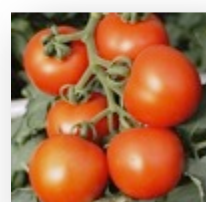
Insecticide Resistance Action Committee

Tuta absoluta: Insecticide Resistance Management Principles and Recommendations

IRAC Tuta IRM Task Team – 2017 (v6)





CropLife International
JTA 2017

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8. Understand Insecticide Resistance Management Principles

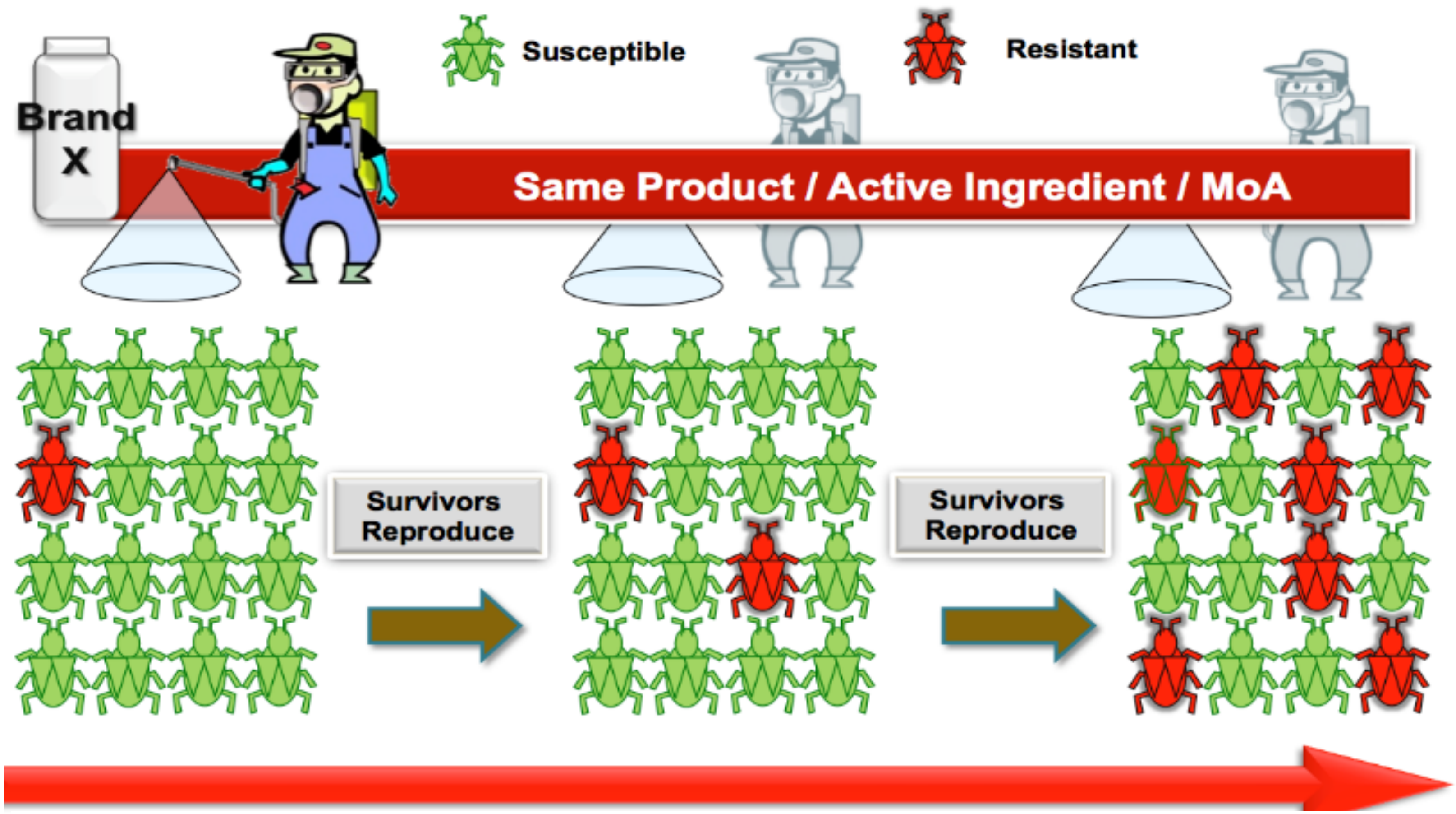
Continued Use of the Same MoA Products Throughout the Season Will Increase # of Resistant Individuals and Spray Expenses

- **Number & timing of applications influence speed of resistance**
- **When insecticides with the same mode of action (MoA) are used repeatedly, <u>exposing multiple consecutive pest generations</u>, less sensitive individuals survive and resistance can evolve.**
- **Continued use accelerates resistance and multiplies the resistant genes in the population**
- **Farmers will increase rates to improve control, accelerating resistance.**
- **Excessive tank mixing with adjuvants and other insecticides increases**
- **Pest control becomes expensive**

8. Understand Insecticide Resistance Management Principles

Continuous use of the same Mode of Action removes the susceptible individuals leaving a tolerant population that survives the insecticide application

Possible Scenario for Resistance Development in an Insect Population



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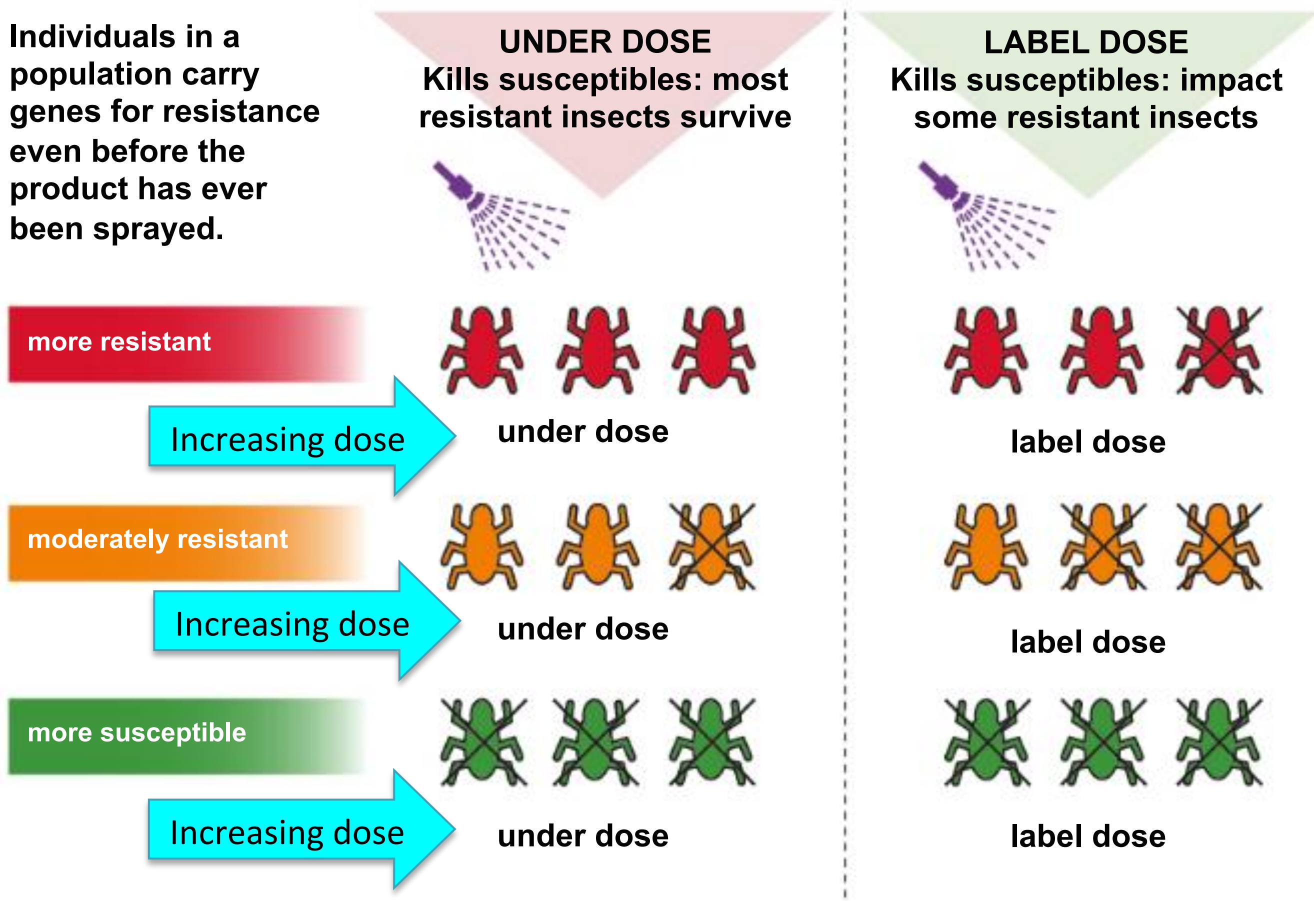
8. Understand Insecticide Resistance Management Principles

Under-dosing Speeds the Rate of Resistance:
Maximize Insect Kill With Every Spray

An under-dosed insecticide application may not remove moderately resistant insects from a pest population. This can accelerate the evolution of resistance



Always apply the recommended label rate that will remove susceptible, some moderately resistant, and even a portion of resistant insects.

8. Understand Insecticide Resistance Management Principles

Acquiring the highest level of pest control within a generation removes Resistant genes.

- Need to remove individuals with at least one resistant gene (RS)
- Need high level of control for an entire insect generation – prevent gene transfer
- Need back to back sprays of products with different or same mode of action if adult flights and egg laying continues

8. Understand Insecticide Resistance Management Principles

Insect Migration (exchange of <u>Resistant</u> insects) Influences the Speed of Resistance.

