



Grapevine leafroll disease (GLD) and its management in South Africa.

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Leafroll affects three grape industries in South Africa



Wine grapes

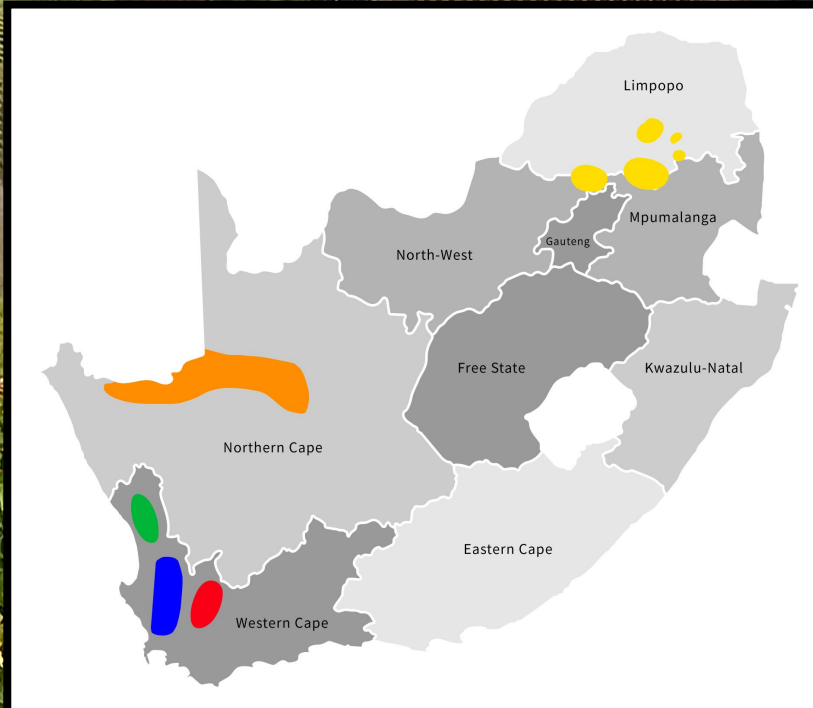


Table grapes



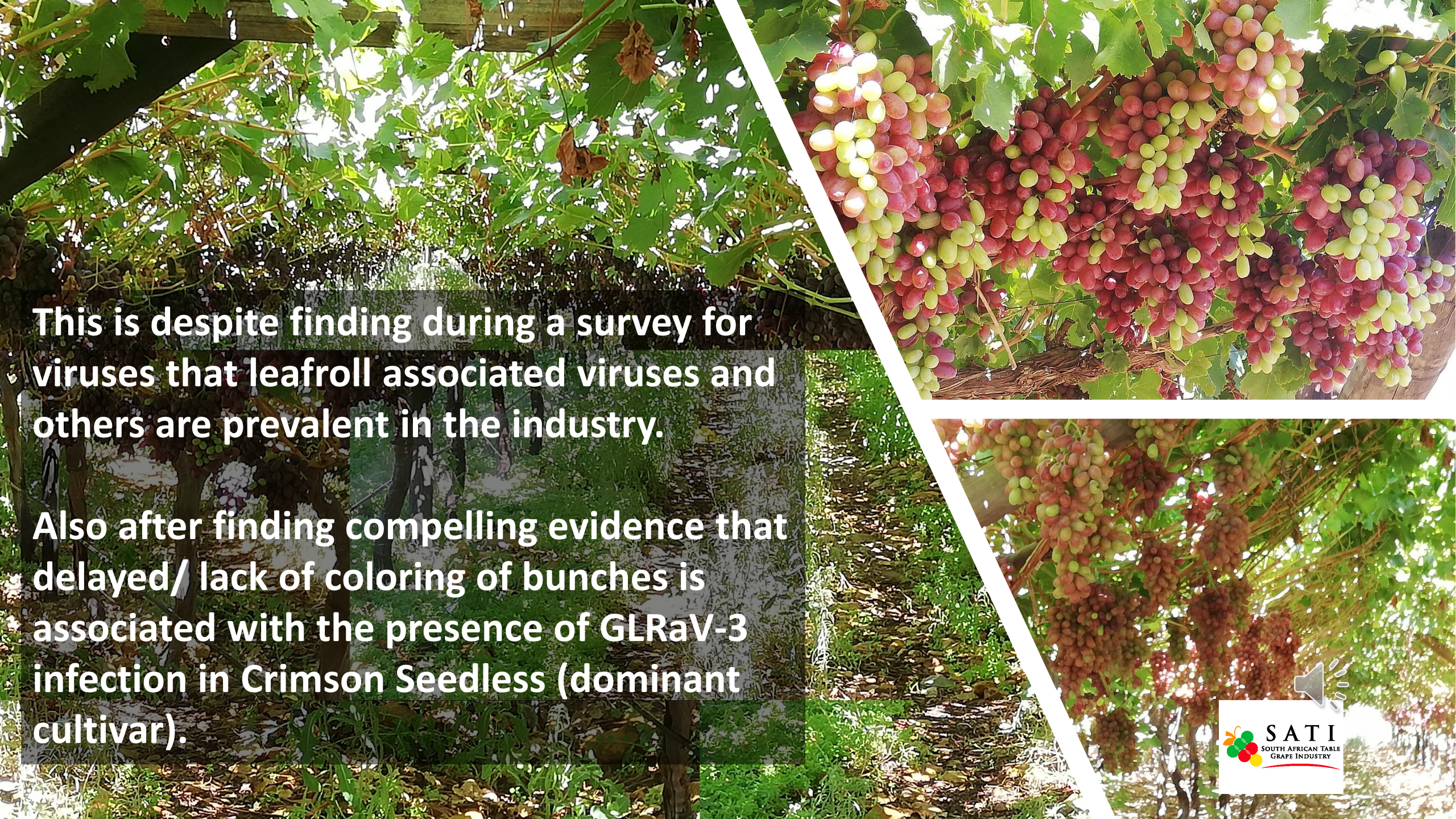
Raisin grapes

Table grape industry do not consider leafroll as important

Low stress growing environment, leaf symptoms of grapevine leafroll are mild (and long after harvesting).

Not aware of ANY roguing and replanting done in commercial setting.





This is despite finding during a survey for viruses that leafroll associated viruses and others are prevalent in the industry.

Also after finding compelling evidence that delayed/ lack of coloring of bunches is associated with the presence of GLRaV-3 infection in Crimson Seedless (dominant cultivar).

Table grape industry would benefit from leafroll control.

Even ripening berries, even coloring bunches.

Earlier ripening.

Already apply very good mealybug (leafroll vector) control.

However extremely loath to rogue (\$\$\$\$).



Raisin industry mainly based on white cultivars (cv. Selma Pete and Merbein). On these do not observe leafroll leaf symptoms when infected.

Awareness of leafroll is increasing however with a greater insistence on virus-free planting material in the last five years.

No roguing or replanting occurring. Would be expensive (laboratory tests to identify infected vines). Profit margins too low to warrant this.





The South African wine industry considers grapevine leafroll as the most important (viral) disease of vines.



Actual losses not quantified (active decision).

All funding on research to control leafroll from the wine industry.

