



Summer Internship 2022-2023

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Massey University



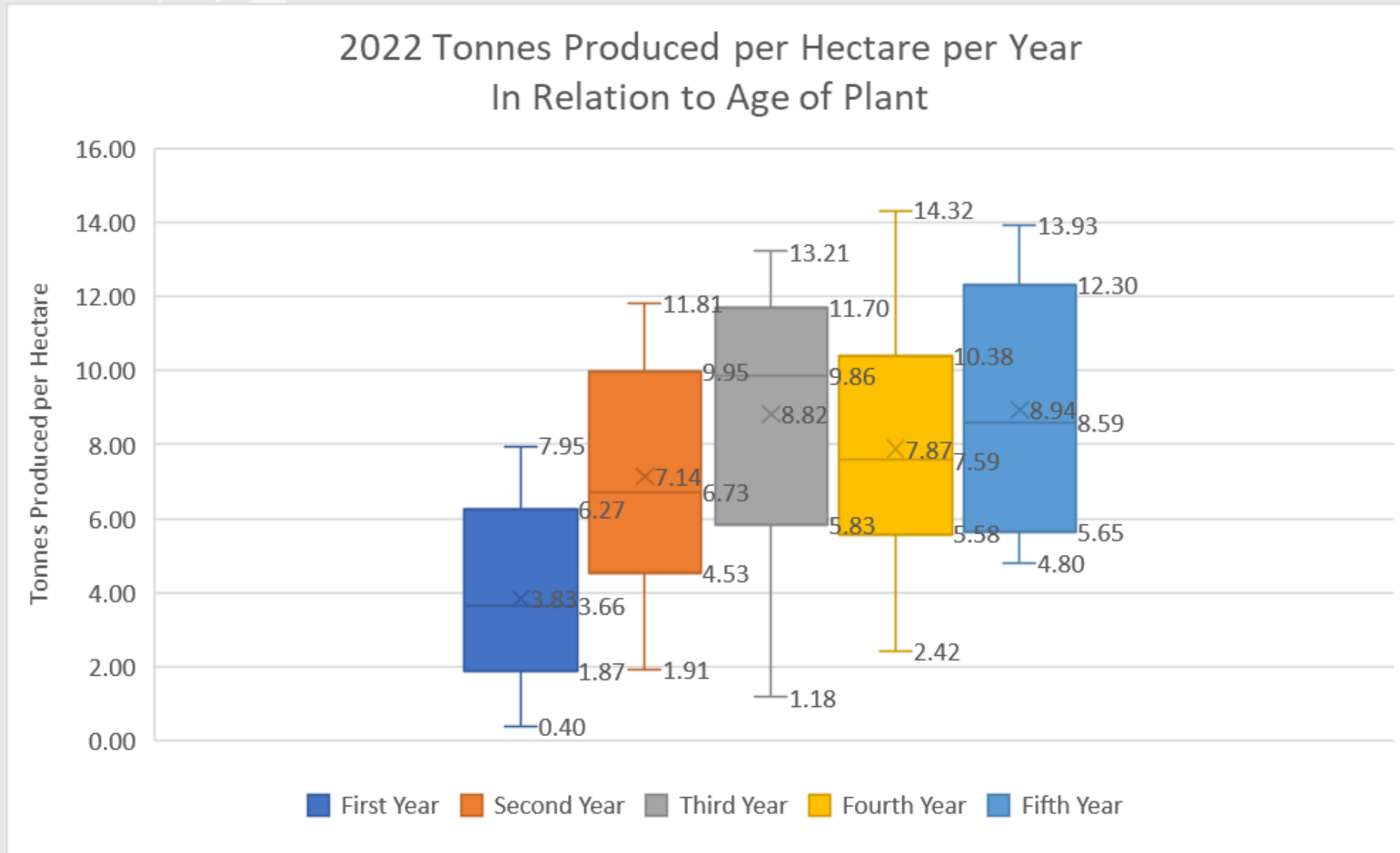
Introduction

- I am about to enter my third year at Massey studying a bachelor of Horticultural Science
- BerryCo hired me over the summer to help contribute research towards the severe issue affecting fruit production and quality due to *Botrytis cinerea*.

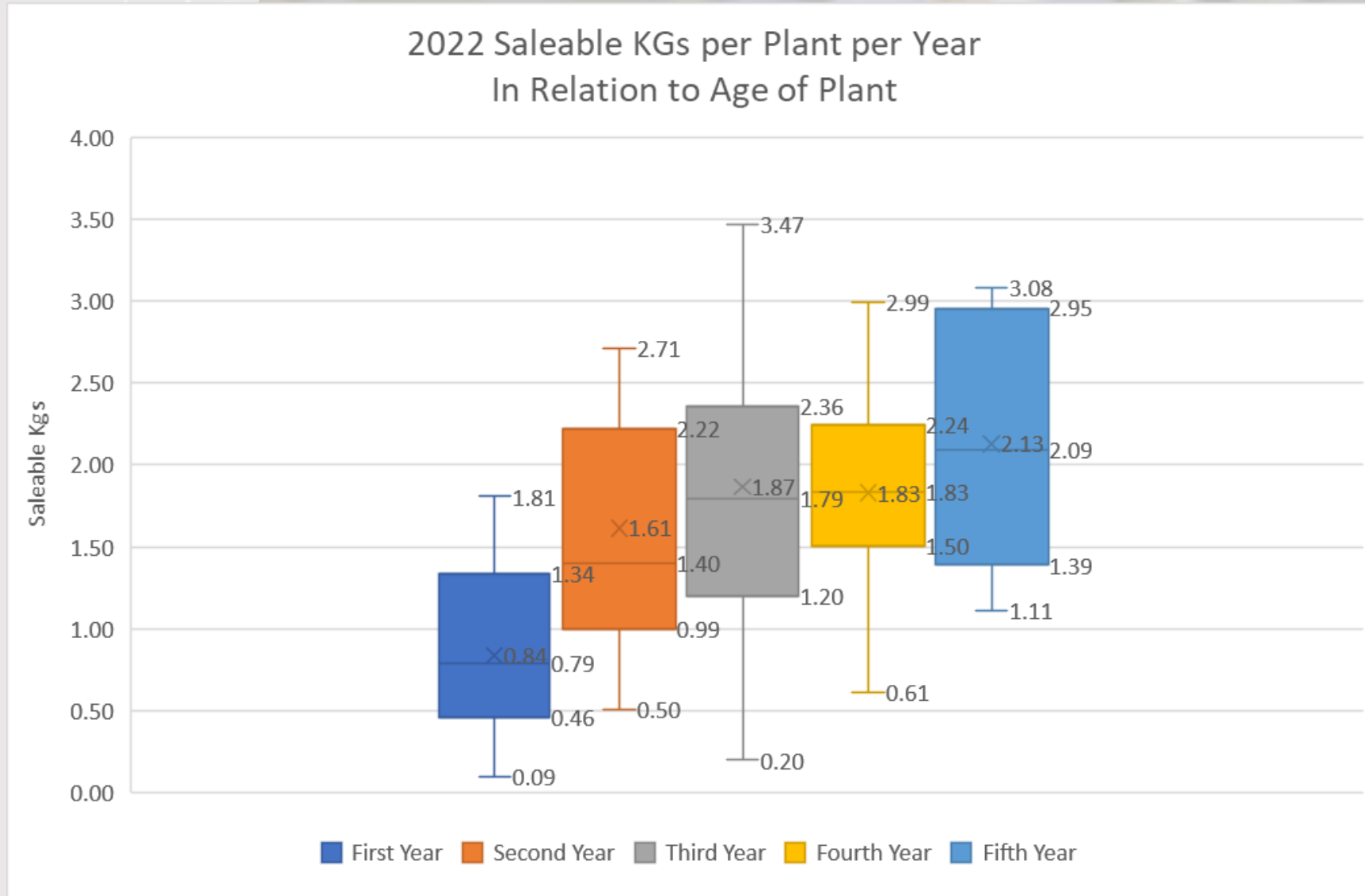
This involved:

1. Collecting and tracking fruit from 5 orchards involved in 'Botrytis Product Testing'
2. Tracking fruit breakdown at different storage temperatures through numerous library trials
3. Mineral analysis of fruit
4. Analysing and comparing climate data against previous years (rain, humidity and light levels)
5. Comparing reject rates from 2021 with 2022.
6. Analysing growers spray diaries and cross referencing with climate data and residue tests.

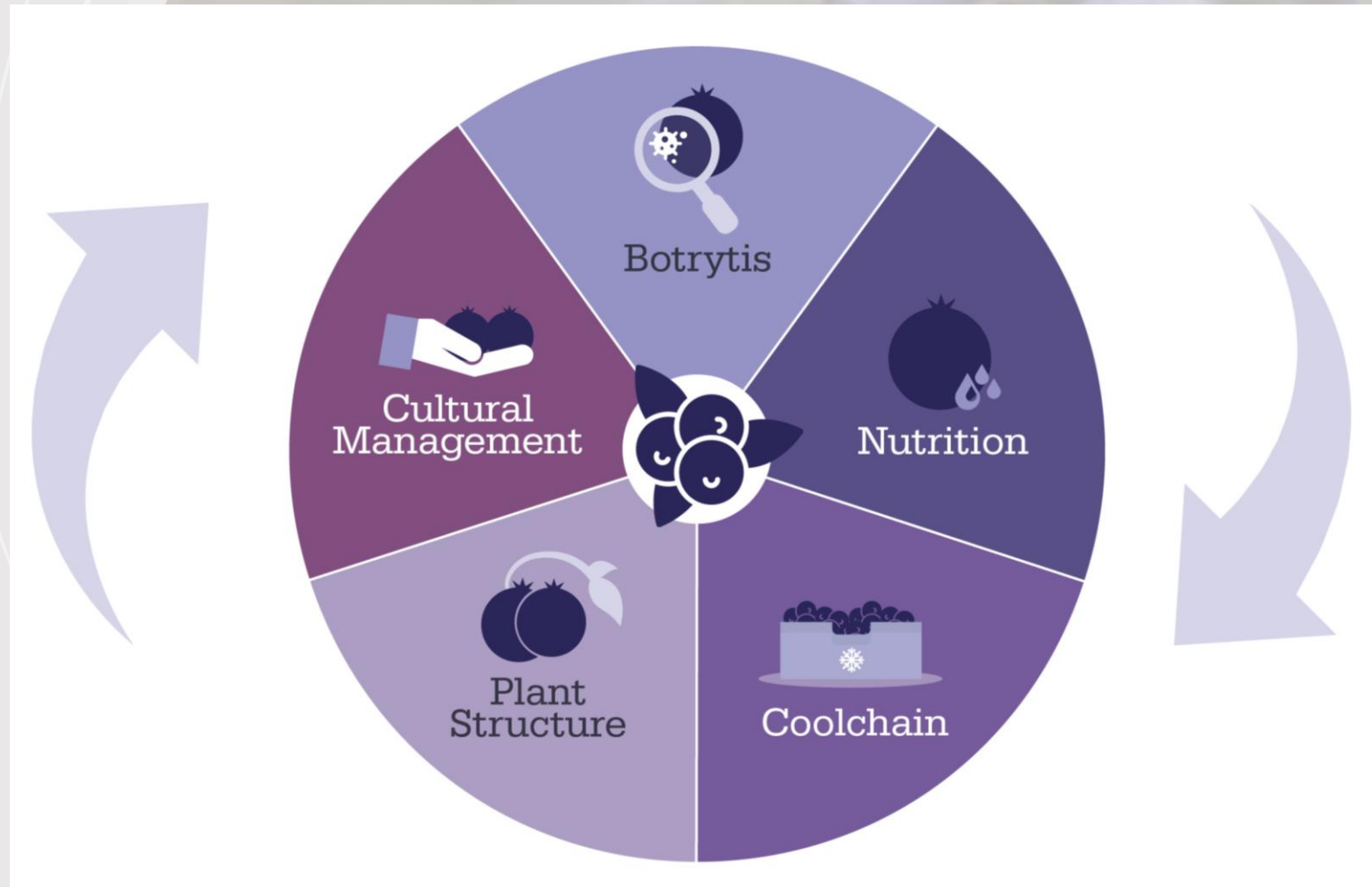
Production per Hectare



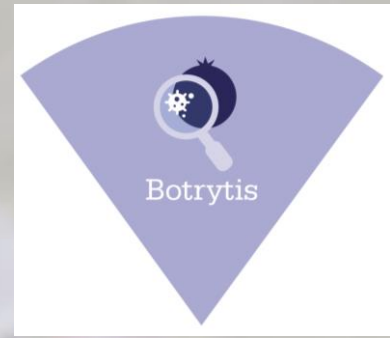
Saleable Production



BerryCo Quality Wheel of Fortune



Background of Botrytis



- *Botrytis cinerea* also known as Botrytis Blight or Gray Mould.
- Affects a wide range of crops, causing severe damage to blueberry plant flowers, twigs and fruit.
- The fungus is present every year, however it flourishes when the conditions are correct (cool, wet periods).
- This damage can cause up to 30% loss of yield.
- Botrytis causes damages in markets and to brand name as blueberries that may be visually “healthy” upon harvest day and okay when packed at packhouse later on “erupt” leading to quality issues.
- MBO Southern Highbush and “Eureka” are more susceptible to botrytis infection due to their high sugar content in berries and large size.

Disease Triangle

Host
(blueberry bush)

Disease



Botrytis

Pathogen
(fungi)

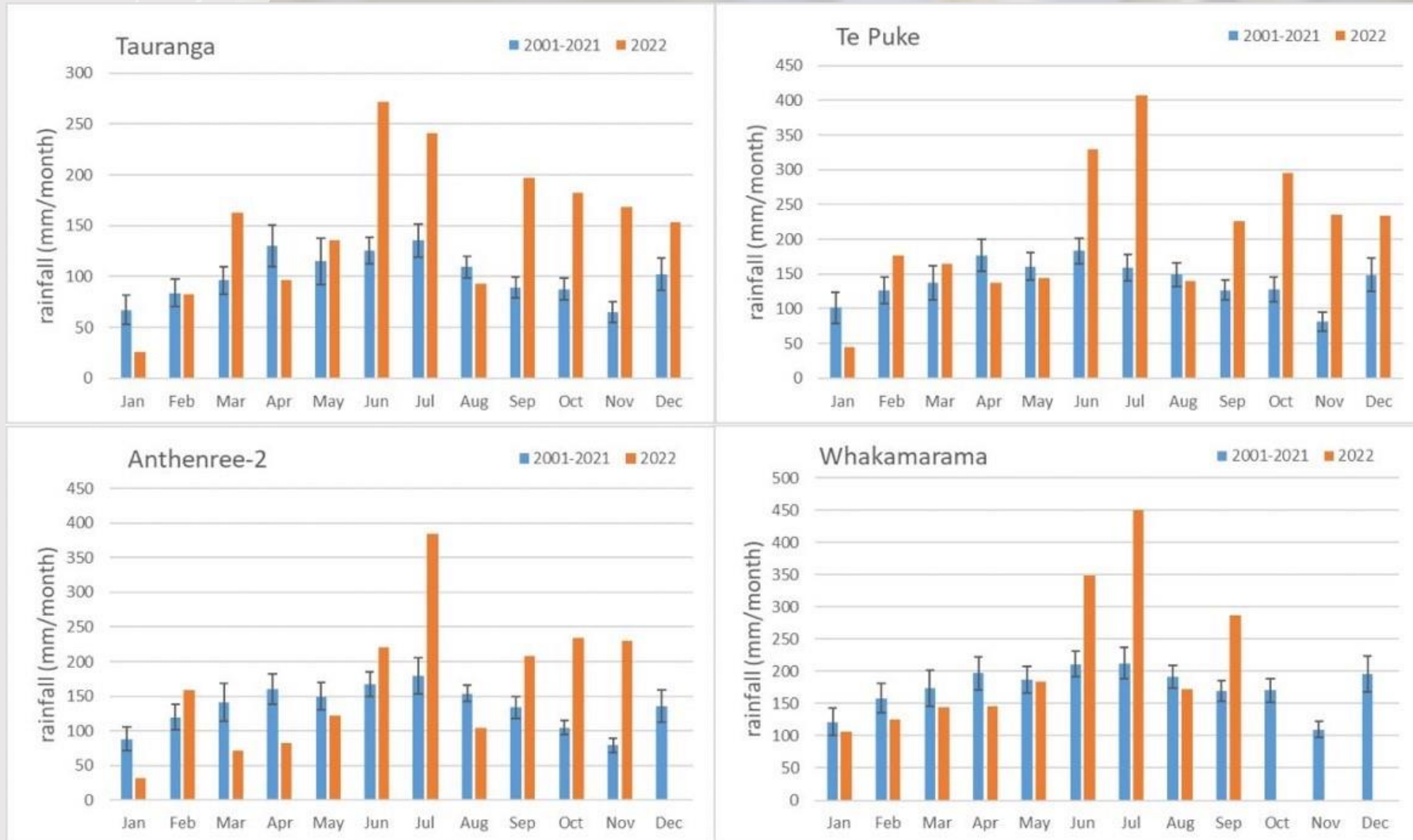
Environment
(climate)

Climate - Rain

	Rain			Rain			Humidity		
	Days over 15mm			Days over 30mm			Days with over 80%		
	2020	2021	2022	2020	2021	2022	2020	2021	2022
Eastern Bay of Plenty	19	25	38	11	13	20	103	137	160
Western Bay of Plenty	19	25	38	9	8	25	103	137	160
Gisborne	6	15	16	2	3	4	198	233	258