- ❑ Resistance levels in pest populations can be <u>INCREASED</u> through immigration of <u>resistant</u> insects. Therefore, the evolution of resistance in the pest population may accelerate.

Immigration of resistant insects into a population of sensitive pest insects

Result: The percentage of resistant insects in the population is increased. The inter-breeding between sensitive and resistant insects will likely increase the level of resistance in the next generation.

8. Understand Insecticide Resistance Management Principles

Reproductive Capacity Influences the Speed of Resistance

- Species with a higher reproductive capacity have a higher risk of developing resistance.
- *Tuta absoluta* can have up to with up to 10 - 14 generations per year.
- Temperature drives reproductive capacity. High temperatures increase the number of generations per year and can accelerate rate of resistance.

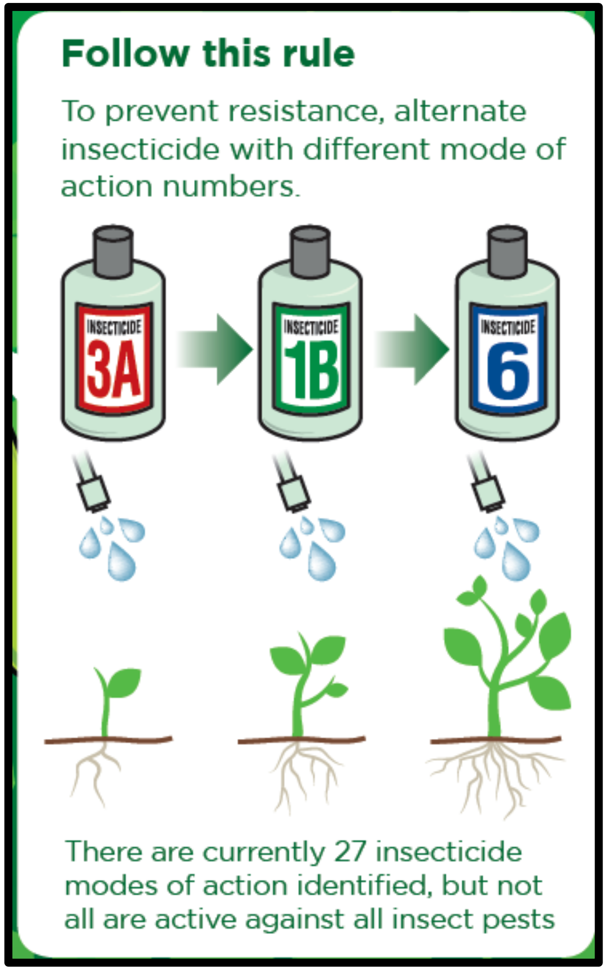
8. Understand Insecticide Resistance Management Principles

Implementing IPM Removes Resistant Individuals from the Population and Improves Level of Pest Control

- Diversify insect control methods: Integrate cultural (sanitation), physical (mass trapping, exclusion), biological (beneficials, pheromones), and chemical control methods
- Monitor pest populations to determine the correct timing of application at the action spray threshold
- Apply the right product at the recommended life stage
- Follow labeled application rates and intervals
- Calibrate sprayer and maintain nozzles and equipment
- Use optimal spray volumes and best management technique
- Select insect control products that are compatible with natural enemies. Allow the simultaneous use of both strategies to more completely reduce a pest population.
- Avoid using products that will reduce non-target organisms
- Adjust water pH and use adjuvants if necessary

Rotating insecticides with Different Modes of Action Reduces Selection Pressure for Resistance

- Repeated exposure of pest populations to insecticides with the same Mode of Action will select for resistant insects.
- Two successive insect generations shouldn't be treated with insecticides that have the same Mode of Action number (examples 3, 1, 6). Products in Mode of Action subgroups (example 3A) should not be rotated among products within the same MoA group (example 3).



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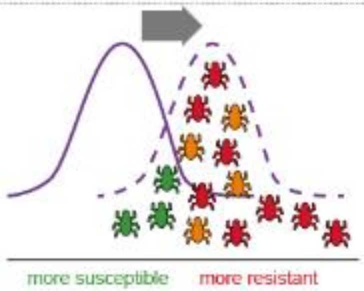
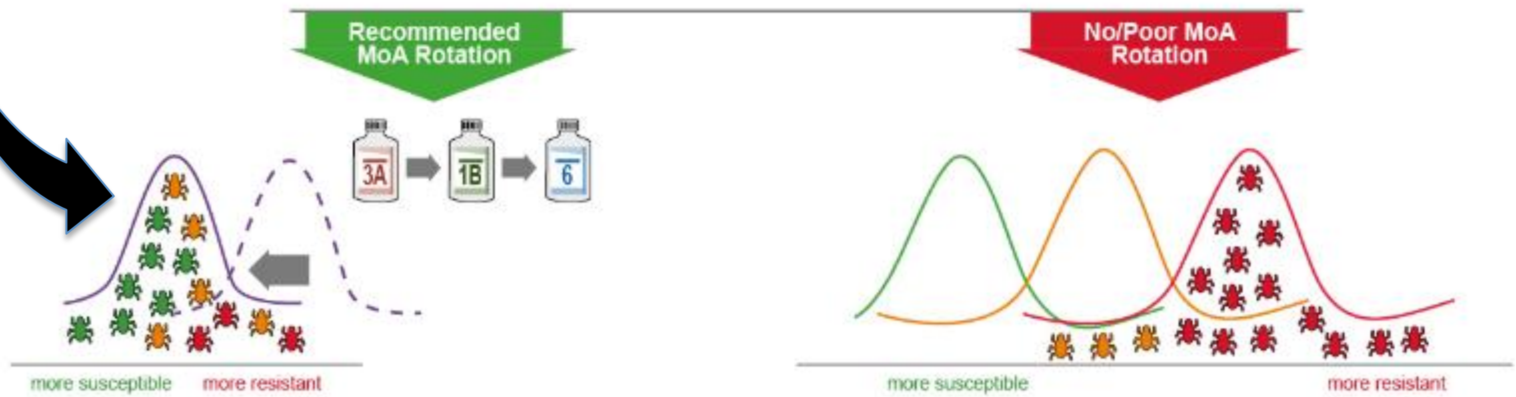
8. Understand Insecticide Resistance Management Principles

Rotating insecticides with Different Modes of Action Reduces Selection Pressure for Resistance



After an insecticide is sprayed, the surviving insects will reproduce and the offspring will be less sensitive.



Rotation of insecticides with different modes of action prevent the build up of resistant individuals in the field. This IRM strategy ensures that most resistant survivors from the MOA 1 spray(s) will be killed by the subsequent rotation of products containing different modes of actions.

Under permanent selection pressure, the overuse of the same insecticide mode of action can select for less and less susceptibility and a resistant population will evolve.

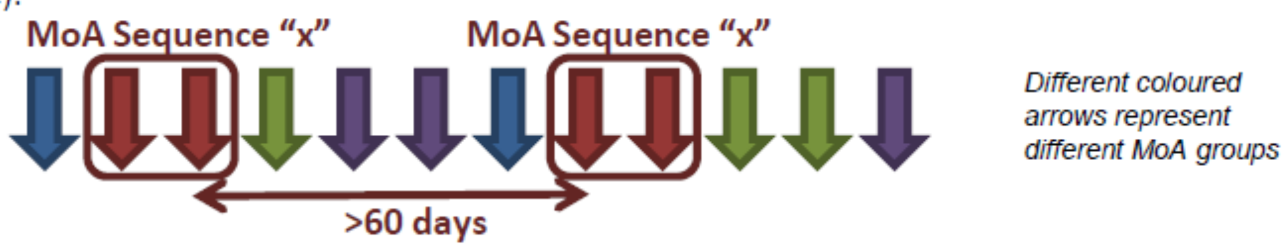
8. Understand Insecticide Resistance Management Principles

Exposing fewer pest generations in a season to insecticides with the same MoA reduces selection pressure for resistance

Rotate MoA Products Within Windows of Time

Mode of Action Gap Approach:

- The basic rule for adequate rotation of insecticides by mode of action (MoA) is to avoid treating consecutive generations of the target pest with insecticides of the same MoA group, by using a scheme of "MoA gap".
- A MoA gap is here defined as a period of 60 consecutive days, based on the maximum duration of a single generation of *T. absoluta*.
- A MoA sequence is here defined as one or more consecutive applications of insecticides belonging to a particular MoA group.
- After the last treatment of a MoA sequence, wait at least 60 days for new applications with insecticides of that MoA (follow label for maximum number of consecutive applications and per crop cycle).



- The proposed scheme seeks to minimize the selection of resistance to any given MoA group by allowing a gap between MoA sequences, ensuring that consecutive generations of *T. absoluta* are not exposed to the same insecticide MoA group.