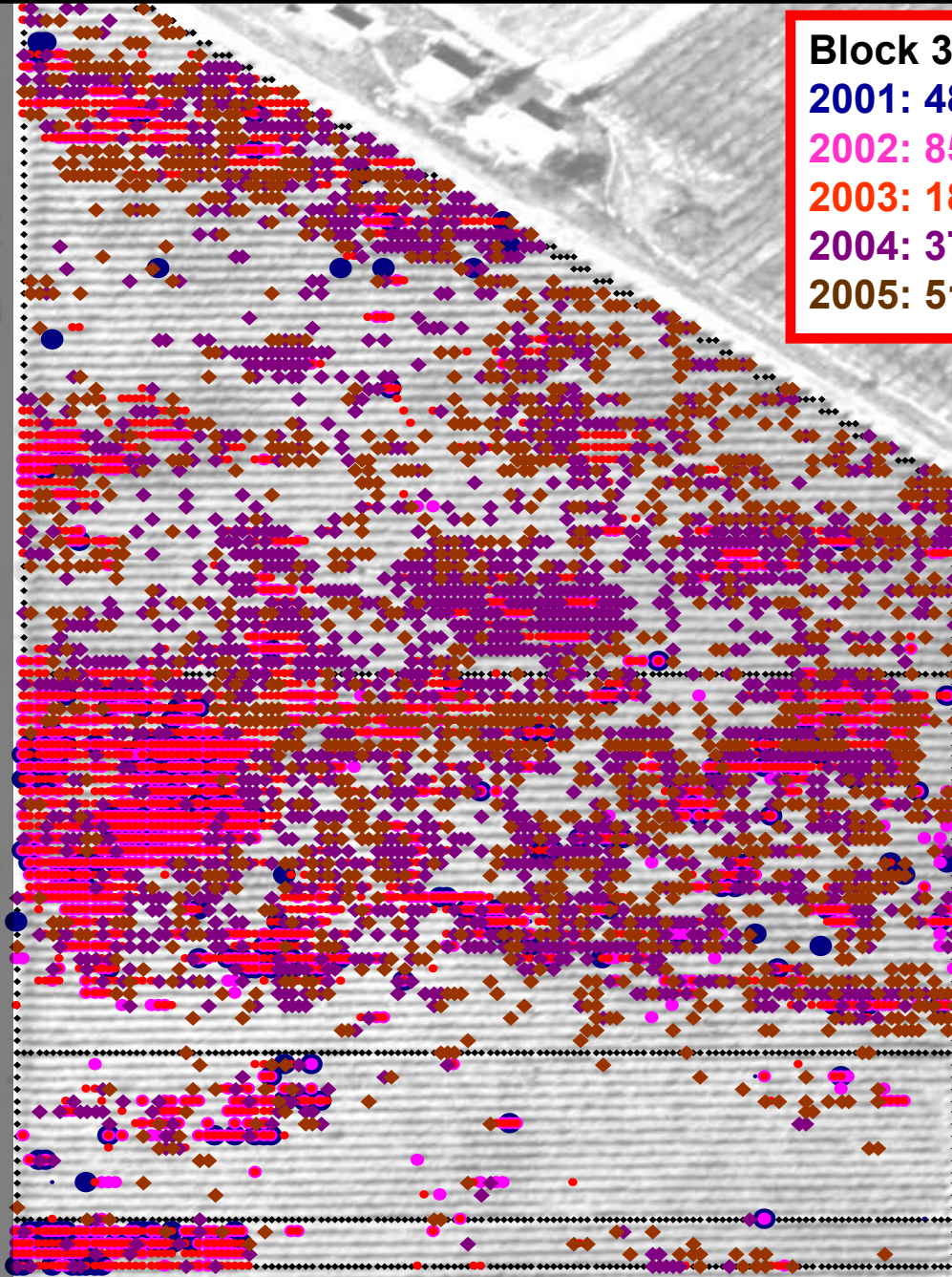


Discussion further based on wine industry



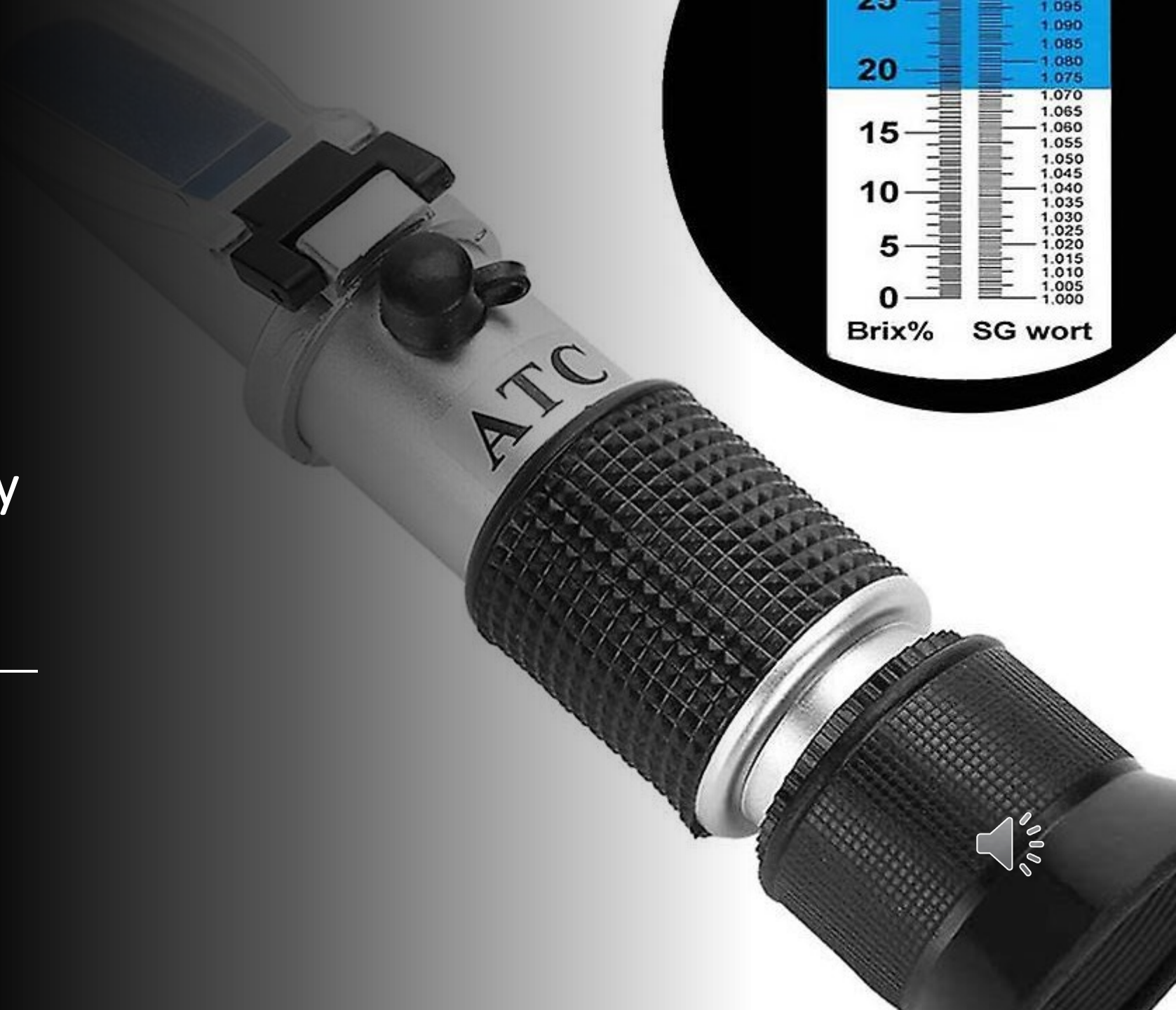
If not managed, the number of leafroll infected vines effectively double annually*.

*Average (n = 55) vineyards monitored for 6 years.



Block 37 (Total 11939):
2001: 487 (4.08%)
2002: 855 (7.17%)
2003: 1847 (15.55%)
2004: 3735 (31.44%)
2005: 5115 (43.09%)

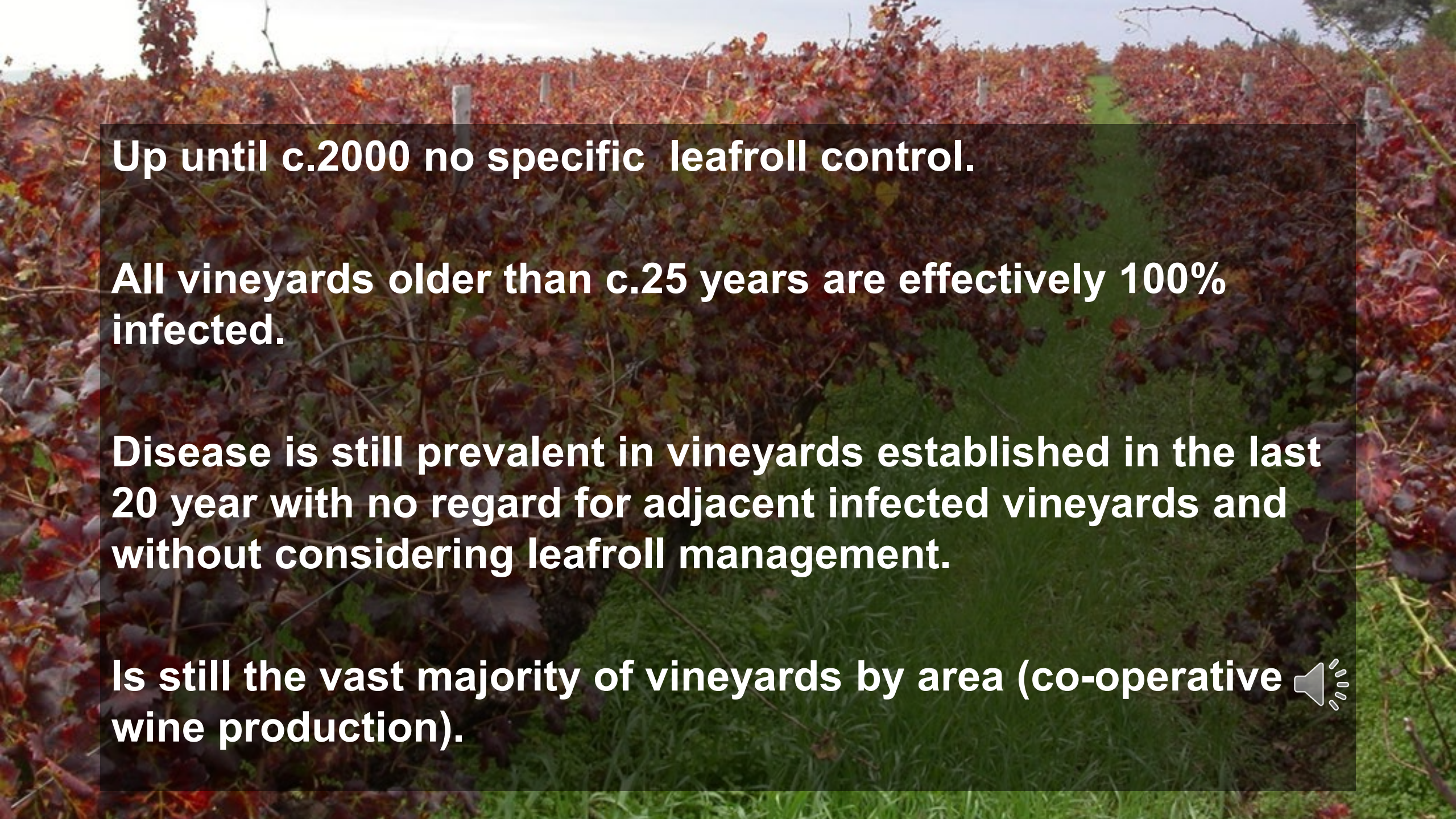
Growers' major concerns are leafroll infected vineyards displaying delayed or reduced sugar development (especially in a cool season) and yield reductions.





Generally, have to replace vineyards after 15 to 20 years because they are no longer economical viable due to reduced yields and quality.





Up until c.2000 no specific leafroll control.

All vineyards older than c.25 years are effectively 100% infected.

Disease is still prevalent in vineyards established in the last 20 year with no regard for adjacent infected vineyards and without considering leafroll management.

Is still the vast majority of vineyards by area (co-operative wine production) 🗣️

Effective leafroll control (near elimination) at own-label wine estates at high-end of market.

(Background image of a red cultivars at Tokara, April, 2020).



Most important Leafroll associated virus:

Grapevine leafroll associated virus type 3 (GLRaV-3)

**Seldom detect GLRaV-1
No longer find GLRaV-2
GLRaV-4, -7 virtually absent.**

Background Photo: K. Kasdorf



Main vector is the vine mealybug (*Planococcus ficus*) which is prevalent on vines in South Africa in all grape growing regions.

Longtail mealybug (*Pseudococcus longispinus*) rarely observed.

