Invertebrate pest management in Maize

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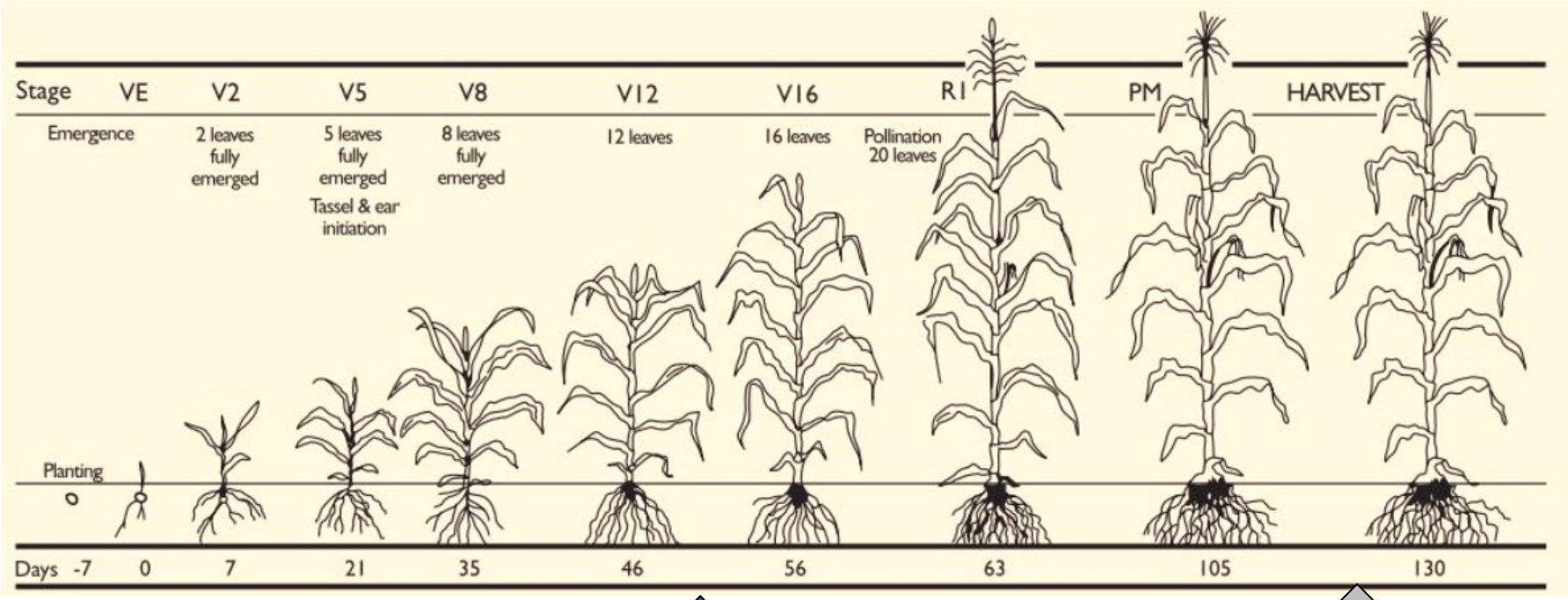
IPM that incorporates:

Soil insects
Helicoverpa
Mites
Corn aphid
Fall armyworm – a new threat?

Questions

IPM in maize

Historically, maize has been a low intervention crop.



Soil insects
Pre-sowing che
A history of issu
Weeds can host pests (thrips, mite

Seedling pests
Neonicitinoid seed
Avoid broadspectr

Reproduction - maturity
Helicoverpa can emerge from whorls and feed on tassels as large, damaging larvae.
Historically helicoverpa impact on cobs not economic to control.
Egg and larval parasitoids suppress populations.
Mites and aphids are most likely induced pests.

Mites – spider mites? Species?

Outbreaks most common when hot and dry.

These conditions favour mites and disadvantage natural enemies.

Populations increase rapidly after pollen shed.

Mites persist on other hosts (e.g. grasses, broadleaf weeds) over winter and spring = source.

Movement into crops as hosts dry down.

Mites are resistant to a number of insecticides.

Mite outbreaks are suppressed by natural enemy activity

- thrips, predatory mites, predatory bugs, lacewings, ladybeetles

Broadspectrum insecticide use will kill the natural enemies, favouring mite build up.

Generation time: 10-20 days
= rapid population build up.

Making decisions about control of mites

Two spotted mites	None established as there are no effective chemicals registered. First seen as webbing on undersides of leaves.	Tasselling and silking crops.	Suck sap, leaves lose colour, reduce plant vigour, cob size and seed development. Promote lodging and premature	Avoid use of synthetic pyrethroids and carbamates on other insects as they 'flare' two-spotted mites.	Intermittent

Source: NSW DPI Insect and mite control in field crops. 2013.

In the absence of established thresholds – these q

Is the crop close to tasselling?
Do most plants have colonies of mites?
Are daily maximum temperatures 35 degrees?
Is the field moisture stressed?
Are natural enemies active in mite colonies?
Is there a history of severe mite issues?