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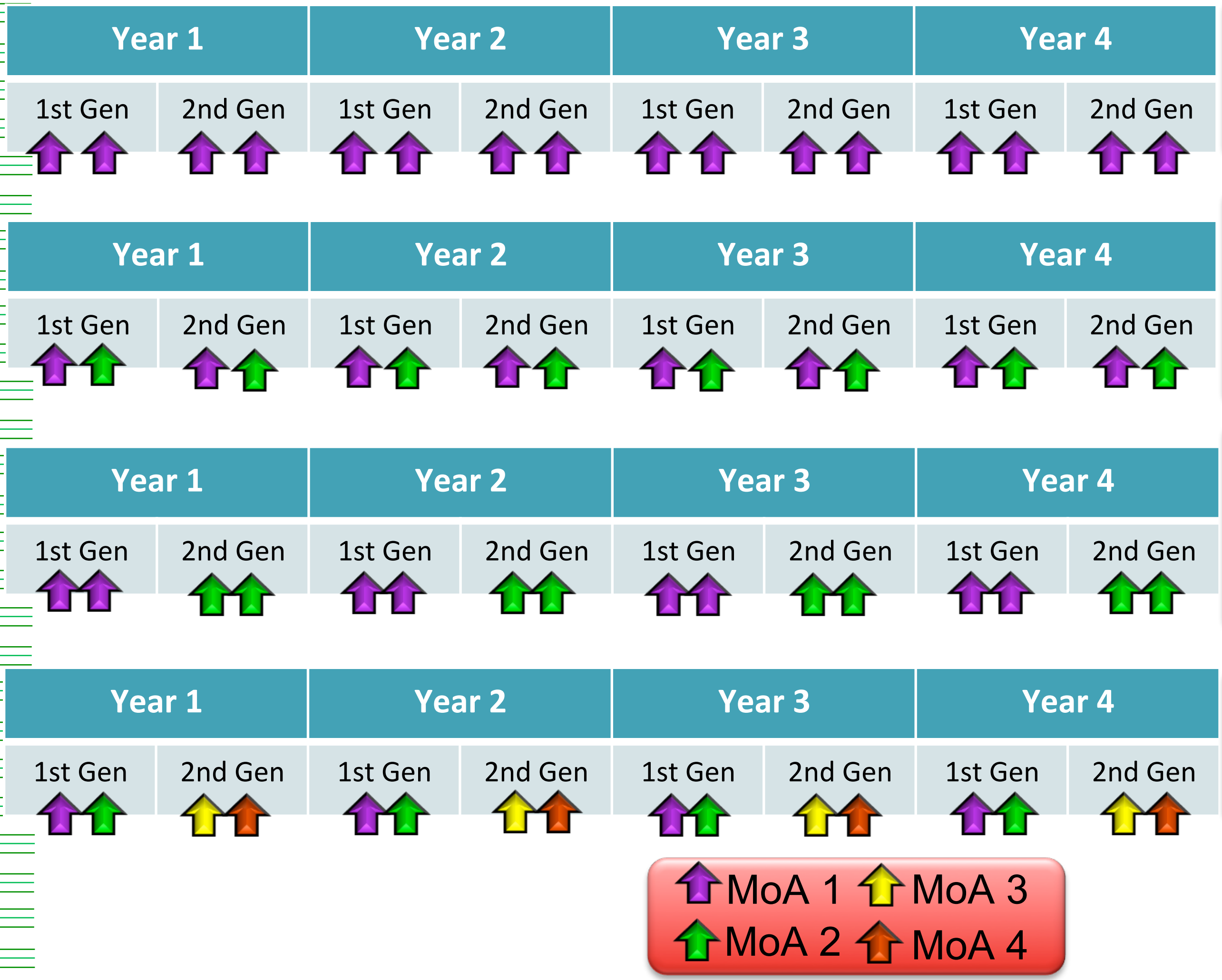
8. Understand Insecticide Resistance Management Principles

Rotate MoA Products Within Windows of Time

IRM guidelines below show least to best product rotaton recommendations

Maintaining insect susceptibility greatly depends on rotation of insecticides with effective products with a different MOA that eliminate resistant individuals. Rotation with products that provide poor control of the target pest increases the risk of developing Diamide resistance.



No alternation/rotation
High selection pressure
No recover of sensitive population

Rotation within generation
Consecutive generation exposed to same MoA. Selection pressure doesn't change between generation. Risk of resistance development for both ai's

Rotation among generations
Following generations are not exposed to same MoA. Selection pressure doesn't increase within the generation. Recovery of susceptible population.

Rotation within and between
Ideal situation (very low risk) Not alway applicable with good efficacy

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8. Understand Insecticide Resistance Management Principles

Practicing Resistance Management is a Benefit to the Grower

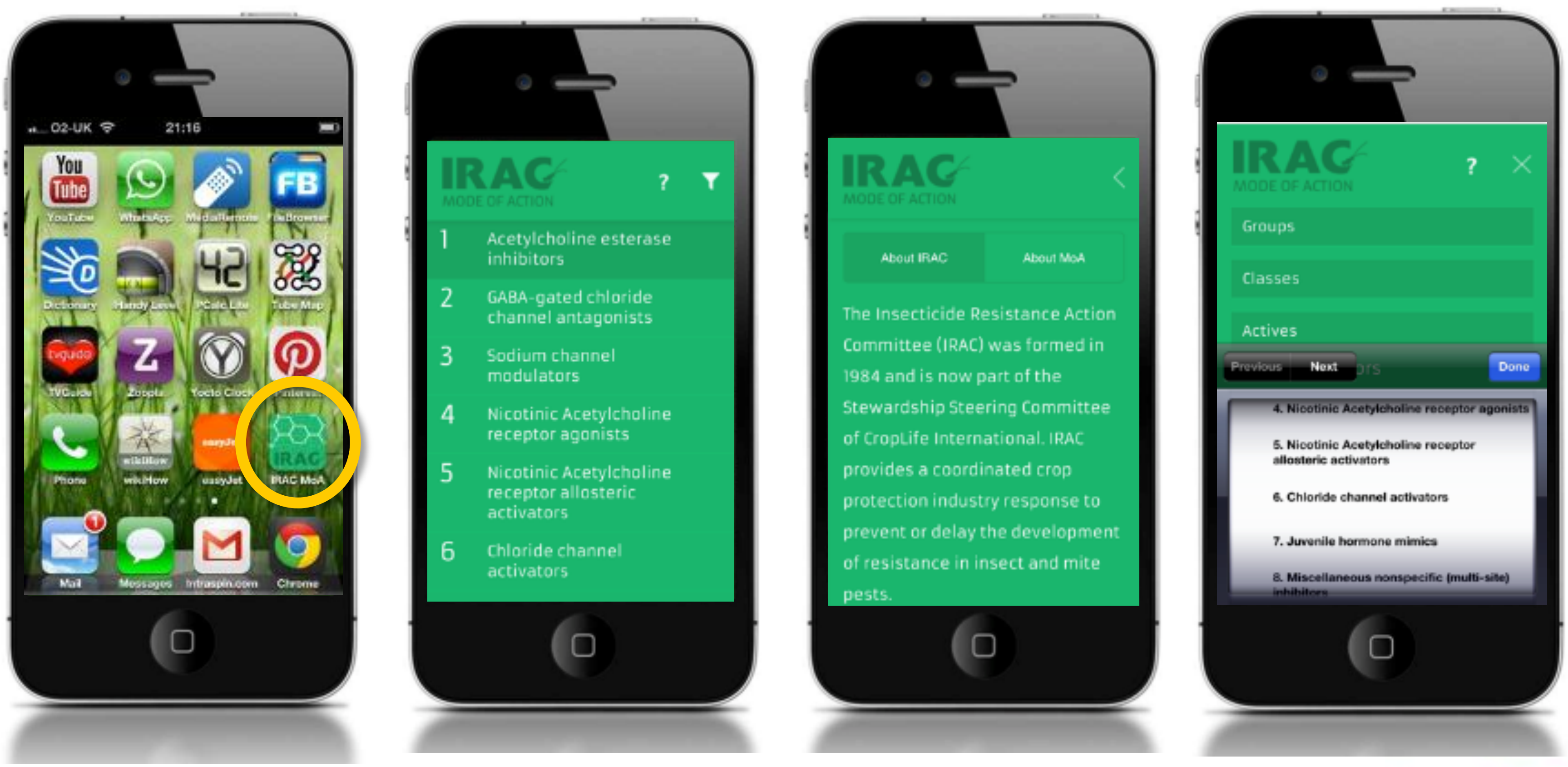
- **Save money**
  - No need to increase number of insecticide applications
  - Reduces need for more expensive products or control methods
  - Helps achieve better pest control and improved yield
- **Save time**
  - Spend less time in the field making repeat applications
  - Less effort and worry trying to achieve effective pest control
- **Enhance safety of produce**
  - Better assurance of consistent crop protection
  - Minimizes residue risk on produce
- **Protect your health and your land**
  - Less active ingredient applied to ecosystem
  - Better worker safety due to fewer applications and less exposure

Source: IRAC

A Tool to Help You Identify Insecticide Chemistries and MoA Group Number

Mode of Action Classification: Phone/Tablet App (Its Free!!)

Search for: IRAC moa



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9. Understand Insecticide Resistance Management STRATEGIES

Manage Insecticide Resistance: Follow These Recommendations

- The following IRM recommendations have been developed by the International IRAC organization, Country IRAC Groups, Country Resistance Action Goups, with leading local experts.
- This information is intended to provide the basis for developing an effective pest management program that minimizes the risk of insecticide resistance.
- These are general guidelines and will not fit all crop production systems. Adapt these recommendations and strategies to your local needs.

Source: IRAC

IRM Recommendations for Tuta absoluta on Tomato - 1

- **Practice Integrated Pest Management**
  - Remove and destroy infested cull tomatoes and plant material
  - Remove all wild Solanaceous and other host plants near greenhouse
  - Rennovate greenhouse to exclude Tuta adults
  - Use phermones and sticky traps to monitor and mass trap adults
  - Augment and conserve natural enemy populations
  - Apply entomopathic nematodes (*Steinernema feltiae*) in a foliar spray
  - Use optimal spray volume, maintain and calibrate spray equipment
  - Treat large areas to same MoA
  - CALIBRATE/ MAINTAIN sprayers. Clean/replace nozzles.

- **Apply insecticides at economic pest thresholds**
  - Follow locally established economic pest thresholds for the application of foliar insecticides in order to optimize insecticide use.
  - Always use labeled rates and water volumes.

- **Use windows of insecticide application**
  - Use windows of application to minimize exposure of sequential generations of a insect pest species to the same insecticide modes of action.
  - Each window should be approximately 30 days.