Scale insect species known to be vectors for GLRaV-3 are also rarely a problem.

**Pathosystem dealing with in South
Africa is GLRaV-3 and *P. ficus***



Control leafroll in **newly planted*** vineyards through integrated strategy:

- 1) Planting of certified (GLRaV-3 negative) material
- 2) Control the vector (mealybugs) population
- 3) Rouge infected vines (**rouging and replanting**)
- 4) Control vector dispersal from external GLRaV-3 sources.

***or vineyards with limited secondary spread and incidence of leafroll**



Control leafroll in new vineyards through:

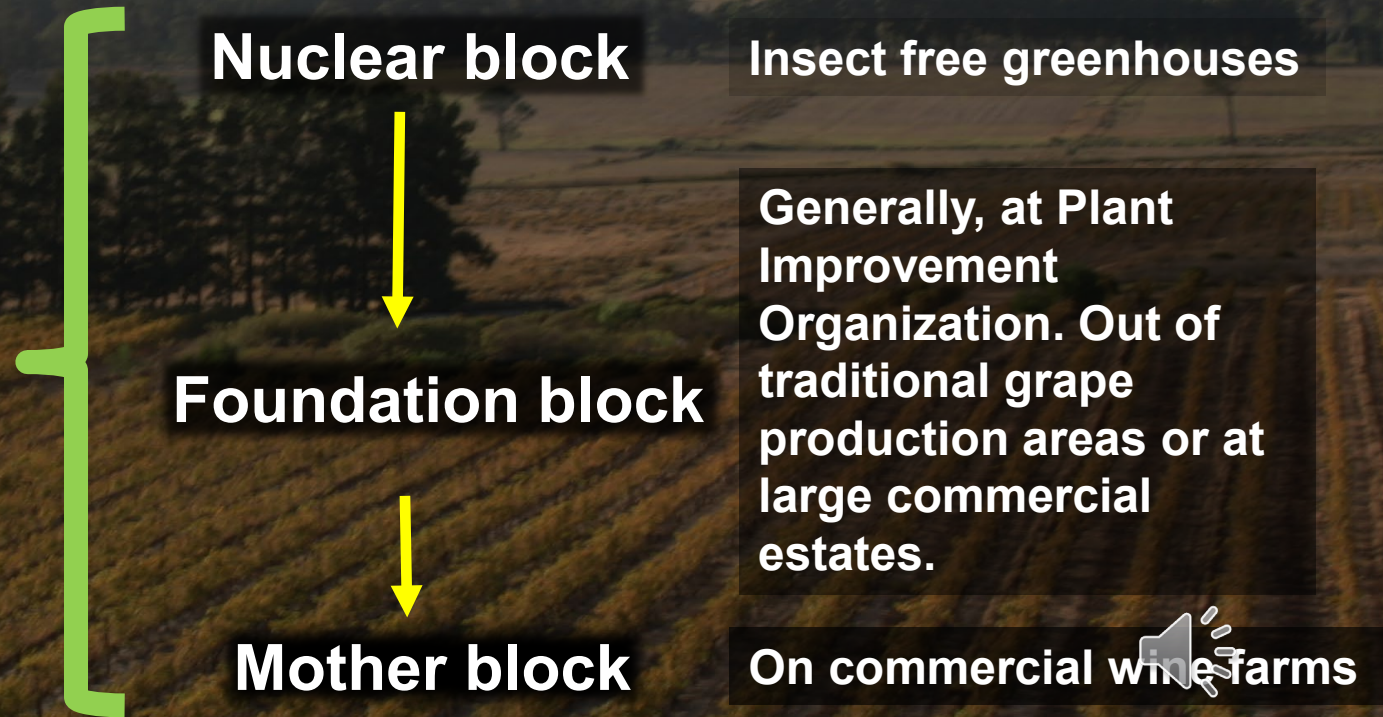
1. Planting of certified (GLRaV-3 negative) material (effectively preventative strategy)
2. Control the vector (mealybugs) population
3. Remove infected vines
4. Control vector dispersal from external GLRaV-3 sources



South African Vitis Certification scheme

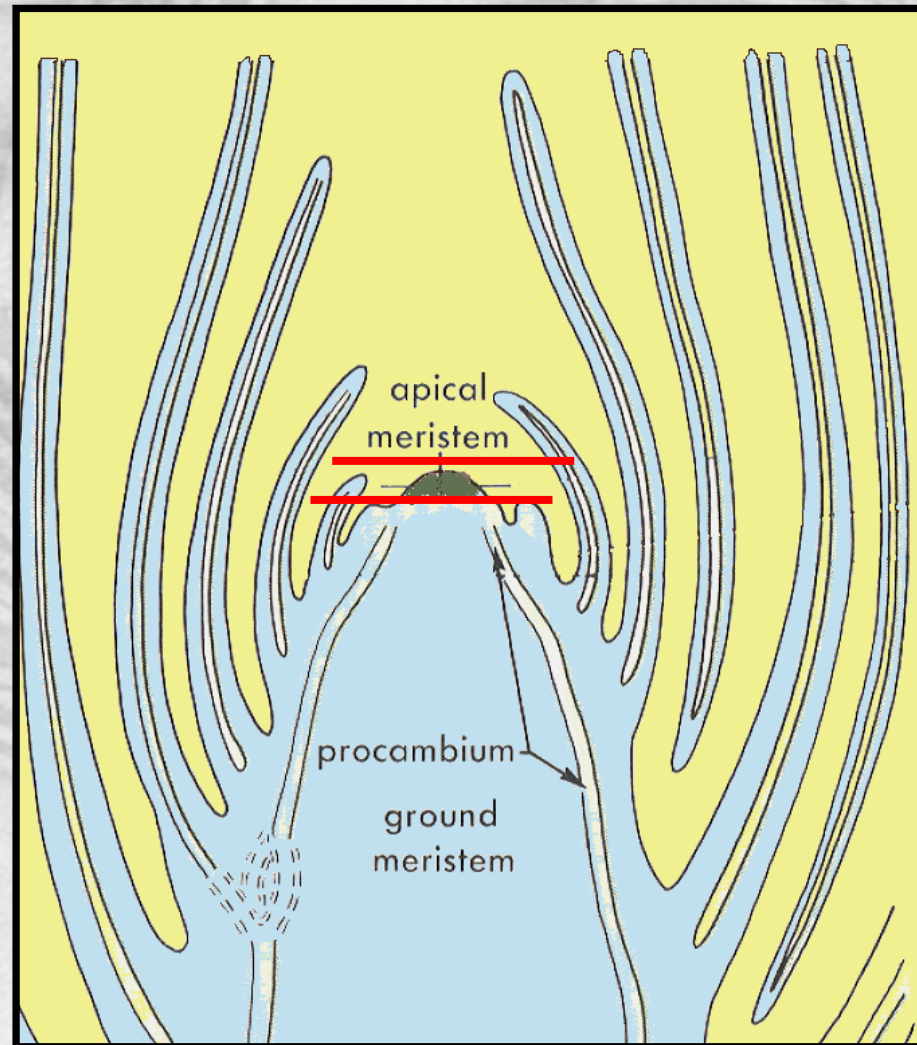
1. Mandatory Virus elimination
2. Virus testing

3. Propagation





Virus elimination by heat therapy and meristem tip culture



**0.24mm slice
(virus-free)**

Virus infected



5 - 7 months

After this process nuclear plants are generally free of all known viruses* but several viroids persist.

***97 nuclear accessions tested by next generation sequencing.**



Test for eight viruses in nuclear plants of the One-Vitis certification scheme.

Disease	Virus	Mandatory Tests		Optional tests
Fanleaf disease	Grapevine fanleaf virus (GFLV)	ELISA		PCR
Fleck disease	Grapevine fleck virus (GFkV)	ELISA		PCR
Leafroll disease	Grapevine leafroll associated virus 1 (GLRaV-1)	(interim dispensation)	Indexing	PCR/ISEM
	Grapevine leafroll associated virus 2 (GLRaV-2)	(interim dispensation)		
	Grapevine leafroll associated virus 3 (GLRaV-3)	ELISA		
Corky Bark	Grapevine virus B (GVB)	ELISA*		PCR
Stem pitting	Grapevine virus A (GVA)	ELISA*		PCR
Rupestris stem pitting	Grapevine Rupestris stem pitting virus (GRSPaV)		Indexing	PCR
Shiraz disease	Grapevine leafroll associated virus 3		Indexing	PCR 
	Grapevine virus A (GVA)			