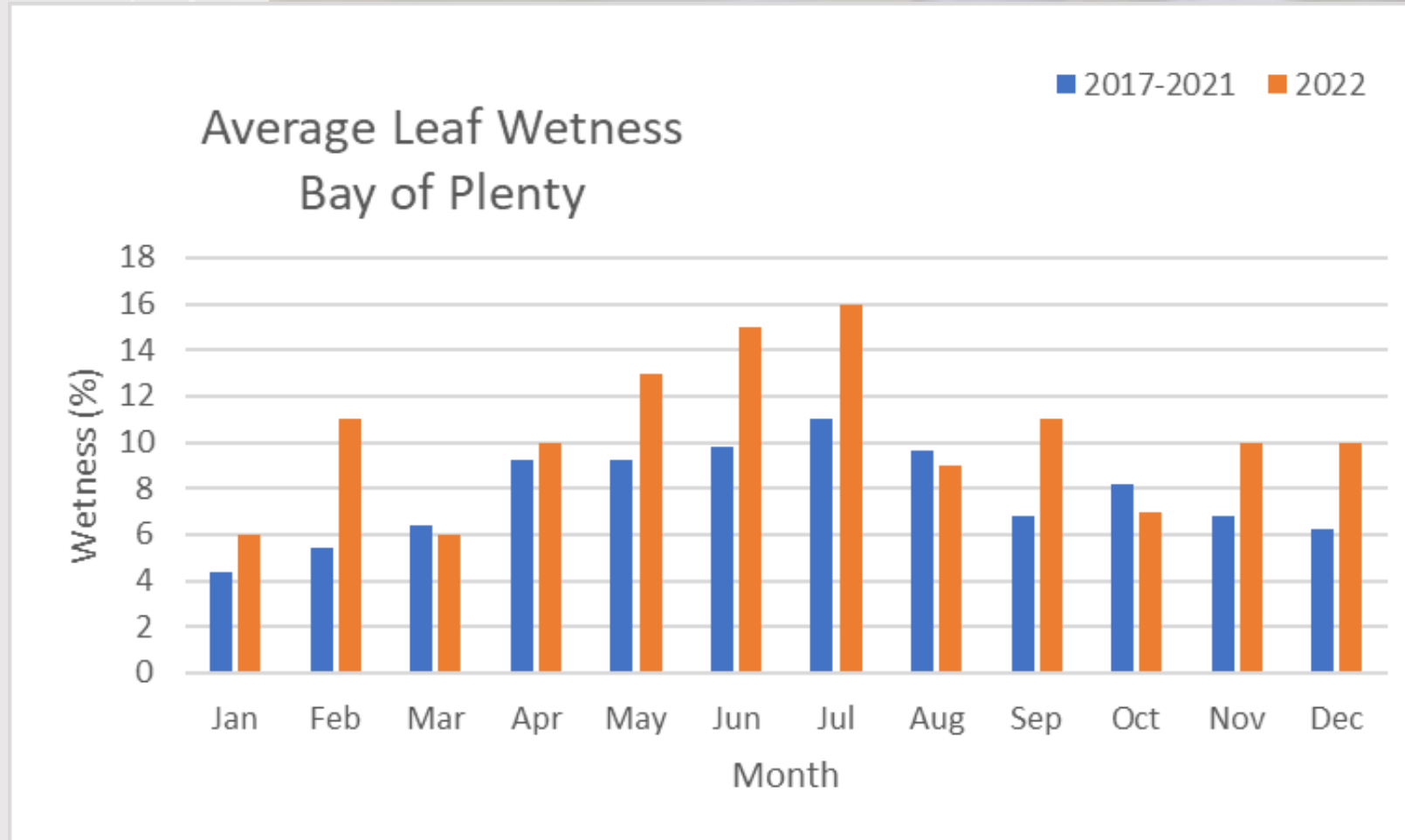
Source: Harvest.com

Climate - Rain



Source: Plant and Food Research

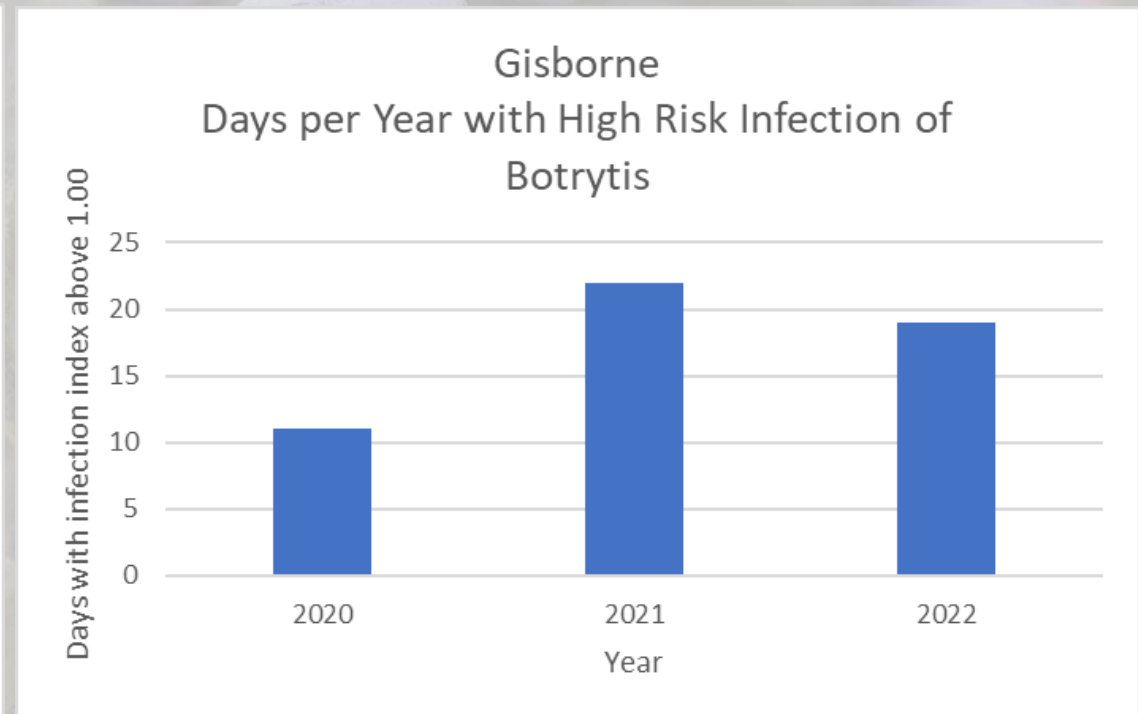
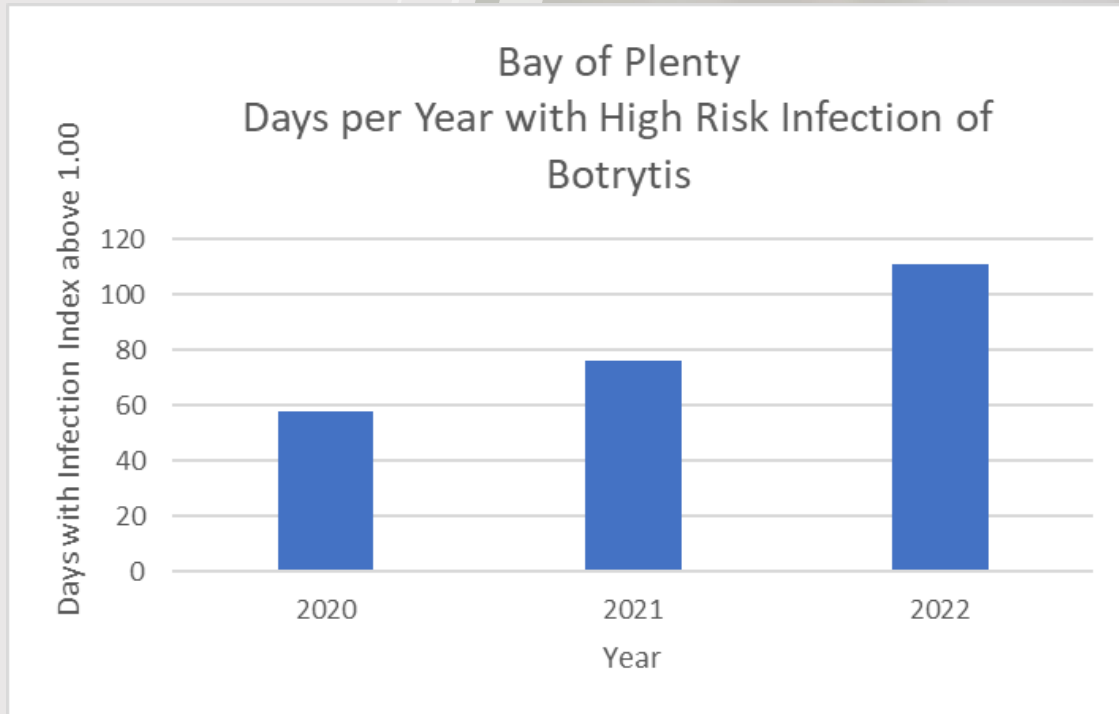
Climate – Leaf Wetness



Source: Harvest.com

Climate – Botrytis Risk

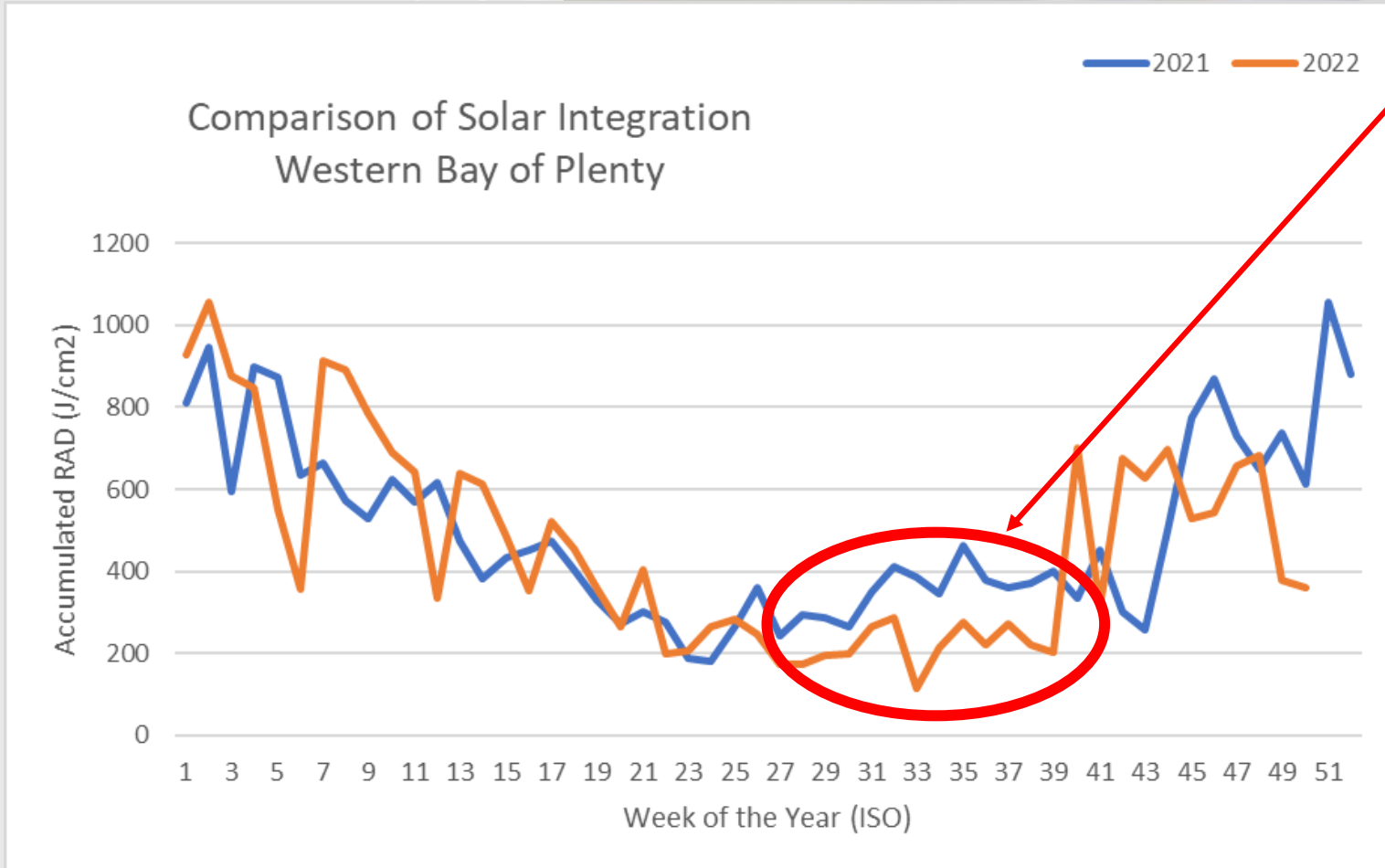
Infection Index Values	Risk Levels
Infection Index ≤ 0	no risk of infection
$0 < \text{Infection Index} < 0.50$	low risk of infection
$0.05 \leq \text{Infection Index} < 1.00$	moderate risk of infection
$1.00 > \text{Infection Index}$	high risk of infection



Source: Harvest.com

Climate – Sunshine Hours

Crucial 12 week period:
Flowering to beginning of harvest



Source: Autogrow



Interpretation of Climate Data

- This last season has had poorer weather conditions compared with previous years.
- The figures show higher rainfall, with more days with humidity on average more than 80%, increase in leaf wetness and more days per year where botrytis risk is critical.
- Solar /sunshine hours were the lowest at one of the most crucial points for growers – flowering to beginning of harvest.
- All these factors play a role to botrytis issues.

Any questions?

Products Testing

Spraying Blueberries, especially at the critical times for botrytis loading, can be difficult due to withholding days for spray residues.

This issue becomes harder as domestic markets and export market have different maximum residue levels (MRL).

To help overcome this issue we trialled six different biological control agents (BCA). Of which majority do not have withholding requirements.

Products trialled:

Botry-zen® / Amour-zen® (blue)

TripleX (orange)

Ecocarb® / HML protector (yellow)

Sentinel® (green)

Loker® (red)

Serenade® Opti (pink)

Product Testing



Stem End Mould



Extreme Mould



Stem End Mould



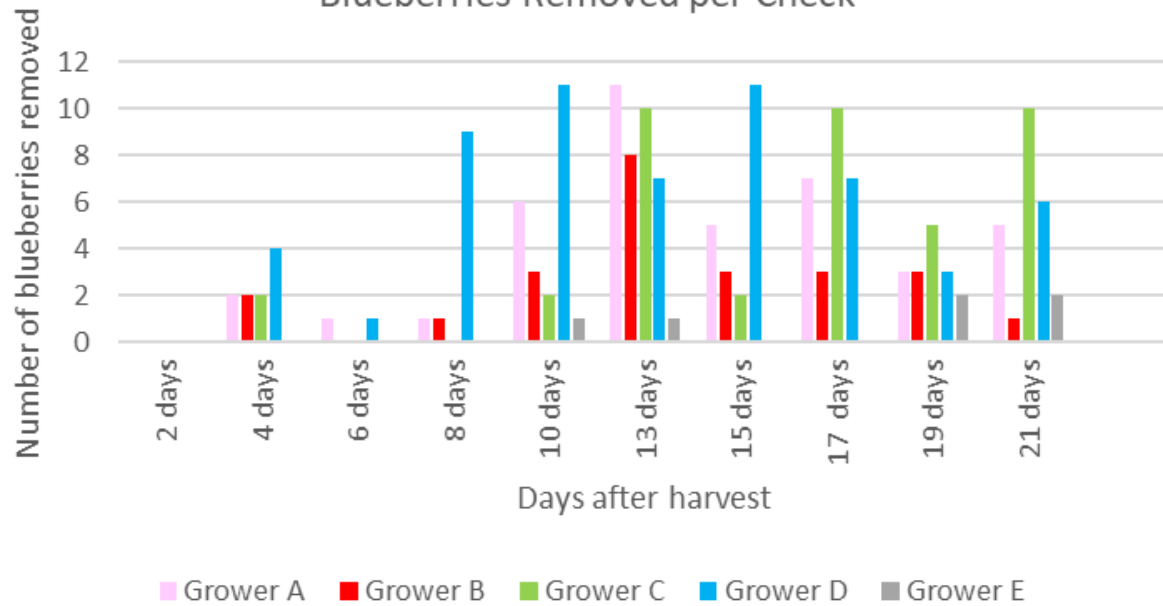
Side Mould



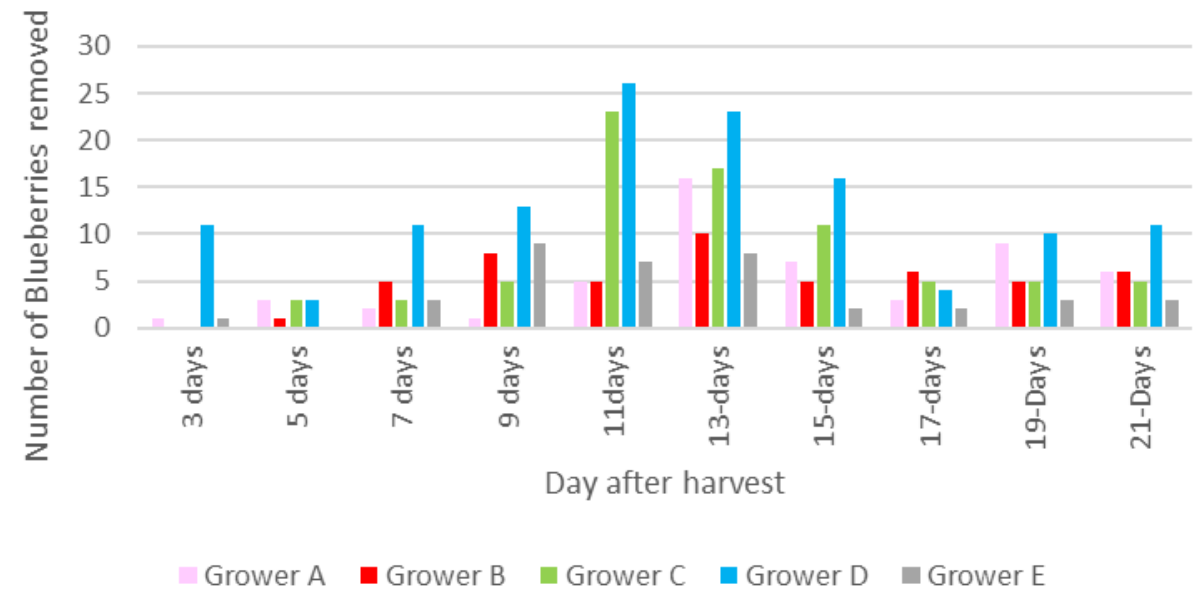
12 Blueberries per punnet
Monitored every 2 days