- **Rotate insecticides with different modes of action.**
  - If more than one insecticide application is required during an application window then it is recommended to use an insecticide with a different mode of action.
  - Multiple applications of insecticides with the same mode of action within a single window are acceptable as long as combined effects (residual activity) of the applications do not exceed approximately the 30-day window.

- **Maximum Number of MoA Applications**
  - Adviseable to use the same MOA products in only 2 windows per season
  - Aoid using the same Mode of Action products in more than 3 windows.

- **Insecticide mixtures - Tank mixing products:**
- Do not tank-mix insecticide products with the SAME MoA.
- When tank-mixing insecticide products with DIFFERENT MoA's, follow label rates for each insecticide.
- Respect maximum number of applications, PHI and REI stated in the label of each product.
- Product(s) applied on subsequent window/pest generation should have an MoA that is different from both tank-mix partners.

- **Avoid insecticides with Tuta resistance**
  Consult with local experts to determine which insecticides are affected by resistance in your locality. A preference to insecticides which are not affected by resistance should be given.

- **Preserve non-target & beneficial organisms**
  The use of selective insecticides with reduced impact on non-target and beneficial organisms is recommended whenever possible.

- **Manage the removal of in-season infested stems and fruit**
  In addition to practicing clean sanitation pre and post season it is critical to remove and destroy plant stems pruned during the season and all cull/waste tomato after each harvest.

- **Rotate crops and Incorporate a Host Free Period**
  - Subsequent crop plantings should be of a different crop type, which is not a host to the insects which are pests of Tuta.
  - Institute an area-wide fallow period where only non-host crops to Tuta can be planted disrupting the life cycle of Tuta.

IRM Recommendations for Tuta absoluta on Tomato - 2

MULTIPLE MoA PRODUCTS AVAILABLE
Different MoA products can be used in the **same** window but they must be rotated to different MoA products in the next window.

Gen 1	Gen 2	Gen 3
MoA **A & B**	MoA **C & D**	MoA **A & D**

FEW MoA PRODUCTS AVAILABLE
Apply products with the same MoA in the **same** window.

Gen 1	Gen 2	Gen 3
MoA **A & A**	MoA **B & B**	MoA **C & C**

- **Rotating products with different Modes of Action delays resistance.**
  Don't apply the same Mode of Action continuously:
  - Rotate insecticides with different modes of action using the window approach to minimize exposure of sequential generations of a pest species to the same insecticide MoA.
  - Each "treatment window" should be approximately 30 days.
  - Multiple applications can be made in a window:
    - If more than one insecticide application is required then attempt to use an insecticide with a different mode of action.
    - Multiple applications of insecticides with the same mode of action within a single window are acceptable if their combined residual activity does not exceed approximately the 30-day window.
  - After a "treatment window" of approximately 30 days rotate to a window with different MoA products for approx 30 days.. Allow at 30-60 days before applying the same mode of action again.
- For crops longer than approximately 100 days, use the same MoA products in only 2 windows per season
- For crops less than approximately 100 days then use same MoA products in only one window within the crop cycle.
  A short cycle crop (< 50 days) is a "treatment window". Rotate products with different MoA in the next planting.
- Don't treat the crop for more than approximately 50% of the cropping season or 50% of the total number of applications with same MoA

IRM Recommendations for Tuta absoluta on Tomato - 3

- Select insecticides based on known local effectiveness and selectivity to beneficials.
  - Know the attributes of your pest control products (adulticide, ovicide, larvicide, safety to beneficials, residual, spectrum)
  - Use larvicides to treat young larvae
  - Do not underdose. Follow label rates and intervals
  - Use surfactants (wetting agents) to assure better coverage or methylated seed oil to acquire leaf cuticle penetration. Surfactants may be important to improve the activity of some insecticides.
  - In high populations combine larvicide with adulticide or ovicidal product

- Use sufficient spray volume.
  - Maximize coverage to maximize pest kill

    .

- Whenever possible, use products and mixes that are selective and conserve natural enemies and pollinators
  - Conserve natural enemies early season so they can assist in pest control season-long.
  - Use B.t's and non-chemical products against low Tuta populations.

- Stop using products that are not providing good efficacy. Try that product again next season.
- Ideal to treat large areas with the same mode of action product and follow the same window rotation strategy
- Tank mix insecticides to control different life stages and manage pest populations.
- Rotate solanaceous crops with crops that are not a host to Tuta.

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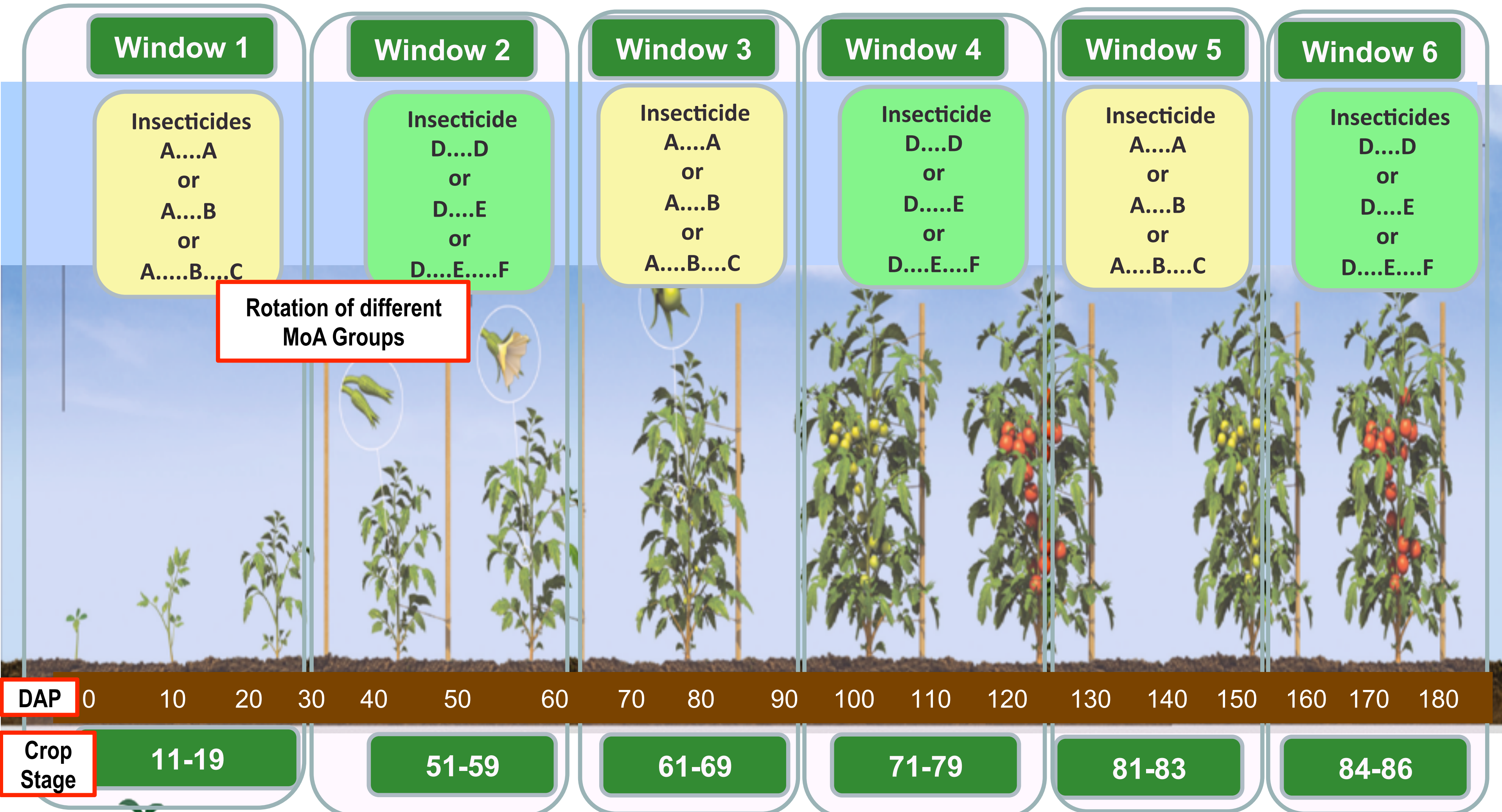
9. Implement Insecticide Resistance Management Strategies

Example: Application Windows for Tuta absoluta on Tomato

Do not to use the same insecticide MoA used in a previous window



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9. Implement Insecticide Resistance Management Strategies

Tuta Population Control and IPM Activities

Pre-Season

- Remove cull piles
- Kill weed hosts
- Renovate GH
- Moth-proof GH (fix screens)
- Monitor adults-Ph Traps
- Choose tolerant varieties
- Use pest free transplants

During-Season

- Manage the removal of in-season infested pruned stems and fruit
- Use phermones and sticky traps to monitor and mass trap adults.
- Use phermone dispensers for Mating Disruption
- Sprat entomopathic nematoeds and nonchemical products that will not select for insecticide resistance.
- Augment and conserve natural enemy populations
- Use optimal spray volume, maintain and calibrate spray equipment

Post-Season

- Remove cull piles
- Kill weed hosts
- Renovate GH
- Moth-proof GH
- Solarize soil
- Rotate to non-host crop & Incorporate a host free period:
  - subsequent crop plantings should be of a different crop type, which is not a host to the insects which are pests of Tuta.
  - Institute an area-wide fallow period where only non-host crops to Tuta can be planted disrupting the life cycle of Tuta

9. IRAC Poster: Implement Insecticide Resistance Management Strategies

Insecticide Resistance Management

Resistance status in L. America vs. Europe, N. Africa, and Middle East: In L. America, high level and widespread resistance is known to exist in field populations of *T. absoluta* mainly to organophosphates (MoA group 1B), synthetic pyrethroids (MoA group 3), and benzoylureas (MoA group 15). However, resistance has also developed to newer classes of insecticides. Because it is likely that resistant populations from L. America may have spread to Europe, N. Africa and the Middle East, it is urgent that regional technical experts understand the susceptibility profile of *T. absoluta* field populations to the available insecticides so that local recommendations can be made.