Reduction in functional leaf area that corn can tole
The earlier outbreaks occur, the more time to build

GO SOFT EARLY

Table 1. Estimated potential corn yield loss due to percent leaf defoliation at various growth stages.

	Percent Leaf Area Destroyed				
Corn Growth Stage*	20%	40%	60%	80%	100%
	% Potential Yield Loss				
7-leaf	0	1	4	6	9
12-leaf	1	5	11	18	28
17-leaf	4	13	28	48	72
Silked	7	20	39	65	97
Blister	5	16	30	50	73
Soft dough	2	8	17	29	41

*This system counts a leaf as fully developed when the leaf tip is pointing below a horizontal line (not fully developed leaf collar).
Source: 2013. Corn loss adjustment standards handbook, 2014 and succeeding crop years. Page 84. FCIC-25080 (11-2013). USDA Federal Crop Insurance Corporation.

Cultural considerations
Minimise moisture stress in the crop.
High N favours mites.
Overhead irrigation can suppress mites.

Chemical control – resistance and impact on NE

TABLE 12: Control of two-spotted spider mite (*Tetranychus urticae*)

Active ingredient	Insecticide group	Mite resistance	Overall Impact on beneficials*	Comments#
Etoxazole	Group 10B	Occasional – low	Low	Good coverage is essential. Refer to label for no spray zones and record keeping. Best on low to increasing populations. Maximum 1 application per season.
Dicofol	Group 2B	No data	Low	NSW registration only. Apply by ground rig at first appearance of mites before row closure. Maximum 2 applications per season.
Diafenthiuron	Group 12A	No resistance	Low	Treatment at higher infestation levels may lead to unsatisfactory results. Maximum 2 applications per season.
Abamectin	Group 6	Widespread – med/ high	Moderate	Best results will be obtained when applied to low mite populations. Maximum 2 applications per season.
Emamectin benzoate	Group 6	CR Abamectin	Moderate	When applied for *Helicoverpa* control will reduce the rate of mite population development. Suppression only. Maximum 2 applications per season.
Propargite	Group 12C	Occasional – low	Moderate	Apply spray before mite infestations reach damaging levels as maximum efficacy is not reached until 2 weeks after spraying. Maximum of 2 non-consecutive applications per season.
Amitraz	Group 19	No data	Moderate	Suppression when used for controlling *Helicoverpa*. Maximum 4 applications per season.
Dimethoate	Group 1B	No data	High	Will not control organophosphate-resistant mites. Do not harvest for 14 days after application. Do not graze or cut for stockfood for 14 days after application. Maximum 2 applications per season.
Phorate	Group 1B	No data	High	Use lower rate for short residual control at time of planting. For extended period of control use higher rates. Only use the highest rate on heavy soils when conditions favour good emergence. Maximum 1 application per season. Note that rates differ by state.
Bifenthrin	Group 3A	Widespread – med/ high	Very High	Applications against *Helicoverpa* will give good control of low mite populations. Maximum 1 application per season.
Deltamethrin	Group 3A	CR Bifenthrin	Very High	Suppression only. Maximum 1 application per season.

#For all control options ALWAYS refer to the label for instructions. Minimise impact on bees.

*For more details about impact on beneficial insects, refer to table 3 in this guide. CR = cross resistance likely.

Source: Cotton pest management guide 2020-21

Table 19. Maize – pests (continued)

Insect	Threshold	Crop growth stage	Crop damage	Comments	Frequency
Heliothis caterpillars	Hybrid maize seed crops 1–2 sprays at tasselling and silking. Processing maize 0–1 sprays during silking. Spraying is unlikely to be economic.	Foliage damage before tasselling does not warrant control. Main damage occurs to the cobs and tassels during tasselling and silking.	Eat holes in leaves, often in the funnels of the plants. Attack the tassels, move to the cobs, attack silks which prevents pollination, eat tops out of cobs. Allow entry of other insects and moulds.	Early sowing can reduce damage. Maize crops tolerate some damage and tight husk cover helps prevent caterpillar entry. Usually not worth spraying in commercial crops. Pupae bust during winter to reduce survival.	Annual
Redshouldered leaf beetles (*Monolepta*) (North Coast)	Usually swarm in large numbers creating hot spots.	Tasselling and silking crops.	Feed on foliage, tassels and silks, open husks at top of cobs, Impair seed set.	Allow entry of other insects and diseases into cobs. Spot spraying may be sufficient.	Intermittent (coastal)
Sugar cane and maize stem borer	None available.	Larvae enters maize stem through lower internodes during vegetative stages.	Eats internal structures of stem causing lodging. If infestation occurs early in crop development it can reduce grain weight. Generally occurs on edge of crops.	Native insect which can cause minor damage in other crops such as wheat or rice. No control possible. Insect may favour softer stem varieties.	Rarely
Two spotted mites	None established as there are no effective chemicals registered. First seen as webbing on undersides of leaves.	Tasselling and silking crops.	Suck sap, leaves lose colour, reduce plant vigour, cob size and seed development. Promote lodging and premature death.	Avoid use of synthetic pyrethroids and carbamates on other insects as they 'flare' two-spotted mites.	Intermittent
Wireworms	Presence of larvae before sowing. Treat if more than 1 larvae per metre of row. No post-sowing treatment.	Larvae feed on germinating seed and bore into stem of young seedling. Larvae are 15–25 mm long.	Kill seedlings by destroying growing point. Damage more severe under cool and wet conditions when growth is retarded. Damage stops when top 50 mm of soil dries out and warms up.	Wireworm numbers can be reduced by clean cultivation. Later sowing using press wheels into warm moist soils reduces damage. Many farmers apply routine control measures at sowing. The common brown earwig is a natural enemy.	Intermittent

Helicoverpa (corn earworm)




Predominantly *H. armigera* in corn – not *H. punctigera* = RESISTANCE issues

Native armyworm species may also be present.