Product Testing – Trials One and Two

Products Trial One
Blueberries Removed per Check



Products Trial Two
Blueberries Removed per Check

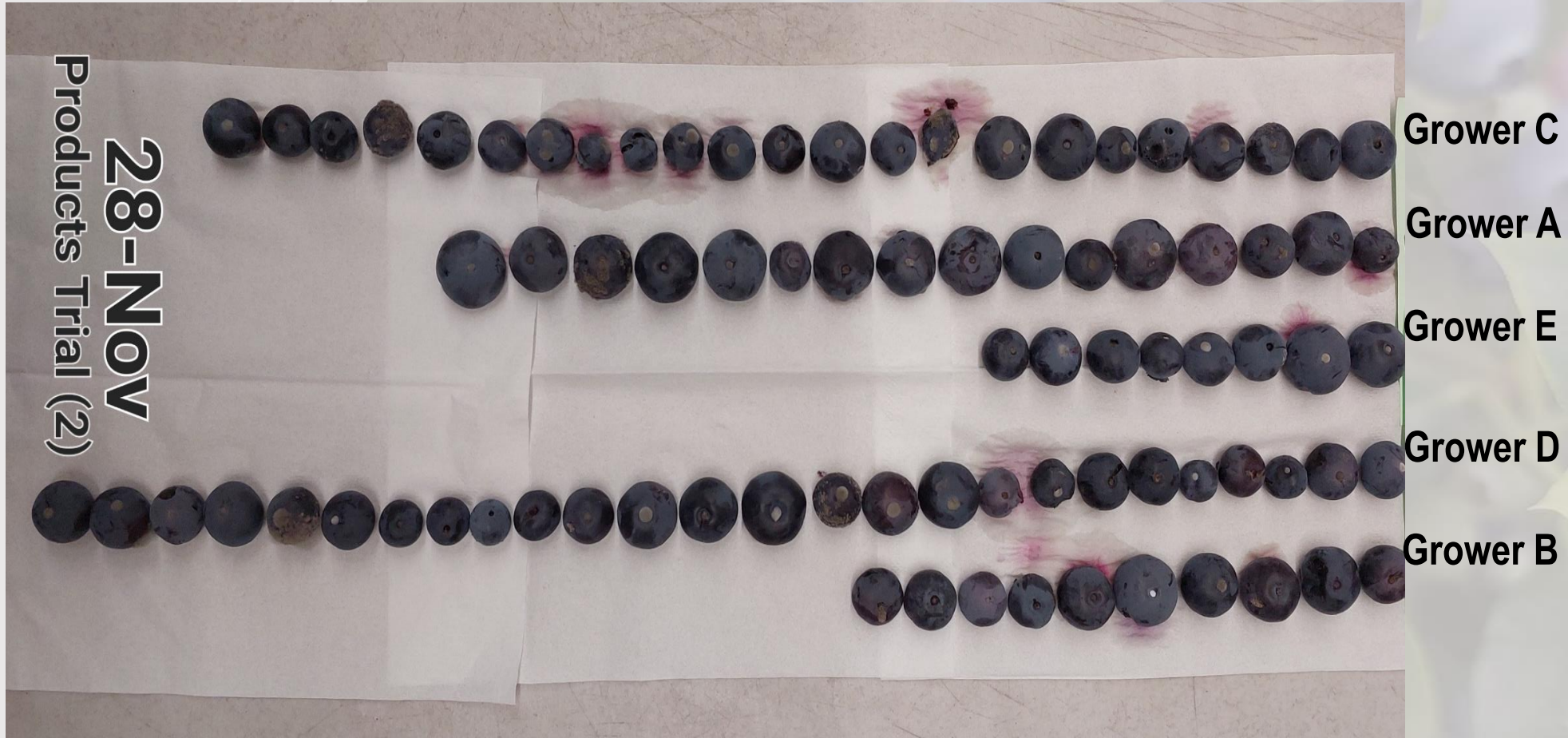


Product Testing – Peak Days



Products Trial One: Day 13

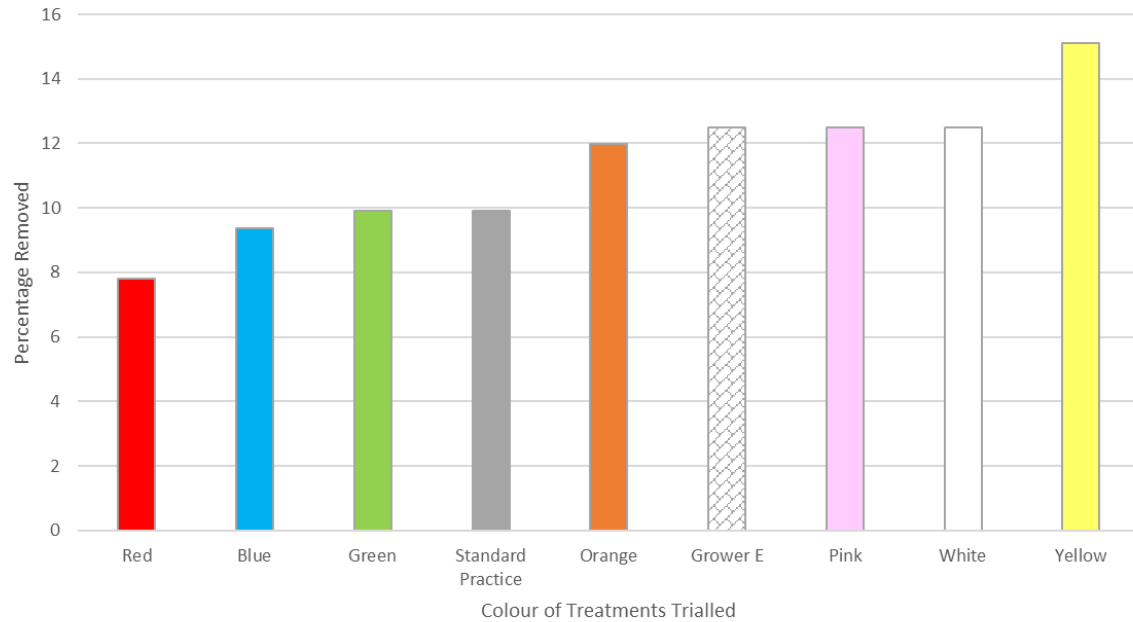
Product Testing – Peak Days



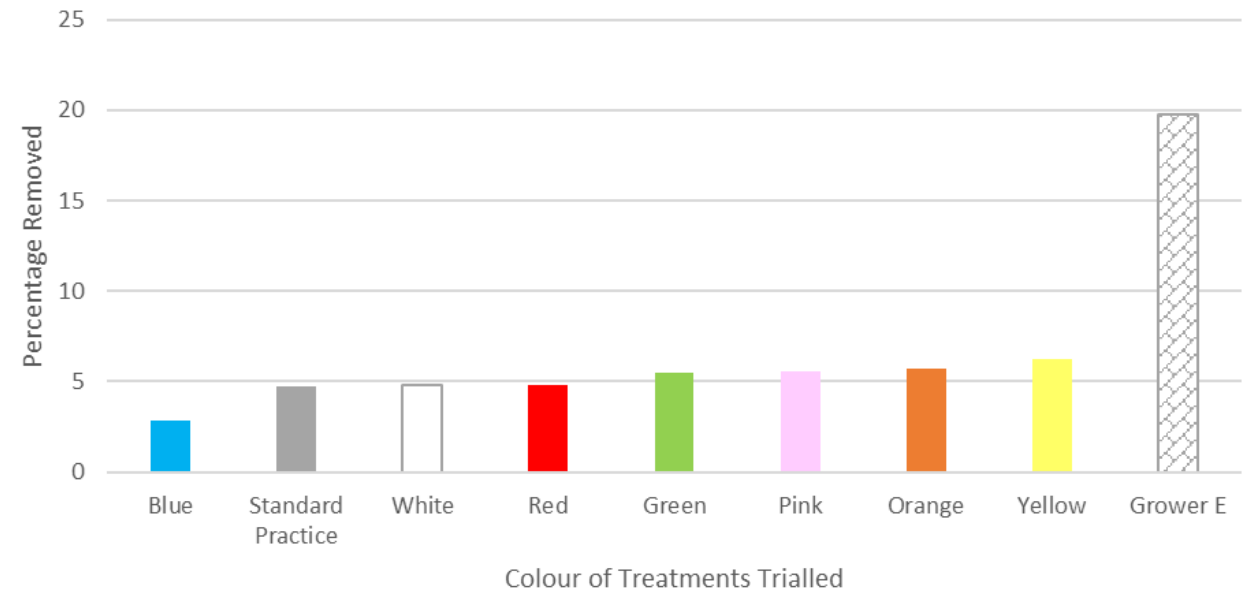
Products Trial Two: Day 13

Product Testing – Trials One and Two

Products Trial One - 21 Days from Harvest
Percentage of Blueberries Removed per Treatment

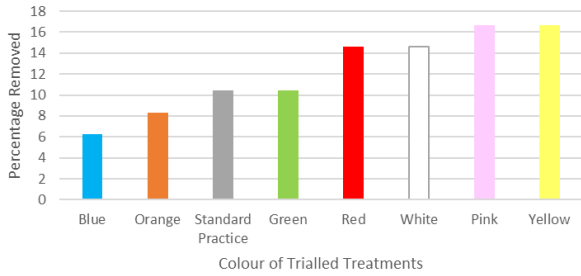


Products Trial Two - 21 Days from Harvest
Percentage of Blueberries Removed per Treatment

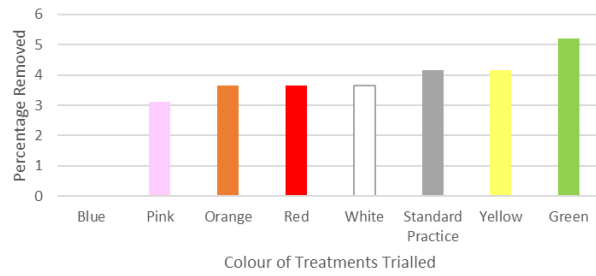


Product Testing – Trials One and Two

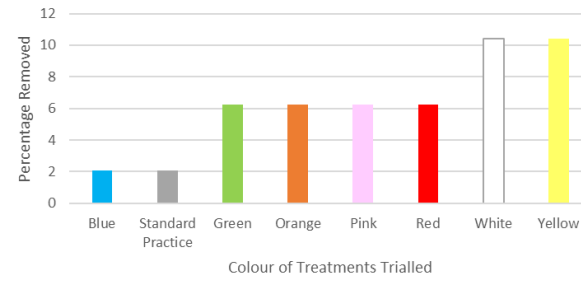
Products Trial One - 21 Days from Harvest
Grower A



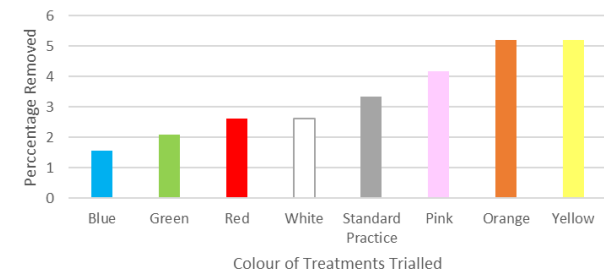
Products Trial Two - 21 Days from Harvest
Grower A



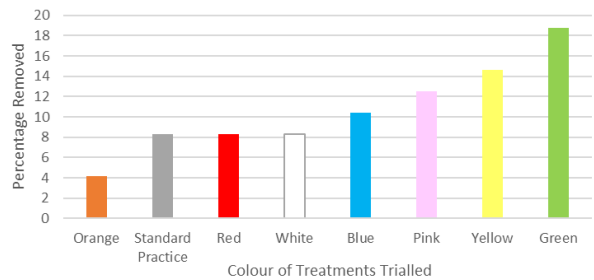
Products Trial One - 21 Days from Harvest
Grower B



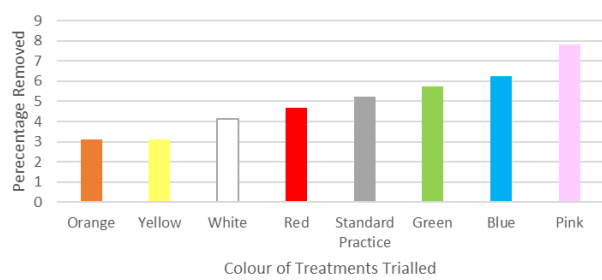
Products Trial Two - 21 Days from Harvest
Grower B



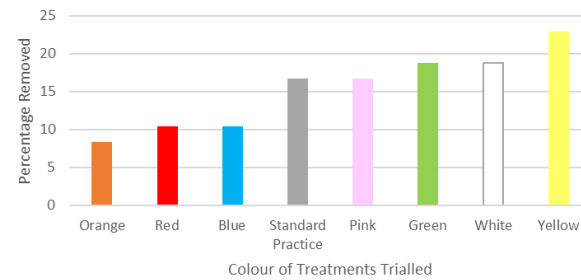
Products Trial One - 21 Days from Harvest
Grower C



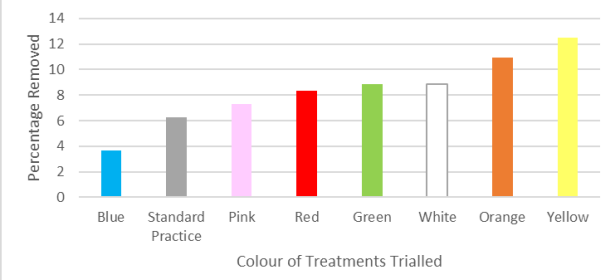
Products Trial Two - 21 Days from Harvest
Grower C



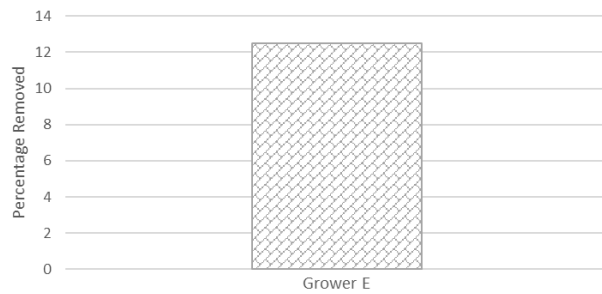
Products Trial One - 21 Days from Harvest
Grower D



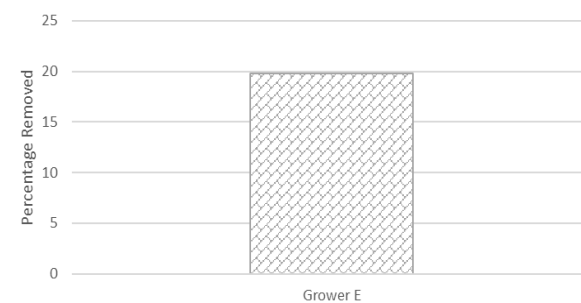
Products Trial Two - 21 Days from Harvest
Grower D



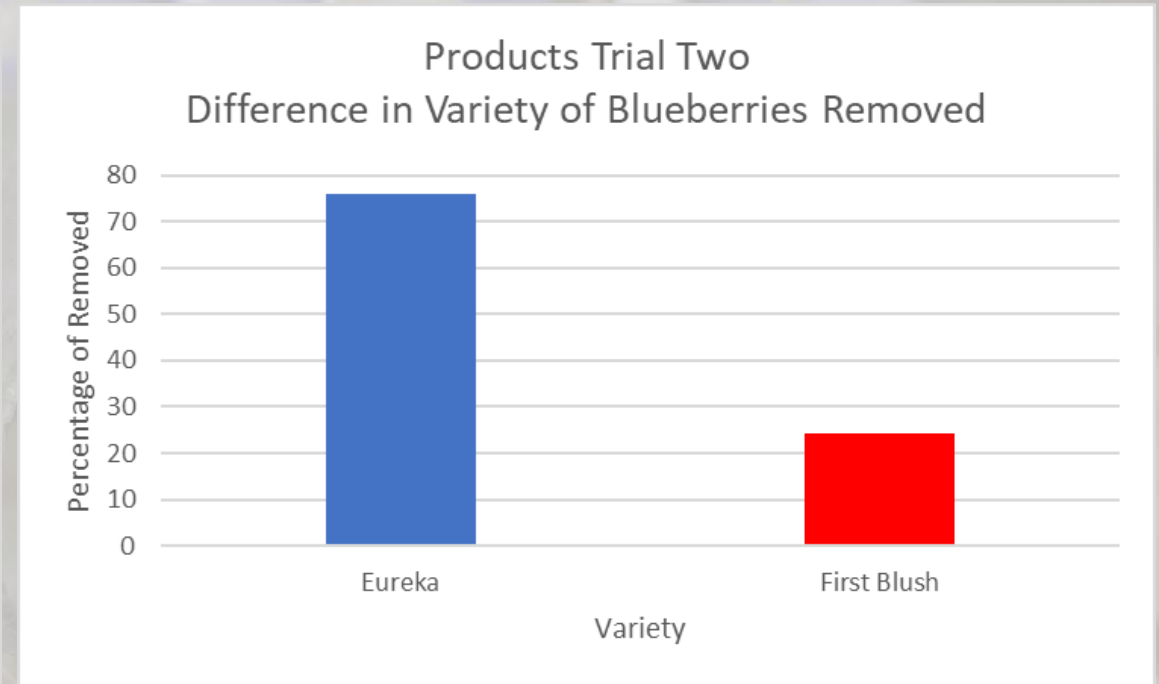
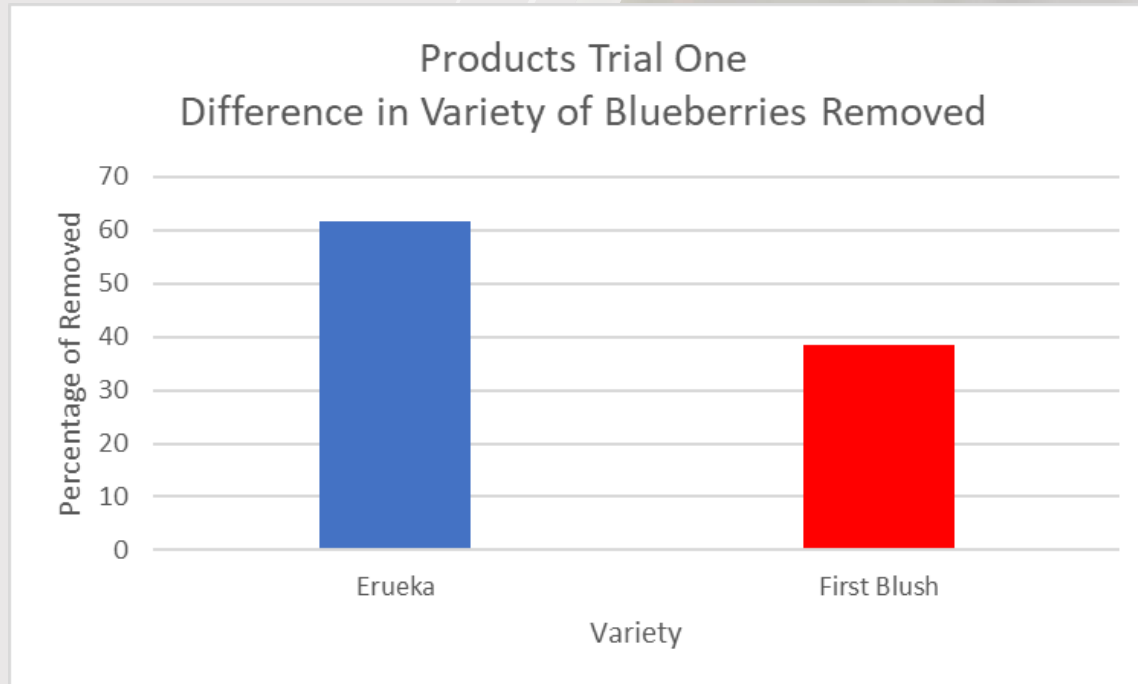
Products Trial One - 21 Days from Harvest
Grower E