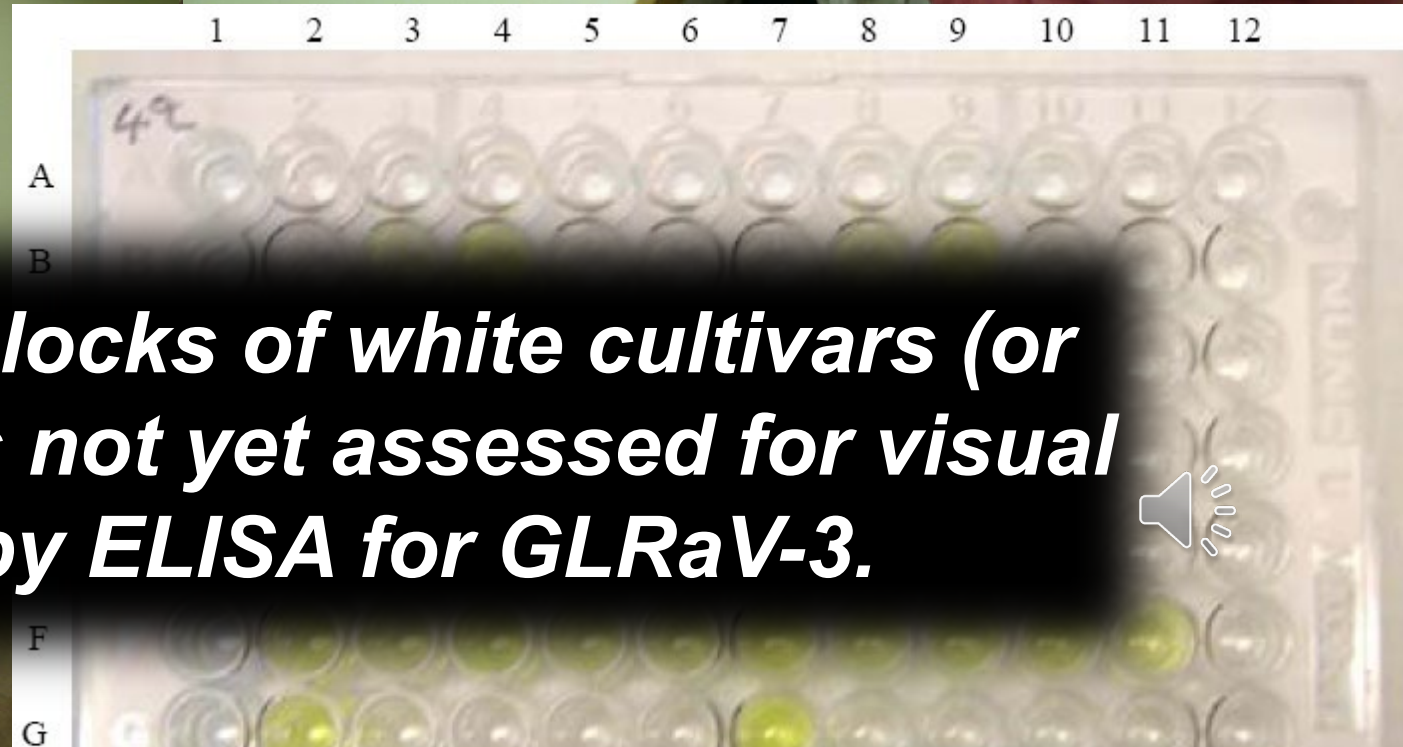


GFLV (Fanleaf)	Nucleus, GV & MB GLRaV 3 (Leafroll)	GFkV (Fleck)	GVA (Stem pitting & Shiraz disease)	GVB (Corky bark)
NUCLEUS UNIT				
every 5 years (Nov/Dec)	every 5 years (April/May)	every 5 years	every 5 years	every 5 years
FOUNDATION UNIT		NOTES: - Only the following rootstock varieties can have W2 status: 143-B; US 8-7; Jacquez *Only varieties as listed in VIA C-1-3 (paragraph 6.2.3) - All tests should be negative with ELISA assays.		
Before planting – Once (X. index)	* Annually Visually Free			
One year after planting – all plants	All plants tested yearly (3 year cycle) - (W2)			
MOTHER UNIT				
Before planting - Once (X. index)	Annually visually free (W1)			
One year after planting – 5% statistical basis	All plants yearly - (W2)			

A photograph of three people riding ATVs through a vineyard. The vines are dense and have yellowing leaves, indicating autumn. In the background, there is a white building and large trees. The scene is brightly lit by sunlight.

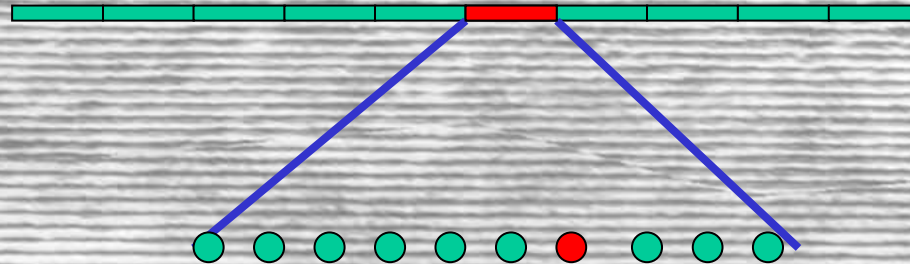
Foundation and mother blocks: Monitor by visual inspection in red cultivars (based on high correlation of symptoms with ELISA tests in major cultivars) (CS, MO, SH, CF, PI but expanding).





Test foundation blocks of white cultivars (or those red cultivars not yet assessed for visual inspection) by ELISA for GLRaV-3.

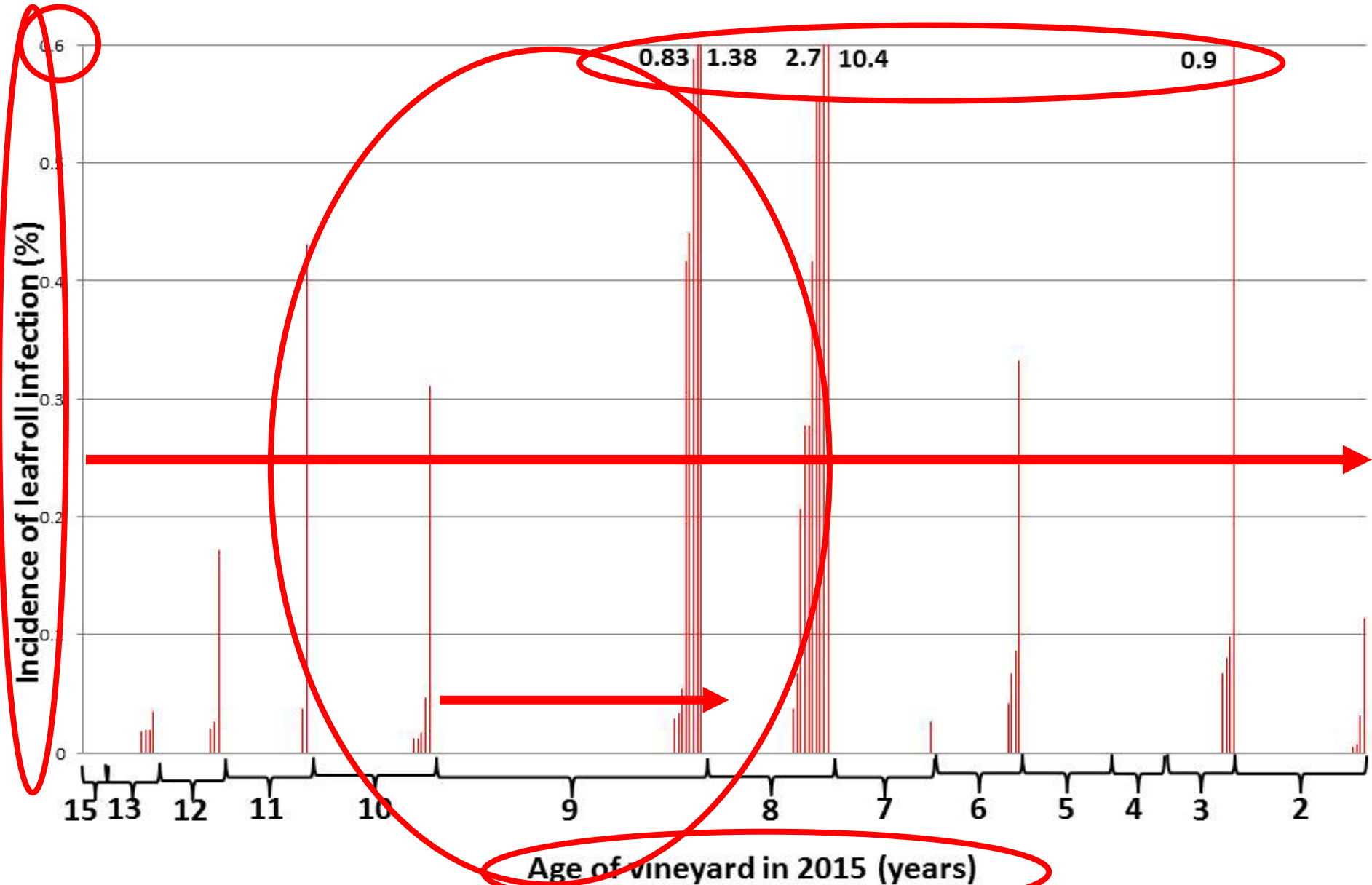
Two tier testing. Sensitivity of ELISA such that one infected plant in 10 can be detected, so test pools of 10 vines each (300 tests/ha).



Test each individuals in positive pools.



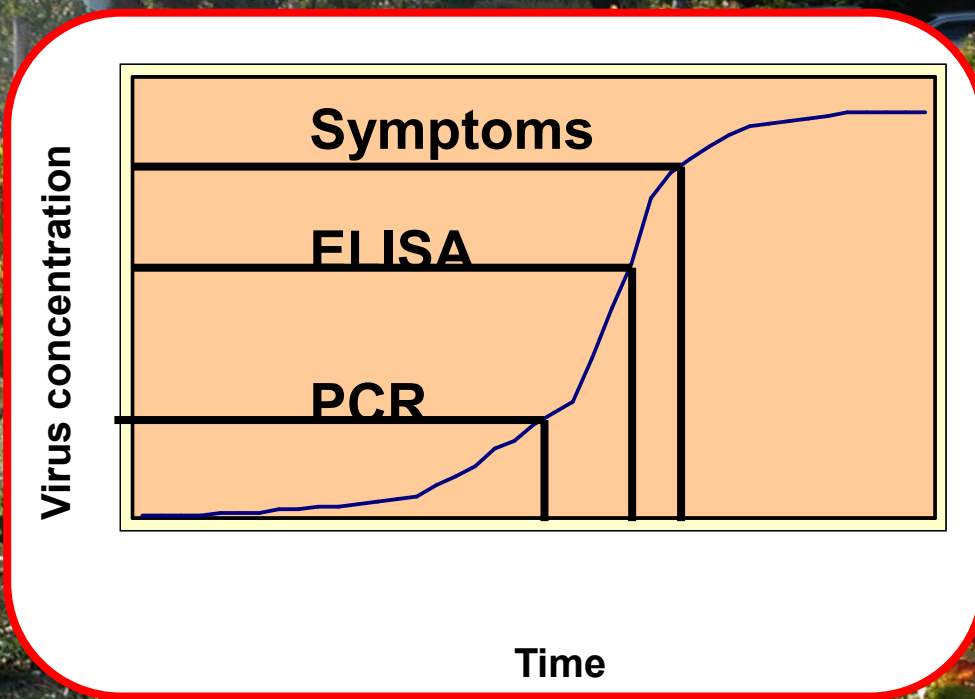
Foundation vineyards (n = 335) in which leafroll spread is controlled, ranked by age and leafroll infection in 2015



