Gideon van Zyl

Gideonvz@procropsa.co.za

Life (or death) after chlorpyrifos: How will we manage mealybug?

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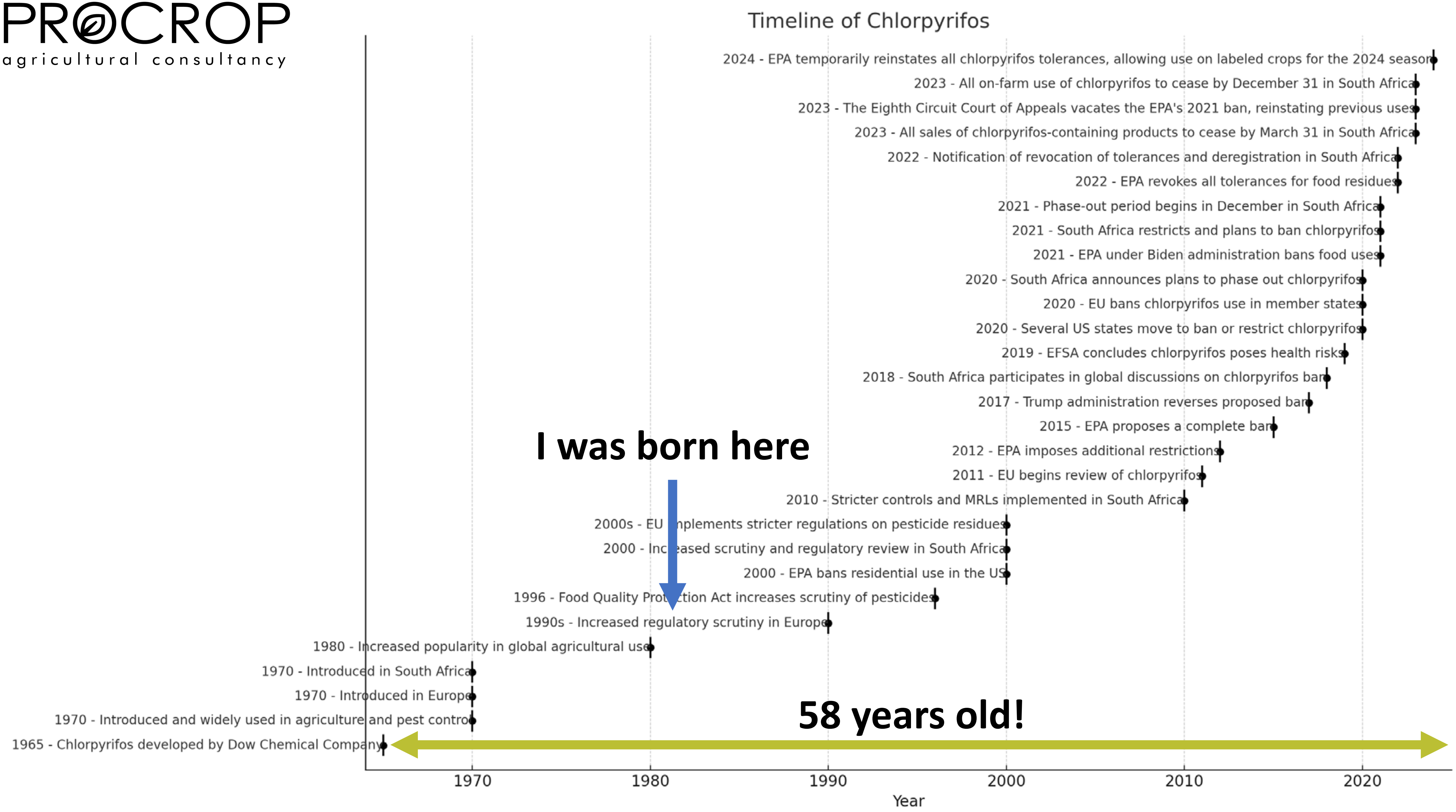

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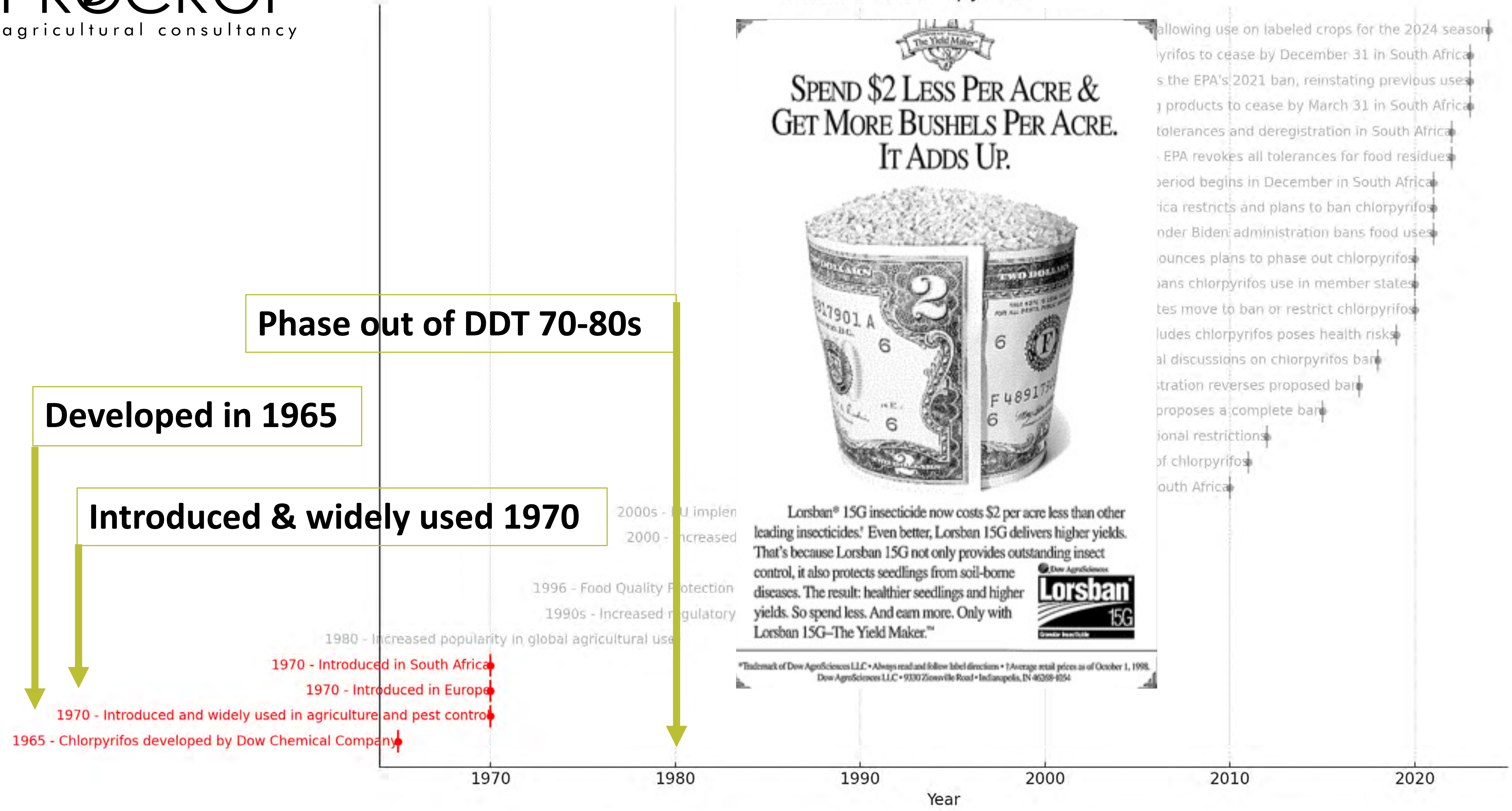
Timeline of Chlorpyrifos



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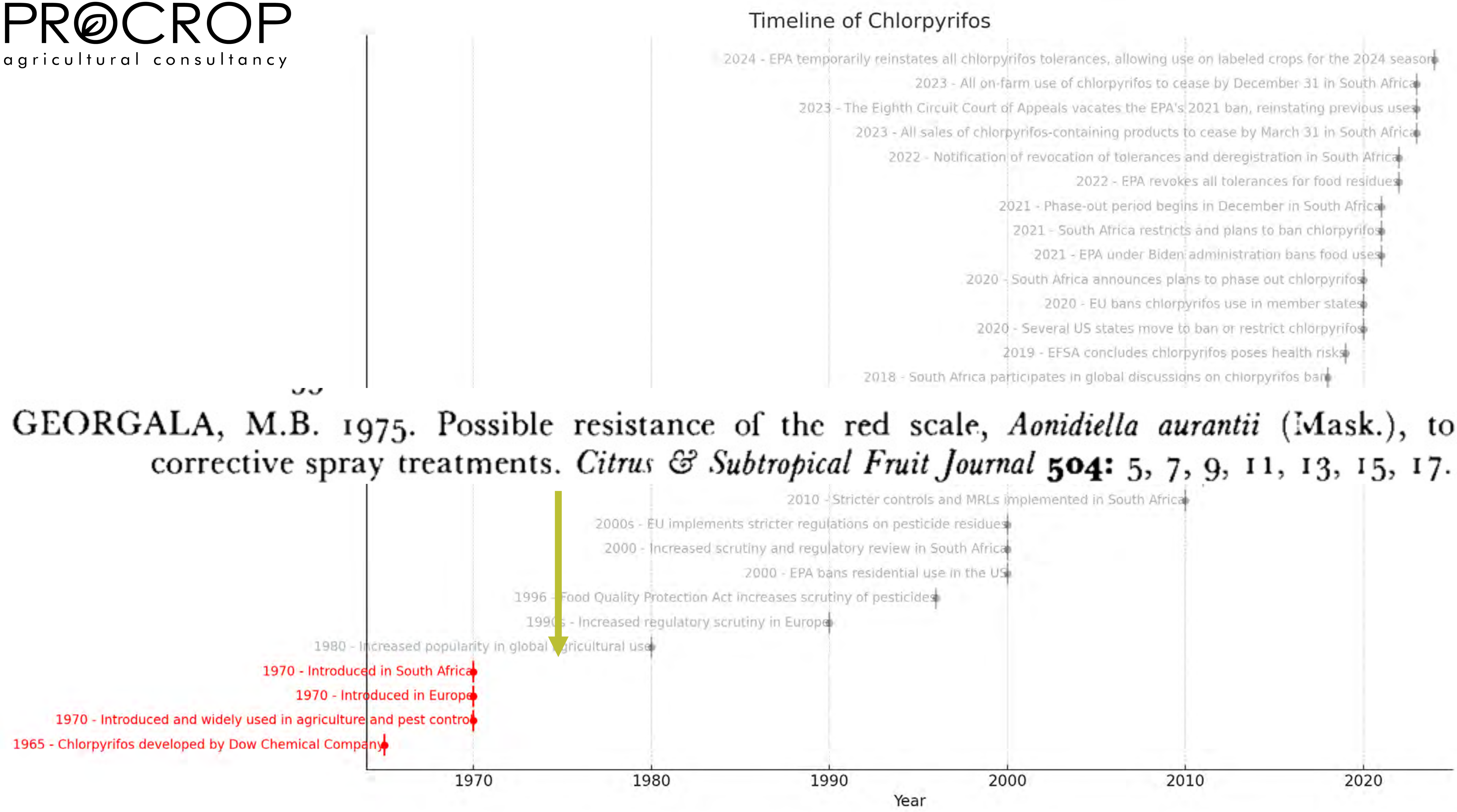

GEORGALA, M.B. 1975. Possible resistance of the red scale, *Aonidiella aurantii* (Mask.), to corrective spray treatments. *Citrus & Subtropical Fruit Journal* **504:** 5, 7, 9, 11, 13, 15, 17.