Products Trial Two - 21 Days from Harvest
Grower E



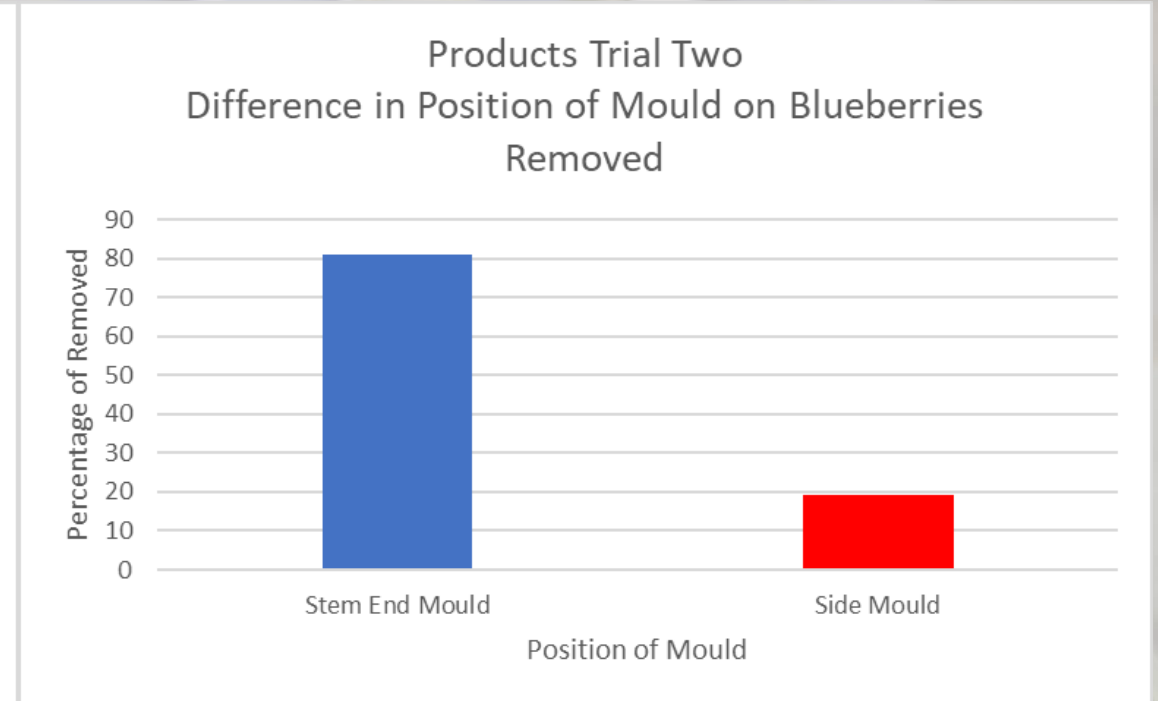
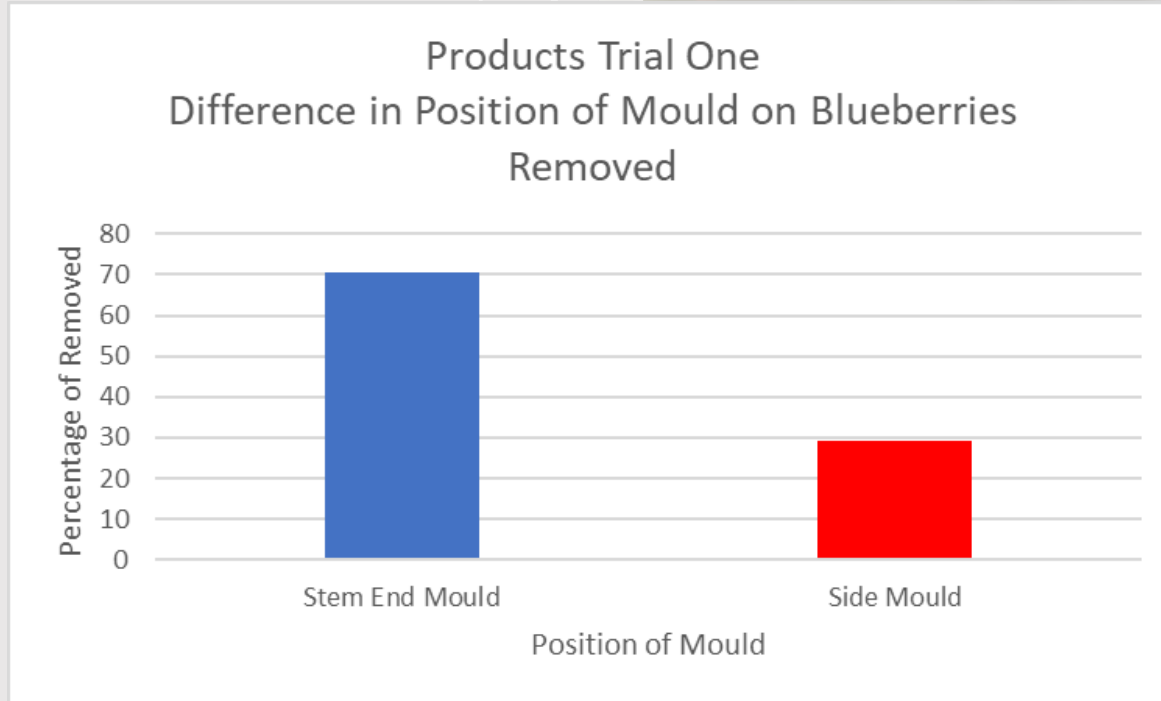
Product Testing – Interesting Observation



	P-value T-test
Trial One	0.1622 ns
Trial Two	6.45005E-10****

Are different varieties more susceptible to botrytis?

Product Testing – Interesting Observation



	P-value T-test
Trial One	4.31181E-7****
Trial Two	7.333289E-19****

Product Testing – Trial Three

Blue Treatment: Botry-zen® / Armour-zen®

Botry-zen® is applied at early flower and is a fungus called *Ulocladium oudemansii* which feeds on the same tissue that botrytis does (the flowers and aborted berries) creating competition. Armour-zen® is applied, as required, a month prior to harvest and is made from chitosan (extract from crustaceans) and stops the botrytis spores from germinating. Botry-zen® can also be used via bee vectoring Which is useful way to protect plants when bushes are fully grown and sprayers cannot fit.



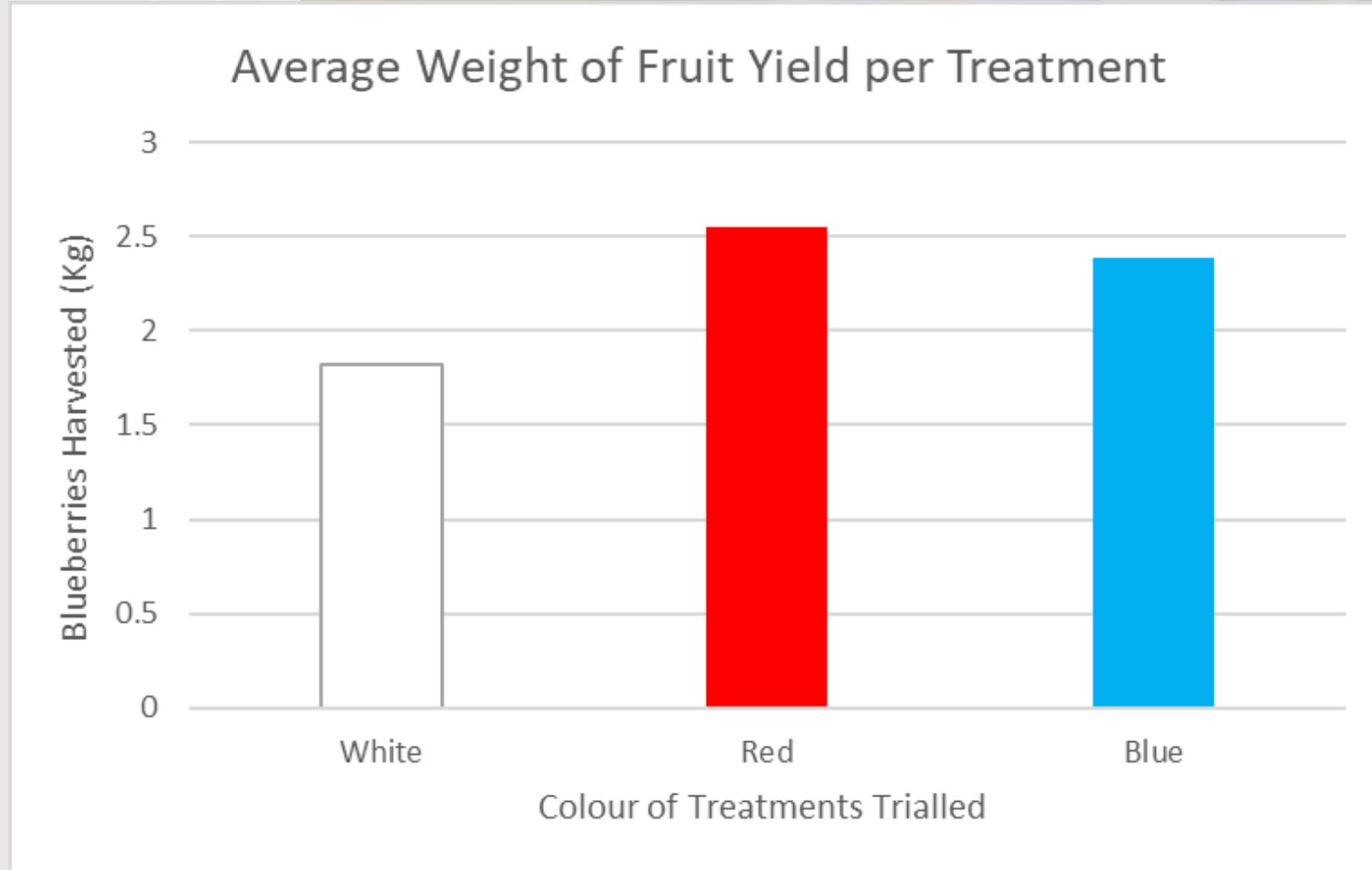
Red Treatment: Loker®

Not a bio-fungicide, it's nutrients and a bio-stimulant, rich in Polysaccharides, Amino Acids, and Phenylpropanoids which help to increase the plants natural barriers and strengthen the cell wall allowing the plant to be More prepared for “attacks”. Can be applied as a foliar spray or via fertigation.



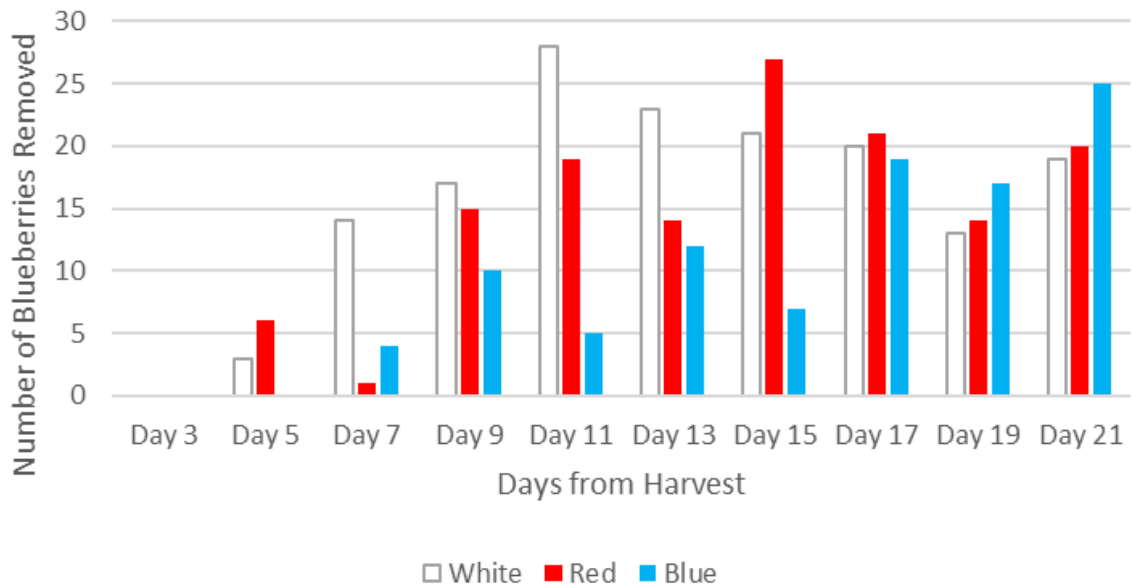
White: In row control (plants which had no sprays applied).

Product Testing – Trial Three

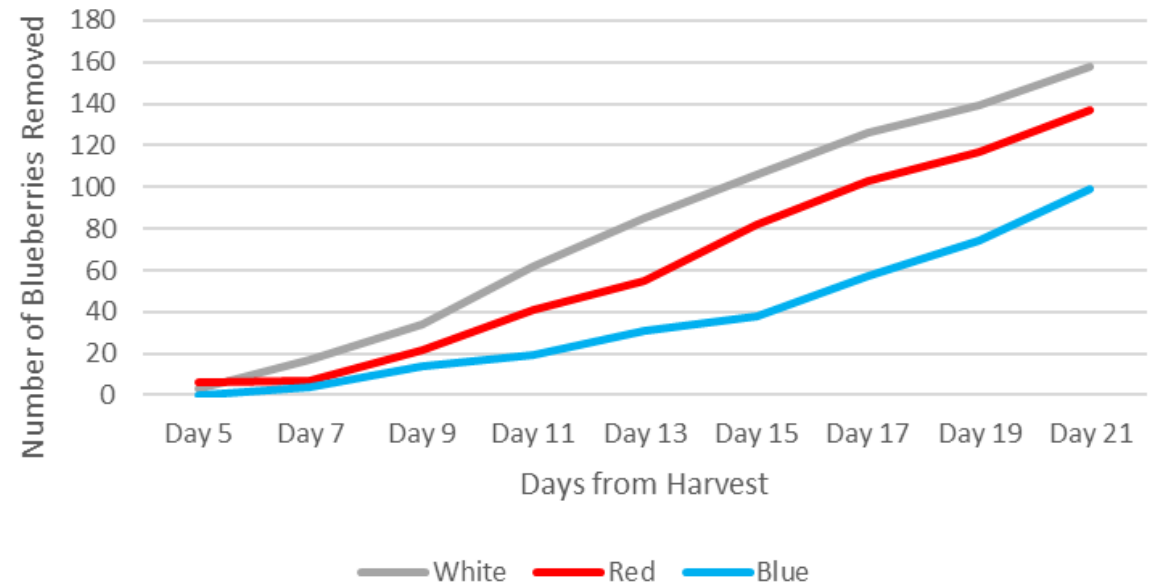


Product Testing – Trial Three

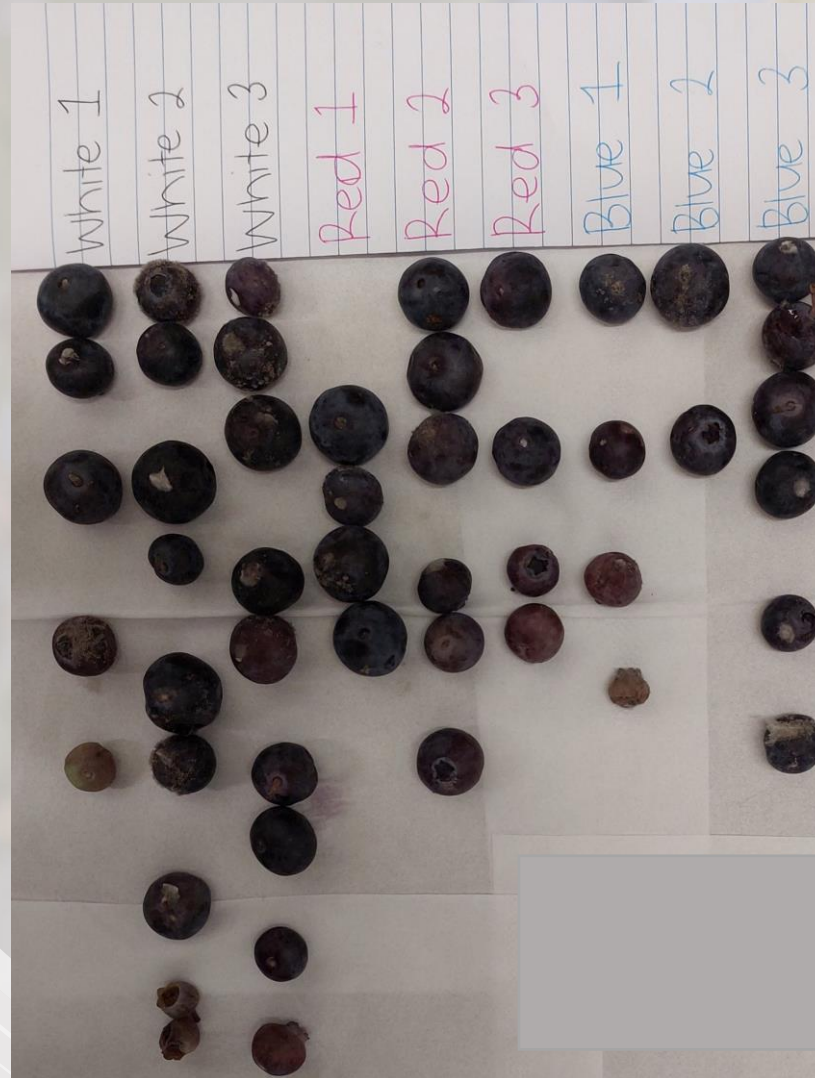
Number of Blueberries Removed per Treatment