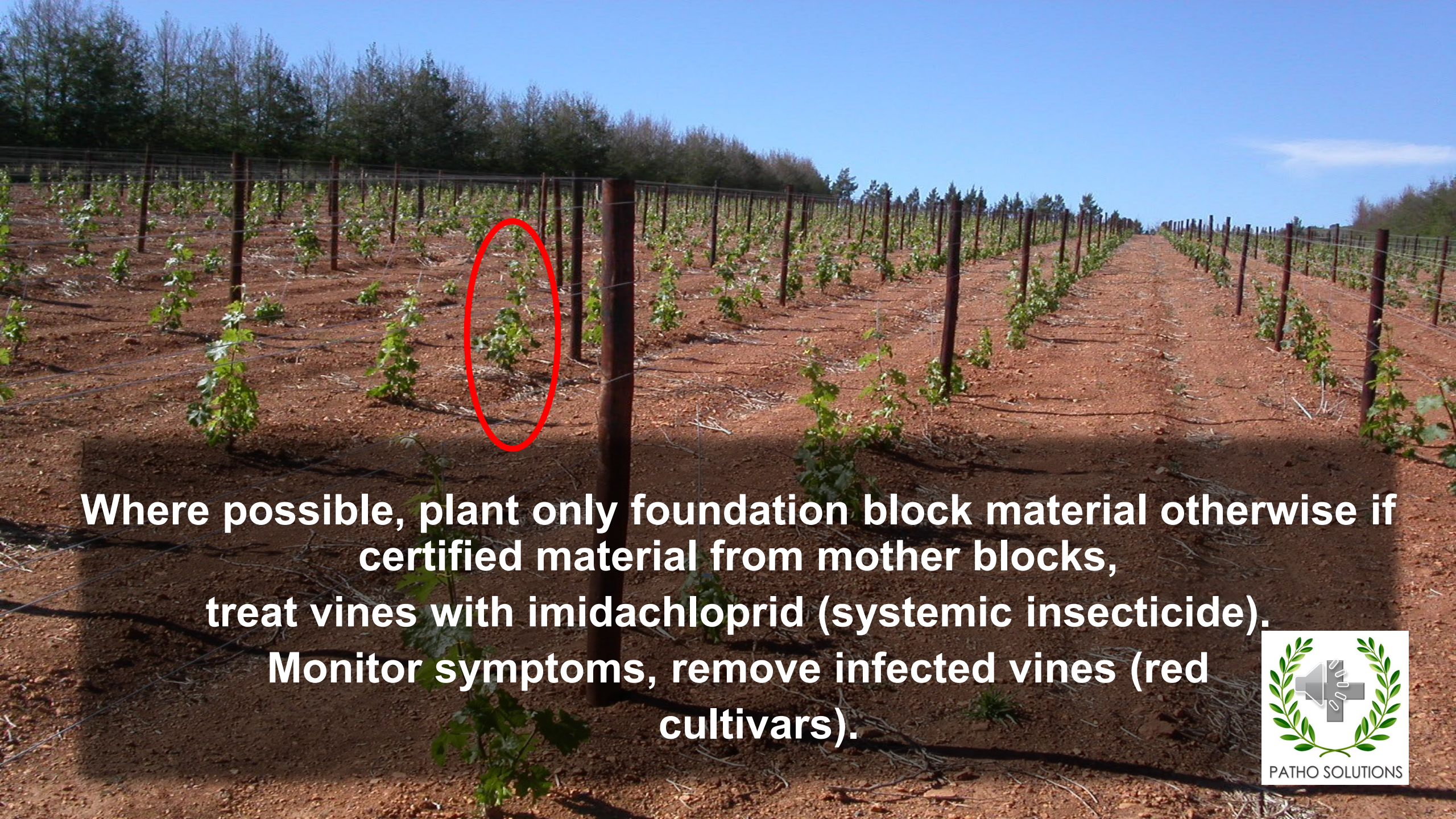
Mother blocks in commercial wine estates where grower-discretion leafroll control takes place.

Mother blocks scrapped once reach 3% leafroll infection.





“Latent” period before detection (graph for illustrative value)



Where possible, plant only foundation block material otherwise if certified material from mother blocks, treat vines with imidachloprid (systemic insecticide). Monitor symptoms, remove infected vines (red cultivars).



Control leafroll through:

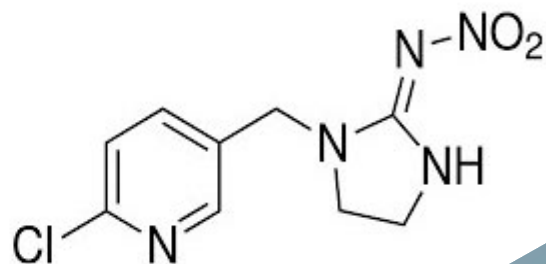
1. Planting of certified (GLRaV-3 negative) material

2. Control the vector (mealybugs) numbers

3. Remove infected vines

4. Control vector dispersal from external GLRaV-3 sources





IMIDACLOPRID



DÉCISION DE JUSTICE | 3 MAI 2023

Neonicotinoids: no exemptions to the
European ban



PATHO SOLUTIONS

Once level of GLRaV-3 low in a region
go over completely to biological
control of mealybugs.



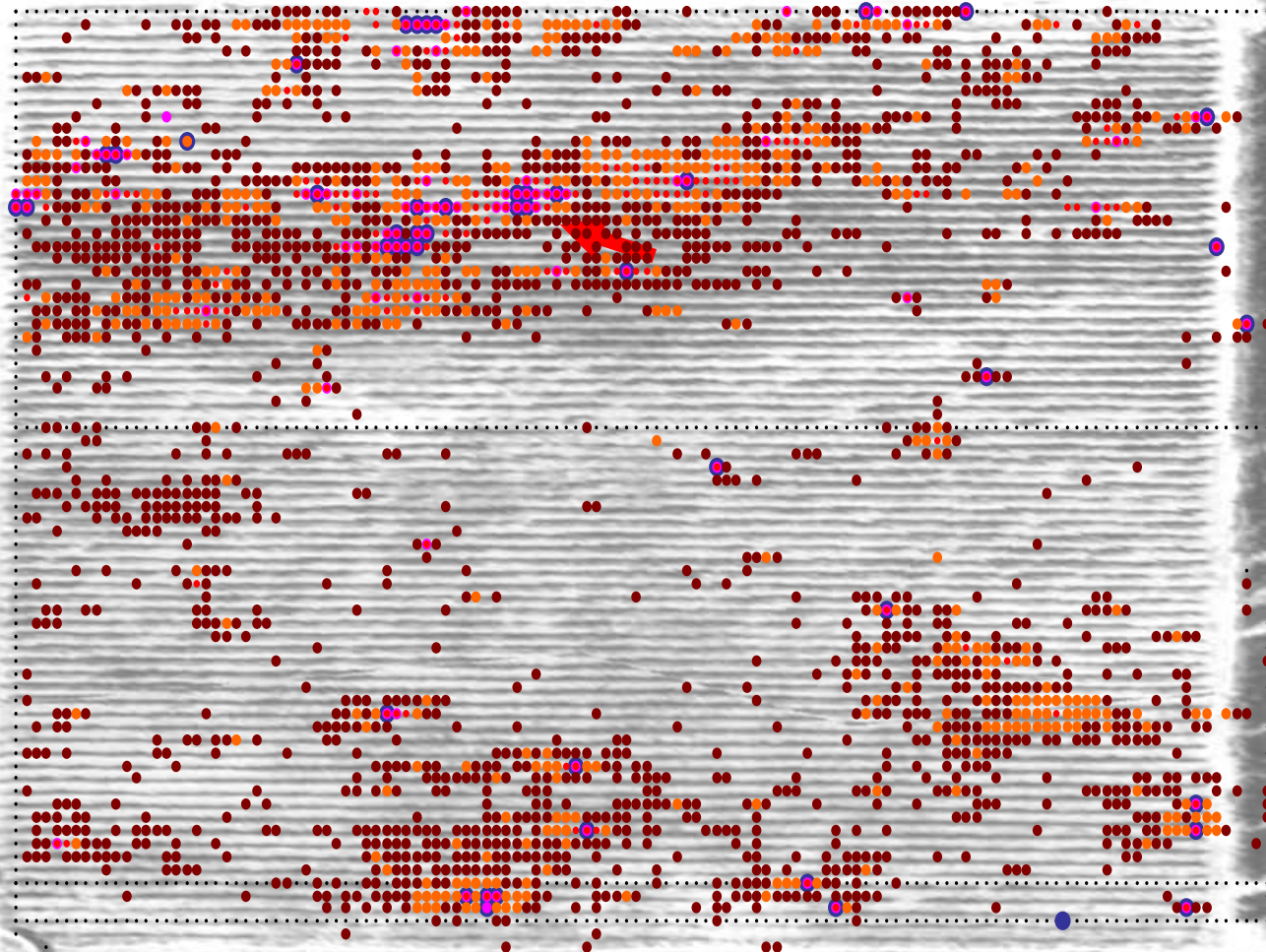
Is also recommended when neighbor
does not control mealybugs



Control leafroll through:

1. Planting of certified (GLRaV-3 negative) material
2. Control the vector (mealybugs) numbers
3. Remove infected vines (roguing and re-planting)
4. Control vector dispersal from external GLRaV-3 sources





2001: 47 (0.52%)
2002: 99 (1.09%)
2003: 220 (2.47%)
2004: 703 (7.9%)
2005: 2307 (26.1%)

**Secondary spread: creation of disease foci
(is by far the main cause of new infections).**



Threshold for roguing (<20%) leafroll incidence (secondary spread dependent).