Control is rarely warranted.
Natural enemies very effective – *Trichogramma* egg parasitoid, larval parasitoids

Pheromone traps can provide early warning of local activity.

TABLE 6: Control of *Helicoverpa*

Active ingredient	Insecticide group	Resistance (*H. armigera*)	Overall impact on beneficials*	Comments#
Bacillus thuringiensis	No group	Non detected	Very low	Restrictions apply –refer to Bt cotton resistance management plan.
Helicoverpa NPV	No group	Non detected	Very low	Use alone or with compatible larvicide. Target application to coincide with egg hatching.
Paraffinic oil	No group	Non detected	Very low	Use a minimum of 80 L/ha of water. Apply only by ground rig before crop closure.
Magnet	Attractant	Non detected	Very low	Use with insecticides as per label instructions.
Indoxacarb	Group 22A	Widespread – moderate	Low	Maximum 3 applications per season.
Clitoria ternatea Extract (Sero-x)	No group	Unknown	Low	Ensure good coverage. Treatment effects may not be seen for 3 or more days. Applications should be timed to coincide with egg hatch and when small larvae are present. Maximum 5 applications per season.
Methomyl	Group 1A	Widespread – moderate	High	Higher rate of larvicidal rate may cause reddening of foliage. Do not use more often than every 14 days, if excessive use an alternative. Do not apply during periods of plant stress. Maximum 2 applications per season.
Thiodicarb	Group 1A	Widespread – moderate	High	This product has ovicidal and larvicidal activity. See label for details. Lower rate is on light to moderate infestations and the higher rate on heavier infestations. Maximum 2 applications per season.
Alpha-cypermethrin	Group 3A	Widespread – high	Very High	Use low rate for eggs or newly hatched larvae. Use higher rates for higher egg pressure or larger larvae. Maximum 1 application per season.
Bifenthrin	Group 3A	Widespread – moderate & Cross Resistance	Very High	Time spray to coincide with egg hatch. DO NOT apply to larvae >5 mm. Use higher rate when pest pressure is high, conditions favour pest development and when increased residual protection is required. *H. armigera* resistance to bifenthrin has increased. Field failures are likely. Maximum 1 application per season.
Cypermethrin	Group 3A	Widespread – high	Very High	See label for specific concentrations and higher rate situations. Maximum 1 application per season.
Deltamethrin	Group 3A	Widespread – high	Very High	Use low rate as ovicide and high rates for small to medium larvae. Maximum 1 application per season.
Esfenvalerate	Group 3A	Widespread – high	Very High	Use low rate when larvae are small and pressure is low. Maximum 1 application per season.
Gamma–cyhalothrin	Group 3A	Widespread – high	Very High	Use low rate as ovicide and high rate when egg lay is heavy and/or *H. punctigera* >10 mm and/or *H. armigera* <5 mm. Maximum 1 application per season.
Lambda-cyhalothrin	Group 3A	Widespread – high	Very High	Use low rate as ovicide and/or for newly hatched larvae. Maximum 1 application per season.

#For all control options always refer to the label for instructions and to minimise impact on bees.
*For more details about impact on beneficial insects, refer to Table 3 in this guide.

Esfenvalerate | Group 3A | Widespread – high | Very High | Use low rate when larvae are small and pressure is low. Maximum 1 application per season.
Gamma–cyhalothrin | Group 3A | Widespread – high | Very High | Use low rate as ovicide and high rate when egg lay is heavy and/or *H. punctigera* >10 mm and/or *H. armigera* <5 mm. Maximum 1 application per season.
Lambda-cyhalothrin | Group 3A | Widespread – high | Very High | Use low rate as ovicide and/or for newly hatched larvae. Maximum 1 application per season.
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Source: Cotton pest management guide 2020-21

