i) **Cultural –** No cultural controls

ii) **Biological –** Biological controls as per Appendix 3.

iii) **Chemical -** Agrichemical controls can be seen in Appendix 3.

5.6 BOTRYTIS

a) Introduction

Botrytis is a common disease of berry crops but in blueberries occurs mostly as blossom infection. In wet humid conditions, especially at flowering, the disease attacks flower parts and may spread to associated stems, although it will usually stop at a branch point. Berries that have been infected at flowering (especially where the flower does not detach) may continue to develop and later express as a postharvest rot.

b) Signs and symptoms

Botrytis can be found on blossoms, twigs, and fruit. Tips of infected shoots will die back and turn brown to black. Infected blossoms appear water soaked and turn brown, and the discoloration can spread down the twig. Immature fruits shrivel and turn a bluish purple, whereas ripe, mature fruits become tan. In damp weather, all infected plant parts become covered with the characteristic "gray mould" of the fungus.

Signs and Symptoms – Botrytis

Botrytis cinerea
Image: *Blueberry Pest and Disease Manual 2018*

Botrytis cinerea
Image: *Blueberry Pest and Disease Manual 2018*

Botrytis cinerea
Image: *Blueberry Pest and Disease Manual 2018*

c) Thresh-holds/Decision Points

Time of year	Thresh-hold
Bloom to fruit set (Sept – Oct)	If more than 10% of inspected stems show botrytis and rain or extended periods of relative humidity above 90% are forecast then take action. If more than 20% of stems show botrytis take action regardless of weather conditions.

d) Control Options and Recommendations

i) **Cultural** – No cultural controls.

ii) **Biological** – Biological controls can be seen in Appendix 2.

iii) **Chemical** - Chemical controls can be seen in Appendix 3.

5.7 BOTRYOSPHAERIA

a) Introduction

Botryosphaeria sp (a member of the Fungi family: Botryosphaeriaceae) is a fungal disease that causes extensive damage to areas of cane, whole shoots and whole plants of blueberries. *Neofusicoccum australe, Neofusicoccum luteum* and *Neofusicoccum parvum* and have been identified on New Zealand blueberries as the asexual forms of *Botryosphaeria sp* .

There is a range of varietal susceptibility to these diseases. Botryosphaeria spores overwinter in dead material, and can enter plant tissue via cuttings, wounds, growth cracks, leaf scars or by direct contact with plant dermis (via pores, branches and stems that allow gas exchange).

b) Signs and symptoms

On branches and trunks, Botryosphaeria can infect plants where there has been a winter injury, pruning wounds or any plant damage from hail or herbicides. Slightly sunken reddish/brown spots appear on the infected areas of bark. These then enlarge to form cankers, which can then enlarge slightly more each year. The bark usually dies and can, after time, be pulled away from the plant. Leaf spots may also be visible – these are small necrotic spots on the leaf surface and the leaf becomes wrinkled.

Cane dieback - The central pith is often darkened, and the leaves may be reduced in size and may be wrinkled. The following season, these canes will be dead. When removing dieback it is important to prune out diseased stems.

Signs and Symptoms – Botryosphaeria

Botryosphaeria on leaf
Image: *Blueberry Pest and Disease Manual 2018*

Botryosphaeria on cane
Image: *Blueberry Pest and Disease Manual 2018*

Botryosphaeriaoncane
Image: *Blueberry Pest and Disease Manual 2018*

	
Botryosphaeria **Image:** *Blueberry Pest and Disease Manual 2018*	***Botryosphaeria*** **Image:** *Blueberry Pest and Disease Manual 2018*

c) Thresh-holds/Decision Points

Time of year	Thresh-hold
Dormancy to bloom	**0% - Presence = Hygiene Prune**
Bloom to fruit set	**0% - Presence = Hygiene Prune**
Fruit set to harvest	**0% - Presence = Hygiene Prune**
Postharvest to dormancy	**0% - Presence = Hygiene Prune**

d) Control Options and Recommendations

i) Cultural – Prune and destroy all affected cane. Prunings should be removed from the crop and preferably burnt, as this material can be a source of inoculum that can cause new infections. Pruning infected individuals before the fungi and or disease is spread extensively throughout the plant is also an effective method for preventing spread between other plants in the area. It is important to prune well past an infection point to ensure the full extent of the disease is captured.

ii) Biological - No biological control options at the stage.

iii) Chemical - Protectant fungicides may help the disease from becoming a serious problem.

APPENDIX 1 – CULTIVAR RUST SUSCEPTIBILITY CHART

CULTIVAR RUST SUSCEPTIBILITY CHART

This list was updated at the Blueberry Growers meeting in September 2015. It was based on the collective knowledge of the people present at that meeting. Harvesting times are based on Waikato conditions.