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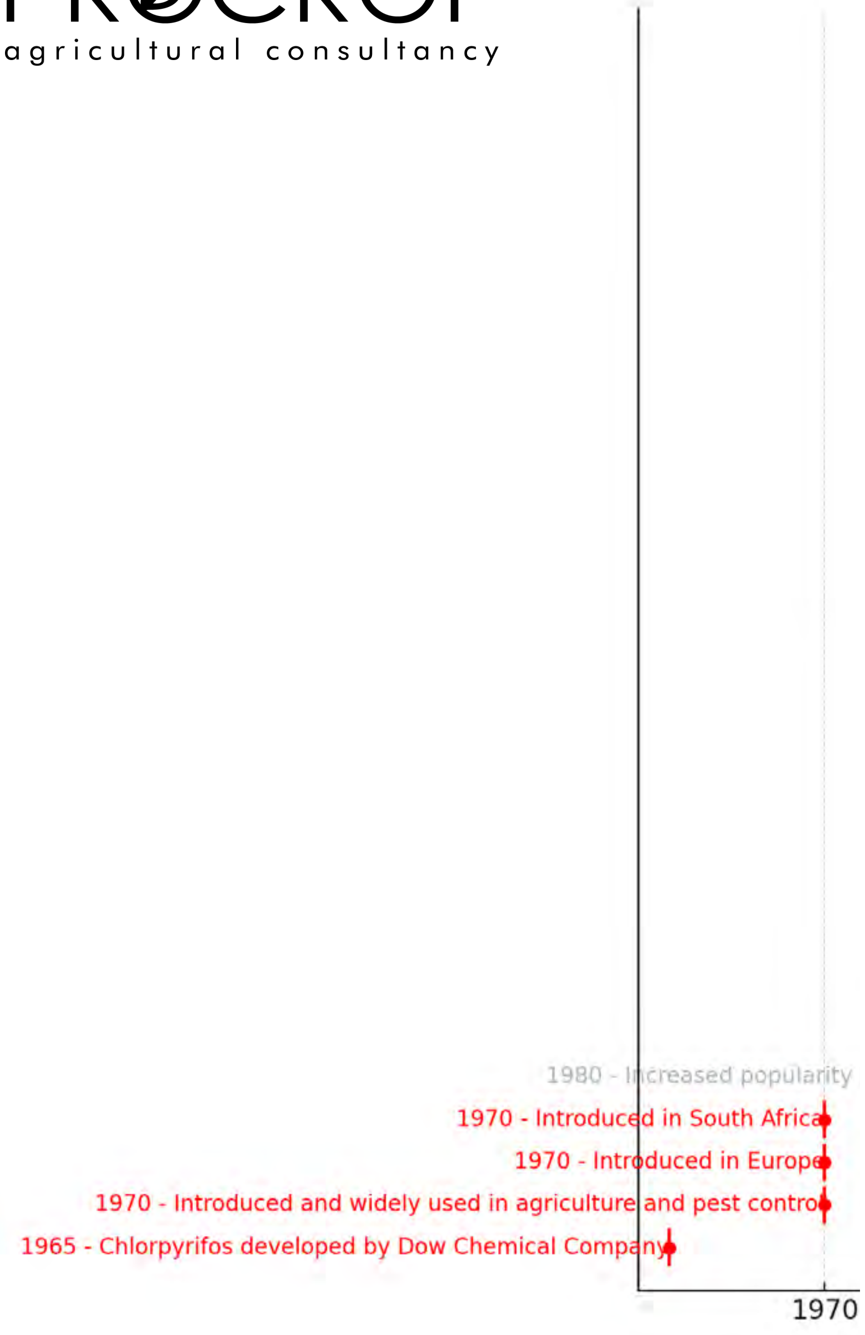
Timeline of Chlorpyrifos



Organophosphate resistance in California red scale (Homoptera: Diaspididae) on citrus in the eastern Cape and the effect of oil as an organophosphate synergist

by

T.G. GROUT and G.I. RICHARDS

Citrus Exchange, P.O. Box 12154, Centrahil, South Africa 6006

Populations of California red scale, *Aonidiella aurantii* (Maskell), in the eastern Cape Province of South Africa acquired operational resistance to organophosphates in 1984, nine years after resistance occurred in the Transvaal. A bio-assay comparing the efficacies of chlorpyrifos, methidathion, prothiofos, parathion and phenthoate at 0,053 of their field dosages was conducted using resistant red scale crawlers. The results showed that the crawlers were resistant to all these organophosphates as had been found in the Transvaal in 1976. It is therefore very likely that the mechanism of resistance is the same as that in the Transvaal. However, field experiments in winter in the eastern Cape showed that combinations of organophosphates with medium grade mineral oil (0,5%) did not differ in efficacy from oil (0,5%) alone (P>0,05). Similar combinations applied in warmer weather in the Transvaal have been shown to be more effective than oil alone. Possible reasons for this difference in the synergistic effect of oil are discussed.

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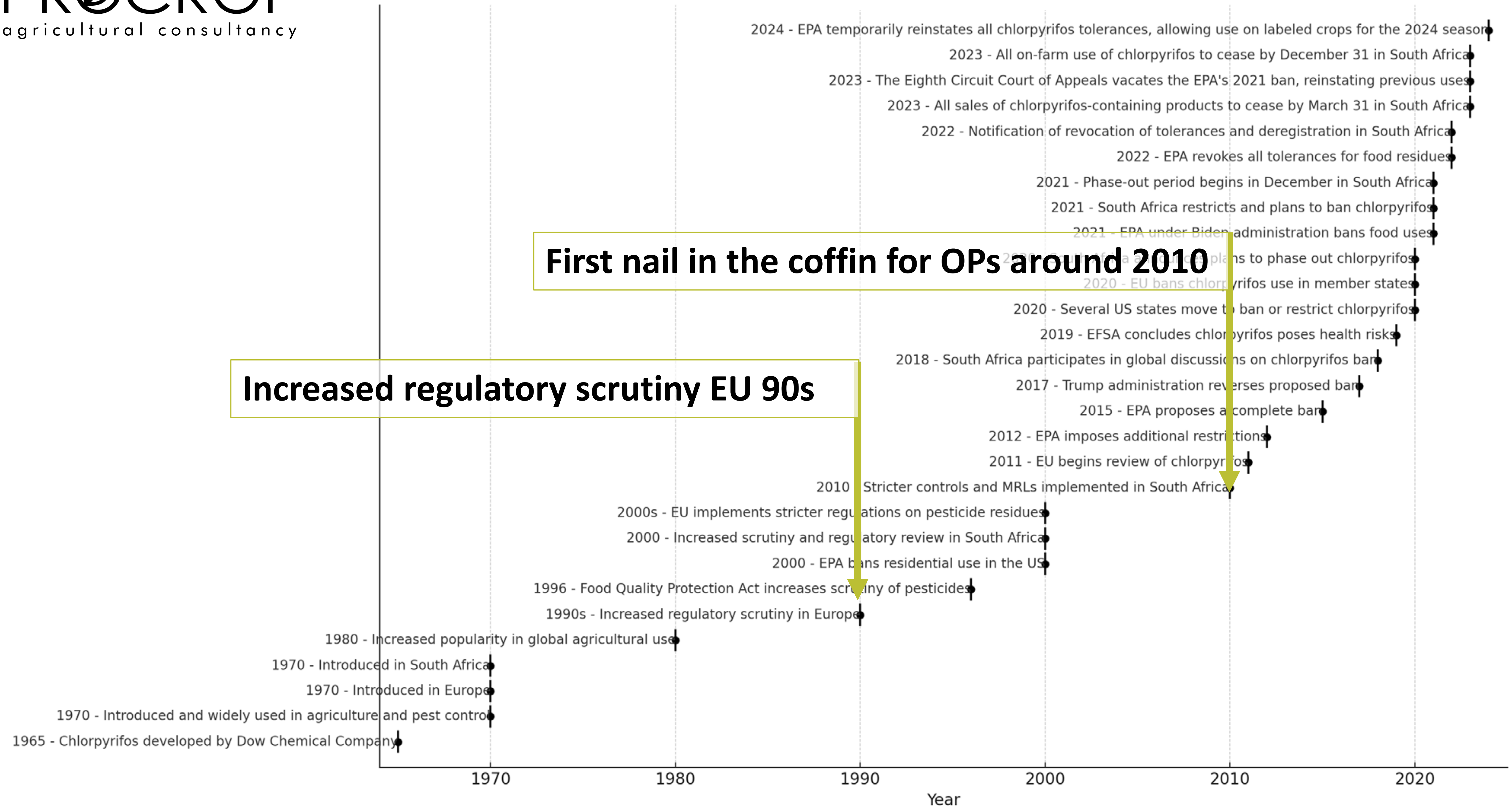

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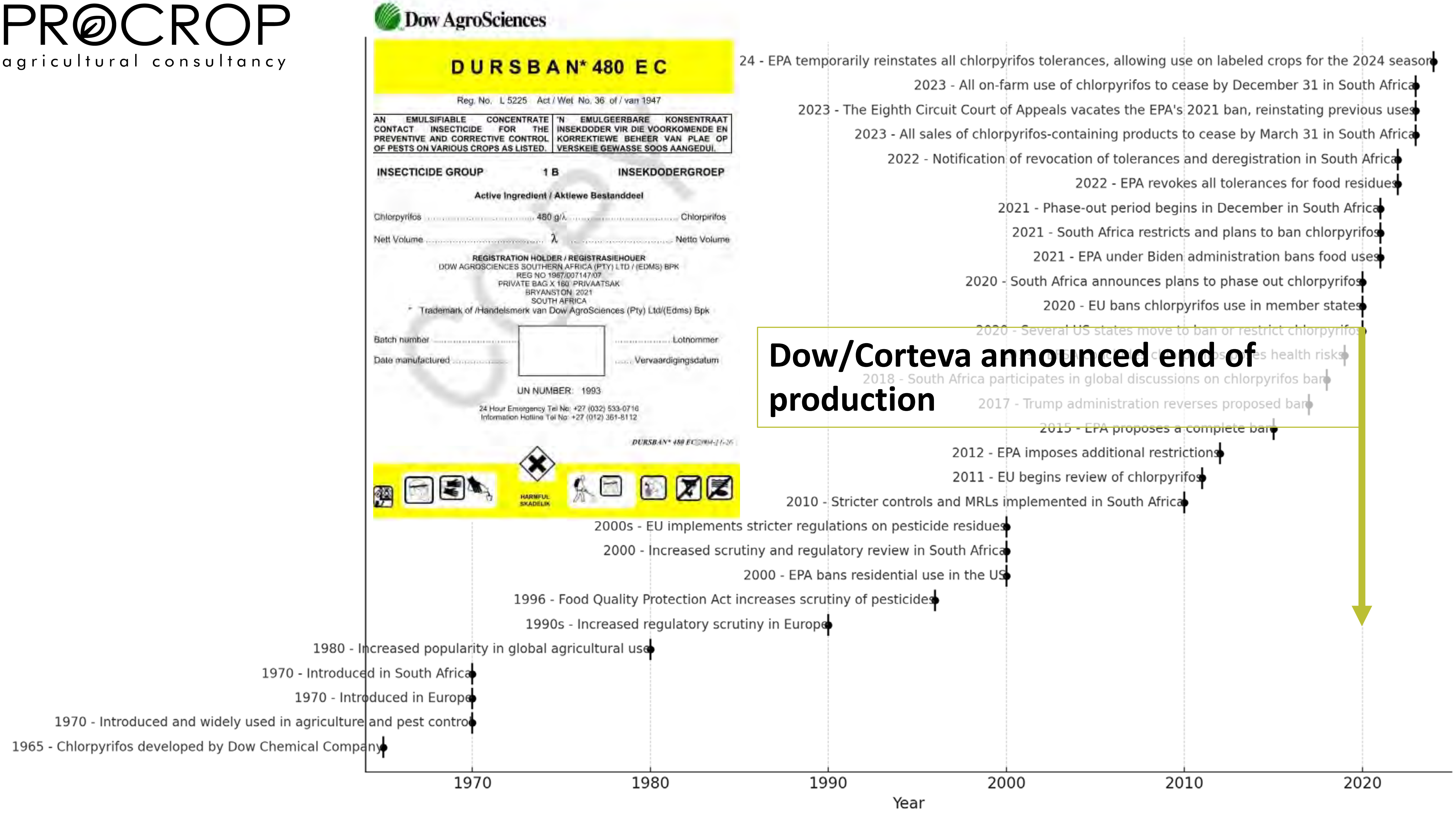