Fall armyworm

FAW trap locations and detections to August, 2020

Detections

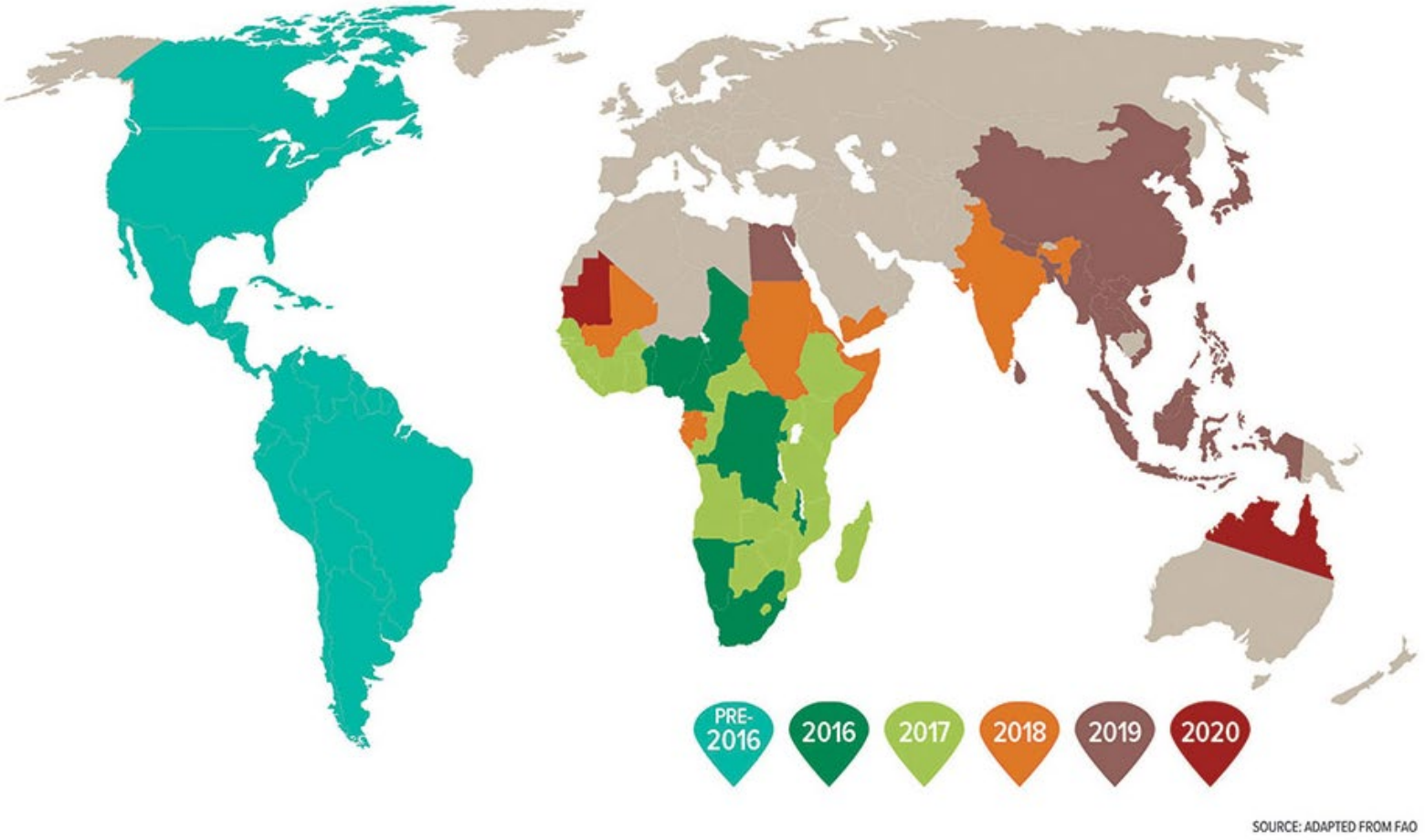
moths

moths & larvae

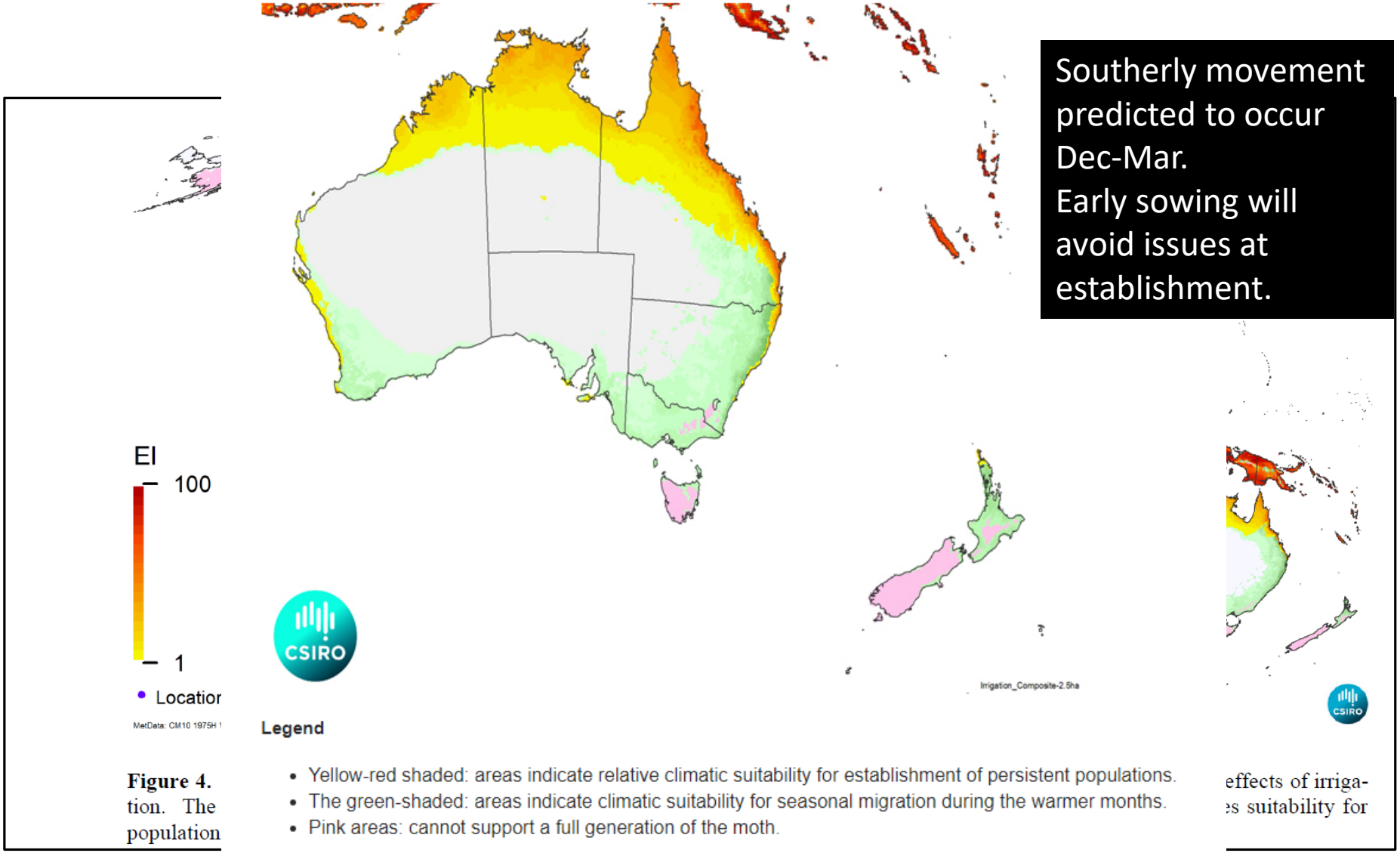
Trap present, no detections to date.

History and worldwide distribution of Fall Armyworm (FAW)

Figure 1. Map of the worldwide spread of fall armyworm since 2016 (as of 21 April 2020)



Forecasting likely distribution in Australia



Southerly movement predicted to occur Dec-Mar.
Early sowing will avoid issues at establishment.

Figure 4. tion. The population

Legend

- Yellow-red shaded: areas indicate relative climatic suitability for establishment of persistent populations.
- The green-shaded: areas indicate climatic suitability for seasonal migration during the warmer months.
- Pink areas: cannot support a full generation of the moth.

effects of irriga-
es suitability for

du Plessis *et al* (2018) *Spodoptera frugiperda* CLIMEX modelling.