Evaluation of Insecticide Susceptibility: IRAC has a standard "leaf-dip" larval bioassay method to assess susceptibility of field populations to insecticides. See IRAC Method No. 022 on the IRAC Website.

Insecticide Resistance Management (IRM):
The recommendations for sustaining the effectiveness of available insecticides is centred on integration of as many pest management tools as possible, use of insecticides only when needed and based on established thresholds, and rotation of effective insecticides with different modes of action.

Mode of Action Window Approach:

- The basic rule for adequate rotation of insecticides by mode of action (MoA) is to avoid treating consecutive generations of the target pest with insecticides in the same MoA group, by using a scheme of " MoA treatment windows".
- A treatment window is here defined as a period of 30 consecutive days, based on the minimum duration of single generation of *T. absoluta*.
- Multiple applications of the same MoA or different MoA's may be possible within a particular window (follow label for maximum number of applications within a window and per crop cycle).
- After a first MoA window of 30 days is completed and if additional insecticide applications are needed based on established thresholds, different and effective MoA's should be selected for use in the next 30 days (second MoA window). Similarly, a third MoA window should use different MoA's for the subsequent 30 days etc.
- The proposed scheme seeks to minimize the selection of resistance to any given MoA group by ensuring that the same insecticide MoA group will not be re-applied for at least 60 days after a window closes, a wise measure given the potential of a longer life cycle based on temperature fluctuations throughout the growing season.
- This scheme requires a minimum of three effective insecticide MoA groups but ideally more MoA groups should be included, if locally registered/effective against *T. absoluta*.

Example: Insecticide Mode of Action (MoA) "Window" Approach – 150 day cropping cycle

0-30 days	30-60 days	60-90 days	90-120 days	120-150 days
MoA x	Do not apply MoA x		MoA x	Do not apply MoA x
Do not apply MoA y	MoA y	Do not apply MoA y		MoA y
Do not apply MoA z		MoA z	Do not apply MoA z	

Sequence of Mode of Action (MoA) Windows throughout the season

Notes:

- Within a "window" (MoA x, y or z in the diagram above) more than one application of the same MoA or different MoA's can be applied if necessary and depending on label advice, as long as these MoA's are not re-applied for 60 days as indicated above.
- Following the "window rotation scheme", example above, use as many effective MoA groups as locally registered/available and always follow product labels for specific directions of use.
- For a comprehensive list of existing insecticides classified by MoA group visit the IRAC website (www.irac-online.org/teams/mode-of-action).

Key Management Strategy Integration of Control Measures

The basis for effective and sustainable management of *Tuta absoluta* is the integration of cultural, behavioural, biological and chemical control.

Key Management Tactics

- Use pest-free transplants
- Prior to transplanting, install yellow sticky traps
- Monitor pest using delta pheromone indicator traps
- Between planting cycles, cultivate the soil and cover with plastic mulch or perform solarisation
- Allow a minimum of 6 weeks from crop destruction to next crop planting
- Seal greenhouse structure with high quality nets suitable for *T. absoluta*
- Inspect the crop regularly to detect the first signs of damage
- For massive trapping, use water + oil traps (20-40 traps/ ha)
- Constantly, remove and destroy attacked plant parts
- Control weeds to prevent multiplication in alternative host
- Establish populations of effective biological control agents (*e.g. Nesidiocoris tenuis*)
- Use locally established thresholds to trigger insecticide applications
- Select insecticides based on known local effectiveness and selectivity
- Rotate insecticides by MoA group using a gap/sequence approach
- Use only insecticides registered for control of *T. absoluta*
- Always follow the directions for use on the label of each product

IRAC general IRM strategy recommendations available as handout and poster

11. Examples of country IRM programs with Mode of Action rotation: Spain, Italy, Greece, Portugal

Source: IRAC

11. Examples of country MoA alternation programs:

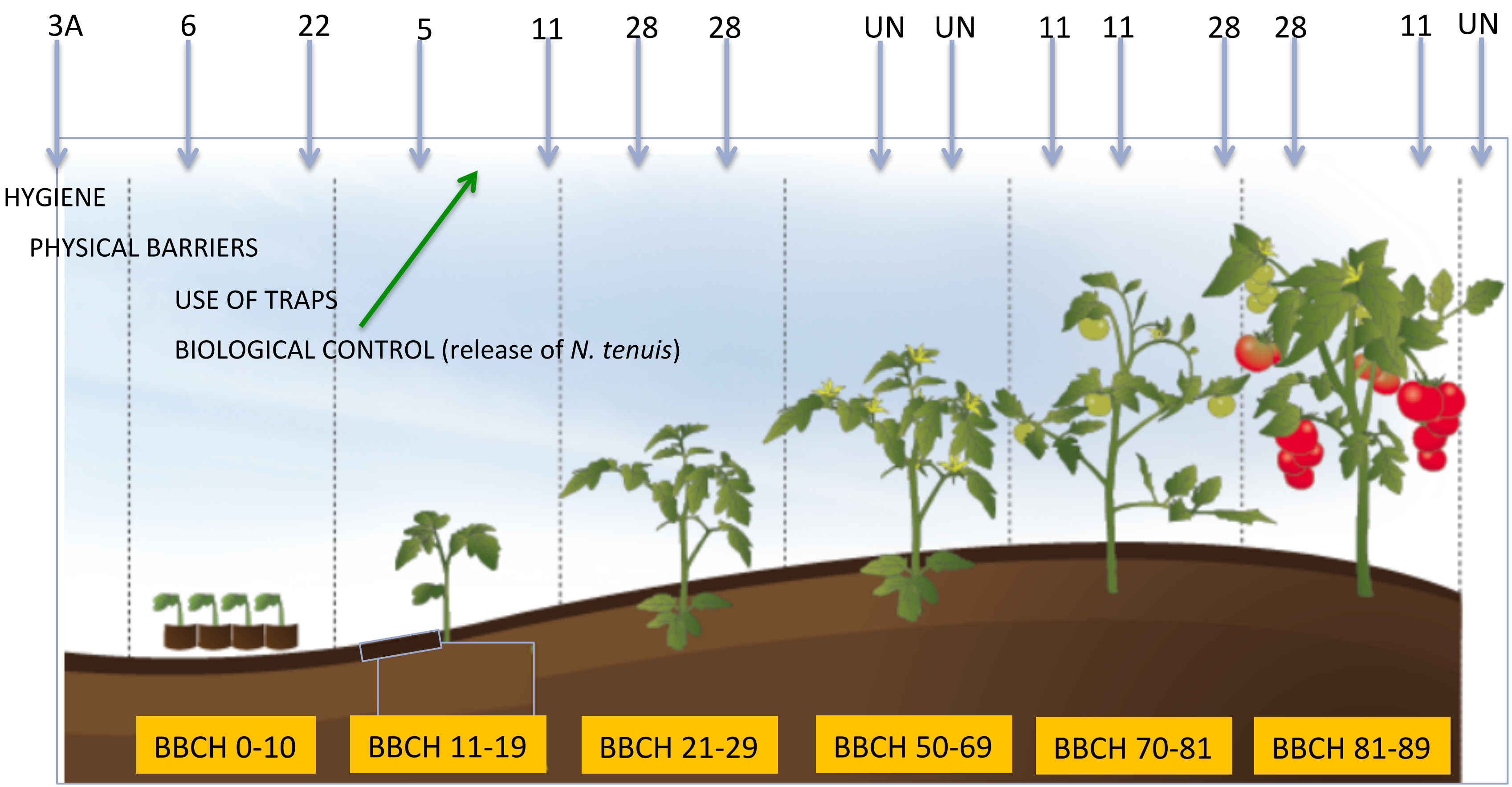
Spain

Pest control practices (general example):

Example: planting Sep and crop removal July.

12-16 applications (as average in a long crop cycle)

Product rotation in this case (by MoA):