Dow/Corteva announced end of production

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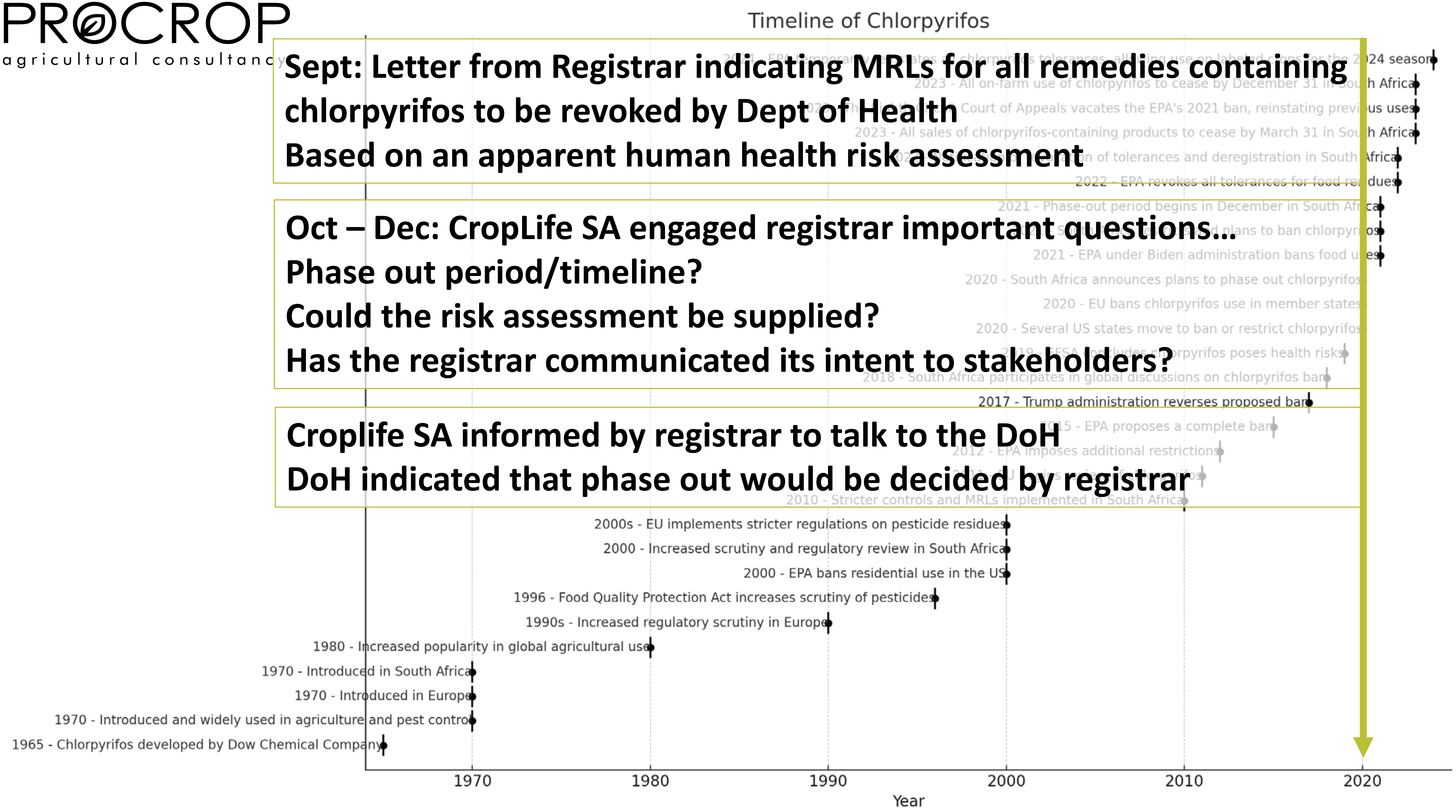

Sept: Letter from Registrar indicating MRLs for all remedies containing chlorpyrifos to be revoked by Dept of Health
Based on an apparent human health risk assessment

Oct – Dec: CropLife SA engaged registrar important questions…
Phase out period/timeline?
Could the risk assessment be supplied?
Has the registrar communicated its intent to stakeholders?

Croplife SA informed by registrar to talk to the DoH
DoH indicated that phase out would be decided by registrar

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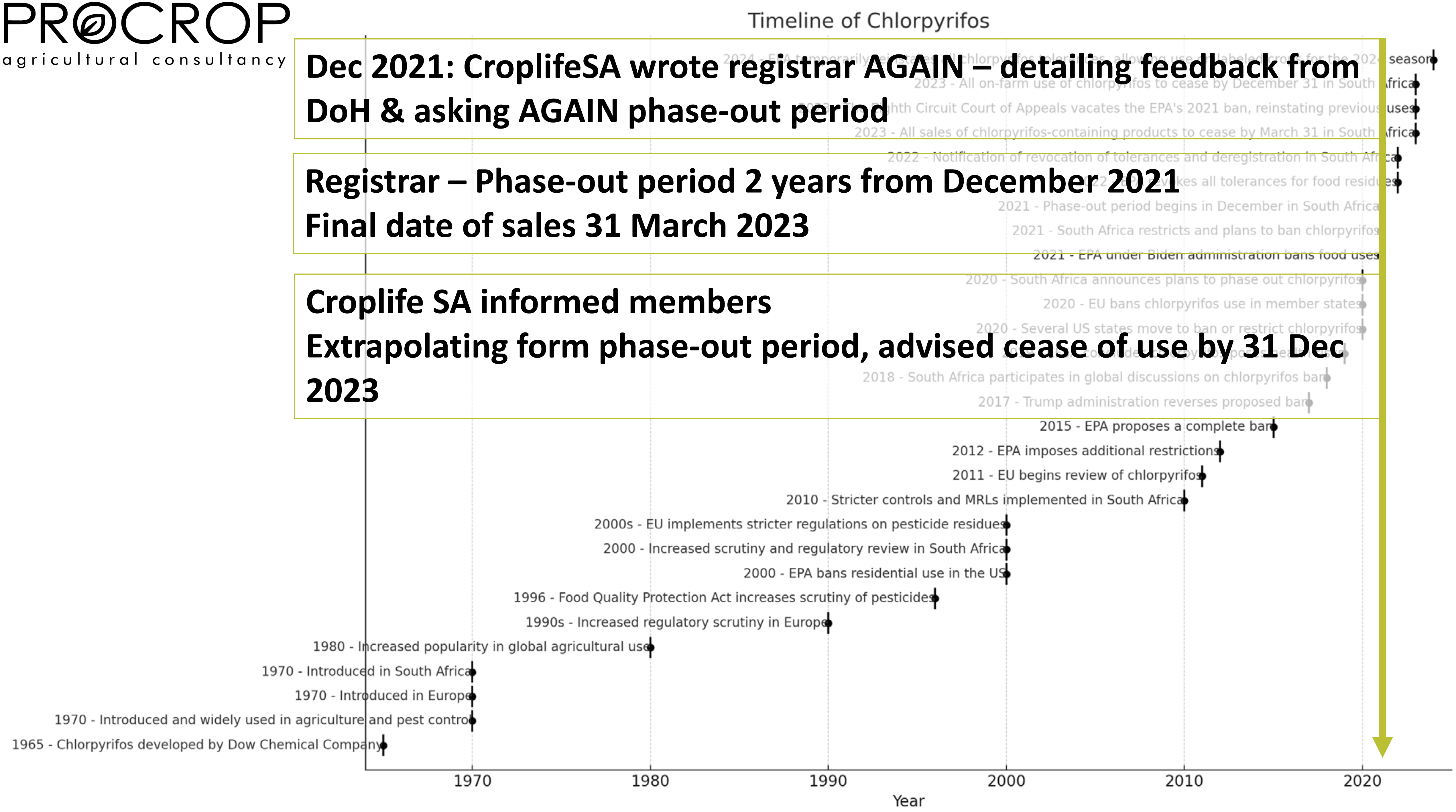
Dec 2021: CroplifeSA wrote registrar AGAIN – detailing feedback from DoH & asking AGAIN phase-out period

Registrar – Phase-out period 2 years from December 2021
Final date of sales 31 March 2023

Croplife SA informed members
Extrapolating form phase-out period, advised cease of use by 31 Dec 2023



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DALRRD has confirmed that the appropriate bans will be issued soon, highlighting necessary steps are taken to comply

DEPARTMENT OF HEALTH

NO. 4388 16 February 2024

FOODSTUFFS, COSMETICS AND DISINFECTANTS ACT, 1972 (ACT No. 54 OF 1972)

REGULATIONS GOVERNING THE MAXIMUM LIMITS FOR PESTICIDE RESIDUES THAT MAY BE PRESENT IN FOODSTUFFS: AMENDMENT

The Minister of Health intends, in terms of Section 15 (1) of the Foodstuffs, Cosmetics and Disinfectants Act, 1972 (Act 54 of 1972), to make the Regulations in the Schedule.

3. The Regulations are hereby amended by the deletion of the following particulars in the Annex to the Regulations —

Chlorpyrifos	Apples	0.05	Human health concerns
	Apricots	0.05	
	Bananas	1.0	
	Barley	0.05	
	Broccoli	0.1	
	Brussels sprouts	0.1	
	Cabbage	0.1	
	Canola	0.3	
	Cruciferae	0.1	
	Grapes	0.5	
	Grapes (wine)	0.5	
	Lettuce	0.05	
	Macadamia nuts	0.01	
	Mangoes	0.01	
	Mealies (green)	0.05	
	Peaches	0.05	
	Pears	0.05	

2000s - EU implen

1996 - Food Qu

1990s - Increased regulatory

1980 - Increased popularity in global agricultural use

1970 - Introduced in South Africa

1970 - Introduced in Europe

1970 - Introduced and widely used in agriculture and pest control

1965 - Chlorpyrifos developed by Dow Chemical Company

South Africa

revious uses

South Africa

uth Africa

residues

Africa

pyrifos

d uses

ifos

ates

ifos

1970 1980 2020

RIP chlorpyrifos

58 years of service in pome and stone fruit production

- **Extremely important compound for the control of mealybug and other sucking pests**
- **Even with reports of resistant mealybug colonies**

- **Dormant use of chlorpyrifos fitted very well into a well-designed IPM strategy – when implemented/applied correctly (GAP)**

  - **Cost effective**
  - **Low impact on natural predators**
  - **Zero/low risk of residues**

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The show must go on!

What?

The insect that needs to be controlled

When & Where?

When and where can susceptible life stages of the insect be found

How?

Available control methods left

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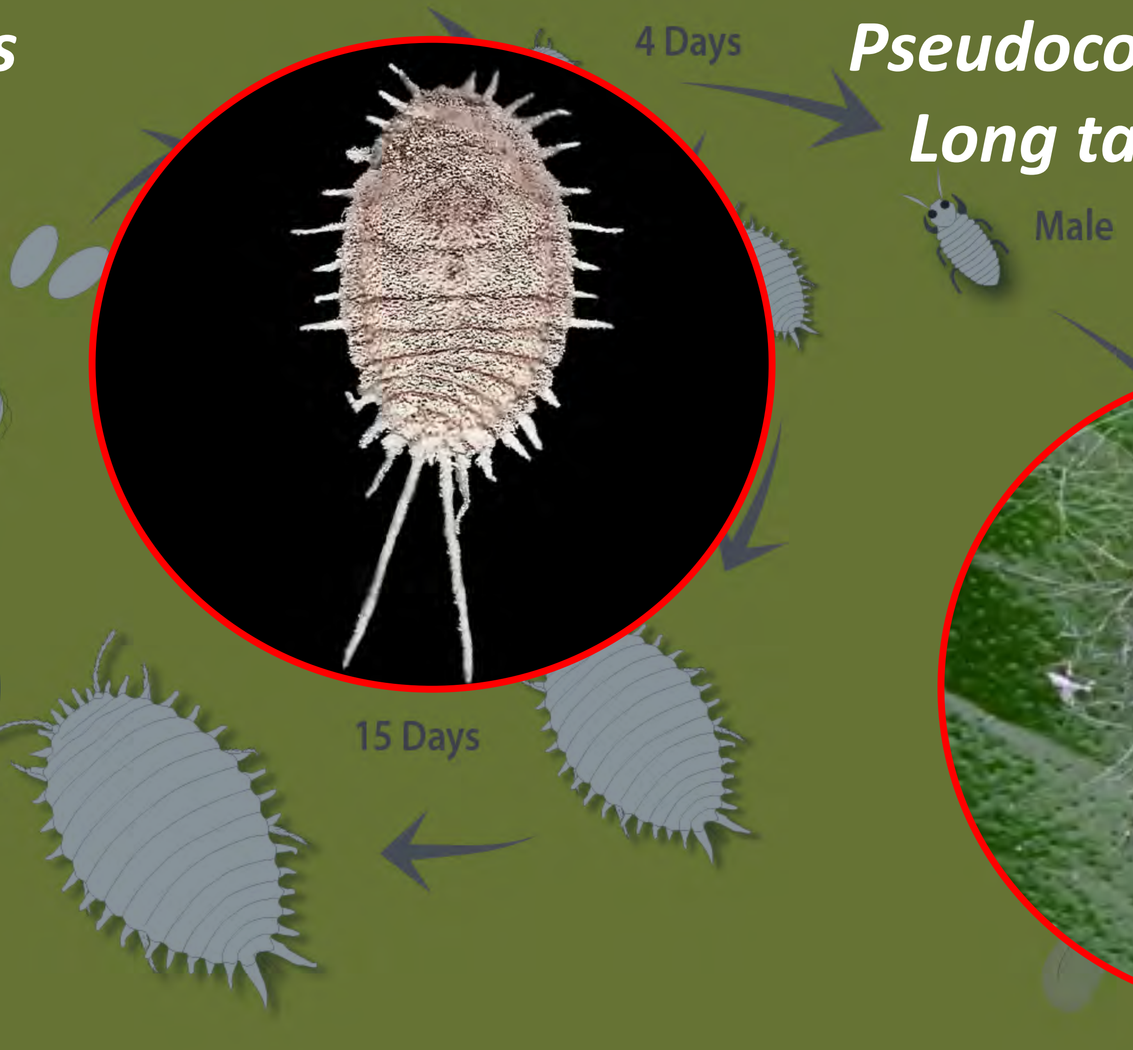
Mealybug what, when and where?