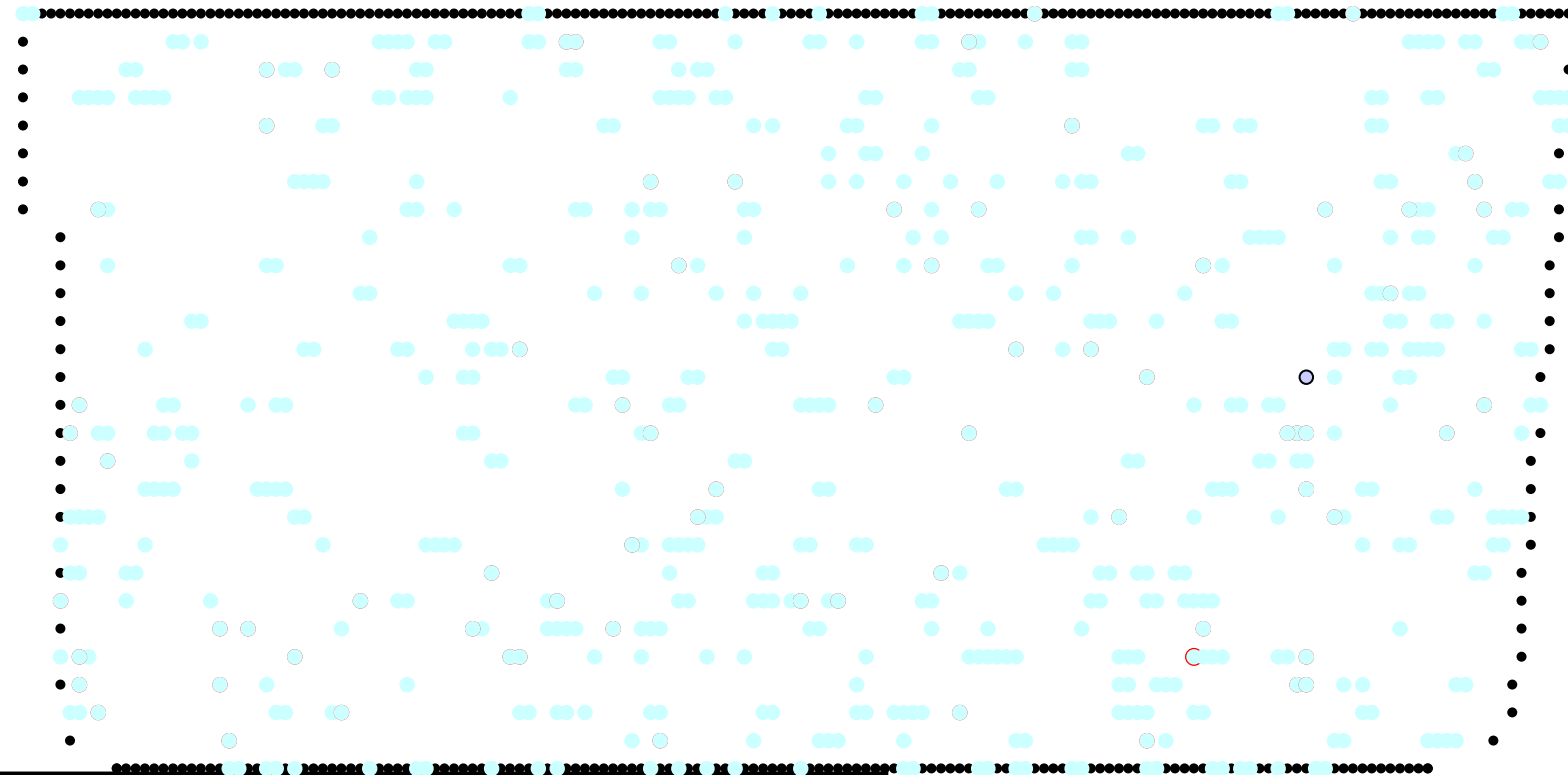
Control mealybugs by treating vines with a systemic insecticide/biological control.

Effective in red cultivars where can monitor symptoms to remove infected vines



Rooiland 7 (CS46 on 101-14, 1.67ha, 4475 vines)

2003: 548 (12.2%): (imidacloprid), removed winter 2003
2004: 27 (0.6%) removed winter 2004
2005: 9 (0.2%) removed winter 2005
2006: 14 (0.32%) removed winter 2006
2007: 17 (0.4%) removed winter 2007
2008: 4 (0.1%),
2009: 3 (0.075%);
2010: 1
2011: 0
2012: 1



Cumulative 13.6% of vines removed

Kopland 5:
Established 2000.
5.16ha, 13830 vines.

2006: 509 (3.7%)

2007: 211 (1.7%)

2008: 101 (0.8%)

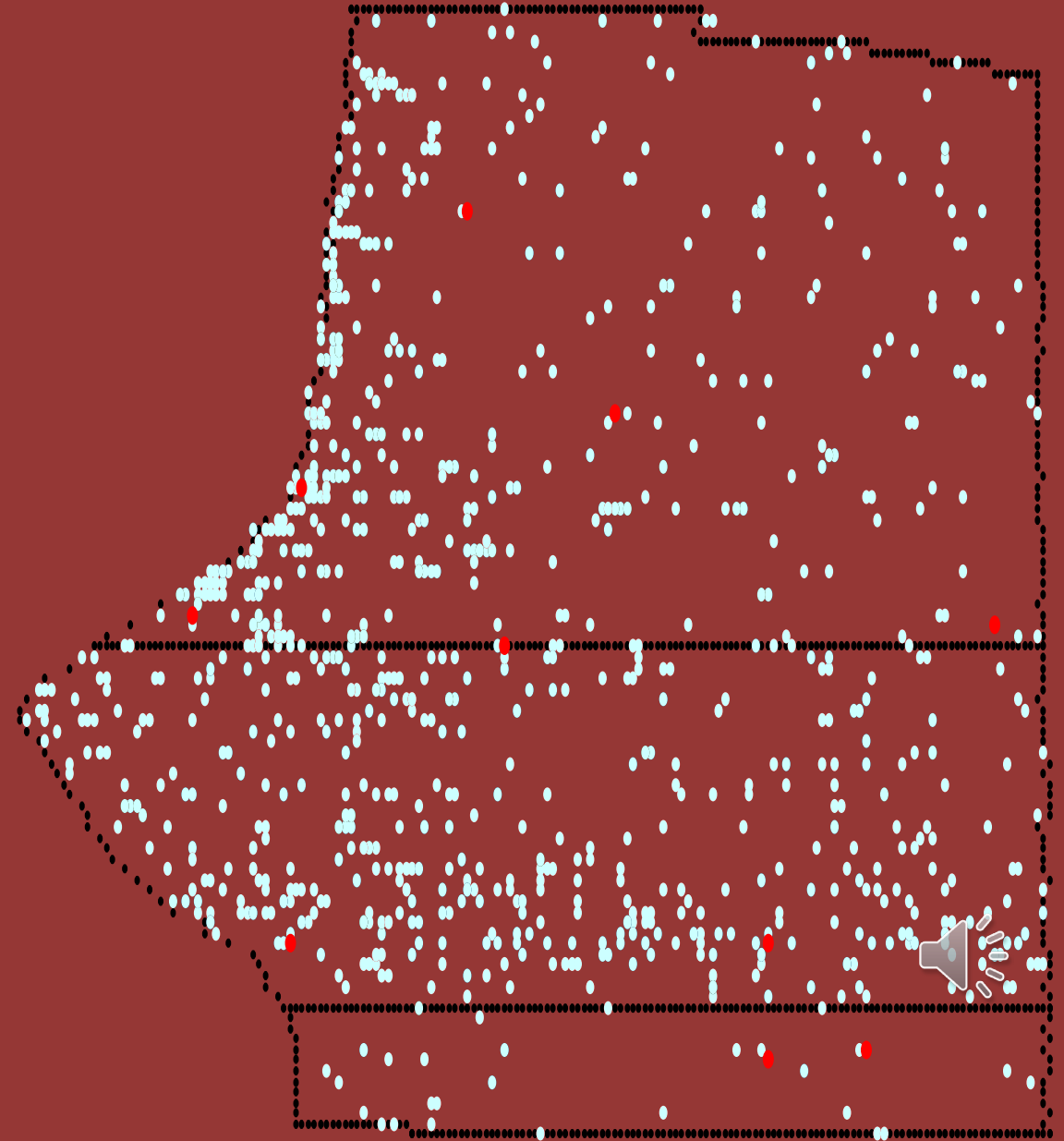
2009: 30 (0.23%)

20010: 22 (0.17%)