Accumulation of Blueberries Removed per Day

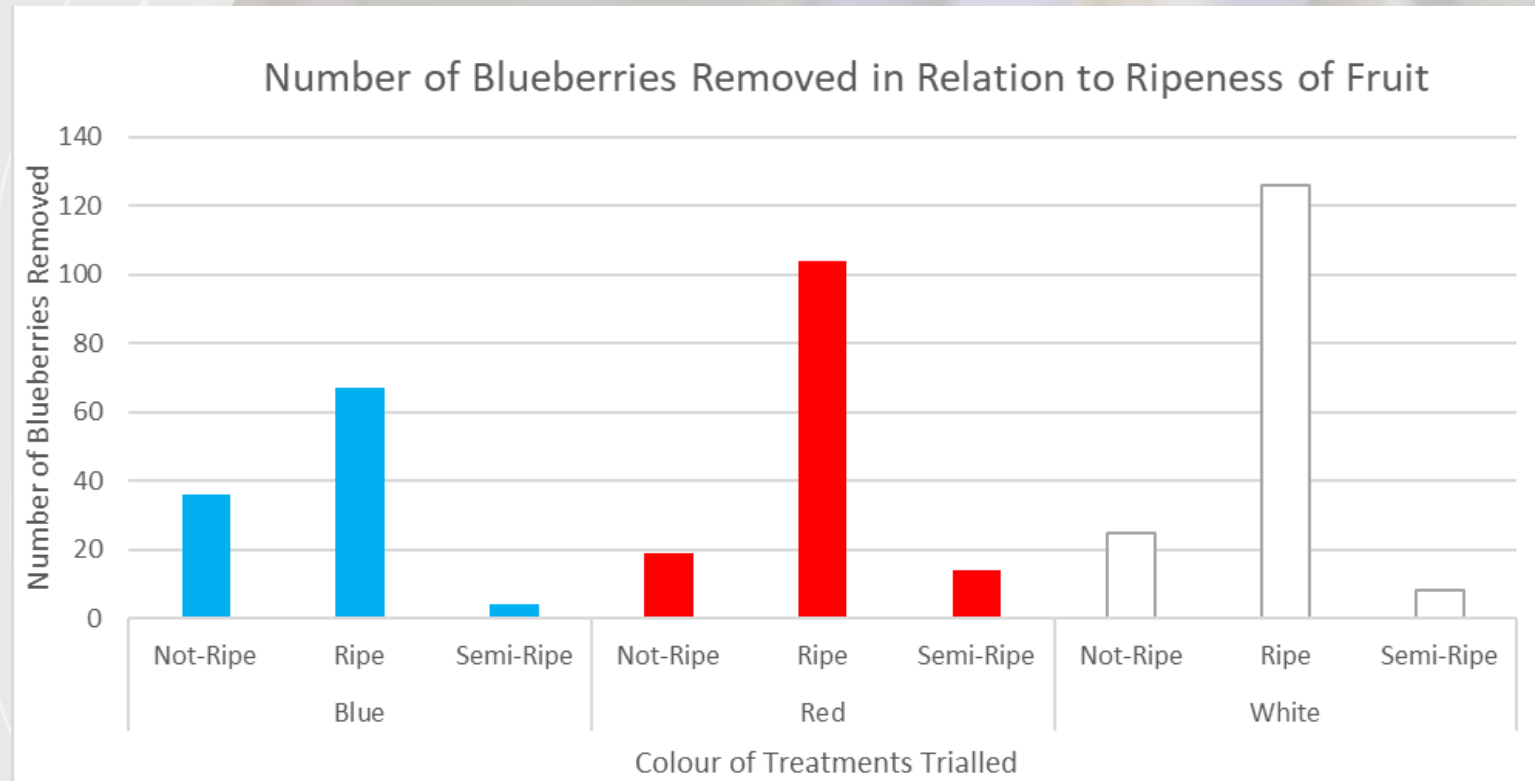


Product Testing



Products Trial Three

Product Testing – Interesting Observation

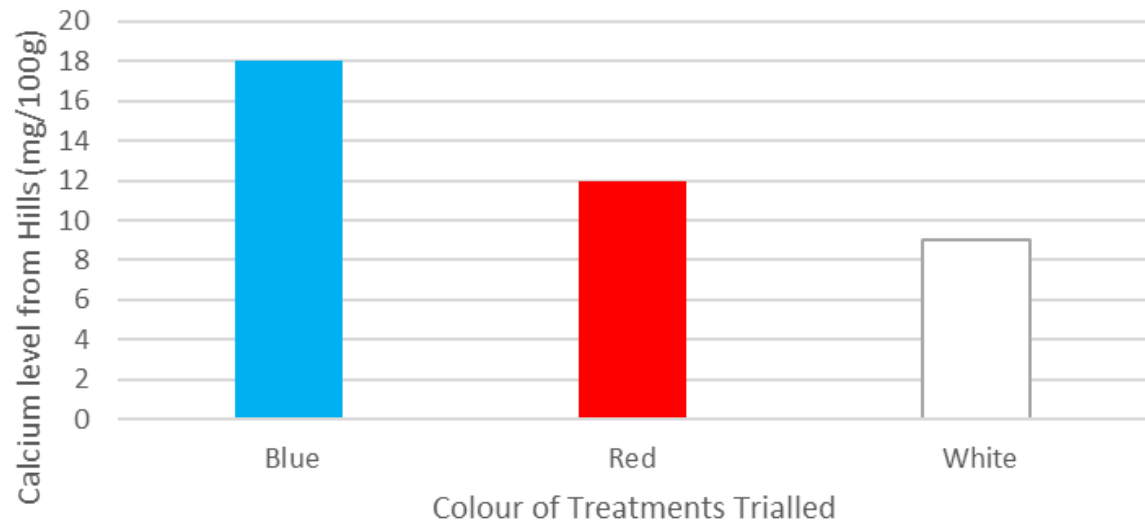


	P-value T-test
Blue vs White (all)	0.02129*
Blue vs White (ripe)	0.000461***
Red vs White (all)	0.3267 ns

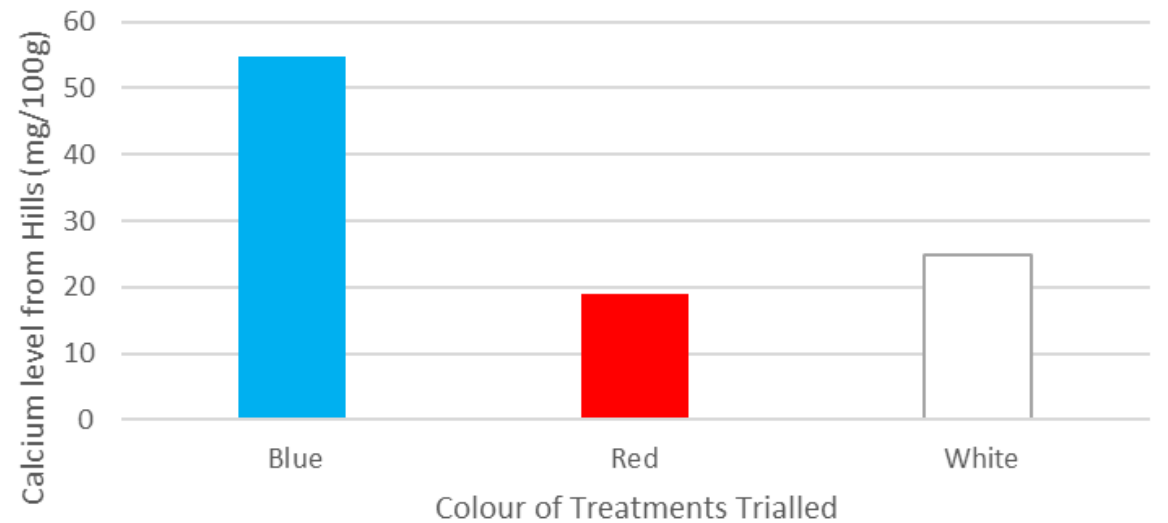
Product Testing – Interesting Observation



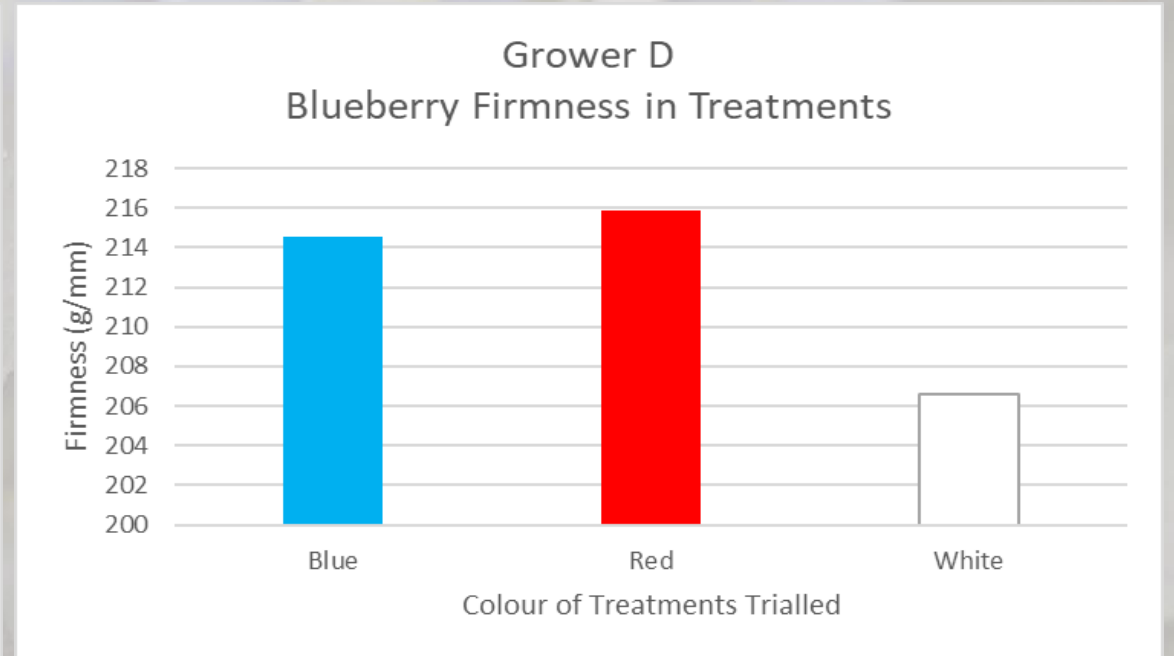
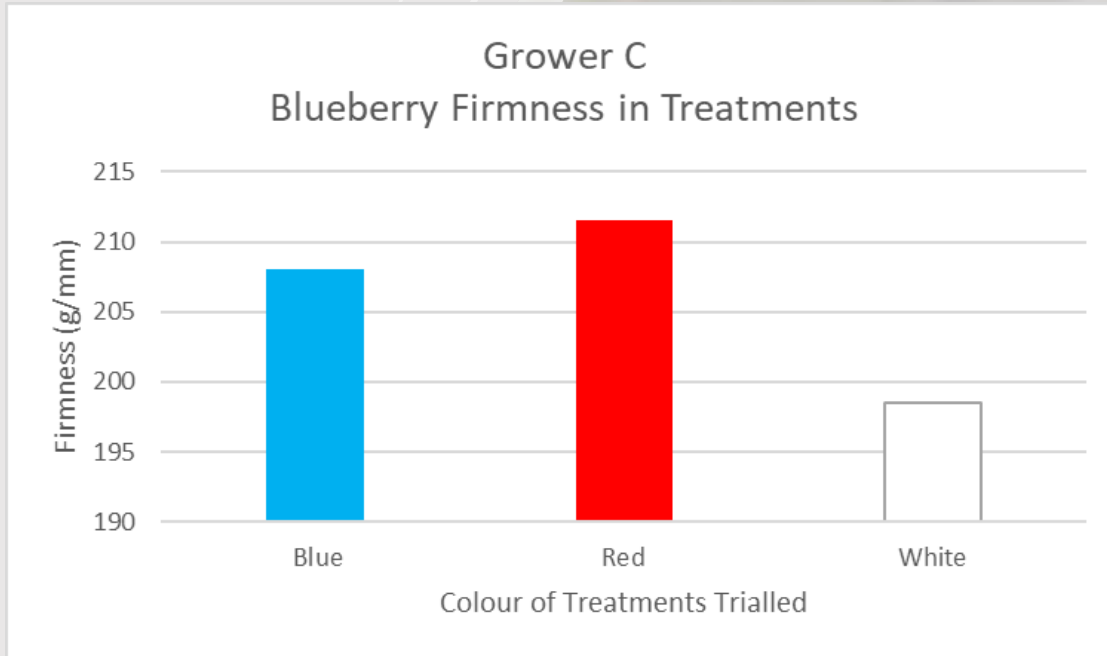
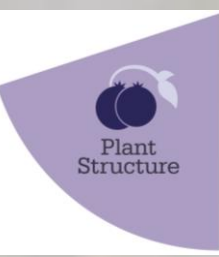
Grower C
Calcium Levels in Treatments



Grower D
Calcium Levels in Treatments



Product Testing – Interesting Observation



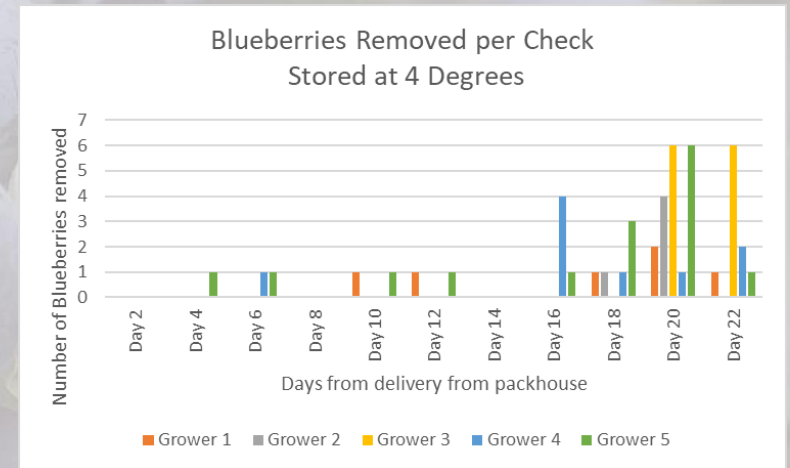
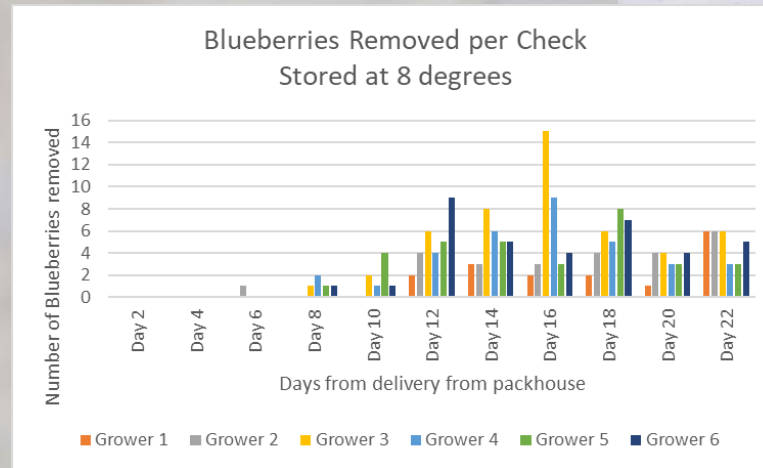
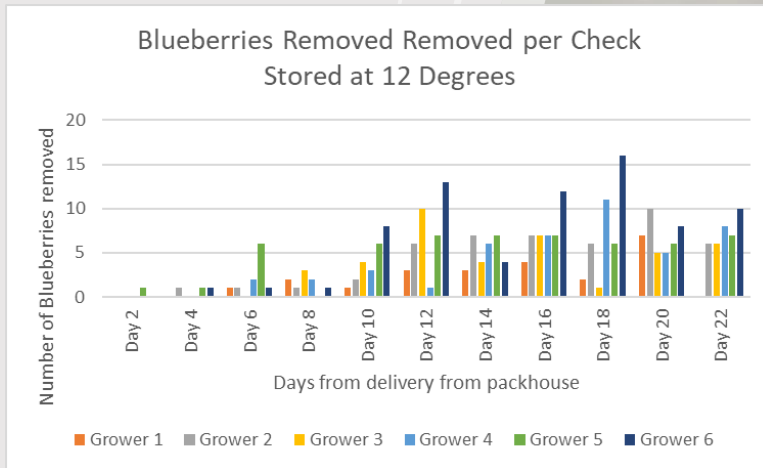
	P-value T-test
Grower C Blue vs White	0.0160*
Grower C Red vs White	0.0053**
Grower D Blue vs White	0.1090 ns
Grower D Red vs White	0.0623 ns