Pseudococcus viburni

Obscure mealybug



Pseudococcus longispinus
Citrophilous mealybug

Pseudococcus longispinus
Long tailed mealybug

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When and where?

Pseudococcus viburni
Obscure mealybug

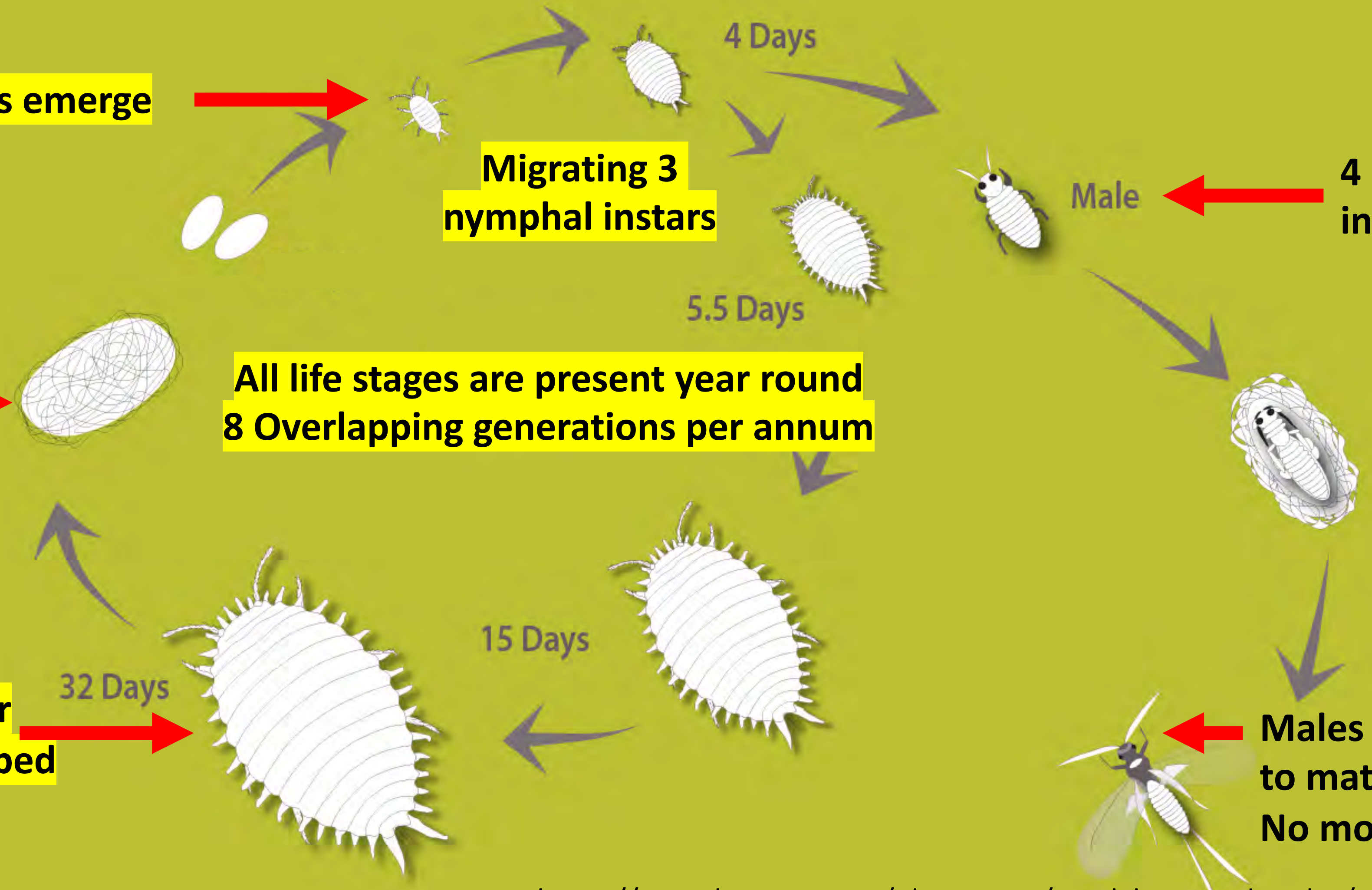
1st instar crawlers emerge
3-16 days

Migrating 3 nymphal instars

4 nymphal instars

White cottony mass
Ovisac (protects eggs)

All life stages are present year round
8 Overlapping generations per annum



Adult females
Protected by waxy layer
Immobile unless disturbed

Males only function is to mate
No mouth parts

https://www.koppert.com/plant-pests/mealybugs-and-scales/obscure-mealybug/

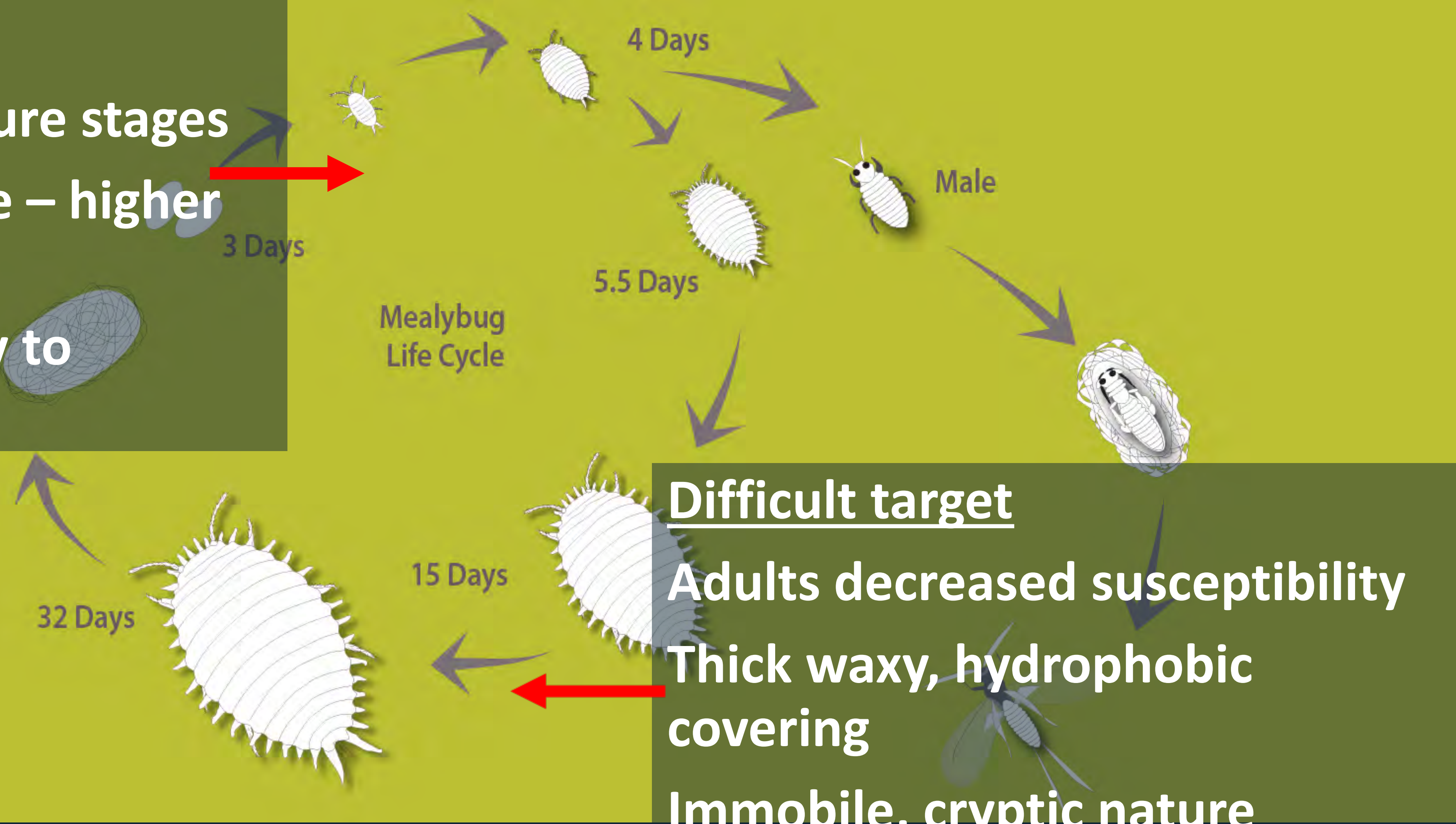
When and where?