11. Examples of country MoA alternation programs:

Spain

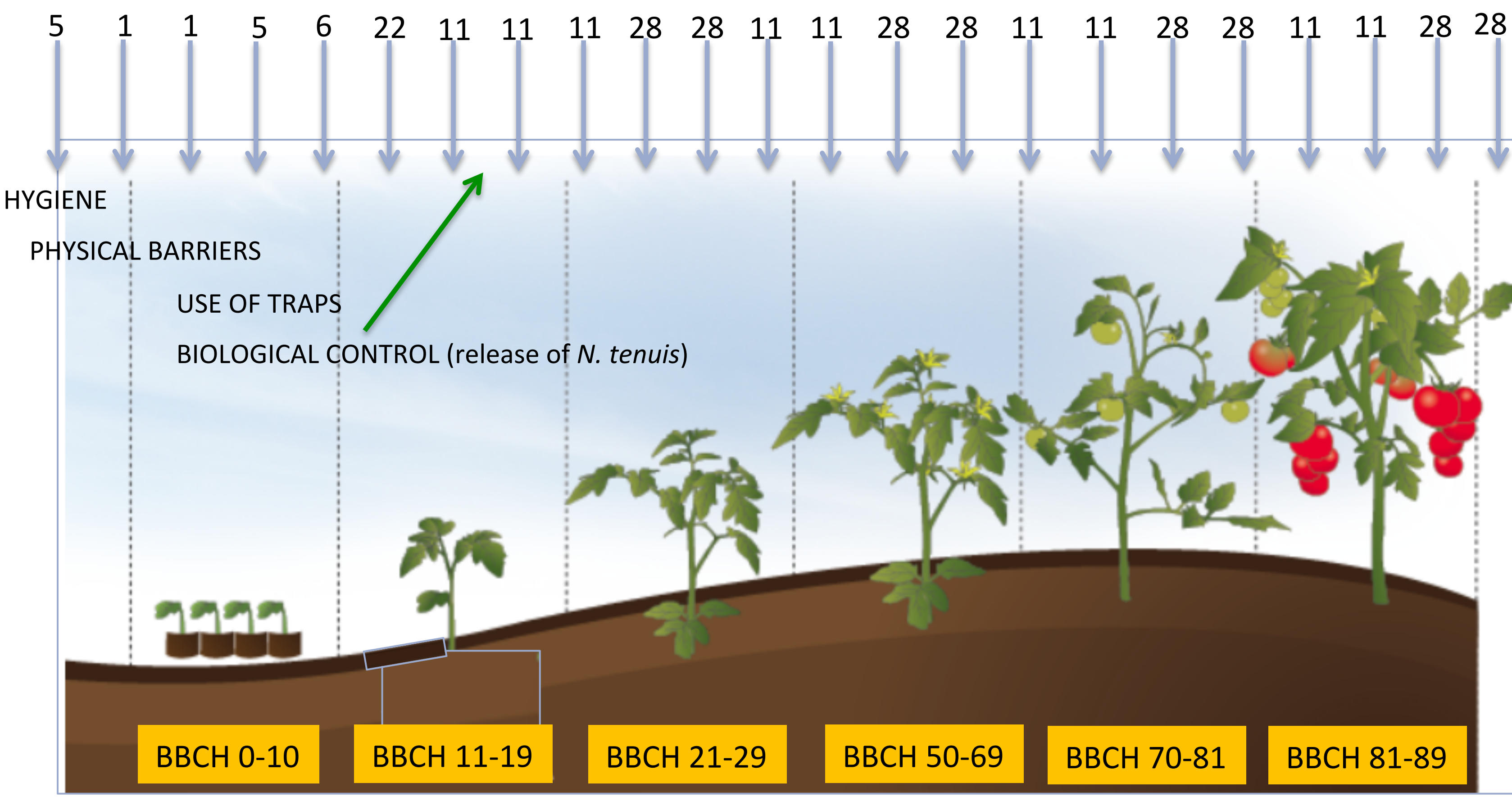
Pest control practices (worse case scenario example):

Example from Murcia: planting 3rd Sep 14 and crop removal 10th July 15

23 applications: 9 BT; 8 Diamides, 2 Spinosad, 1 Emamectine, 1 Indoxacarb and 2 Methomyl.

Up to 11 generations/crop cycle => shorter intervals with warm Tª and longer day light.

Product rotation in this case (by MoA):



11. Examples of country MoA alternation programs:

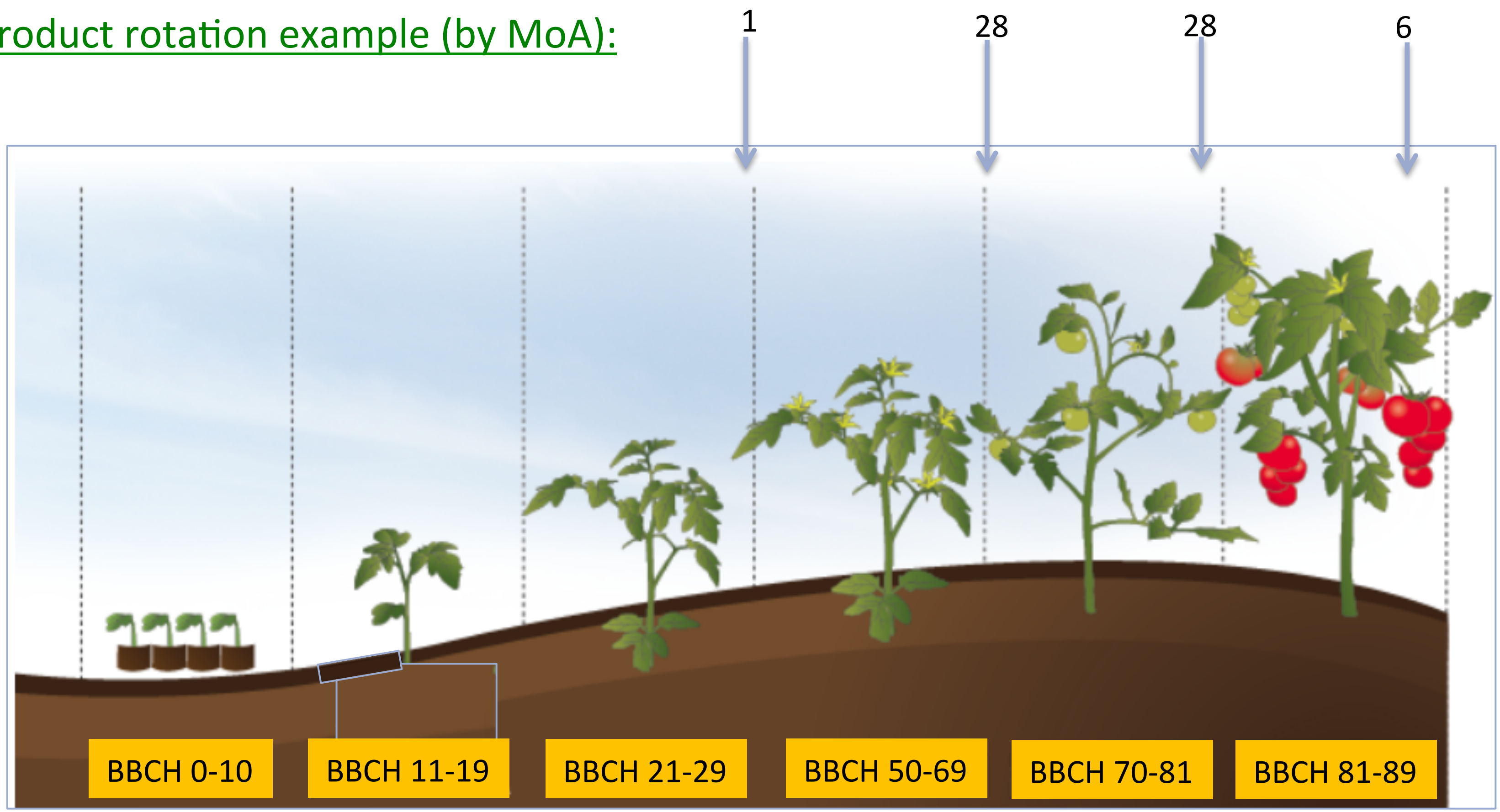
Portugal – Open Field

Pest control practices (general example):

Example from Portugal industry –open field-: planting Mar-Jun and crop removal Aug-Oct

3-5 applications: Diamides, Emamectine, Pirethrins (farmers try to rotate)

Product rotation example (by MoA):



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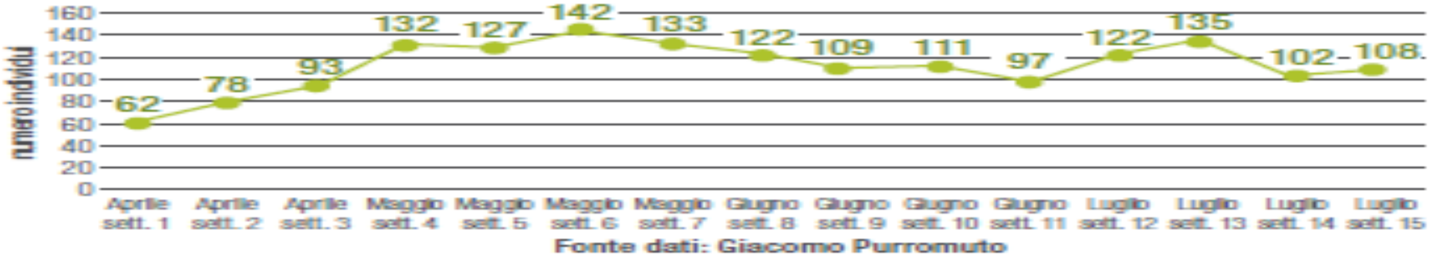
11. Examples of country MoA alternation programs:

Italy (Syngenta)

SPRING-SUMMER CYCLE: example of sustainable program

Flight example






0-30 giorni	30-60 giorni	60-90 giorni	90-120 giorni
2 applications with emamectine	2 applications with clorantraniliprole	Apply products with different MoA (eg. Indoxacarb, metaflumizone)	1 application with emamectine
In case of persistant infestation, make also 1 application with *Spinosad*			In case of persistant infestation, make also 1 application with *Spinosad*

Spray proposal

- ➢ In case of high Tuta pressure, and with applications made with short spray interval (7-10 days), integrate the spray calendar with other MoA (eg. Metaflumizone, Spinosad, *B. thuringensis*), FOLLOWING the IRAC recommendations
- ➢ In case of control of other Lepidopteran species, consider insecticides with different Moz (e.g. Lufenuron – IGR)

DO NOT APPLY INSECTICIDES WITH SAME MoA WITHIN 60 DAY FROM THE LAST APPLICATION

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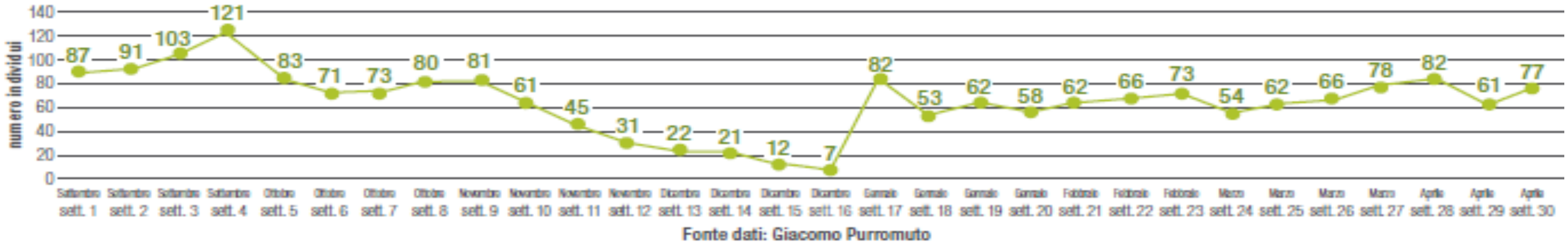
11. Examples of country MoA alternation programs:

Italy (Syngenta)

Flight example

SPRING-SUMMER CYCLE: example of sustainable program



0-30 giorni	30-60 giorni	60-90 giorni	90-120 giorni	120-150	150-180
2 applications of clorantraniliprole	2 applications of Indoxacarb	2 applications of emamectine	2 applications of *B. thuringensis*	2 applications of Indoxacarb	1 application of emamectine
			In case of more consistent infestation, make 1-2applications of *metaflumizone*		In case of persistant infestation, make also 1 application with *Spinosad*

- ➢ In case of high Tuta pressure, and with applications made with short spray interval (7-10 days), integrate the spray calendar with *B. thuringensis*)

- ➢ In case of control of other Lepidopteran species, consider insecticides with different Moz (e.g. Lufenuron – IGR)

DO NOT APPLY INSECTICIDES WITH SAME MoA WITHIN 60 DAY FROM THE LAST APPLICATION

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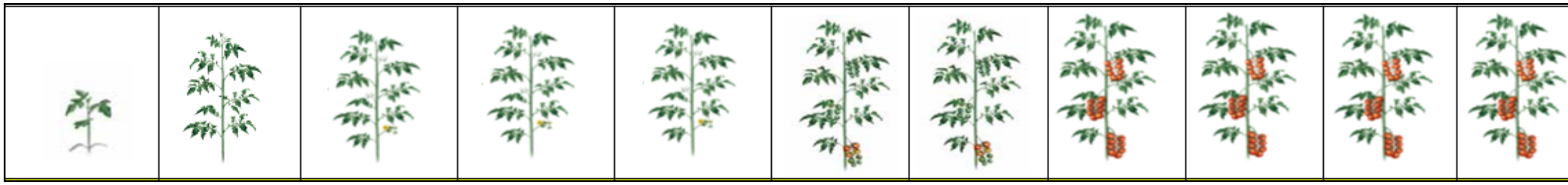
11. Examples of country MoA alternation programs:

Italy DuPont™ Greenhouse fall cycle

Descrizione stadio	Post-trapianto (prime foglie sviluppate)	Fase di preparazione palchi fiorali	Fase di fioritura	Continua fioritura e comparsa prime bacche	Colorazione bacche e inizio primi stacchi	Termine fioritura e proseguimento raccolta	Raccolta
Periodo indicativo per trapianti campagna autunnale	1 - 20 sett.	20 sett. - 10 ott.	10 - 31 ott.	1 - 30 nov.	1 dic. - 28 febb.	1 - 31 marzo	1 - 30 aprile
Caratteristiche periodo	Pianta in attiva crescita, elevata pressione *Tuta*	Pianta in attiva crescita, elevata pressione *Tuta*	Immissione bombi nelle serre	Presenza bombi nelle serre e calo pressione *Tuta*	Calo temperatura e quiescenza *Tuta*	Ripresa pressione *Tuta*	Ripresa pressione Tuta
							
Stadio BBCH	11 - 19	51 - 59	61 - 69	71 - 79	81 - 83	84 - 86	87 - 89
Prodotti e dosi per ettolitro	2 trattamenti con Steward® 12.5 g + bagnante (intervallo 10-12 gg fra primo e secondo tratt.)	2 trattamenti con Spinosad 25 ml (intervallo 10 gg fra primo e secondo tratt.)	2 trattamenti con Altacor® 12 g + Codacide® (intervallo 7-10 gg fra primo e secondo tratt.)	2 trattamenti con ememectinabenzo-ato® 150 g (intervallo 7-10 gg fra primo e secondo tratt.)	Trattamenti con *Bacillus thuringensis* (intervallo 8-10 gg fra i tratt.)	2 trattamenti con Steward® 12.5 g + bagnante (intervallo 10-12 gg fra primo e secondo tratt.)	Trattamenti con *Bacillus thuringensis* (intervallo 8-10 gg fra i tratt.) o con Spinosad in caso di infestazioni perduranti
	x2	x2	x2	x2	x2/3	x2	x2/3
	Group 22A Oxadiazine	Group 5 Spynosins	Group 28 Diamides	Group 6 Avermectines	Group 11 Bacillus	Group 22A Oxadiazine	Group 11 Bacillus

11. Examples of country MoA alternation programs:

Italy DuPont Greenhouse spring/summer cycle



Product	Steward + Codacide	Steward + Codacide	Spinosad + bagnante	Spinosad + bagnante	Altacor + Codacide	Altacor + Codacide	Emamectina Benzoato 0,95% + Bagnante	Emamectina Benzoato 0,95% + Bagnante	Steward + Codacide	Steward + Codacide
Rate 1000 m^2	12,5g + 150 ml	12,5g + 150 ml	30 ml + 0,02 V/V	30 ml + 0,02 V/V	12 g + 150 ml	12 g + 150 ml	150 ml + 0,02 V/V	150 ml + 0,02 V/V	12,5g + 150 ml	12,5g + 150 ml
IRAC	Group 22	Group 22	Group 5	Group 5	Group 28	Group 28	Group 6	Group 6	Group 22	Group 22

Rules for the proper use of insecticides and the best of resistance management strategy:

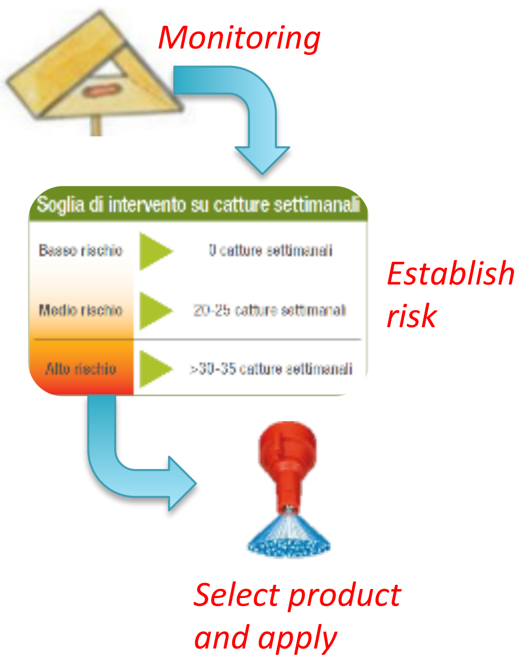
1. Respect label rates and do not use the products in drip irrigation if not provided on the label.
2. Respect intervals between treatments provided and max. number of applications per year.
3. Use only products and active ingredients registered on the crop.
4. Make the required rotations of active ingredients suggested by the label and IRAC.
5. During the crop cycle use the greatest number of active ingredients effective against *Tuta*
6. Do not use insecticides in mixtures.
7. Do not use active ingredients with low activity in the control of Tuta absoluta.

11. Examples of country MoA alternation programs:

ITALY

Tuta absoluta: pest control practice

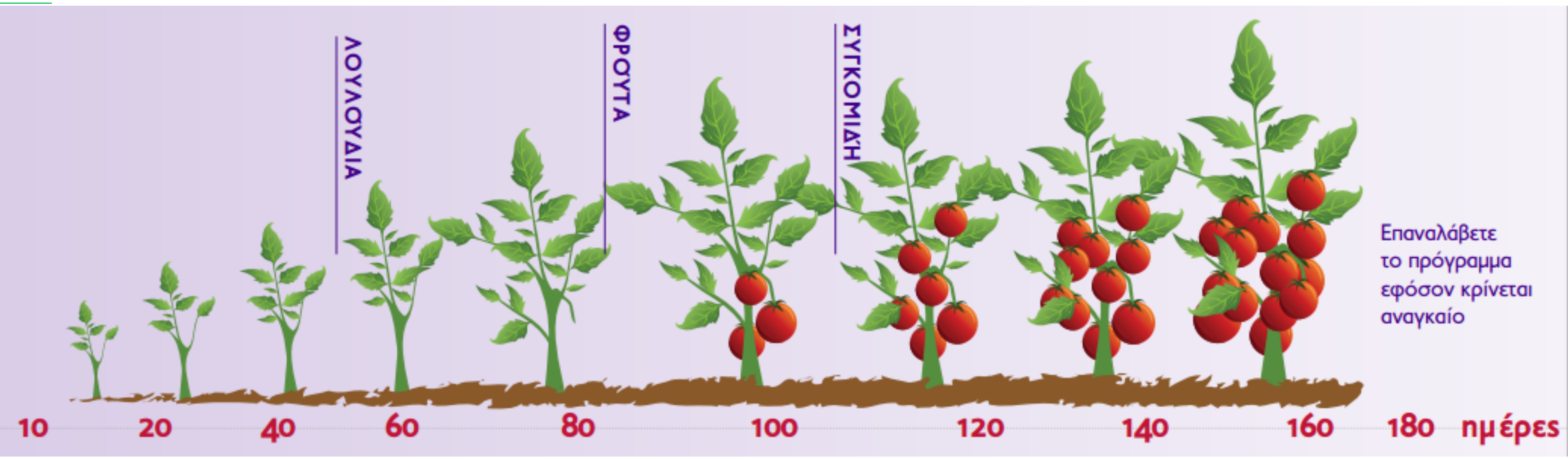
1. Buy **plants** from nursery **free of infestations**
2. Clean the field from **crop residues**, use **mulching, solarizati** and **nets** for insect exclusion
3. **Monitoring**: use pheromone traps for monitoring the flight curve and then decide the control strategy to adopt
4. **Remove the infested parts** from the GH and destroy them
5. **Select the product** to be applied according to the **label reccomendation** (dose, spray interval, number of applications)
6. **Rotate the insecticides** available, following the IRAC reccomendations
7. Relese favorite **beneficials**



11. Examples of country MoA alternation programs:

DuPontGreece Greenhouse

Tuta absoluta: Διαθέσιμα εργαλεία και διαχείριση ανθεκτικότητας



Steward X2	Coragen X2	Affirm X2	Laser X2	Alverde X2	Belt X2	Affirm X2	Laser X2
	B.t.			B.t.			B.t.
Group 22	Group 28	Group 6	Group 5	Group 22	Group 28	Group 6	Group 5

IRAC

11. Examples of country MoA alternation programs:

Greece Greenhouse – Roditakis et al

Πίνακας 1.