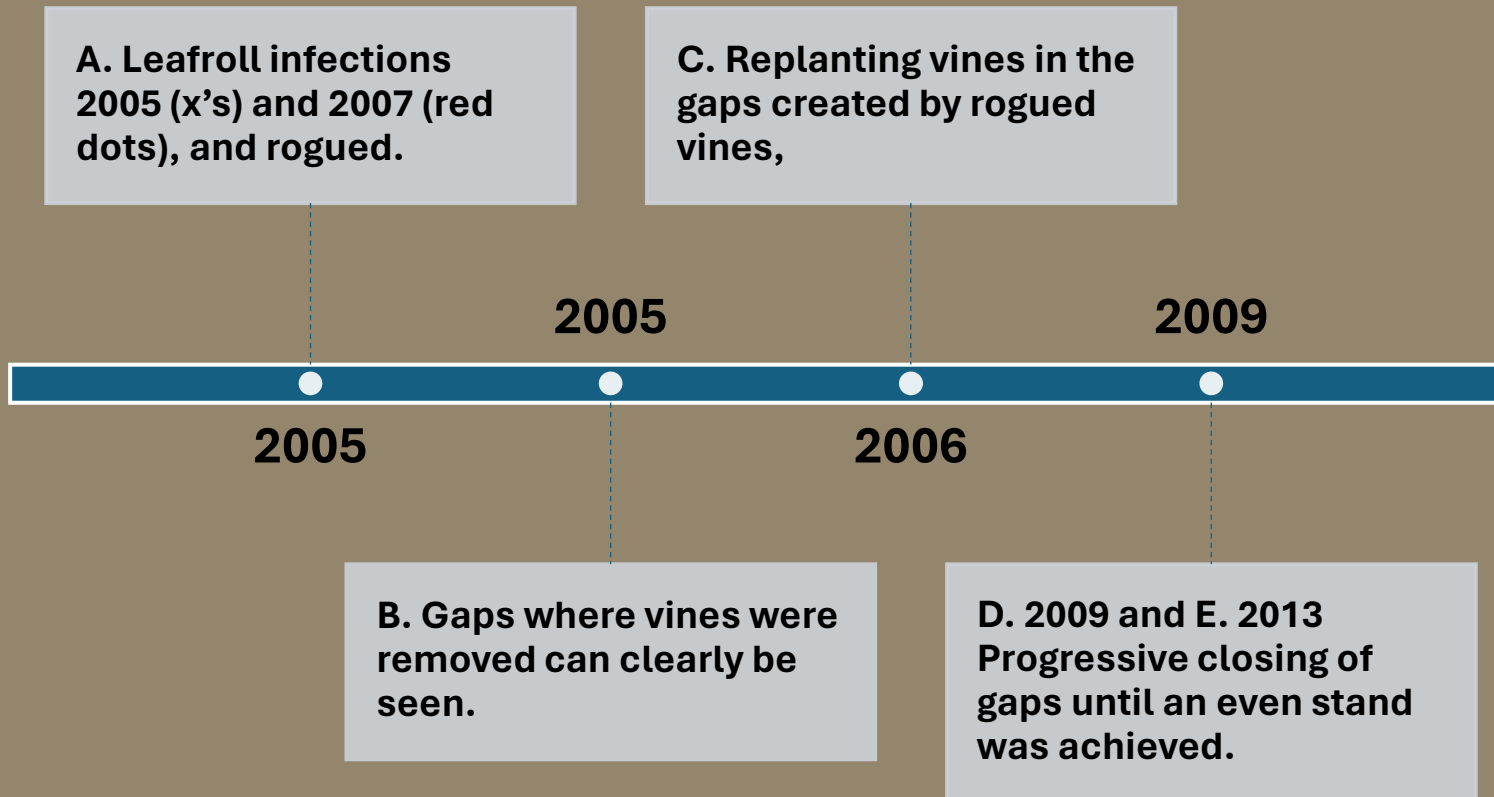
2011: 12 (0.09%)

2012: 10 (0.08%)

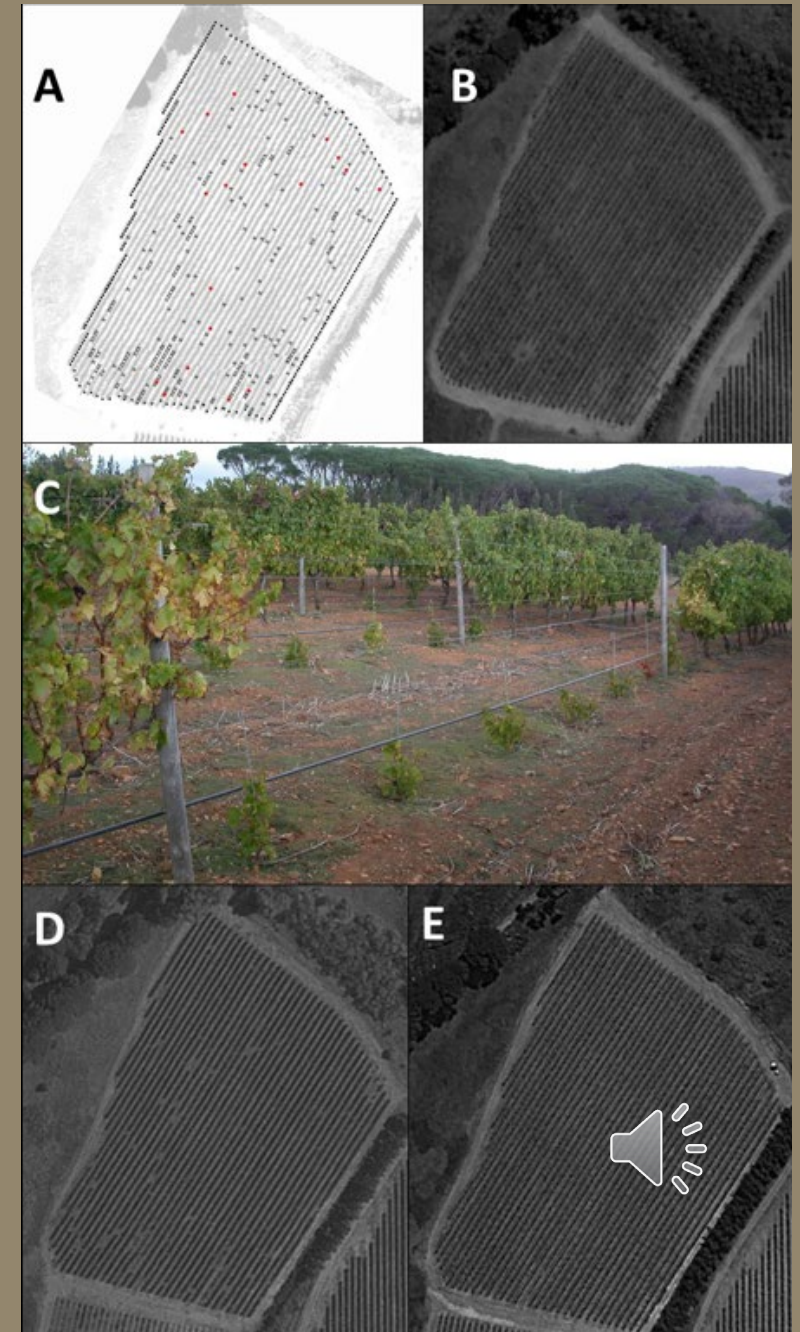
**481 more (almost
double)
vines removed
than initially recorded**



Reset of rogued vine clusters



Cabernet Sauvignon vineyard planted in 1999 on Vergelegen Wine Estate, South Africa.



Reset of individual rogued vines within rows

- **Can be re-planted without additional measures in irrigated vineyards in the first 3 seasons of a vineyard. Thereafter need additional measures.**
- **Extra dripper irrigation lines.**
- **Potted, large and well-rooted vines, planted in large hole.**



Control leafroll through:

1. Planting of certified (GLRaV-3 negative) material
2. Control the vector (mealybugs) numbers
3. Remove infected vines
4. Control vector dispersal from external GLRaV-3 sources



Replanting a vineyard. Must control leafroll from the preceding infected vineyard.

a) mealybugs on volunteer plants, or

b) viruliferous mealybugs survival in soil or non-host plants for short periods (poorly understood).

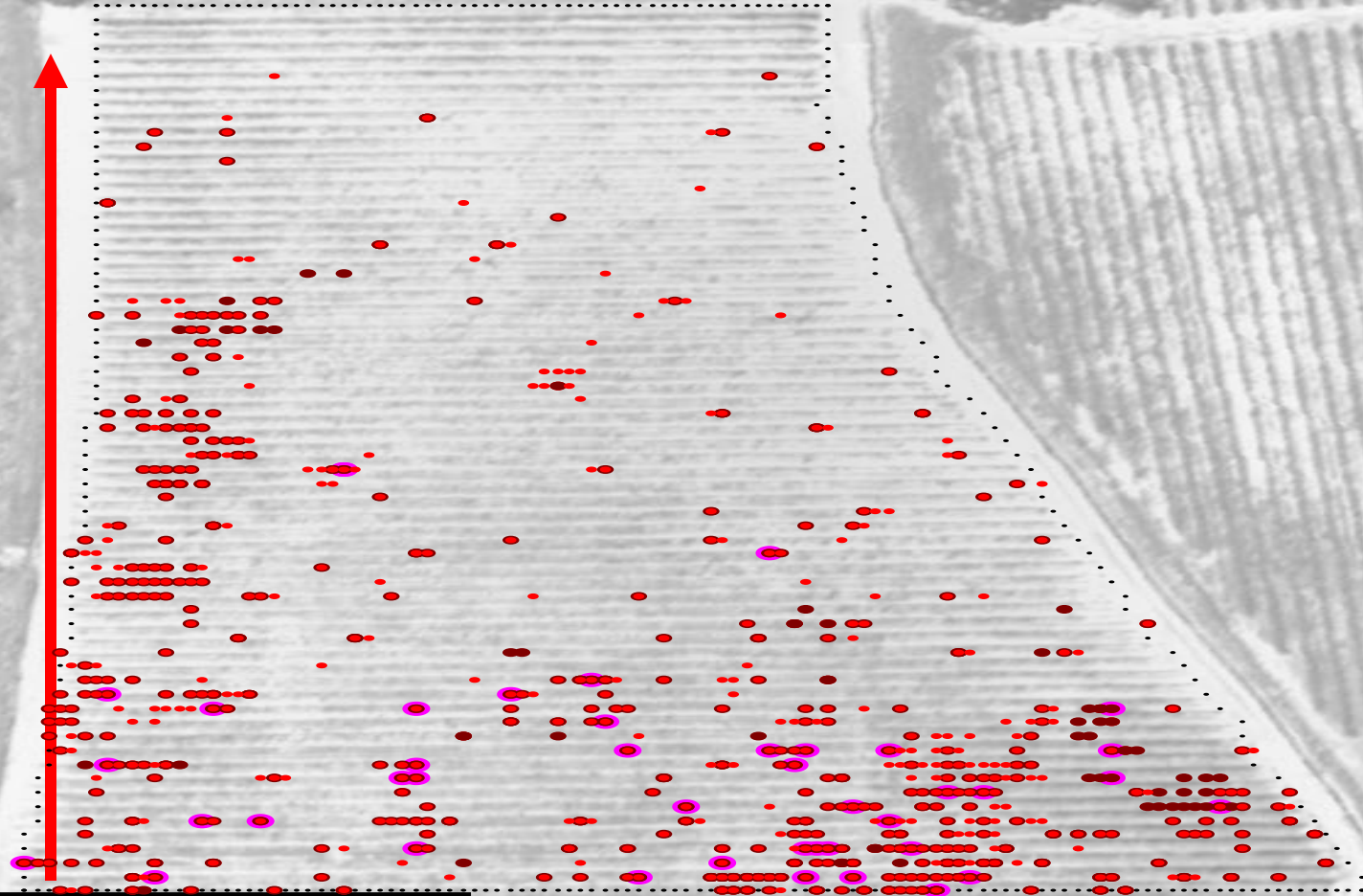
Use fallow period to remove volunteers.