<u>**Best target**</u>

Mostly target immature stages

Mobile cryptic nature – higher chance of contact

Greater susceptibility to insecticides



<u>**Difficult target**</u>

Adults decreased susceptibility

Thick waxy, hydrophobic covering

Immobile, cryptic nature

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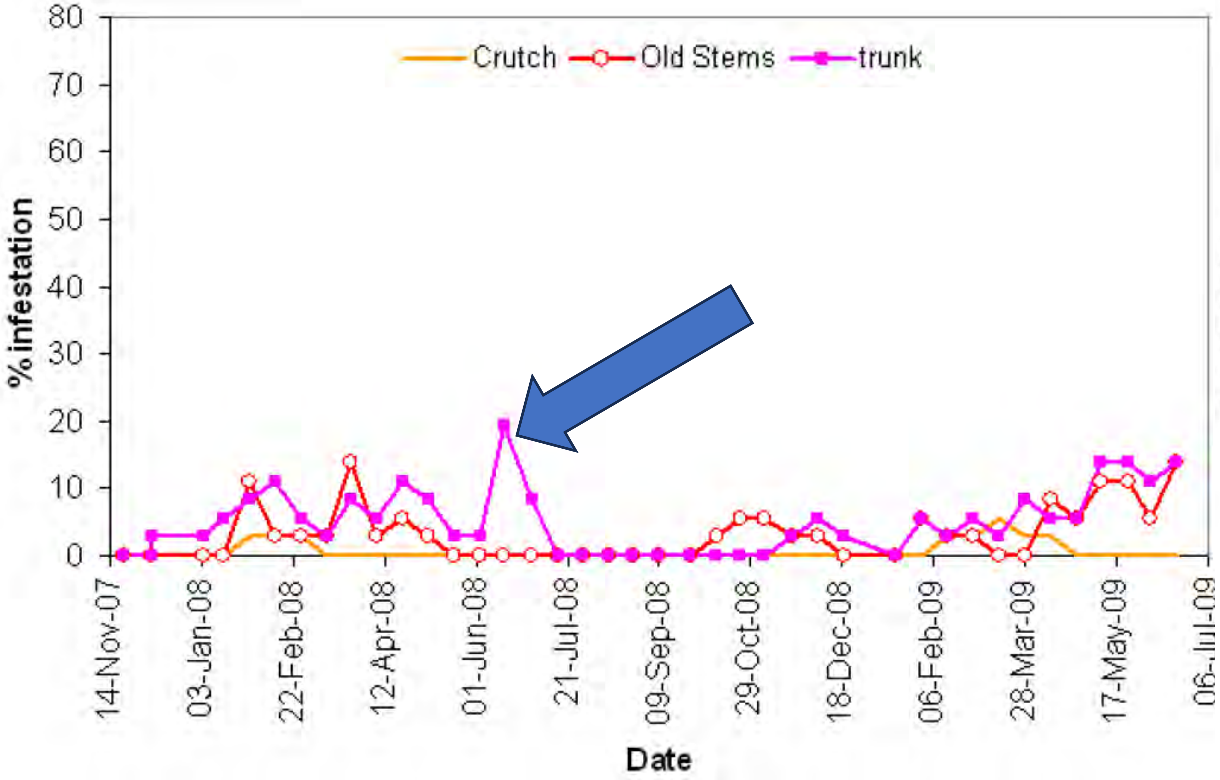
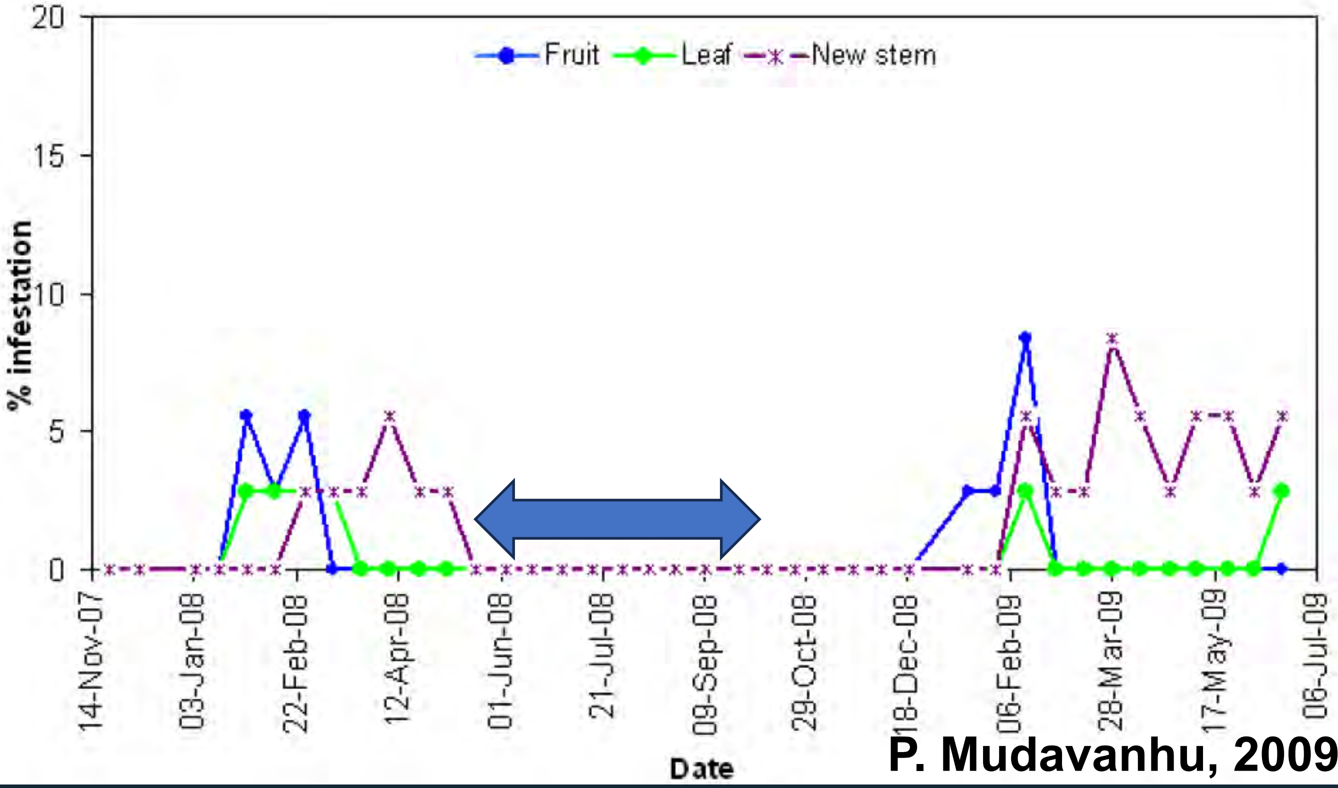
All life stages present throughout the season

During winter

- Overwinters underneath bark, cracks & crevices on host tree
- Breeds slowly
- Minimum development 16 ˚C
- Lifecyle can take up to 3 months to complete





P. Mudavanhu, 2009

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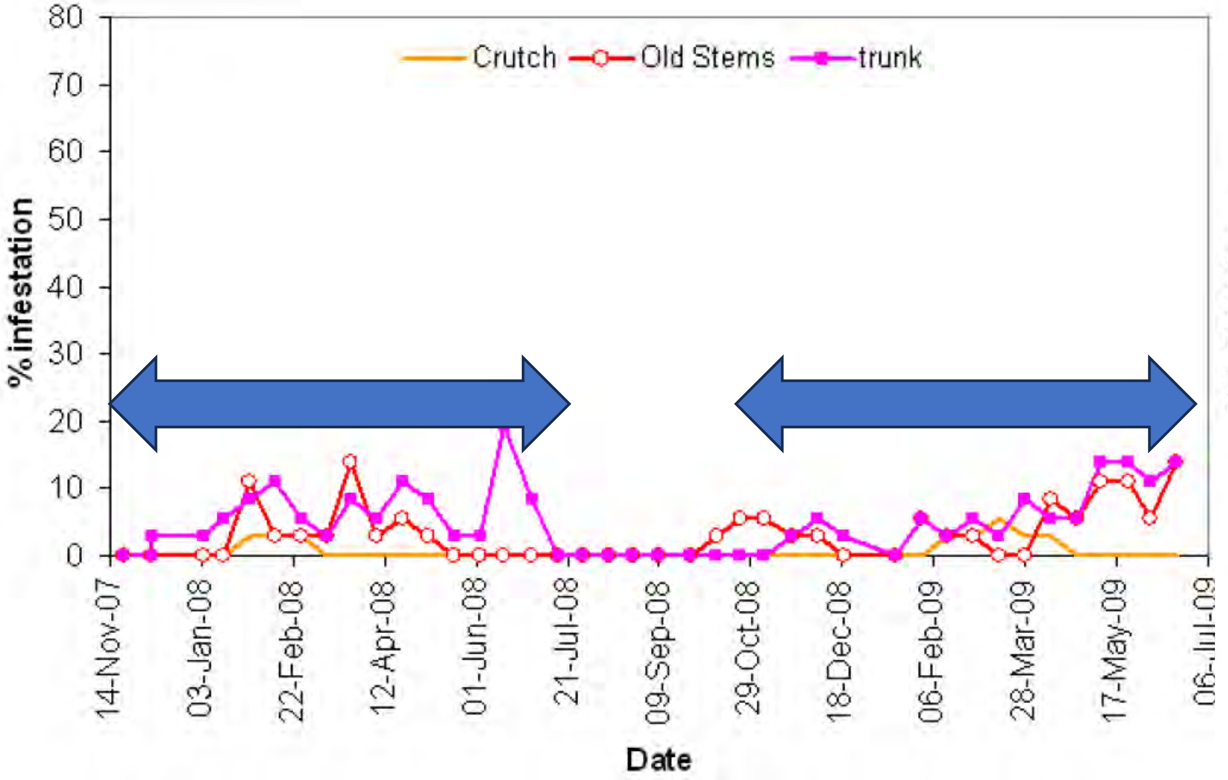
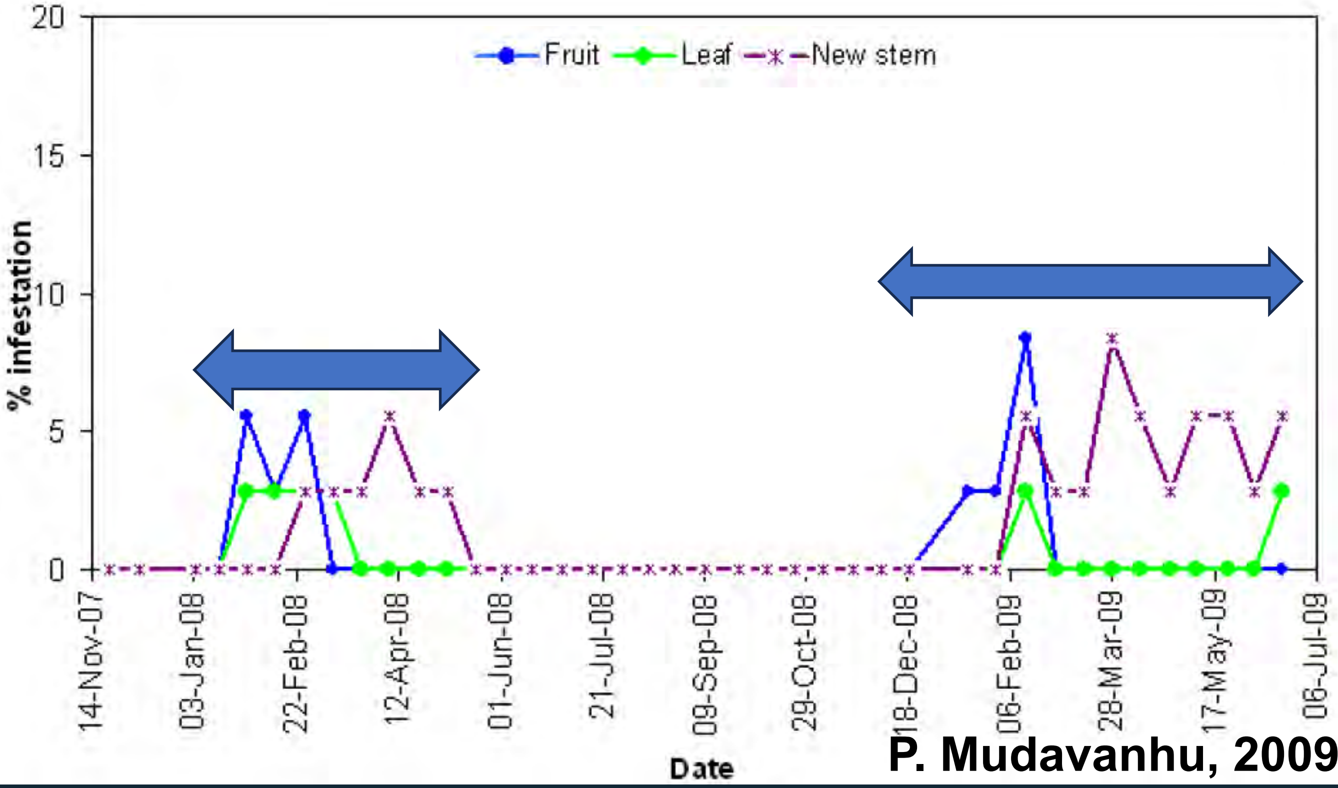
All life stages present throughout the season

Growing season

- Crawlers migrate to the rest of the tree from old stems and trunk
- To rest of the tree – new stems, leaves and then fruit
- Temperature optimal during summer
- Max development temp 28 ˚C
- 2 – 3 weeks to complete lifecycle





P. Mudavanhu, 2009

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How?

Monitoring and detection

Cultural control

Chemical control

Biological control?

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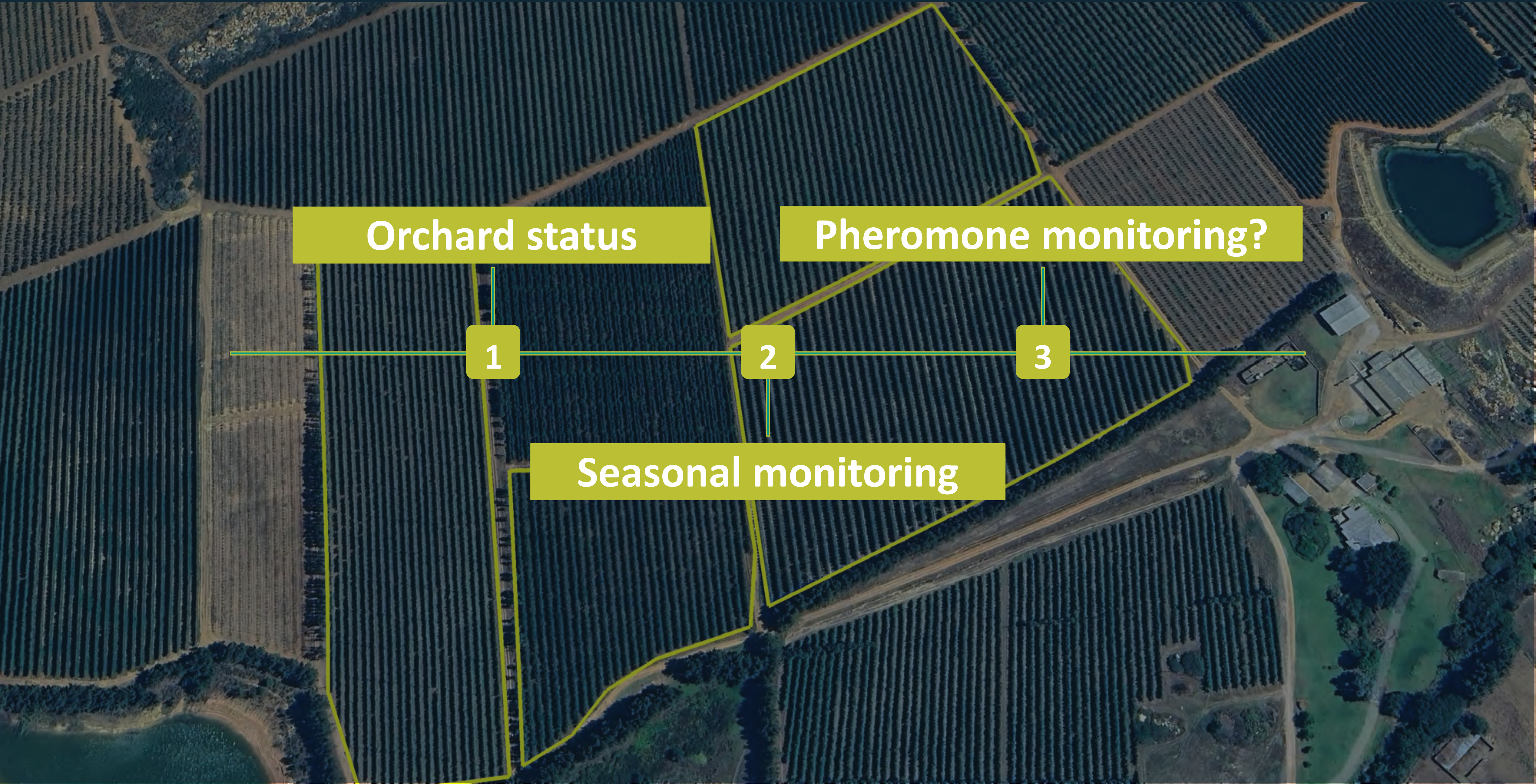
Monitoring and detection