Cultivar	Type	Ripening Time	Rust
Blue Bayou (F126)	SHB	3	4
Blue Moon (RH34)	NHB	4	1
Bluecrop	NHB	6	3
Brigitta	NHB	8	2
Burlington	NHB	8	2
Centra Blue	RE	14	1
Centurion	RE	12	1
Climax	RE	10	3
Delite	RE	10	4
Dixie	NHB	7	0
Dolce Blue (D122)	RE	10	2
Duke	NHB	5	0
Elliott	NHB	9	0
Island Blue	SHB	1	1
JU83	NHB	3	1
Marimba	SHB	1	2
Maru	RE	11	4
Misty	SHB	1	4
Nui/PBBB	NHB	2	3
Ocean Blue (F107)	RE	10	0
O'Neal	SHB	2	2
Ono	RE	10	1
Powder Blue	RE	10	1
Puru	NHB	3	2
Rahi	RE	11	3
Reka	NHB	3	4
Sky Blue (F110)	RE	11	1
Southland	RE	12	1
Sunset Blue (RH11)	NHB	2	0
Tifblue	RE	11	2
Velluto Blue	RE	10	0
Whitu	RE	10	0

SHB = Southern highbush blueberry
NHB = Northern highbush blueberry
RE =Rabbiteye blueberry

Number	Start of harvest
1	Early November
2	Mid November
3	Late November
4	Early December
5	Mid December
6	Late December
7	Early January
8	Mid January
9	Late January
10	Early February
11	Mid February
12	Late February
13	Early March
14	Mid March
15	Late March

Rust Scoring System Rating
0 = No Rust
1 = 5% rust
2 = 25% rust
3 = 50% rust
4 = 75% rust
5 = Decimated by rust

APPENDIX 2– BIOLOGICAL CONTROL OPTIONS

Pest/Disease	Biological control available
Light brown apple moth, green headed leaf roller, brown headed leaf roller	*Bacillius thuringiensis* sp. *kurstakiI*. Available as Dipel DF
Melon aphid, Green peach aphid	*Aphidius colemani*. Available as Aphidius from Bioforce.
Grass grub, black vine weevil	*Heterorhabditis bacteriophora.* Available as *Nematop from Bioforce*
Phytophthora	Superzyme - *Bacillus subtilis, Pseudomonas putida, Trichoderma koningii*, *and Trichoderma harzianum*
Botrytis	Triple X - *Bacillus amyloliquefaciens,* BS 1b. Serenade optimum – *Bacillus subtilis* (Strain QST 713)
Anthracnose and Rust	Serenade optimum– *Bacillus subtilis* (Strain QST 713)
Thrips	Bioforce provides the following options: Orius, Hyper-mite and Mite-A, all of which attack different life stages of thrips. It is best used in a preventative manner as opposed to a curative manner meaning it should be applied to the crop prior to increases in thrips populations through the season.
Lantania Scale	The predatory mite *Hemisarcoptes coccophagus* is a possible biological control option in New Zealand and has shown to reduce the pest's populations to manageable levels.
General predatory mites (may have limitations or require specific conditions – will require investigation relevant to situation)	*Amblydromalus limonicus* (used for thrips and other mites) Mite A (*Neoseiulus cucumeris*) (used for thrips and other mites) Mite E *(Phytoseiulus persimilis)(used for two spotted mite)* *Orius vicinus (used for larger prey)* Parasitoids (aphids)
NB: Where no label claim exists for this product. Any use is at grower's own risk .	

APPENDIX 3 - BLUEBERRY PEST AND DISEASE CHEMICAL CONTROL OPTIONS

The table below gives options of pest control products. T

This table contains off label products that some growers have used and that fit into a pest control programme. These products are used at the grower's risk and testing first on a small area for phytotoxicity on the cultivars on your farm and for residue testing is recommended.

Stage	Disease/Pest	Chemical options *(All rates per 100 litres or as specified on the label)*	Alternatives
Bud movement	Leaf spots, anthracnose, Bacterial blast, rust Scale Phytophthora	Chlorothalonil copper spray #chlorpyrifos and oil #phosphorous acid	
Over flowering	Anthracnose, botrytis Bronze beetles	Switch (Note 3) Lannate L 120ml (Note 1)	captan wp 125g flo 200ml
Post blossom*	Anthracnose Rust Mealy bug, scale Leaf roller, thrips Phytophthora	Switch (Note 3) copper spray label rates Movento #spinosad 40ml #phosphorous acid (Note 2)	 Lannate L 120ml
Post harvest as required	Leaf spot, rust, blast Phytophthora	copper spray label rates #phosphorous acid	

No label claim exists for this product. Any use is at grower's own risk
*** Only choose chemicals suited to the markets intended (refer to Blueberry Quality Manual)**
Note 1: Lannate should only be applied in the evening after bees have stopped flying
Note 2: Phosphorous acid has caused some phytotoxicity on fruit of some varieties. Do a check before using generally
Note 3: Do not use more than 2 applications

APPENDIX 4 – EXAMPLE OF SCOUTING RECORDING SHEET

Crop Scouting Record Sheet			
Block:		**Field Conditions:**	**Weather:**
Date:			
Name:		**Growth Stage:**	
Pest	**Number of branches/stems inspected.**	**Number of infected branches/stems**	**Thresh-hold reached/Action taken**
Scale			
Thrips			
Leaf-rollers			
Mealy Bug			
Rust			
Botrytis			
Botryosphaeria			
Other (specify)			
Other (specify)			

NB: It is important record absence of any pests i.e. if during an inspection no pests are found record zero in the relevant "number of infected branches/stems" row.