Interpretations from Products Testing

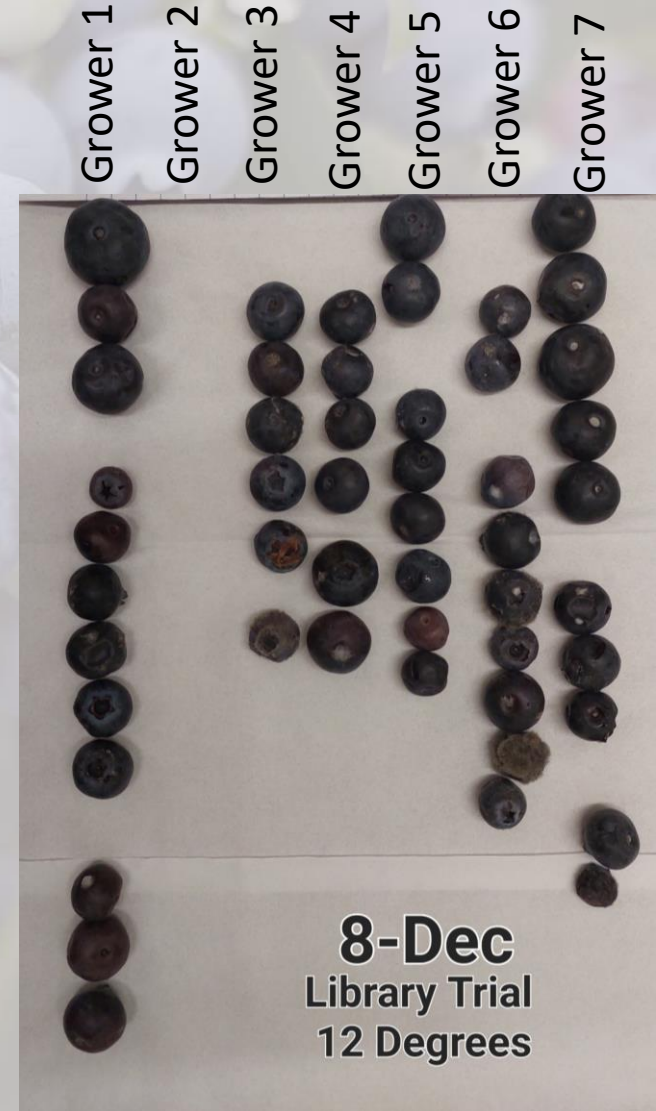
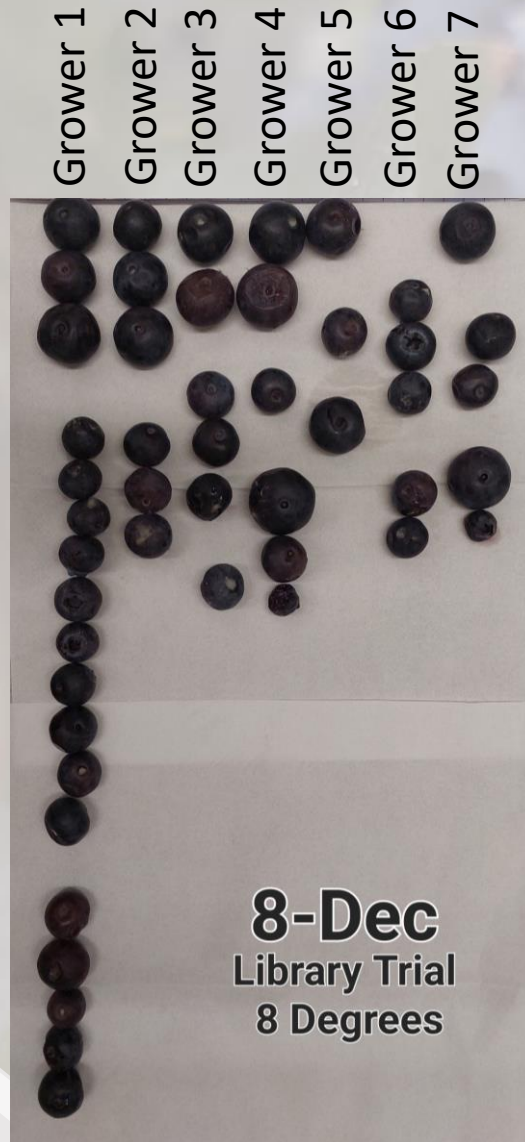
- Blueberries with botrytis break down faster, some can be as fast as 2 days post harvest.
- Although trials show an increase in breakdown at 10-11days.
- The Blue treatment (Botry-zen® / Armour-zen®) showed the most consistent reduction in botrytis over the 3 products testing trials.
- The Red treatment (Loker®) also provided encouraging results.
- The blue and red treatments also showed a increase in firmness and increase in calcium which literature states is also key in a longer storage life and less susceptible to breakdown
- Results from trials give an assumption that First Blush as a variety may have more resistance to botrytis than Eureka - more trials based on variety are recommended.

Any questions???

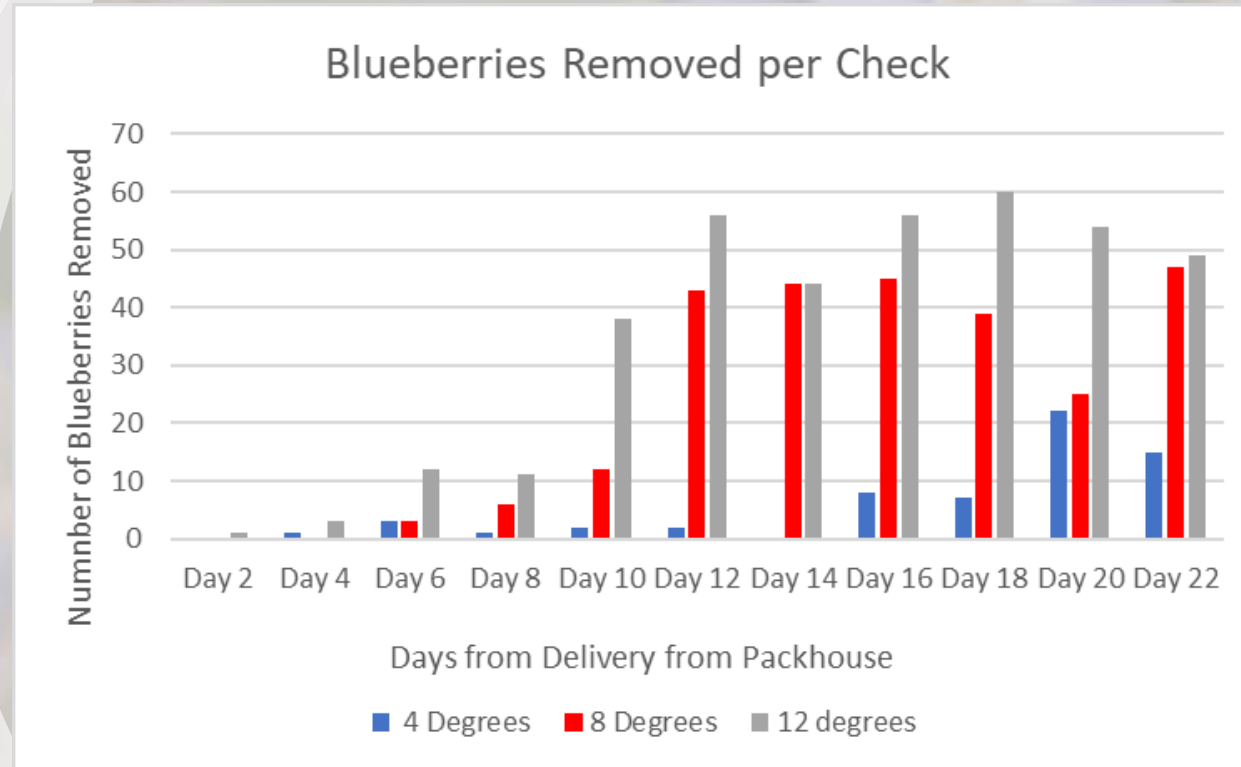
Storage Trial at Different Temperature



Product Testing

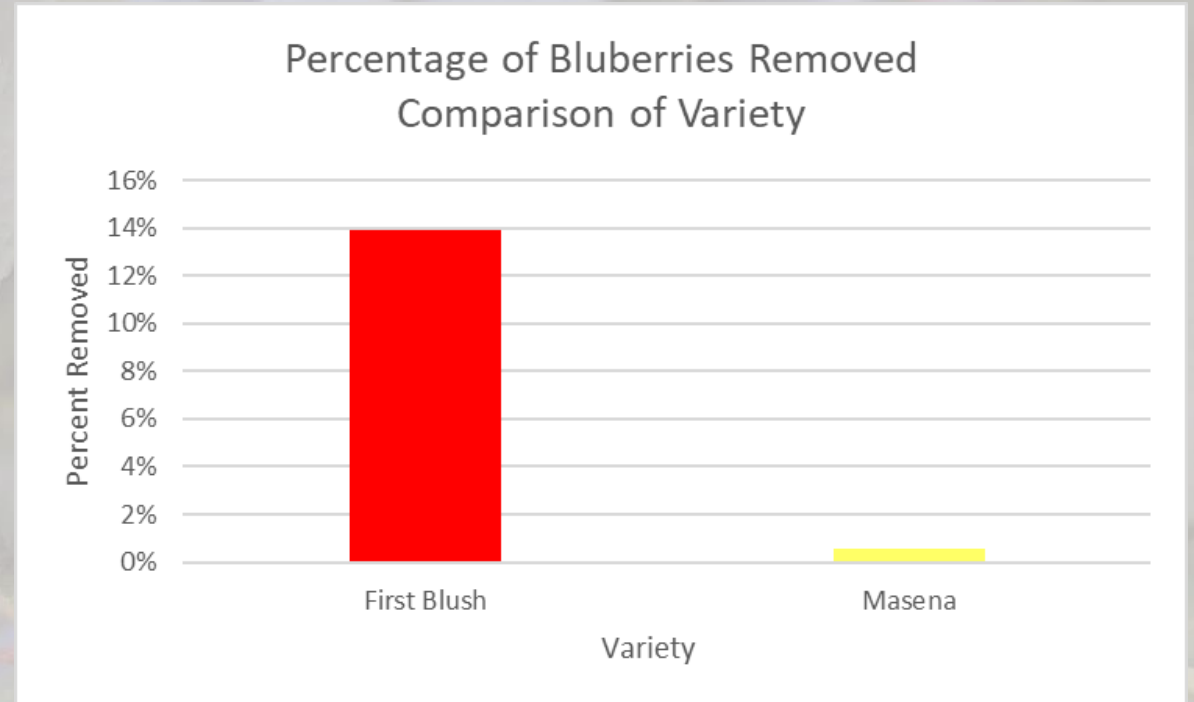
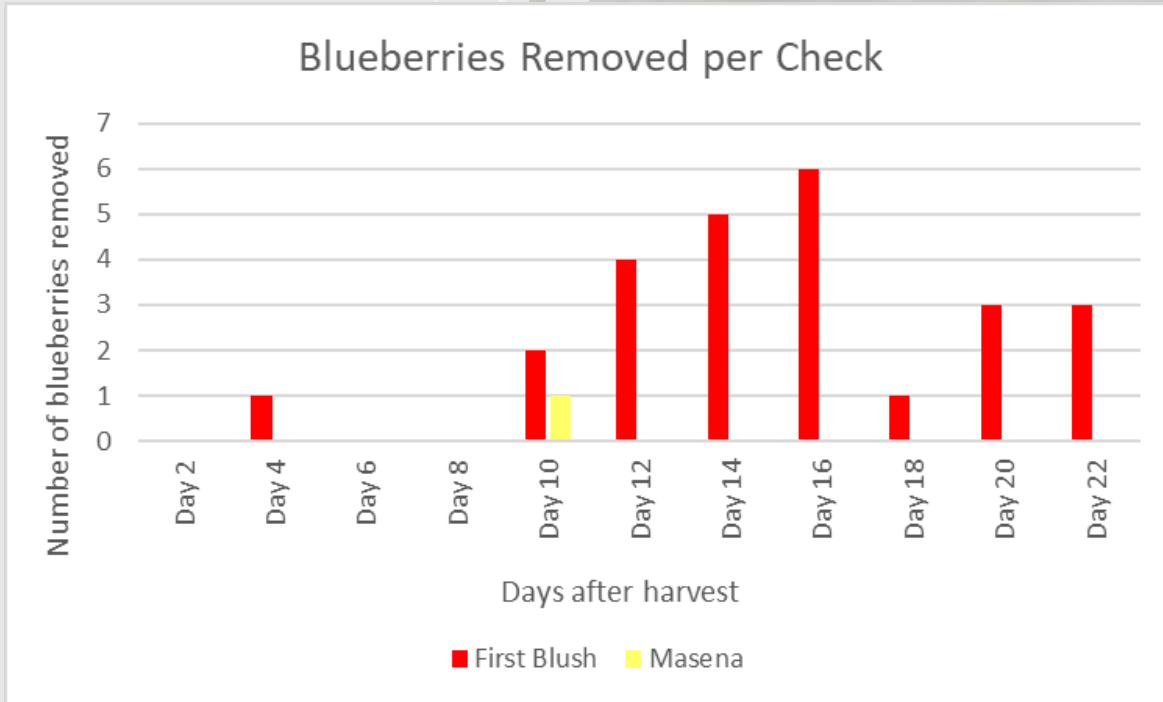


Storage Trial at Different Temperatures



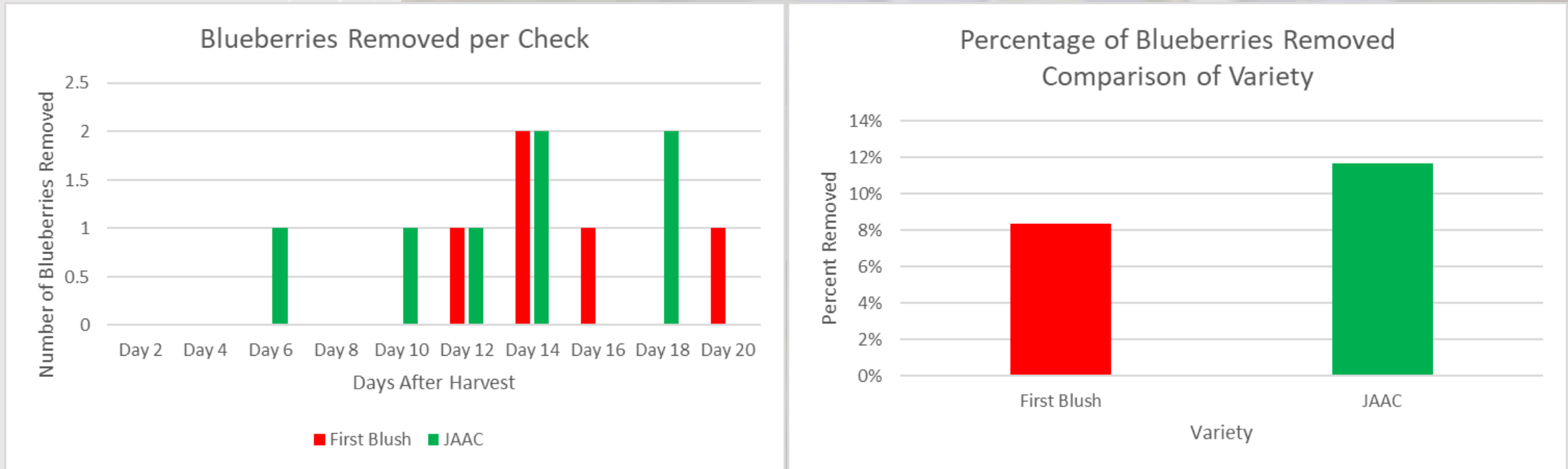
	P-value T-test
12 degrees vs 4 degrees	1.02691E-5****
12 degrees vs 8 degrees	0.0977 ns
8 degrees vs 4 degrees	1.02691E-5****

Other Trials – Masena vs First Blush



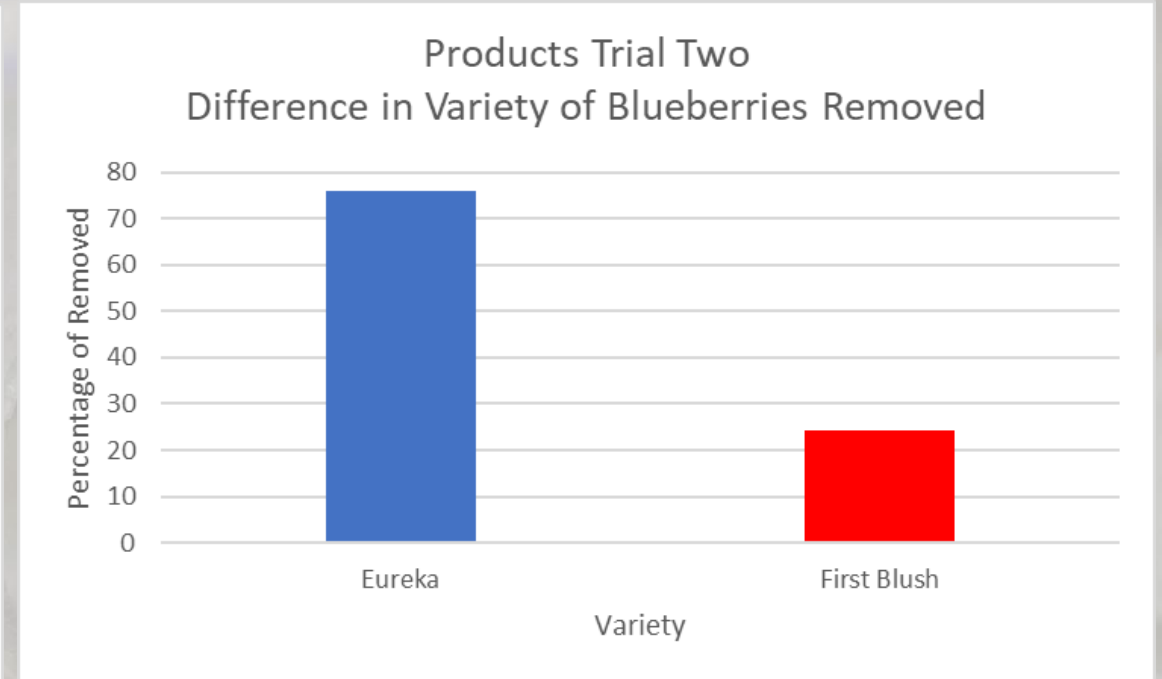
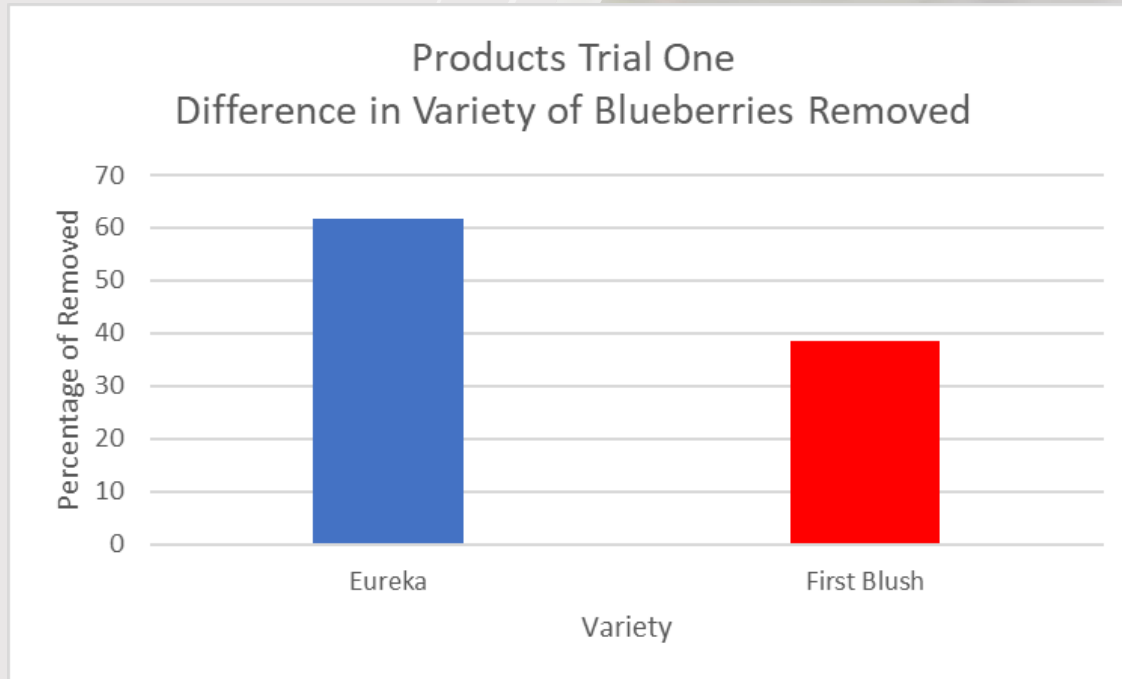
	P-value T-test
First Blush vs Masena	0.00060***

Other Trials – JAAC vs First Blush



	P-value T-test
First Blush vs JAAC	0.5650 ns

Eureka vs First Blush



	P-value T-test
Trial One	0.1622 ns
Trial Two	6.45005E-10****

Interpretations from Storage & Variety Trials

- The storage trials leads us to assume that keeping the fruit at lower temperatures can delay the expression of the botrytis.
- The trials show there is possibly a difference of susceptibility in variety to botrytis. First Blush more resilient than the Eureka, with Masena showing to be even more promising - recommend more trials based on variety.
- It is also interesting to note that the trials from late December onwards, along with having less blueberries with botrytis, those that were removed did not appear as “covered” in mould as those trialled in November, this could also potentially be related to climate and the later flowering berries contracted less botrytis – more trials recommended.