Σκευάσματα εγκεκριμένα από το Υ.Π.Α.Π.ΕΝ. για την αντιμετώπιση του εντόμου Tuta absoluta στην τομάτα

Ομάδα δράσης (1)	Εγκεκριμένα σκευάσματα	Δραστική ουσία	Τομάτα Υ: υπαίθρου Θ: Θερμ/πίου	Ημέρες προ της συγκομιδής	Μέγιστος αριθμός εφαρμογών /καλ. περίοδο	Τοξικότητα στο αρπακτικό Miridae(2)	Διάρκεια επίδρασης στο αρπακτικό
1A	LANNATE 20 SL, LANNATE 25WP	methomyl	Υ	7	2	Τοξικό	8–12 εβδομάδες
5	LASER 480 SC	spinosad	Υ/Θ	3	2	Ελαφριώς έως μετρίως τοξικό	2 εβδομάδες
6	AFFIRM 095 SG	emamectin benzoate	Υ/Θ	3	3	Ασφαλές	–
	CAL EX	abamectin	Υ/Θ	3	3	Τοξικό	≥3 εβδομάδες
11A	BELTHIRUL 32000 WP	*Bacillus thuringiensis* ssp. *kurstaki*	Υ/Θ	0	3	Ασφαλές	–
	BACTOIL SC		Υ/Θ	0	3	Ασφαλές	–
	BACTOSPEINE 6,4 WG		Υ/Θ	0	8	Ασφαλές	–
22A	BOLERO 30 WG	indoxacarb	Υ/Θ	1	3	Ελαφριώς έως μετρίως τοξικό	2–3 εβδομάδες
	STEWARD 30 WG		Υ/Θ	1	3	Ελαφριώς έως μετρίως τοξικό	2–3 εβδομάδες
22B	ALVERDE 24 SC	metaflumizone	Θ	1	2	Τοξικό	>3 εβδομάδες
28	ALTACOR 35 WG	chlorantraniliprole	Υ/Θ	1	2	Ασφαλές	–
	BELT 24 WG	flubendiamide	Θ	3	2	Ασφαλές	–
28/6	VOLIAM TARGO 063 SC	chlorantraniliprole + abamectin	Θ	7	2	Τοξικό	≥3 εβδομάδες
28/3A	AMPLIGO 150 ZC	chlorantraniliprole + λ-cyhalothrin	Υ	3	2	Τοξικό	8–12 εβδομάδες

(1): Κωδικοποίηση τρόπου δράσης κατά I.R.A.C. (International Resistance Action Committee, www.irac-online.org).
Η αναγράφηση αποσκοπεί στην οπτική ομαδοποίηση των εντομοκτόνων κατά τρόπο δράσης.
(2): Τα στοιχεία αφορούν στα είδη *Macrolophus pygmaeus* και *Nesidiocoris tenuis*.
Πηγές: α) http://side-effects.koppert.nl
β) http://ipmguidelinesforgrains.com.au/ipm-information/chemical-control/pesticide-impact
γ) http://www.ipm.ucdavis.edu/PMG/r783900111.html
δ) http://www.biobestgroup.com/en/side-effect-manual
ε) Arno, J. and R. Gabarra. 2011. J. Pest Sci. 84: 513–520
στ) Lopez, J. A. et al. 2011. Sp. J. Agric. Res. 9(2): 617–622
ζ) Martinou, F.A. et al. 2014. Chemosphere 96: 167–173

ΠΡΟΣΟΧΗ

Η αλόγιστη εφαρμογή χημικών σκευασμάτων

- **Α** έχει αρνητική επίδραση στους βομβίνους (κοινώς: σβούροι, μέλισσες) που χρησιμοποιούνται για την επικονίαση των φυτών στη θερμοκηπιακή καλλιέργεια τομάτας
- **Β** επιταχύνει την ανάπτυξη ανθεκτικότητας από τον εχθρό μειώνοντας την δραστικότητα των εντομοκτόνων
- **Γ** αυξάνει το κόστος παραγωγής και τέλος
- **Δ** αυξάνει την πιθανότητα εμφάνισης μη επιτρεπτών υπολειμμάτων γεωργικών φαρμάκων στα γεωργικά προϊόντα.

Στον Πίνακα 2 παρουσιάζονται συνοπτικά σε γράφημα οι οδηγίες διαχείρισης της ανθεκτικότητας, όπως αυτές περιγράφονται από τις ετικέτες των σκευασμάτων και τις συστάσεις από τον IRAC.

Οδηγίες διαχείρισης ανθεκτικότητας	Καλλιεργητική περίοδος – Χρόνος από την έναρξη των ψεκασμών (σε ημέρες)					
	0–30 ημέρες	30–60 ημέρες	60–90 ημέρες	90–120 ημέρες	120–150 ημέρες	150–180 ημέρες
Εναλλαγή ομάδων εντομοκτόνων / Έναρξη ψεκασμών	Ομάδα Χ (*) μέγιστος αρ. εφαρμογών/καλ. περ.	Ομάδα Ψ (*) μέγιστος αρ. εφαρμογών/καλ. περ.	Ομάδα Ζ (*) μέγιστος αρ. εφαρμογών/καλ. περ.	Ομάδα Χ (*) μέγιστος αρ. εφαρμογών/καλ. περ.	Ομάδα Ψ (*) μέγιστος αρ. εφαρμογών/καλ. περ.	Ομάδα Ζ (*) μέγιστος αρ. εφαρμογών/καλ. περ.
Οδηγίες IRAC		Μην εφαρμόζετε εντομοκτόνα από την Ομάδα Χ	Μην εφαρμόζετε εντομοκτόνα από την Ομάδα Χ		Μην εφαρμόζετε εντομοκτόνα από την Ομάδα Χ	Μην εφαρμόζετε εντομοκτόνα από την Ομάδα Χ
			Μην εφαρμόζετε εντομοκτόνα από την Ομάδα Ψ	Μην εφαρμόζετε εντομοκτόνα από την Ομάδα Ψ		Μην εφαρμόζετε εντομοκτόνα από την Ομάδα Ζ
				Μην εφαρμόζετε εντομοκτόνα από την Ομάδα Ζ	Μην εφαρμόζετε εντομοκτόνα από την Ομάδα Ζ	

(*) Προσοχή στον μέγιστο αριθμό εφαρμογών ανά καλλιεργητική περίοδο (αναφέρεται στην ετικέτα των σκευασμάτων)

Πίνακας 2.

Σύνοψη των οδηγιών διαχείριση της ανθεκτικότητας όπως αυτές περιγράφονται από τις ετικέτες των σκευασμάτων και τις συστάσεις του IRAC (www.irac-online.org). Οι Ομάδες Χ, Ψ ή Ζ αντιστοιχούν σε εγκεκριμένα σκευάσματα που περιέχουν δραστικές ουσίες από την ίδια ομάδα δράσης (Mode of action). Ο χρόνος στον πίνακα αρχίζει με την έναρξη των ψεκασμών για το *Tuta absoluta*.

Ενέργειες που πρέπει να γίνουν σε προσβεβλημένες καλλιέργειες

α) Απομακρύνουμε και καταστρέφουμε με **θάψιμο** τα υπολείμματα της προσβεβλημένης καλλιέργειας, ώστε να περιορίσουμε την εξάπλωση του εχθρού σε γειτονικές καλλιέργειες. Αν αυτό δεν είναι εφικτό, τότε μπορούμε να στοιβάξουμε τα υπολείμματα σε σωρούς και να τα **καλύψουμε ερμητικά** με πλαστικό θερμοκηπίου για 2 μήνες. Οι ελεύθερες άκρες του πλαστικού να παραχωθούν επιμελώς.

β) Απολυμαίνουμε το χώρο του θερμοκηπίου πριν την νέα φύτευση.
Η εφαρμογή **ηλιοαπολύμανσης** του εδάφους για 4 έως 8 εβδομάδες (ανάλογα με την εποχή εφαρμογής της) μπορεί να συντελέσει στη μείωση των πληθυσμών του εντόμου στο έδαφος του θερμοκηπίου, πριν την έναρξη της νέας καλλιέργειας τομάτας.

Γενικές παρατηρήσεις

Η αντιμετώπιση του ***Tuta absoluta*** είναι ιδιαίτερα δύσκολη και οι πρώτες ενδείξεις για ανάπτυξη ανθεκτικότητας έχουν δημοσιευτεί. Μόνο ο συνδυασμός διαφορετικών μεθόδων, στα πλαίσια της ολοκληρωμένης διαχείρισης των εχθρών της καλλιέργειας, μπορεί να δώσει ένα ικανοποιητικό αποτέλεσμα με χαμηλό κόστος.

11. Examples of country MoA alternation programs:

IRAC Training Tuta Poster