Resistance management of moths

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Both the potato tuber moth (PTM), *Phthorimaea operculella*, and the tomato leaf miner moth, *Tuta absoluta* (*Tuta*) or *Phthorimaea absoluta*, are micro-lepidopterans from the family Gelechiidae. Both pests have caused significant economic damage to solanaceous potato and tomato crops in large parts of the world.

These pests have been reported to be difficult to control in the potato and tomato growing regions of South Africa. Concerns for possible resistance have increased because producers are still observing substantial damage despite following rigorous spray programmes.

These pests are prone to develop resistance because of their high reproduction capability and multiple overlapping generations. It is important to consider that all insect populations have the potential to harbour individuals that are naturally resistant to any substance, but only becomes problematic when these resistant individuals start to dominate a population of concern. Scientific research must be conducted to confirm resistance.

Whether or not these pests are resistant, producers are facing enormous challenges controlling their numbers and are subsequently suffering major losses because of crop damage. Aside from shifts in sensitivity or possible resistance to currently registered insecticides, other factors may be influencing the levels of efficacy producers are achieving when trying to combat PTM and *Tuta*. These factors and other challenges may also lead to more rapid development of resistance.

High population numbers

Populations may be high in numbers due to many factors including, but not limited to, weather conditions such as temperature and humidity, a build-up of populations by leaving infected plant material lying around, not spraying crops that have been deemed too far gone, and not removing weeds that may act as alternative hosts. These factors may lead to a farm inadvertently building up the pest population for itself and its neighbours.

Insect pests are notoriously difficult to control, and an insecticide's control is substantial if it can control around 80% of a population. Pests such as PTM and *Tuta* can rapidly go through multiple generations and lay large amounts of eggs to beat the odds. For example, if an area has 100 000 individuals and we achieve 80% control, we still have roughly 20 000 individuals who are able to quickly reproduce and build up numbers fast.

Ineffective application

A major issue in chemical pest control is application quality. This can start in the spray tank if the mixture contains too many products (that may not

The potato tuber moth can rapidly go through multiple generations and can quickly reproduce. (Image: Central Science Laboratory, Harpenden, British Crown, Bugwood.org)

Tuta is known to affect potato and tomato crops worldwide and, like potato tuber moth, is difficult to control. (Image: Marja J van der Straten, NPPO, the Netherlands)

ideally partner), if dirty water is used, if the products are not mixed in the right order, or even if the pH is not optimised for the products in the tank.

Before the products even reach the plant, there can be blocked or dirty nozzles that decrease spray deposition and penetration. Lastly, incorrectly calibrated sprayers may lead to insufficient spray deposition or runoff.

Incorrect product use

All insecticides are not equally made, and each has its strengths and weaknesses. Some products, for example, are contact only and others can be translaminar (moving from one side of the leaf to the other) or systemic (moving up or down or in both directions in the entire plant). Other chemicals effectively control eggs, and some may only kill larvae of a certain size. Some insecticides do not affect the pest it makes initial contact with but will only affect the next generation.

Product attributes should be clearly understood before they can be used effectively. Products that are routinely used as a drip or drench application can lead to the rapid development of resistance.

Over-reliance on MoA IRAC group

Insecticides are grouped into modes of action (MoA) and classified into IRAC groups. For example, a well-known contact insecticide group, pyrethroids, are classified as Group 3A and works by modulating sodium channels in the target. The MoA for this group indicates that it works on nerve and muscle functions *(irac-online.org/mode-of-action/classification-online)*.

Major problems may arise when a single group of insecticides is applied week after week without alternating the IRAC group. A common mistake is to use different products (of registered trade names) from the same group, thinking that the IRAC group is being alternated in a spray programme. Using the same group multiple times on a single generation can lead to a quicker buildup of resistance in that group (all products) because surviving individuals reproduce offspring that have a higher likelihood of having natural resistance.

Contributing to this issue is the lack of an abundance of registered IRAC groups to control PTM and *Tuta*.

The perfect storm

Unfortunately, all these factors play a major role in efficacy and can drastically lower the working of a product before we even consider resistance. Even more concerning is that these practices can lead to the development of resistance because it exposes surviving individuals to sublethal dosages of the active ingredients, a perfect pathway to resistance.

There are several ways to delay insecticide resistance:

- Do not exclusively rely on insecticides. Rather make use of an integrated approach by monitoring populations and by using cultural and biological methods to reduce population pressure.
- Do not exclusively use products from a single IRAC group. Alternate with alternative groups and apply tank mixes when applicable.
- Follow label instructions and apply the correct product for the intended outcome.

Insecticide resistance management

Follow basic integrated pest management (IPM) practices:

- Plant clean seedlings.
- Maintain host-free periods to reduce population build-up.
- If possible, use physical exclusion such as netting with double-door exclusion.
- Solarise or cultivate soils to kill pupae.
- For PTM, ensure crack formation is minimised to reduce access to tubers.
- Rotate plantings with crops that are not hosts.
- Monitor pest populations.
- Control weeds that act as alternative hosts.
- Use pheromones to monitor, mass trap and disrupt mating.
- Manage natural enemy populations.
- Applying these strategies across a large production area will ensure better results (management practices, spraying the same IRAC group in the same week and alternating according to IRAC guidelines).
- Understand the insecticide and use it at the correct life stage for specific pests.
- Use clean water and correct the pH with the required buffer.
- Add the products to the spray tank in the recommended order.
- Calibrate and maintain all equipment.
- Ensure correct application penetration and deposition with minimal runoff.
- Apply these strategies across a production region to ensure effectiveness.

Table 1: Number of products registered for each crop and pest.

Crop	Potatoes		Tomatoes	
Target	Tomato leaf miner moth	Potato tuber moth	Tomato leaf miner moth	Potato tuber moth
Products	7	30	11	6
IRAC groups	4	12	8	4

Using the window application method:

- Expose a single generation to a single mode of action group as far as possible to avoid successive exposure and resistance selection.
- Spray windows should be calibrated to a pest's life cycle and should be around 30 days for *Tuta* and PTM.
- Multiple applications within a window are acceptable if the combined residual activity does not exceed the window period (follow label guidelines for the maximum number of applications).
- Allow enough time to pass before the same IRAC group is applied (60 days in most cases) and adhere to local MRL and PHI guidelines.
- Keep other pests in mind that will also be affected by applied modes of action as the window method is applied on a crop basis and not on a pest basis.
- Rotate IRAC group modes of action.
- Follow up with alternate modes of action by using products from a completely different IRAC group and not just a product with a different trade name.
- Maintain cultural practices such as the removal of old plant material that may increase population numbers throughout.
- Remove tomatoes that are no longer producing fruit and are not being sprayed.
- Bury or burn plant material that can harbour pests.
- An example of the window method for *Tuta* can be found at *irac-online.org/pests/tuta-absoluta*.

In conclusion, these pests are notoriously difficult to control, and, understandably, we want a quick and simple solution to manage them. Applying alternative methods of control and strategising spray programmes might be written off as time-consuming and ineffective.

Unfortunately, if we do not follow every single step to reduce population numbers and subsequently reduce or delay resistance, we will only exacerbate the problem and reduce the quality of the few products we have available. Try to keep in mind that every single percentage of efficacy we can gain by following these strategies could lead to hundreds or thousands of fewer pests on our crops.

We should aim to work together in production regions, strategise, execute, measure and thus improve our strategy weekly and consequently annually.

For more information and references, contact the author at Gustav.venter@syngenta.com or visit *www.irac-online.org*.

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