Any Questions?

Fungicide Sprays

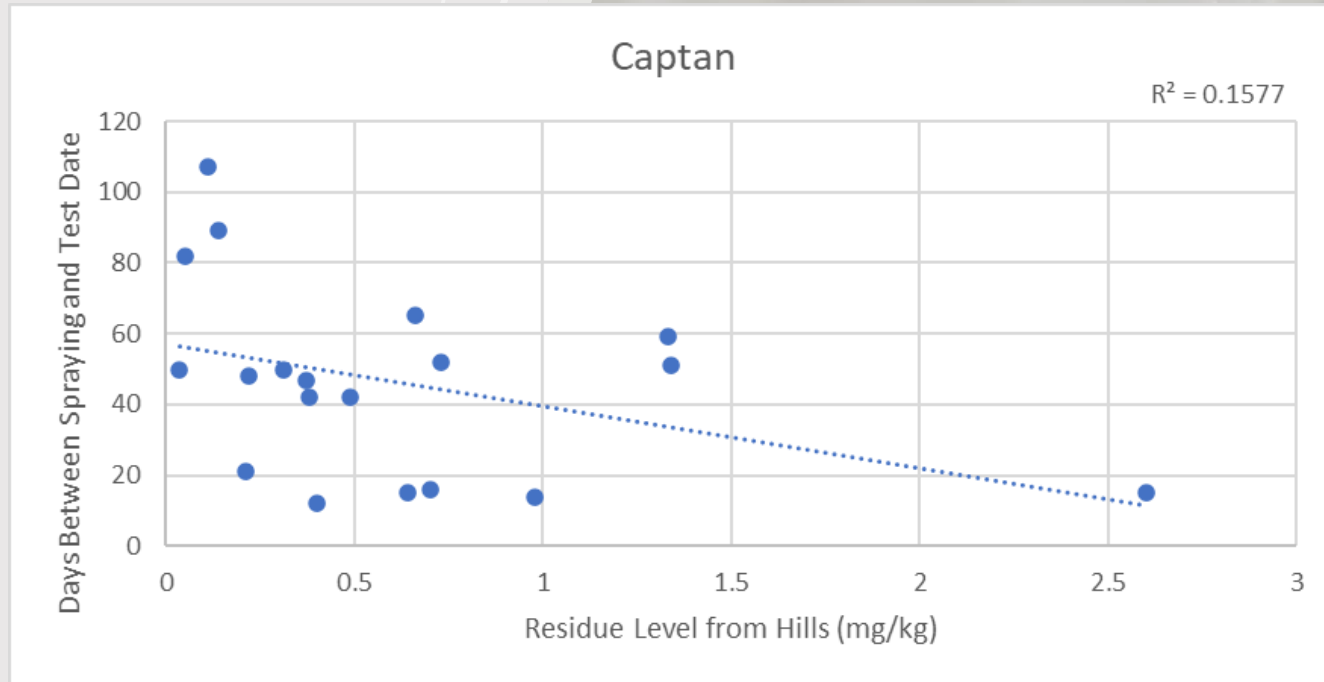
Spraying is a crucial factor to reduce botrytis. MBO agronomists say when the pressure is high we need to be spraying weekly.

Pristine and Switch are two products BerryCo highly recommended for growers to use – Captan recommended to mix in conjunction during application. Best practice is 2 applications of each during the season. The season just past only 5/22 growers did this.

Issues we are currently facing in regards to sprays:

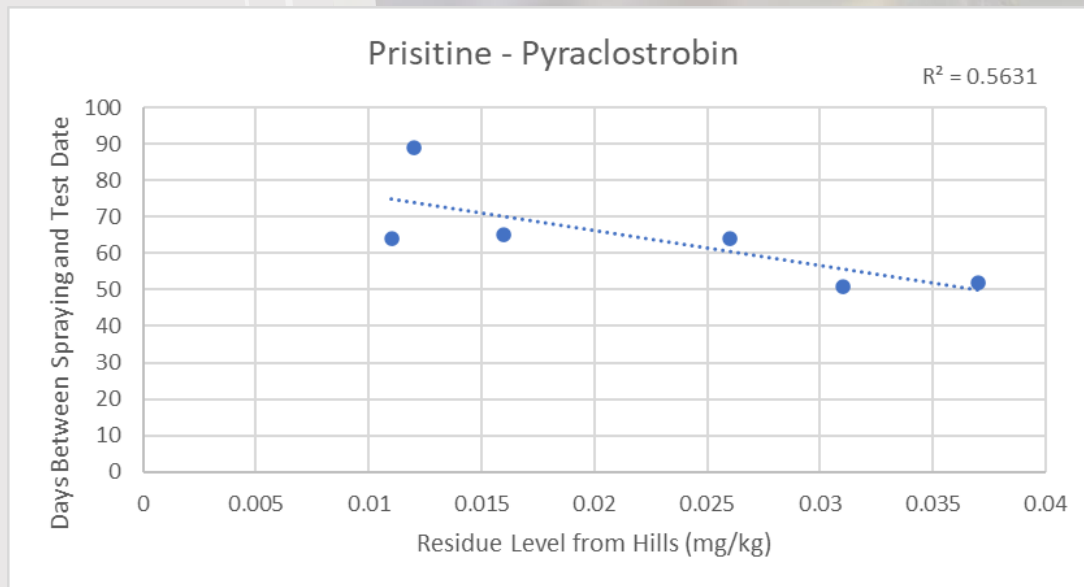
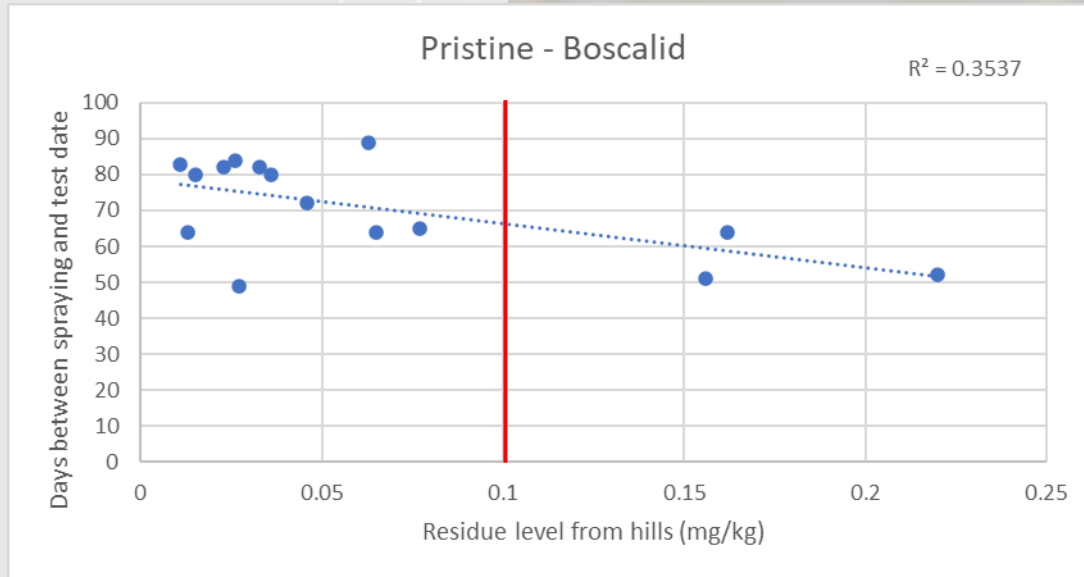
- Spraying Blueberries, especially at the critical times for botrytis loading can be difficult due to withholding days for spray residues.
- Maximum Residue Levels (MRL) differ between countries.
- When sunshine hours are lower, spray residue remains longer on the berries.
- Once bushes get too much growth, sprayers cannot fit easily into tunnels without crop damage.

2022 Residue Tests - Captan



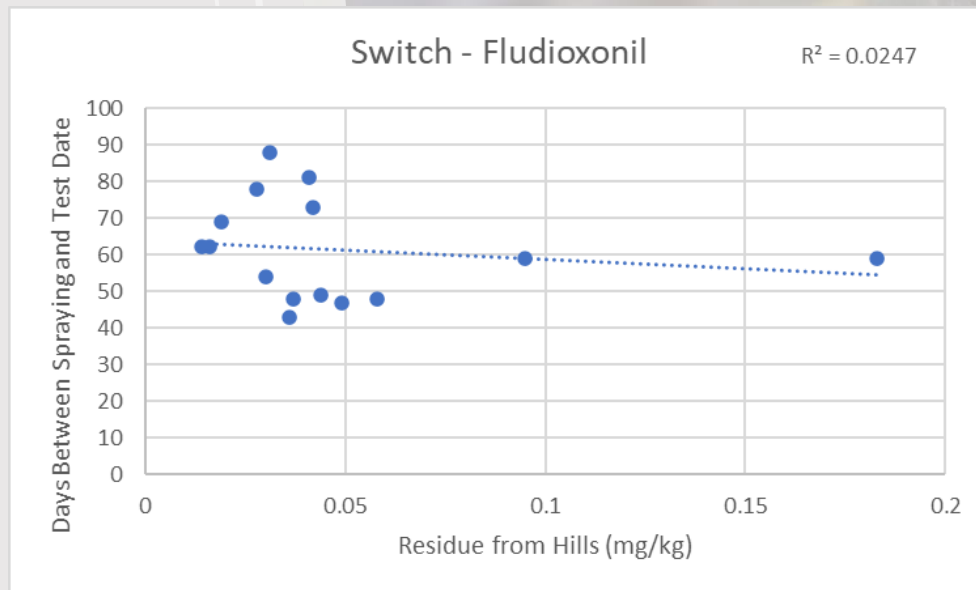
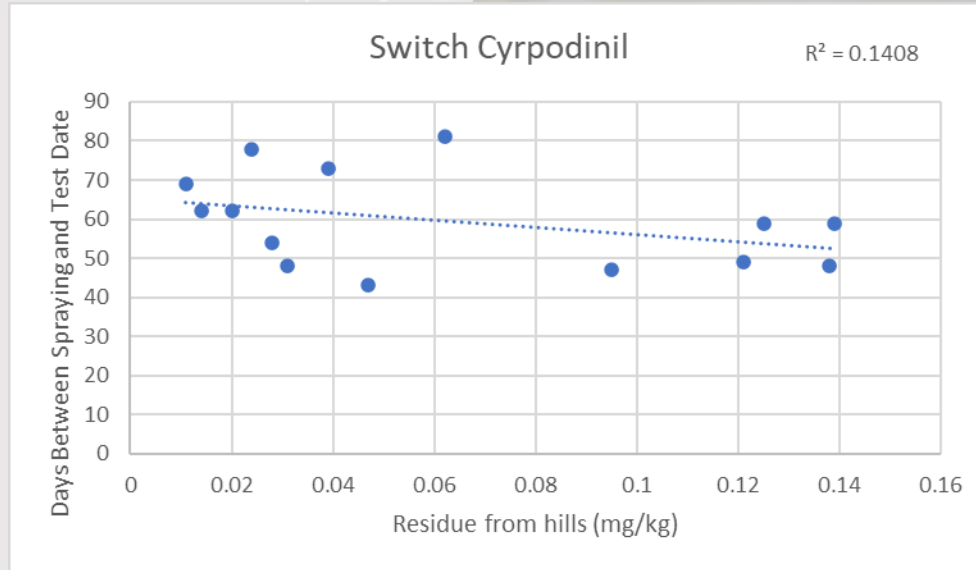
- All growers residue tests returned well within MRL of 20.
- Captan is best used in conjunction with other fungicide sprays – no more than 5 applications per season.
- Best applied early flowering, 80-100% petal fall, ripening and pre-harvest
- Low R-squared value showing weak relationship between last spray date and residue test date.

2022 Residue Tests - Pristine



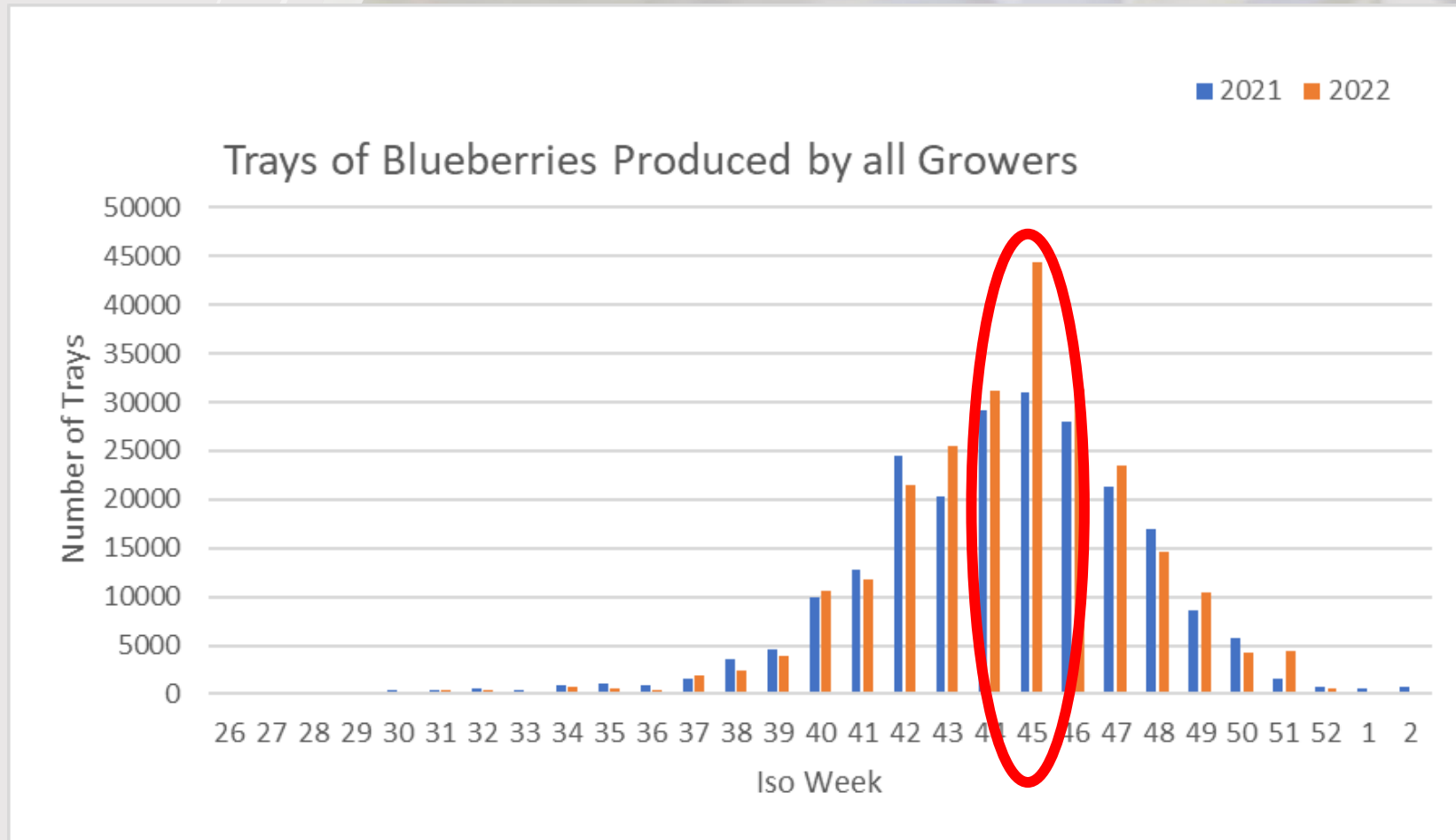
- Has 2 active ingredients, both have the same MRL, except Boscalid has a much longer breakdown period.
- Out of all growers only 2 had residue over the MRL of 0.1 for Boscalid. One grower had to test multiple times.
- Majority of growers follow 50g/100L
- Best applied at early flowering to pre-harvest – no more than 2 applications per season.
- R-squared value for both ingredients is between 0.3 – 0.7 showing a moderate relationship between last spray date and residue test