Crop management will change now FAW is here: MAIZE/CORN

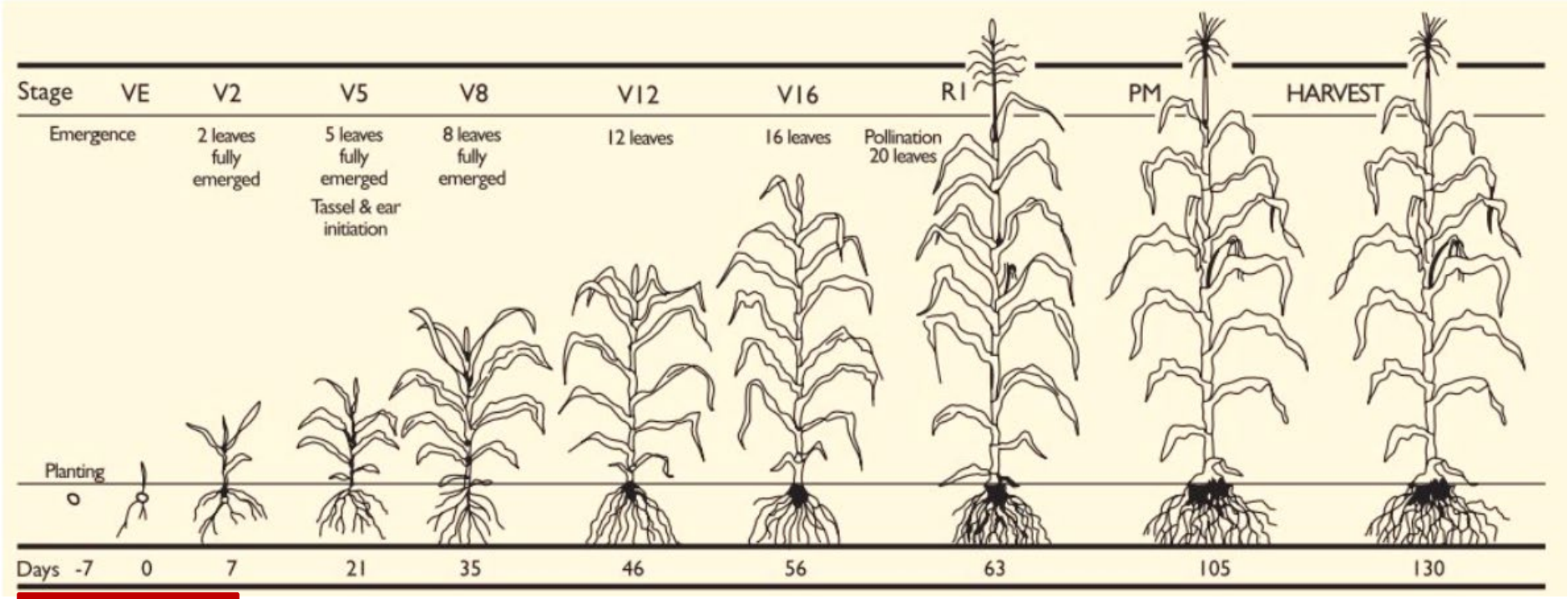


Image: https://cornindustryppnikolakostic.wordpress.com/life-cycle-of-corn/

Check for large larvae moving off grass weeds.

Seedling death.
Defoliation.

10-20% plants with damage

Check for eggs and small larvae - defoliation.

Larvae will move into whorl.
Damage to emerging leaves.
Protected from insecticides.

Early vegetative: 10-20%, 50% plants with feeding damage.
Egg masses present.
Whorl stage: 20-40% plants with 1+ larvae.
75% of plants with feeding damage.

Check for larvae on tassels and cobs

Tip and side damage to cobs.
mycotoxin risk (maize, popcorn).

No thresholds set.
Control at tasselling can assist in minimising damage to cobs.

Now FAW is here, what will change?

Crop	Preparation	Crop Monitoring (in addition to current)	Yield and Quality considerations
Sorghum	Review products available for FAW control (APVMA, Permits), and cost/availability. Discuss increased crop checking requirements with agronomist. Familiarise yourself with FAW eggs and larvae. Compare with similar species (e.g. helicoverpa, native armyworm)	Necessary during vegetative stages (prior to head emergence)	Similar to helicoverpa.
Maize, pop corn		Intensive at crop emergence and post tasselling.	Side cob damage potentially allows for entry of pathogens and production of aflatoxins under wet conditions. Discuss risk and management with agronomist and grain trader.
Sweet corn		Constant crop monitoring required.	Significant impacts on yield and quality possible.
Forage & silage crops		Identify larvae causing defoliation. Potential damage to hay and seed crops. Watch for defoliation and cob damage in silage maize.	Reduction in biomass and seed yield. Biomass reduction in silage maize and possible impact of fungal infection from cob damage.
Millet		Monitor late crops for infestations.	Defoliation and direct feeding on grain.
Pasture	Familiarise yourself with FAW eggs and larvae. Compare with native armyworm species.	Identify 'armyworm' species in event of outbreaks and significant pasture loss.	Limited options and capacity for controlling outbreaks.
Winter cereals	Early sowing (late summer) at risk.	Check establishing early crops for characteristic FAW feeding damage.	Early defoliation has little impact on yield. Severe plant damage may reduce stand.

FALL ARMYWORM LIFE-CYCLE

Eggs

Figure 2. Egg mass of the fall armyworm, *Spodoptera frugiperda* (J.E. Smith).
Credits: Jim Castner, UF/IFAS

Larvae (=caterpillars)

Source: Bulletin OEPP/EPPO Bulletin (2015) 45 (3), 410–444

FALL ARMYWOM LARVAL IDENTIFICATION GUIDE

Early instar caterpillars (stages 1-3)

Early instar larvae are very similar to young caterpillars of other species; DNA confirmation/rearing may be required for conclusive identification. Things to look for, however, are:

1) Overall yellowish/greening colour
2) Length approximately 1.5mm – 6.5mm (covering stages L1-L3)
3) Rows of black dots
4) Developing white lines running down the body
5) Developing pinkish blotches running down side of body (red arrow)

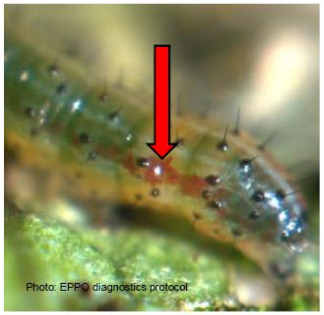


Figure 6. Typical adult male fall armyworm, *Spodoptera frugiperda* (J.E. Smith). Photograph by Lyle J. Buss, University of Florida.

Figure 7. Typical adult female fall armyworm, *Spodoptera frugiperda* (J.E. Smith). Photograph by Lyle J. Buss, University of Florida.

Fall armyworm vs native armyworm larvae

Spodoptera sp. armyworm larvae

Difficult to distinguish species from eggs and small larvae.

What to look for in grassy crops (e.g. sorghum and maize)

Image: Angus Dagliesh, Brent Wilson

Fresh frass, active larvae

Insecticide resistance management and FAW

It is possible that FAW has arrived with resistance to insecticides – CSIRO investigating

Increased spraying for FAW increases the risk of resistance development in *Helicoverpa armigera*

The management of resistance in both FAW and Helicoverpa has to 'harmonised'

Dr Lisa Bird (NSW DPI) suggests the following key principles to guide insecticide use and resistance management

1. Chemical rotation to limit exposure to the same chemical group in consecutive generations of insects. **Achievable given the large number of insecticides with emergency permits for FAW**.