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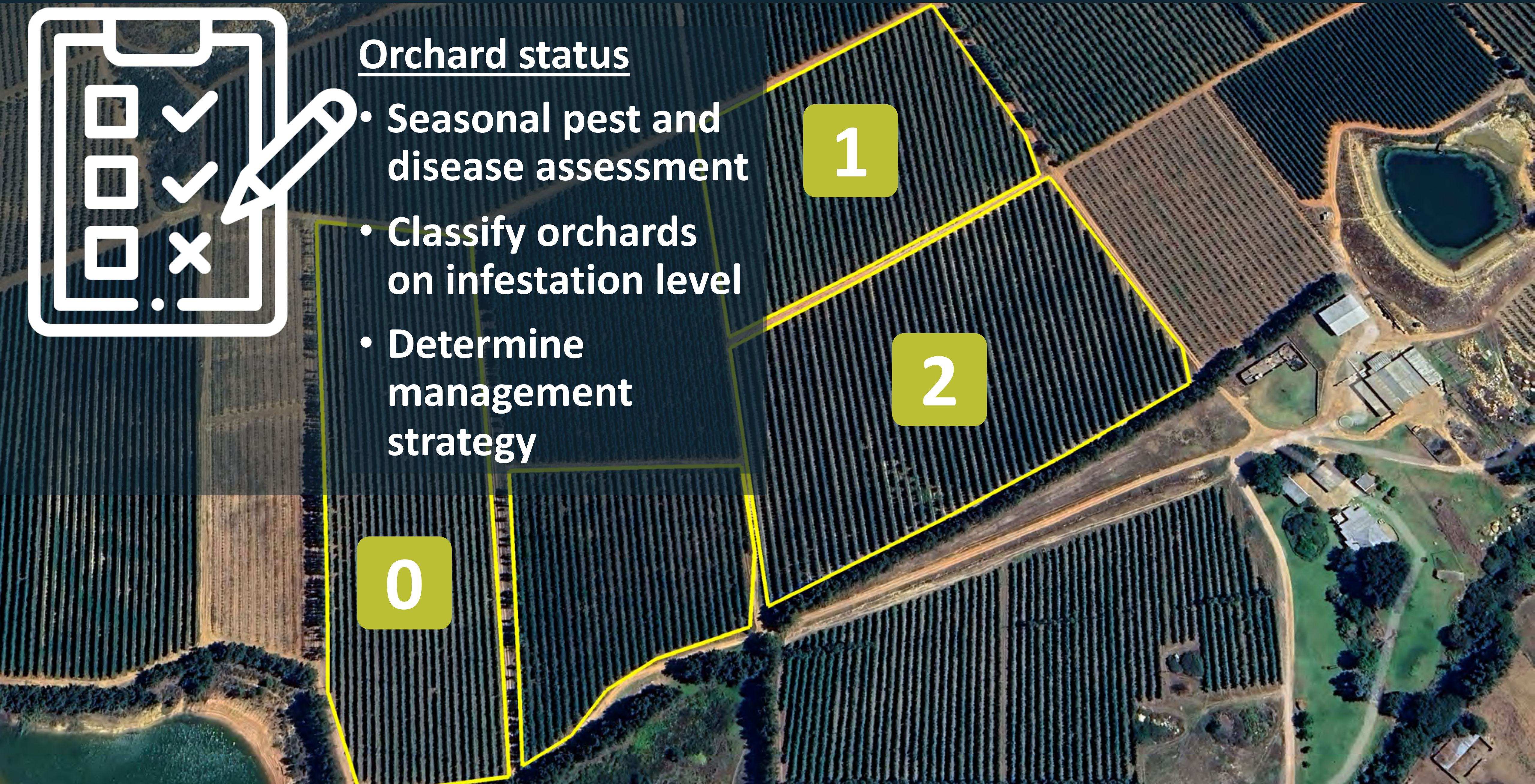
Monitoring and detection

Orchard status

- Seasonal pest and disease assessment
- Classify orchards on infestation level
- Determine management strategy



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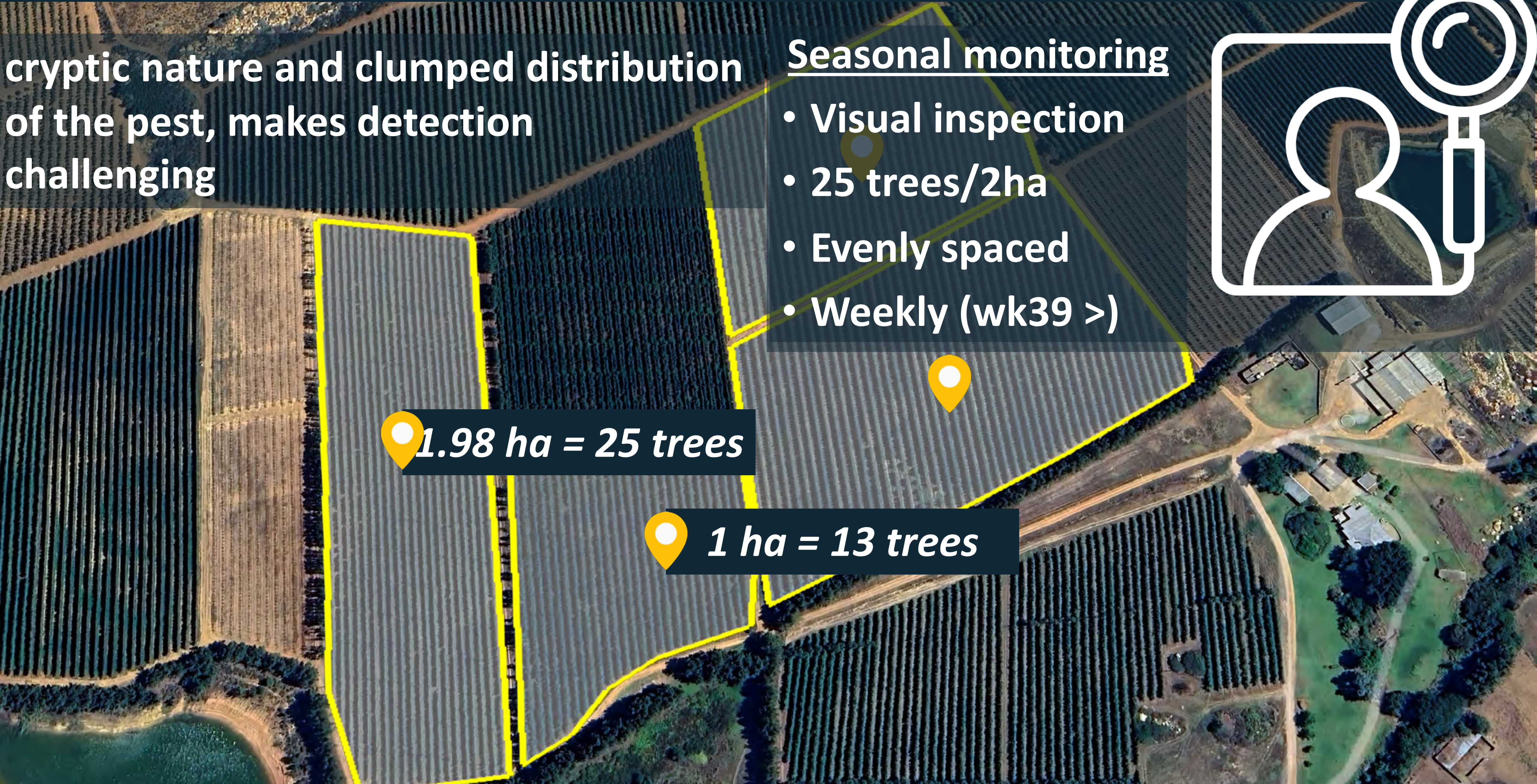
Monitoring and detection

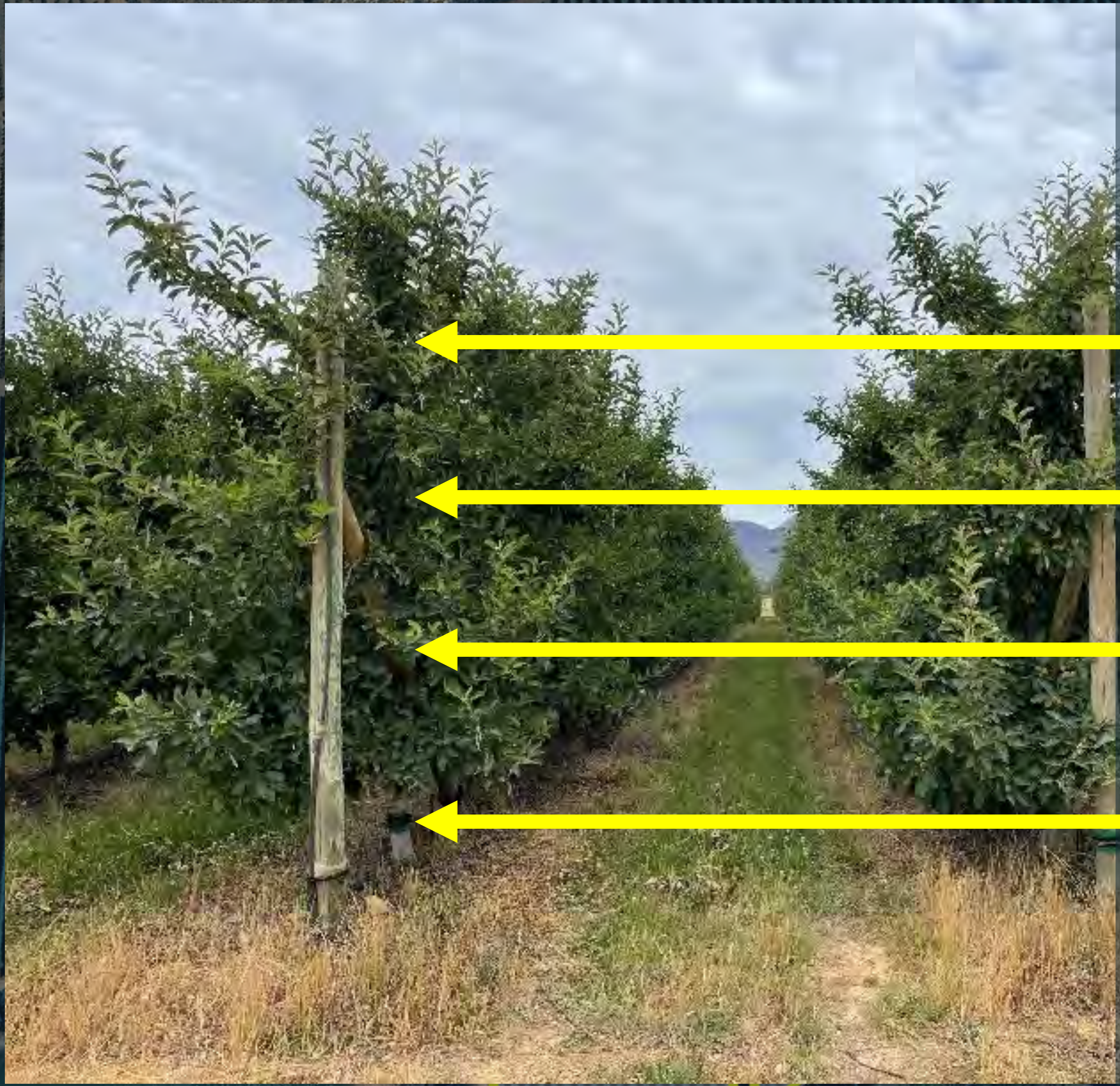
cryptic nature and clumped distribution of the pest, makes detection challenging