2022 Residue Tests - Switch



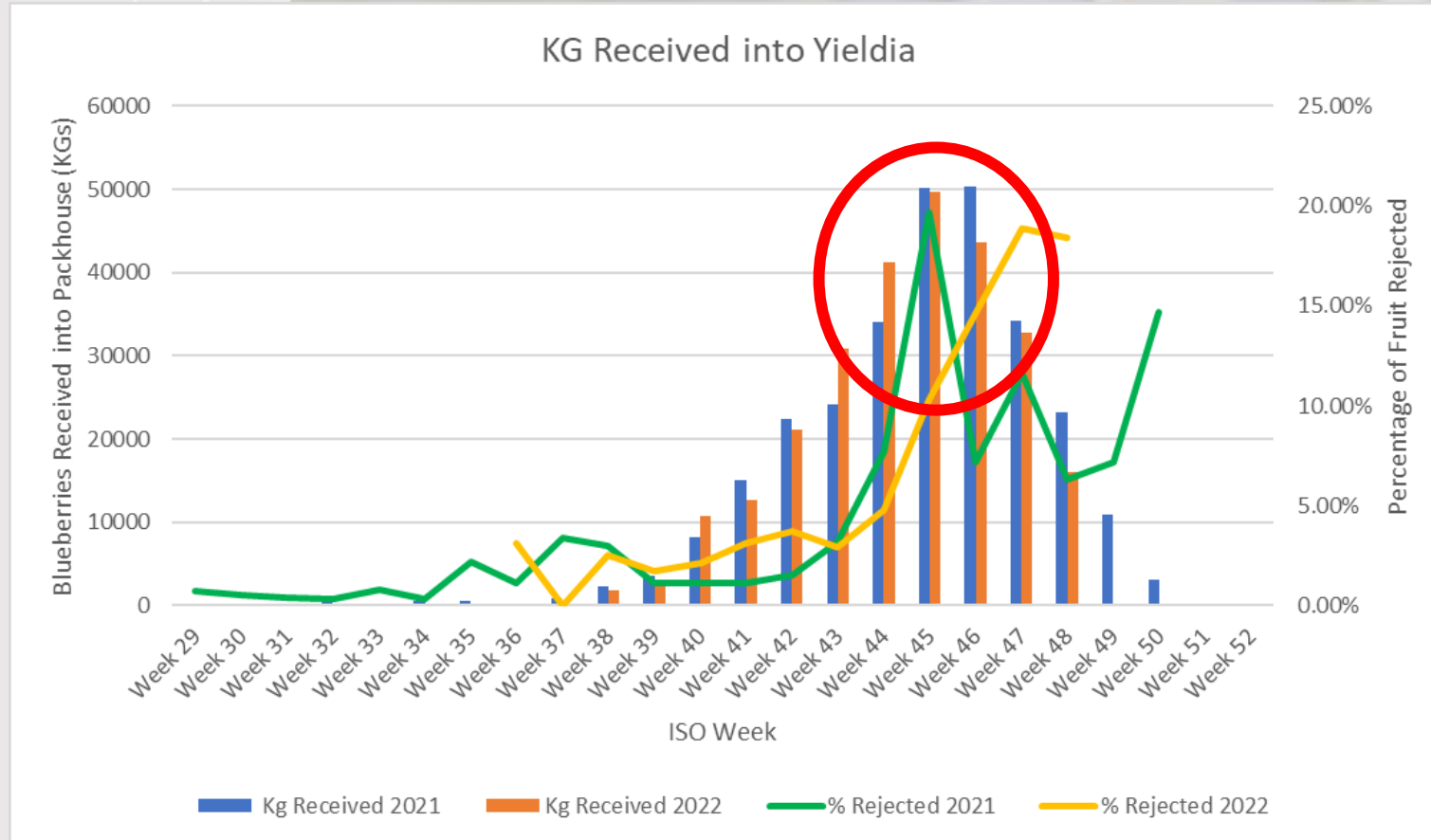
- All growers residue tests returned well within MRL.
- Recommended rate is 0.8 kg/ha
- Only 1 grower was close to this recommendation, majority applied considerably lower at an average of 0.5 kg/ha.
- First application to be applied at full flowering, second no later than completion of flowering – no more than 2 applications per season.
- Low R-squared value showing a weak relationship between last spray date and residue test date.

Production for 2021 & 2022



Week 45 is peak production

Production vs Rejects from Yieldia



Along with peak production it's the peak of rejects
What sprays were applied 12 weeks ago at flowering?

Calendar of Events

Colour Codes	
Adjuvant/ Sufactant	
Fungicide	
Bio-Fungicide	
Insecticide	
Plant Nutrition	
Soil Nutrition	

Grower A															
Product	Use	Grower Justification	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Triplex	Bio-fungicide										9, 21				
Pristine	Fungicide	Botrytis						23		4					
Kocide Opti	Fungicide	Rust							1						
Mancozeb	Fungicide	Fungicide							14						
Switch	Fungicide	Botrytis							22	10					
Captan	Fungicide	Botrytis							22	10					
Nordox	Fungicide	Copper								10					
Movento	Insecticide	Thrips				3									
Seasol	Plant Nutrition	Foliar						16							
Seaweed	Plant Nutrition							23							
Bonebroth	Plant Nutrition							23							
MKP	Plant Nutrition	Leaf roller							14						
Calcium from bone	Plant Nutrition	Botrytis							22	4, 10					
CarboK	Soil Nutrition	Foliar				3									
Genko/Braken tea	Soil Nutrition							23							

Grower B															
Product	Use	Grower Justification	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
LAT-B®	Adjuvant			1	3										
TRIPLEX	Bio-fungicide	Bio - botrytis prevention					25								
ESCOLTA®	Fungicide	Rust			3										
THIRAM 80 WDG	Fungicide	Botrytis prevention			30	21	12								
CAPTAN 800WG	Fungicide	Botrytis prevention						14, 21	10	8, 24					
PRISTINE®	Fungicide	Botrytis prevention						21		8					
SWITCH®	Fungicide								10	24					
APHIDEX® WG	Insecticide	Aphids			3										
AVID®	Insecticide	Leafroller		1											
SUCCESS® NATURALYTE®	Insecticide	Leafroller		17											
MOVENTO® 100SC	Insecticide	Thrip/leafroller					20								

Calendar of Events

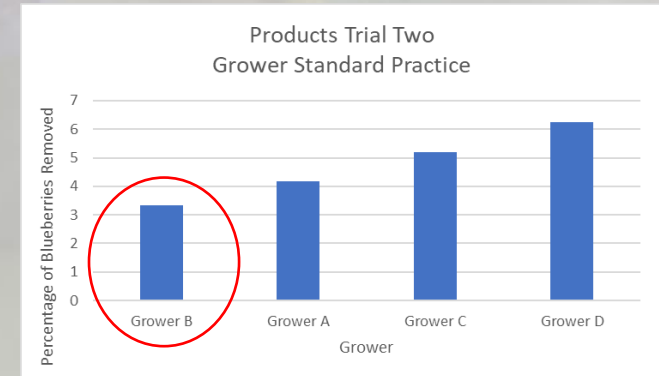
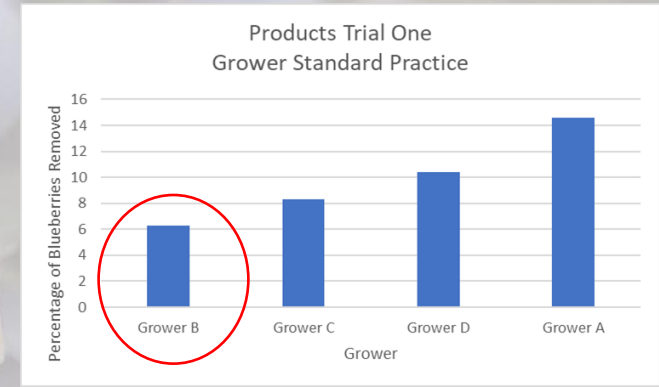
Colour Codes	
Adjuvant/ Sufactant	
Fungicide	
Bio-Fungicide	
Insecticide	
Plant Nutrition	
Soil Nutrition	

Grower C														
Product	Use	Grower Justification	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
HML Silco	Adjuvant	Plant health						17	1, 15	10, 21	2			
WETCIT®	Adjuvant	Aphids									7			
BOTRY-ZEN®	Bio-fungicide	Botrytis protection				17	3							
MANCO 75WG	Fungicide	Rust prevention	29											
ESCOLTA®	Fungicide	Rust & Botrytis prevention		2										
CAPTAN 800WG	Fungicide	Botrytis					22	4, 17	15, 23		16			
PRISTINE®	Fungicide	Botrytis prevention						17						
SWITCH®	Fungicide	Botrytis protection							1, 23					
HML 32	Fungicide	Botrytis prevention								10				
ESTEEM®	Fungicide	Botrytis								21	2			
CAPTAN 600 FLO	Fungicide	Post pruning protection												2
PROTEK®	Insecticide	Aphids, Caterpillars	2											2
PIRIMOR® 50	Insecticide	Aphids	29					17						
PRODIGY	Insecticide	Leaf Roller, Caterpillars				3								
TRANSFORM	Insecticide	Aphids					22							
SEASOL	Plant Nutrition	Plant health		2		3, 17	3, 22	4, 17	1					
YARAVITA BORTRAC 150	Plant Nutrition	Plant health				17	3, 22	4, 17	1, 23	21				
YaraVita ZINTRAC 700	Plant Nutrition	Plant health						17	1, 23					
YaraTera KRISTA MKP	Plant Nutrition	Plant health							15					
TECHNICAL GRADE UREA	Plant Nutrition	Plant health							15					
YARA REOXLIN	Plant Nutrition	Plant health								10, 21	2			
TECHNICAL GRADE UREA	Plant Nutrition	Plant health								10				
DU-WETT® SUPER SPREADER	Surfactant		29						23					2

Grower D														
Product	Use	Grower Justification	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MANZATE EVOLUTION	Fungicide				12									
PRISTINE®	Fungicide							17						
CAPTAN	Fungicide									5				
SWITCH	Fungicide									5				
SUCCESS® NATURALYTE®	Insecticide	Thrips found		6										
MOVENTO® 100SC	Insecticide	Thrips			13									
ZETaPY	Insecticide							25						
Seasol	Plant Nutrition							25						

Calendar of Events - fungicides

Grower A			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Product	Use	Grower Justification												
CAPTAN	Fungicide	Botrytis							22	10				
KOCIDE OPTI	Fungicide	Rust							1					
MANCOZEB	Fungicide	Fungicide							14					
NORDOX	Fungicide	Copper								10				
PRISTINE®	Fungicide	Botrytis						23		4				
SWITCH	Fungicide	Botrytis							22	10				
TRIPLEX	Bio-fungicide										9, 21			
Rainfall above 30mm			6,7		23	22	19, 30	6, 18	5, 8, 12, 25	18	5, 9, 10	1, 30	11, 18, 22	15
Grower B			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Product	Use	Grower Justification												
CAPTAN 800WG	Fungicide	Botrytis prevention						14, 21	10	8, 24				
ESCOLTA®	Fungicide	Rust			3									
PRISTINE®	Fungicide	Botrytis prevention						21		8				
SWITCH®	Fungicide								10	24				
THIRAM 80 WDG	Fungicide	Botrytis prevention			30	21	12							
TRIPLEX	Bio-fungicide	Bio - botrytis prevention					25							
Rainfall above 30mm			6,7		23	22	19, 30	6, 18	5, 8, 12, 25	18	5, 9, 10	1, 30	11, 18, 22	15
Grower C			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Product	Use	Grower Justification												
BOTRY-ZEN®	Bio-fungicide	Botrytis protection				17	3							
CAPTAN 600 FLO	Fungicide	Post pruning protection												2
CAPTAN 800WG	Fungicide	Botrytis					22	4, 17	1, 15, 23		16			
ESCOLTA®	Fungicide	Rust & Botrytis prevention		2										
ESTEEM®	Fungicide	Botrytis								21	2			
HML 32	Fungicide	Botrytis prevention								10				
MANCO 75WG	Fungicide	Rust prevention	29											
PRISTINE®	Fungicide	Botrytis prevention						17						
SWITCH®	Fungicide	Botrytis protection							1, 23					
Rainfall above 30mm			6,7		23	22	19, 30	6, 18	5, 8, 12, 25	18	5, 9, 10	1, 30	11, 18, 22	15
Grower D			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Product	Use	Grower Justification												
CAPTAN	Fungicide									5				
MANZATE EVOLUTION	Fungicide				12									
PRISTINE®	Fungicide							17						
SWITCH	Fungicide									5				
Rainfall above 30mm			6,7		23	22	19, 30	6, 18	5, 8, 12, 25	18	5, 9, 10	1, 30	11, 18, 22	15



Formulation of a fungicide spray guide

Using current recommendations and residue levels from grower tests I have calculated a possible spray schedule over the most critical time for botrytis loading.

Taking into account:

- MRL for both New Zealand and the lowest maximum for export
- Times recommended for applications of each product and compatibility.
- Using week 40 as the beginning of harvest as this is the most common start date – then leads to assume week 28 is start of flowering
- Using week 33 as full flowering as that's 12 week prior to the week 45 “boom”
- Growers whose beginning of harvest is not at week 40 can adjust accordingly (see revised BerryCo Botrytis Countdown Framework once updated).

Month	June	July				August					Sept				Oct
Iso	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Product	Botryzen Captan	Pristine	Botryzen Captan	Esteem	Switch Captan	Pristine	Esteem	Botry-zen	Switch Captan	Esteem		Amour-zen	Esteem	Amour-zen	

Interpretation of Spray Data

In order to be getting the best use out of protection via fungicides growers need to be applying
The recommended number of applications from BerryCo of x2 Pristine and x2 Switch.
Pristine should be applied first as it has a longer withholding period.

Can be difficult with MRL but we need to be applying these sprays when botrytis loading pressure
is at its highest – the month of August.

Any Questions?

Overall Summary of Key Points

This past season was a hard year for horticultural production in general.

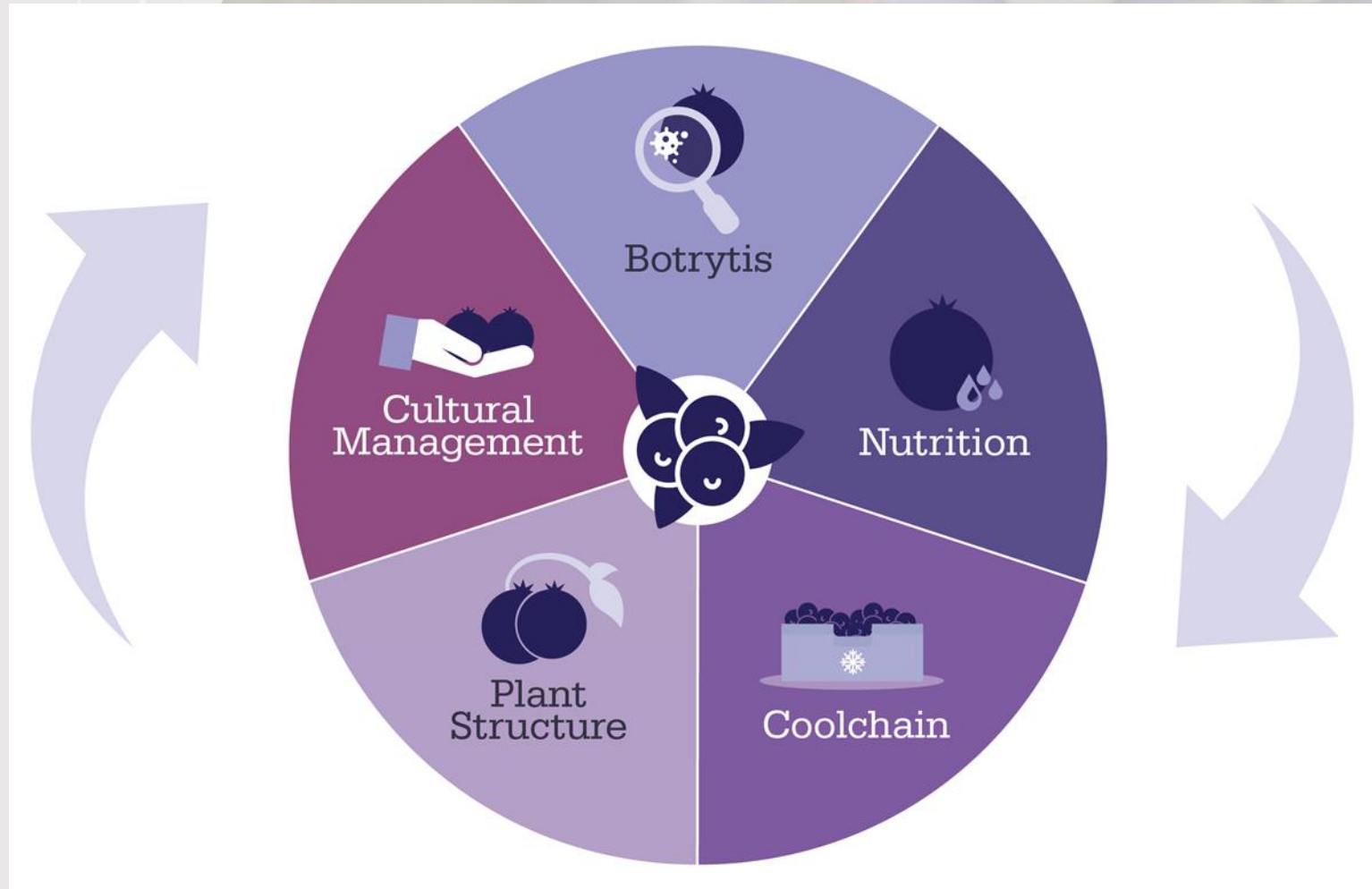
The weather was wetter, colder and more humid therefore leading to many days where the pressure for botrytis was high.

To help gain a better understanding into habits of botrytis within MBO varieties 3 major trials were conducted, where blueberries were monitored every 2 days for symptoms of botrytis, to look for trends.

One of these trials was to test the effectiveness of bio-fungicides, Botry-zen® showed the best results in reduction of blueberries with breakdown/botrytis while Loker® showed promising results.

Spray diaries were made into individual “calendar of events” and compared with residue tests. To help analyse and present a possible spray diary to be used in the 2023 season. It was found that during the previous season many growers did not use the current fungicide recommendations of x2 Pristine and x2 Switch. Growers who followed these recommendations had less botrytis.

Recommendations



Recommendations

There has been some fascinating finds from this years research – most still in the preliminary stages, the highlights have been:

- Botry-zen® has show very encouraging results in the reduction of botrytis in blueberries. It can also be administered through bee-vectoring at pollination.
- Loker® is a promising product that can be used help to add strength to the blueberry which results in not only a reduction in botrytis but a increase in storage shelf life. It can be used in forms of a foliar spray or in fertigation – useful when sprayers are unable to fit in tunnel rows.
- More trials recommended between varieties to confirm susceptibility to botrytis – including more Masena.

From the research made around bio-fungicides and spray diaries my recommendations are:

- Spray the currently guided recommendations of x2 Pristine and x2 Switch in combination with Captan.
- Growers should reassess their current spray diary and spray rates to get optimum use of fungicides.
- Growers can use tools such as Harvest.com to monitor rainfall events and botrytis sensors to plan spraying around days where the botrytis pressure is high. As current weather patterns potentially could become the “new normal”.
- Look at including Botry-zen® / Armour-zen® and Loker® within their spray schedule or fertigation with Loker®.
- Consider bee-vectoring Botry-zen® at flowering.





Thank you
Any questions?



Appendix

	P-value Symbol Meaning
$P > 0.05$	ns
$P \leq 0.05$	*
$P \leq 0.01$	**
$P \leq 0.001$	***
$P \leq 0.0001$	****

Appendix