2. Area wide management to limit localised selection pressure to a single generation because insect migration can increase risk of exposing cohorts previously selected for resistance. **Achievable by the use of product windows that do not exceed insect generation time.**

3. Adoption of a one-size-fits-all approach to management of FAW and *H. armigera*, particularly for products at high risk of resistance such as Group 28's and indoxacarb. **Achievable by single use of insecticides within product usage windows, regardless of species.**

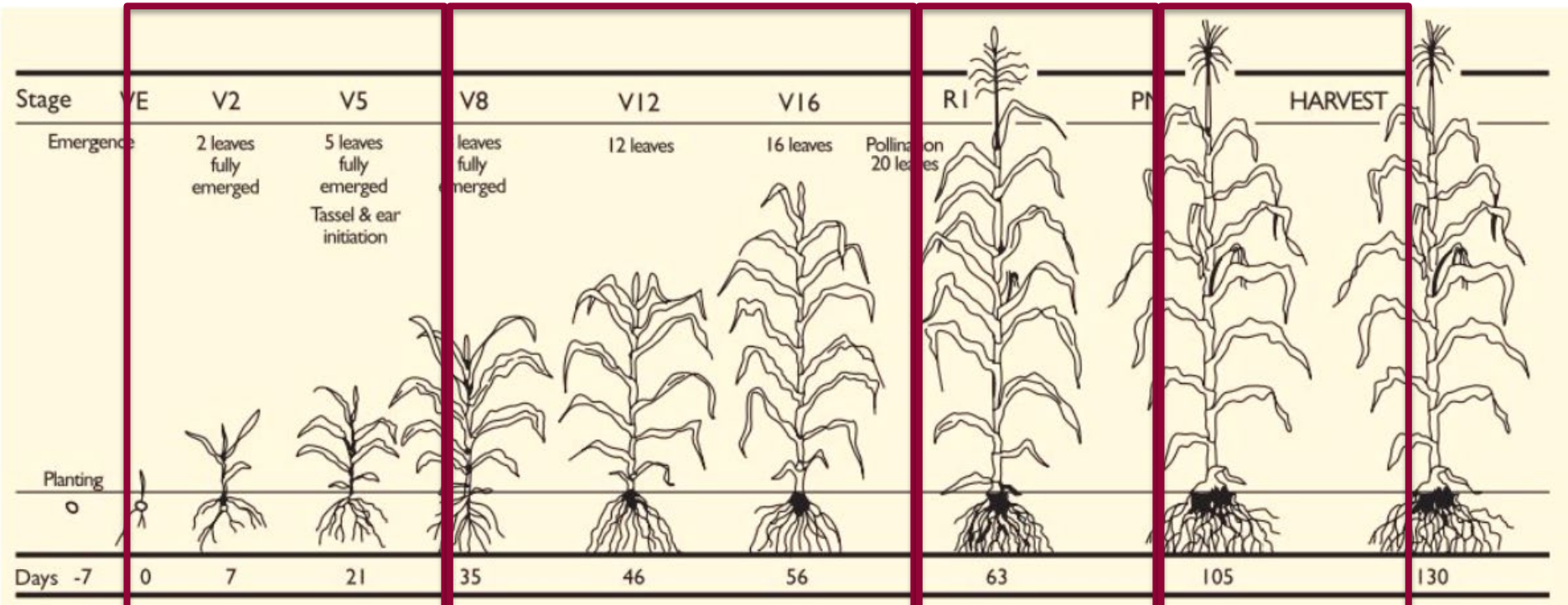
Practices that will drive insecticide resistance development

- Repeated use of the same MoA group
- Cutting rates

Co-formulation products make resistance management challenging

How might resistance management look for maize?

Manage FAW and helicoverpa together (not NPV, Vivus Max®)



Window 1

Group 28
Altacor®

Window 2

Group 22
e.g. Steward®

Window 3

Group 6
e.g. Affirm®

Window 4

Group 1/3/5

Window = 1 generation (20-30 days)

Search results (6 results)