Seasonal monitoring

- Visual inspection
- 25 trees/2ha
- Evenly spaced
- Weekly (wk39 >)



Monitoring and detection



Looking for:

Presence/Absence

5 Fruit clusters

5 shoots & 2 Leaves

Preferred overwintering sites

Old stems, cruches

Trunk – use of corrugated cardboard bands

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Monitoring and detection

Looking for:

1st, 2nd Crawler movement detection (changes in crawler population)

- **Use of 15 cm corrugated cardboard strips**
- **Limbs and trunk**
- **Sheltered sites for females**

- **Timing of applications**
- **Parasitiod detection**

Pheromone monitoring

- Pheromone baited traps trap males
- Mealybug species pheromones very specific
- 2, 3, 4, 4 –tetramethylcyclopentyl (methyl acetate)
- Not commercially available in South Africa?
  - Difficult to synthesize commercially
- Can be used to indicate possible fruit infestation risk
- DD models to expect first flush of crawler movement

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Chemical control

Dormant applications of organophosphates and systemic insecticide applications during the growing season form the basis of mealybug control

Chemical control

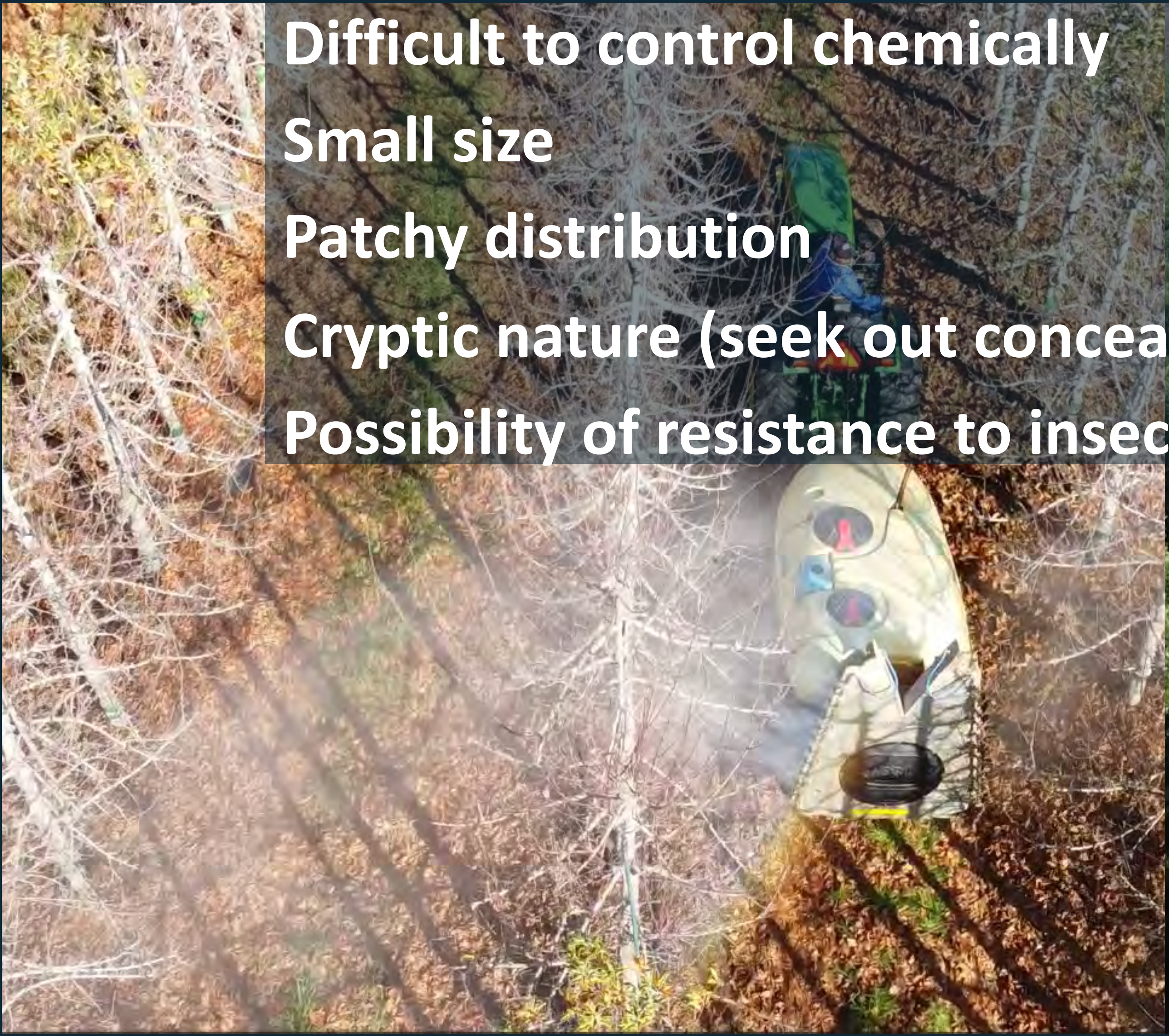
Difficult to control chemically

Small size

Patchy distribution

Cryptic nature (seek out concealed spaces)

Possibility of resistance to insecticides (organophosphates)



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Chemical control

Dormant applications			Growing season applications			
Active ingredient	IRAC	Max a[illegible]ications	Active ingredient	IRAC	max. applications	Witholding period
Chlorpyrifos	1B		[illegible]	4A	2	50
Mercaptothion	1B		*Beauveria bassiana*	UNF	NA	0
Methidathion	1B	Not indicated	*Metarhizium anisopliae*	UNF	NA	0
Mineral oils			Natural pyrethrum	3A	NA	0
Prothiophos	1B		Sulfoxaflor	4C	3	7

Challenge: Loss of chlorpyrifos

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Chemical control

Dormant applications		
Active ingredient	IRAC	Max applications
Chlorpyrifos	1B	Not indicated
Mercaptothion	1B	
Methidathion	1B	
Mineral oils		
Prothiophos	1B	

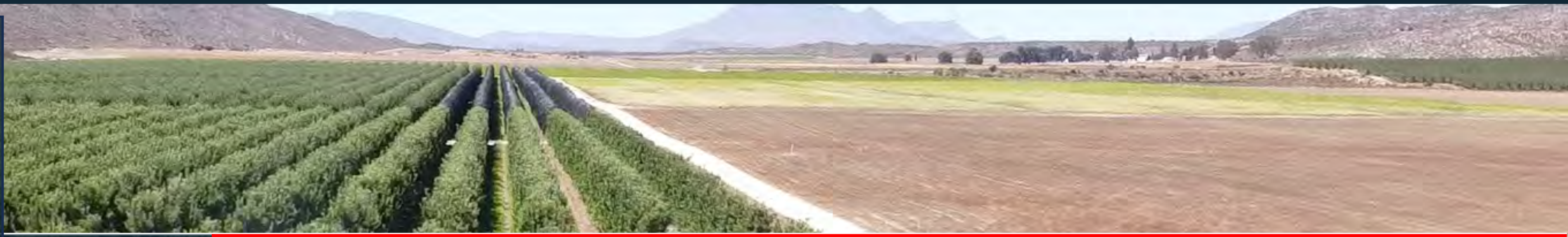
Growing season applications			
Active ingredient	IRAC	max. applications	Witholding period
Acetamiprid	4A	2	50
Beauveria bassiana	UNF	NA	0
Metarhizium anisopliae	UNF	NA	0
Natural pyreth[illegible]	3A	NA	0
Sulfoxaflor	4C	3	7

Organophosphates (Prothiofos & Methidathion)

Challenges:

- Cost
- Availability
- Depending on pressure (1-3 sprays)
- Residue risk late dormant applications

Chemical control



Acetamiprid and Sulfoxaflor

- Product choice – combined targets.
- Timing and number of sprays pending on:
- First movement of crawlers
- Infestation pressure
- Simultaneous control of other pests
- Market access restrictions

Growing season applications			
Active ingredient	IRAC	max. applications	Witholding period
Acetamiprid	4A	2	50
Beauveria bassiana	UNF	NA	0
Metarhizium anisopliae	UNF	NA	0
Natural pyrethrum	3A	NA	0
Sulfoxaflor	4C	3	7

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Chemical control
Positioning & timing

TIMING	ACTIVE INGREDIENT	
	Maintenance	High pressure
Early winter		Prothiophos
Mid-Winter	Prothiophos	Methidathion/Prothiophos
Bud swell	Methidathion	Methidathion
WK47- WK50	Acetamiprid x 1	Acetamiprid x 2
WK 51 till harvest		Sulfoxaflor 1-2 applications

Note: Important to add Cipron oil @ 500ml/100L water with winter sprays and a rest breaking oil according to recommendation (Not less than 2%) at green point.

Chemical control
Positioning & timing

TIMING	ACTIVE INGREDIENT	
	Maintenance	High pressure
Early winter		Prothiophos
Mid-Winter	Prothiophos	Methidathion/Prothiophos
Bud swell	Methidathion	Methidathion

Aim: Reduce overwintering populations

Targeting immature mobile stages in late winter and early spring – not female adults underneath bark

Canopy easier target – older limbs and trunk

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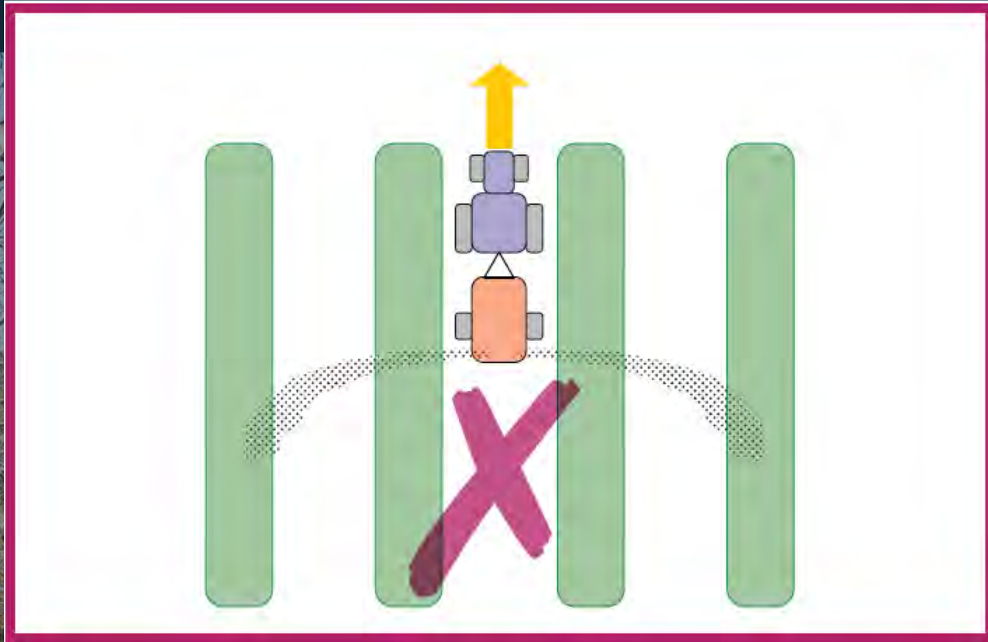
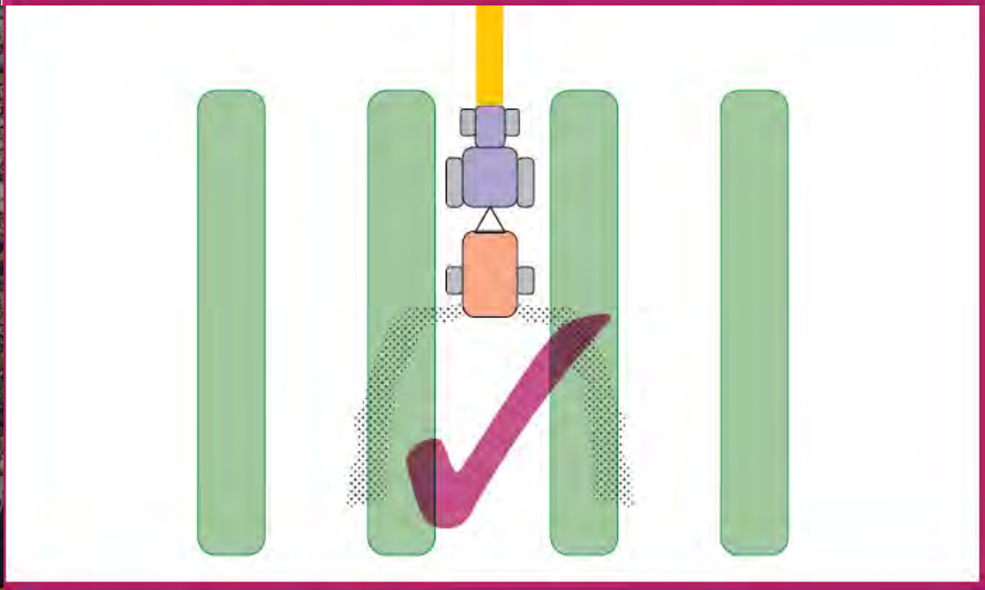
Chemical control
Dormant spray applications

- Adapt sprayer speed & air volume of sprayer to just exit canopy (CAS)
- Spray trees from both sides (up & down)
- Use the correct spray volume
- Adjust volume wit nozzle selection
  - More is not better (you are not going to get in behind the bark)
  - Only a film is needed
  - Be careful of percentage of TRV calculations
- NB for high density orchards





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Chemical control
Positioning & timing

Aim: Crawlers moving to new foliage (new stems, leaves and fruit)

Applications need to happen before crawlers reach fruit calyx

Difficult target due to increasing foliage

WK47- WK50	Acetamiprid x 1	Acetamiprid x 2
WK 51 till harvest		Sulfoxaflor 1-2 applications

Note: Important to add Cipron oil @ 500ml/100L water with winter sprays and a rest breaking oil according to recommendation (Not less than 2%) at green point.