Infection from proximal external sources (primary spread): Gradients or edge effects.

2002: 40 (0.8%)
2003: 148 (2.8%)
2004: 432 (8.3%)
2005: 539 (10.4%)

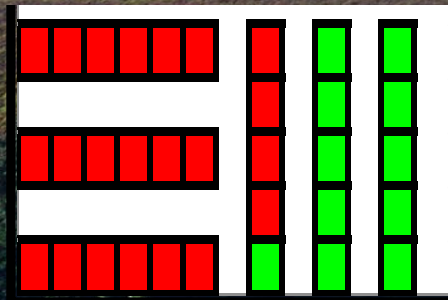
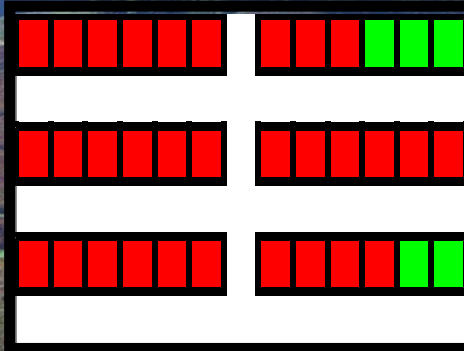
2004
 $Y = -9.458x + 0.429$
Significant slope ($P > 0.001$); $r^2 = 0.63$



Spatio-temporal study on 60 vineyards from 2001 to 2006.
Gradients* observed where origin of infection is obvious (proximity with older, known infected sources)

Prevalence: In 25% of blocks in orientation of rows;

17% of blocks across rows.

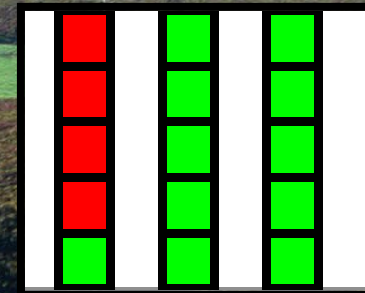
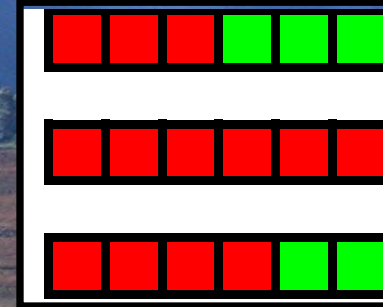


***Significant slope ($P > 0.01$) in one of the regression models, in which $r^2 > 0.60$.**

Gradients observed with no obvious external infection source

18% of blocks in orientation of rows.

10% of blocks across rows.



*Significant slope ($P > 0.01$) in one of the regression models, in which $r^2 > 0.60$.

A blue Braud tractor is shown working in a vineyard. The tractor is positioned in the center-left of the frame, moving through rows of grapevines. The vine leaves are green, with some showing signs of yellowing or damage. In the background, a dense forest of tall, thin evergreen trees stands against a bright sky. The tractor has the word 'BRAUD' written on its side in white capital letters. A person is visible in the driver's seat of the tractor.

Border effects and gradients probably due to GLRaV-3 viruliferous mealybugs carried from external sources. e.g. on implements



or GLRaV-3 viruliferous mealybugs picked up and carried on workers clothing from external sources



*Slide modified from
Vititec slide*

***Some evidence also that viruliferous mealybugs from external sources
dispersed by wind (egg sacks or crawlers) or on leaves***





On Vergelegen (where leafroll is **near-eliminated). Single vine infections not associated with any previous infection seemingly anywhere within vineyards. Suspect long-distance wind dispersal of mealybugs. Is very low levels, average of c30 vines annually over a healthy vine population of 210 000 (red cultivars)**



Control mealybugs in adjoining and distant leafroll infected vineyards!





**Work in healthy vineyards before moving to leafroll
Infected vineyards (implements & workers)!**



Image: L. Koekemoer





**Wash off mealybugs if implements were used
in leafroll infected vineyards**

Control leafroll in new vineyards through:



Planting of certified (GLRaV-3 negative) material

Certified material uptake >90%.

Control the vector (mealybugs) numbers

Most growers do this to control it as a pest.

Remove infected vines

Only c. 3% of industry try to eradicate the virus in red cultivars. Only about 10 estates rogue in white cultivars (Patho Solutions)

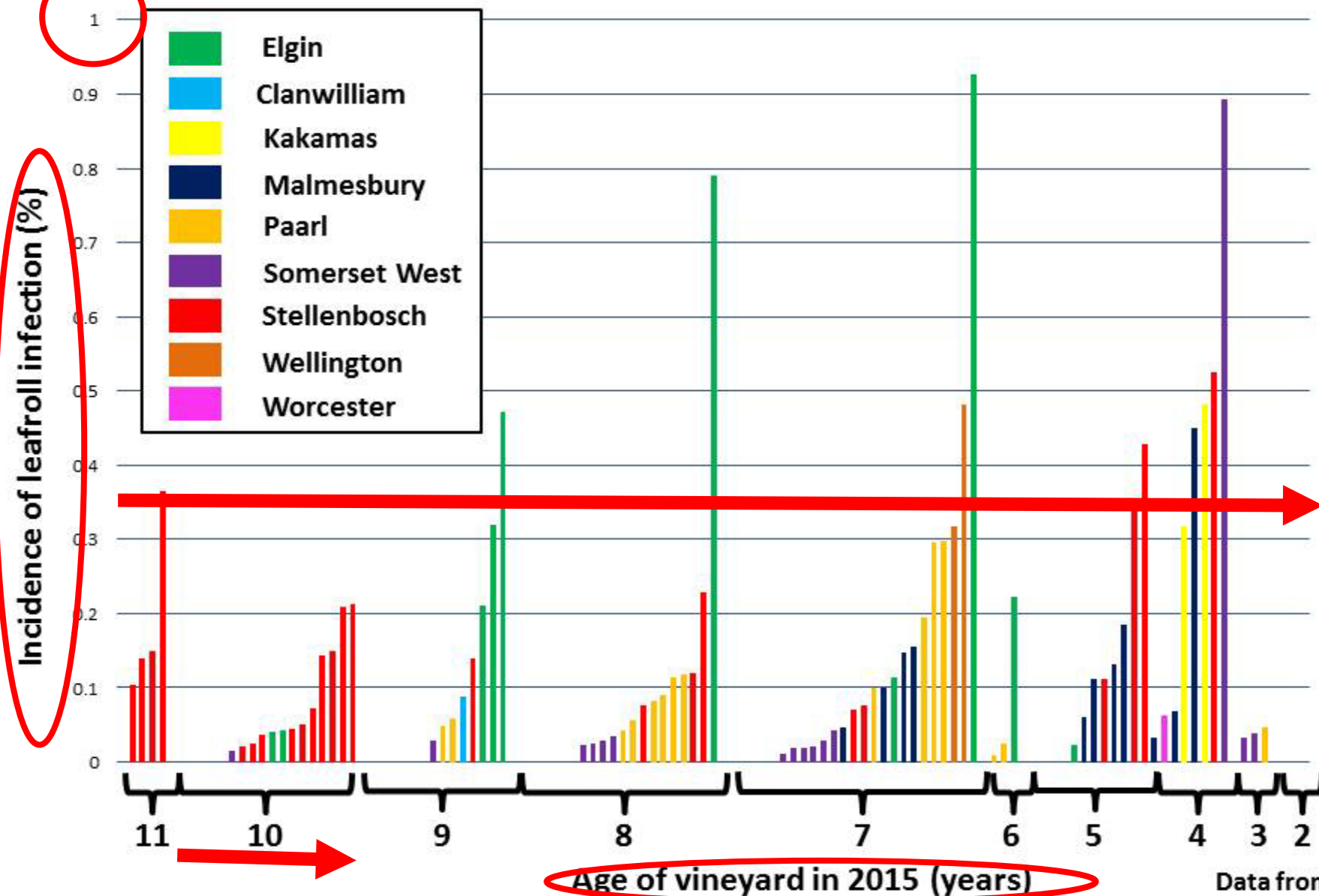
Control vector dispersal from external GLRaV-3 sources

Most growers apply fallow period. Most still plant within infected areas, most control mealybugs in adjacent vines

Few apply implement/worker sanitation measures.



Commercial vineyards (n = 119) in which leafroll spread is controlled, ranked by age and & leafroll infection in 2015.



PATHO SOLUTIONS

Exception to find leafroll infected vines in >24-year-old red cultivars on Vergelegen, following integrated control strategy. No decline in production or berry quality.



**Cost of leafroll control borne by producers
(no state subsidy to remove infected
vineyards, rogue infected vines etc.).**

No state funding on research of leafroll.

Poor uptake because of cash flow issues.

**Leafroll control difficult and expensive in
situations where highly infected and new
vineyards in proximity.**

**Very few growers can afford large scale
renewal of vineyards despite obvious
vineyard economic longevity.**



Patho Solutions established with the aim of providing grapevine leafroll support to the industry by:

- **Conducting research on behalf of the industry.**
- **Developing and providing ELISA kits for Plant Improvement Organisations (PIO's) and wine estates to conduct in-house control in especially white cultivars.**
- **Provide a diagnostic service to growers and PIO's**
- **Guide growers throughout the leafroll management processes. Long term planning and current issues.**
- **Identify and map position of infected vines for growers (by monitoring for symptoms in red cultivars or doing two-tier whole vineyard testing in white cultivars.**
- **Rogue infected vines for growers.**
- **Can do infected vine specific insecticide applications for growers (spot treatments).**





I look forward to our Question-and-Answer session