SORGHUM

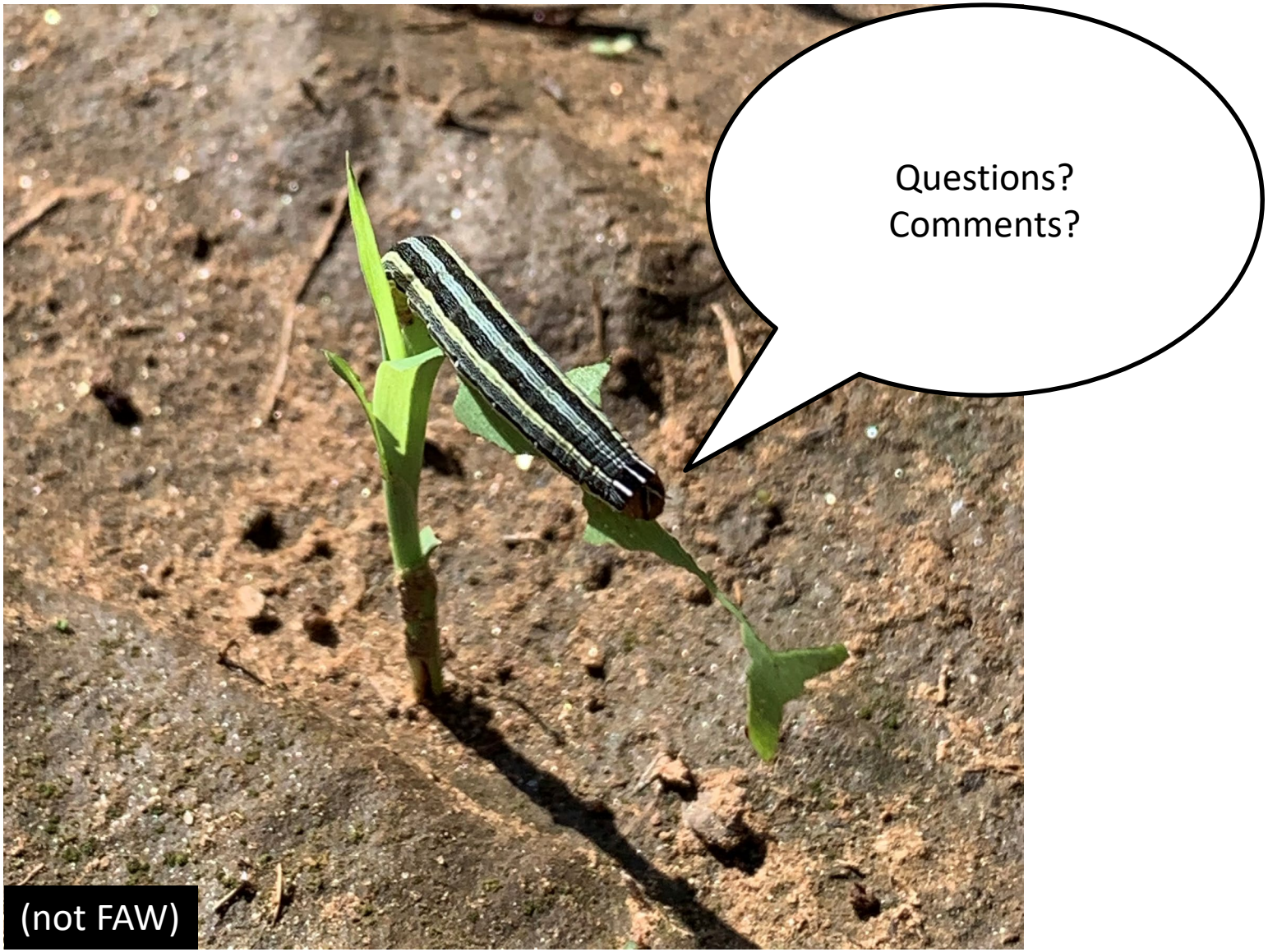
Permit No.	Type	Description	Status	Issued date	Expiry date	Details
PER89398	AG	MAGNET INSECT ATTRACTANT TECHNOLOGY / Various Crops / Fall Armyworm	CURRENT	10-Jun-2020	30-Jun-2022	View
PER89390	AG	Success Neo / Maize cereals, Sorghum Grain and Millet / Fall Armyworm	CURRENT	24-Apr-2020	30-Apr-2023	View
PER89358	AG	Trojan Insecticide / Various Crops / Fall Armyworm	CURRENT	24-Apr-2020	01-May-2021	View
PER89279	AG	Various products / Various crops / Fall armyworm	CURRENT	11-Mar-2020	31-Mar-2023	View
PER88638	AG	Various Products / Maize and Sorghum / Fall Army Worm	SURRENDERED	18-Feb-2020	31-Mar-2025	View

Maize/sorghum:
Alpha cypermethrin
Zeta cypermethrin
Methomyl
Up to 2 applications per crop, at least 7 day apart

Search results (8 results)

MAIZE, POPCORN

Permit No.	Type	Description	Status	Issued date	Expiry date	Details
PER89366	AG	Altacor Insecticide / Maize / Fall Armyworm	CURRENT	20-Apr-2020	31-May-2023	View
PER89530	AG	Steward EC Insecticide / Maize and Popcorn / Fall Armyworm	CURRENT	13-May-2020	31-May-2023	View
PER89398	AG	MAGNET INSECT ATTRACTANT TECHNOLOGY / Various Crops / Fall Armyworm	CURRENT	10-Jun-2020	30-Jun-2022	View
PER89390	AG	Success Neo / Maize cereals, Sorghum Grain and Millet / Fall Armyworm	CURRENT	24-Apr-2020	30-Apr-2023	View
PER89371	AG	Affirm insecticide / Various Cereals / Fall Armyworm	CURRENT	14-Aug-2020	31-Aug-2023	View
PER89279	AG	Various products / Various crops / Fall armyworm	CURRENT	11-Mar-2020	31-Mar-2023	View
PER88638	AG	Various Products / Maize and Sorghum / Fall Army Worm	SURRENDERED	18-Feb-2020	31-Mar-2025	View


Questions?
Comments?
(not FAW)