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Chemical control
Future?

- Existing active ingredients coming to pome fruit
    - Spirotetramat (in development)
    - Pyriproxyfen as post-harvest/dormant and seasonal application
    - Buprofezin as post-harvest & dormant application
    - Flupyradifurone – work to start in near future (use during season)
- Future:
    - Plenexos (Spidoxomat)
    - Arylsulfoxide – acaricide possible use for mealybug

Biological control

Challenges:

- Only 3 products registered
- Little to no efficacy data
- Multiple applications advised
    - Low residual activity
    - UV sensitive
- Hitting the target essential
- Costly
- Managing resistance?
- Not replacing chemistry

Growing season applications			
Active ingredient	IRAC	max. applications	Witholding period
Acetamiprid	4A	2	50
Beauveria bassiana	UNF	NA	0
Metarhizium anisopliae	UNF	NA	0
Natural pyrethrum	3A	NA	0
Sulfoxaflor	4C	3	7

BIOCONTROL SCIENCE AND TECHNOLOGY
2022, VOL. 32, NO. 4, 397–417
https://doi.org/10.1080/09583157.2021.2010653

Taylor & Francis
Taylor & Francis Group

RESEARCH ARTICLE

Check for updates

Laboratory screening of entomopathogenic fungi and nematodes for pathogenicity against the obscure mealybug, *Pseudococcus viburni* (Hemiptera: Pseudococcidae)

Letodi L. Mathulwe, Antoinette P. Malan and Nomakholwa F. Stokwe

Department of Conservation Ecology and Entomology, Faculty of AgriSciences, Stellenbosch University,

Promising results in lab…How would they do in field?, other challenges?

- **EPF Effectiveness: *M. robertsii* (6EIKEN) & *M. pinghaense* (5HEID) most effective, causing high mortality rates of 96% and 91%, respectively, within seven days.**
- **EPN Effectiveness: Heterorhabditis indica most effective EPN, causing 79% mortality within 48 hours.**

Biological control
Positioning & timing

TIMING	ACTIVE INGREDIENT	
	Maintenance	High pressure
Early winter		Prothiophos
Mid-Winter	Prothiophos	Methidathion/Prothiophos
Bud swell		Methidathion
WK47- WK50		Acetamiprid x 2
WK 51 till harvest		Sulfoxaflor 1-2 applications

Bio-control: Start applications when crawler movement is noticed

Note: Important to add Cipron oil @ 500ml/100L water with winter sprays and a rest breaking oil according to recommendation (Not less than 2%) at green point.

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Biological control
Parasitoids & predators

Globally *P. viburni* have abundant parasitoids

(Does not mean efficacy locally)..why?

- Parasitoids on mealybugs are host specific
  - Host abundance & availability
  - Temperature sensitive

- Naturally isolated parasitiods
  - *Pseudectroma sp.*
  - *Pseudaphycus maculipennis*
- Locally no predators have been IDed
- Control with Cryptolaemus?

Table 2. Primary encyrtid parasitoids reared from *Pseudococcus viburni* on apple fruit collected in the Western Cape Province, South Africa, in 2003.

Parasitoid species	*n* (% of total)
Anagyrus sp.	4 (2.0)
Acerophagus sp.	10 (4.9)
Pseudaphycus maculipennis	12 (5.9)
Pseudectroma sp.	172 (84.3)
Tetracnemoidea sp.	6 (2.9)

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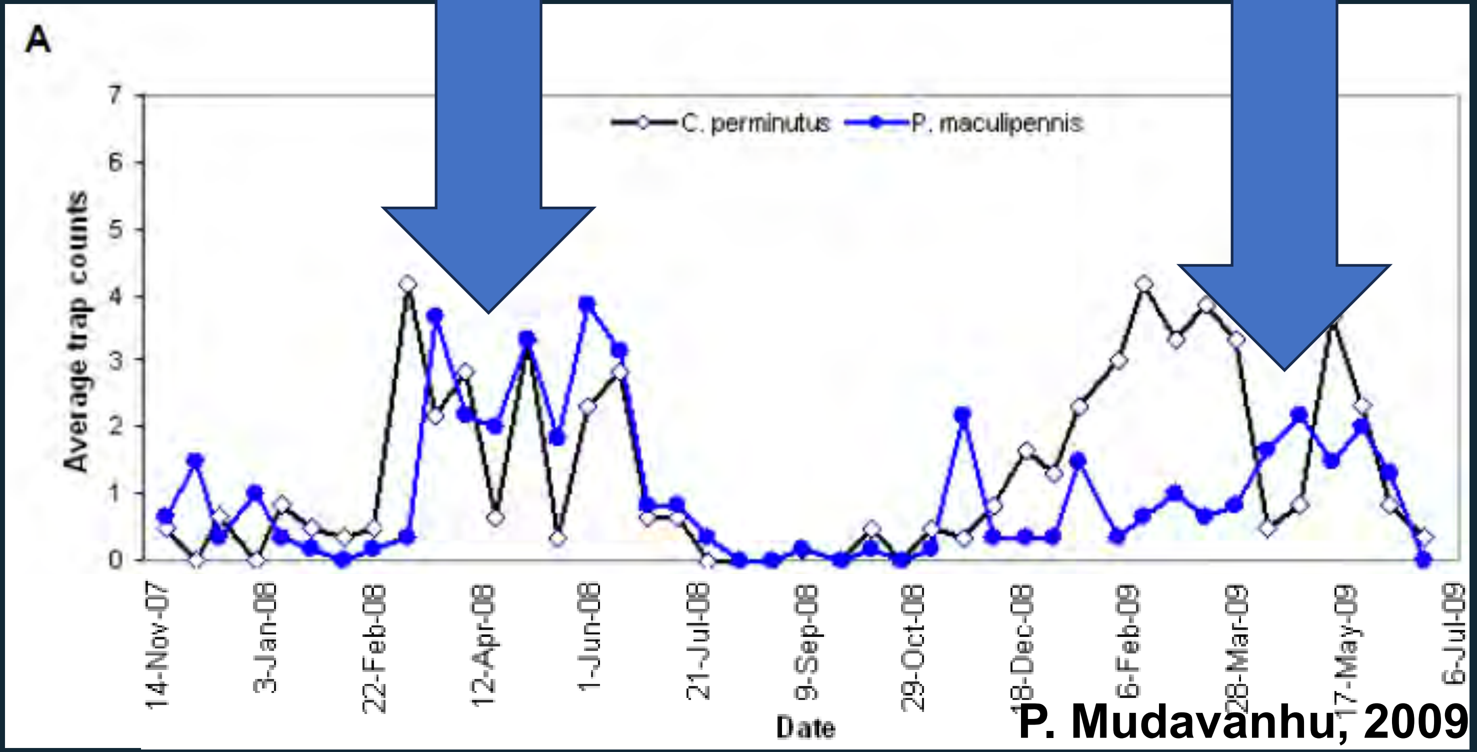
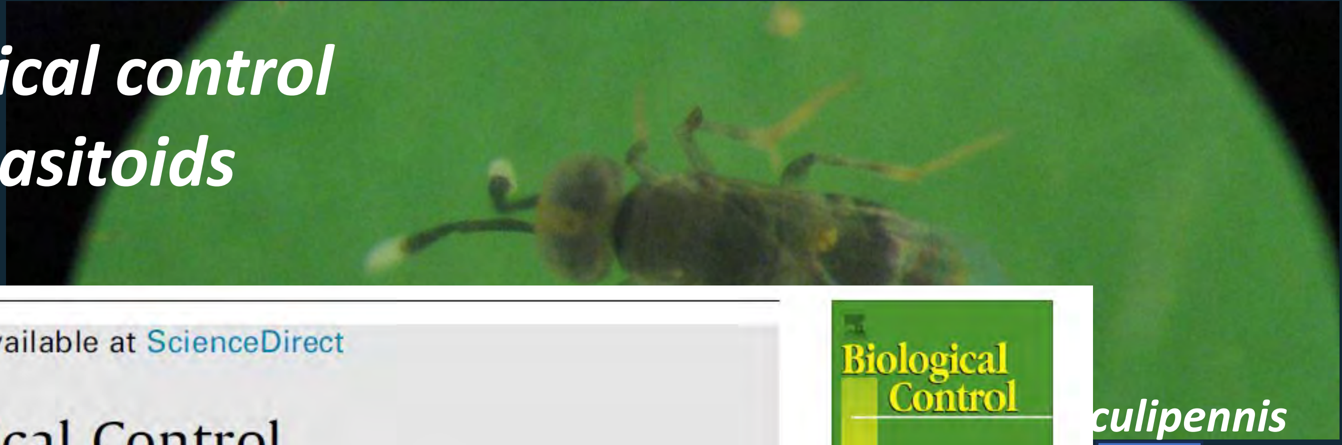
Biological control
Parasitoids

Challenges:

- **Need to prevent fruit infestation**
- **Only parasitising large bodied instars (3rd instar and adult female)**
- **These are instars already found on fruit**
- **Release window**
    - **Late season population control/not damage control before/after harvest**
    - **If released early in season enough 3rd instar/adult females?**
    - **Effect of CM pesticide applications on parasitoid populations early?**
    - **Distribution efficiency – patchy distribution**



Biological control
Parasitoids



Challeng

- Need t
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    - Late
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    - If re
    insta
    - Effect of CM pesticide applications on parasitoid populations early?
    - Distribution efficiency – patchy distribution

Contents lists available at ScienceDirect

Biological Control

journal homepage: www.elsevier.com/locate/ybcon

Nontarget effects of orchard pesticides on natural enemies: Lessons from the field and laboratory

Elizabeth H. Beers [a,*], Nicholas J. Mills [b], Peter W. Shearer [c,1], David R. Horton [d], Eugene R. Milickzy [d], Kaushalya G. Amarasekare [c,2], Lessando M. Gontijo [a,3]

[a] Department of Entomology, Tree Fruit Research and Extension Center, Washington State University, 1100 N. Western Ave., Wenatchee, WA 98801, USA
[b] Department of Environmental Science and Policy Management, University of California, Berkeley, CA 94720-3114, USA
[c] Mid-Columbia Agricultural Research and Extension Center, Oregon State University, 3005 Experiment Station Drive, Hood River, OR 97031-9512, USA
[d] USDA-ARS, Yakima Agricultural Research Laboratory, 5230 Konnowac Pass Road, Wapato, WA 98951, USA

P. Mudavanhu, 2009

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Conclusion:

- **Chlorpyriphos fate was inevitable? (Rest of Ops?)**

- **US: certain states on certain crops use is back for the 2024 season based on risk assessment**

- **We still have the tools to effectively control mealybug**

- **Good positioning & spray application is key to success**

- **There are more tools on the way – need to be protected**

- **Bio trials are needed to evaluate field efficacy = challenge mass production (logistics)**

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