Insecticide Mode of Action and Resistance Management in Production Nurseries

SUMMARY

Insecticides are an important component in the management of pests in virtually all horticultural crops. However, they should not be solely relied upon as overuse is increasingly costly, can induce insecticide resistance and may cause phytotoxicity. This nursery paper will discuss how to reduce the risk of inducing resistance in pest insect and mite populations. Important aspects of the mode of action of insecticides are summarised; understanding the traits of insecticides assists in purchasing pesticides to best suit your situation and in applying products to gain maximum benefit. For the purposes of this paper, 'insecticide' refers to any product active against insects and or mites.

INSECTICIDE MODE OF ACTION

There are a number of important aspects of insecticide mode of action that should be understood before applying the product to a crop. These include the mode of action (MoA) classification assigned by the Insecticide Resistance Action Committee (IRAC), whether the product is contact or systemic and basic information about how the product kills pests. Sometimes, this information is found on the product label, but not always.

MoA Classifications

Almost all product labels have a MoA classification printed on it clearly. It is a number, or a number followed by a letter, in a black and white box. All products with the same MoA kill pests the same way, e.g. Group 6A products all activate a particular nerve function that causes paralysis and death. While products from the same MoA group kill pests the same way, it does not mean that they are all equal. For example, some active ingredients or formulations within the same MoA can be systemic, while others are not.

Sometimes pesticides are produced that are similar, but may have a slightly different chemical structure or MoA from other products. Such products may then result in a different number-letter combination, e.g. 7A, 7B, 7C. It is best to assume that all products with the same number function in the same way, even if they have a different letter. Determining the MoA can take years of intensive research, which is why some products are in the 'UN' group for compounds with unknown or uncertain MoA.

GROUP 6A INSECTICIDE

GROUP 3A 4A INSECTICIDE

The mode of action group appearing on most insecticide labels is depicted as a number, sometimes followed by a letter in a black and white box. When insecticides are present from two MoAs, both are present in the box.

Contact, Systemic and Translaminar Products

Insecticides interact and move within plants in different ways; understanding how the product will behave is important for successful application. ***Contact*** insecticides are products that remain on the epidermis of plants only; they do not enter plant cells. Such products are active against insects when they are applied, contacting individuals directly. Some contact insecticides may have activity when ingested or touched a period of time after application. The residual period of some pesticides is very short, while others can be weeks after application.

Systemic insecticides enter plant cells and are mobile within plant vascular tissue. Most systemic products move upward in vascular tissue, but not down (the notable exception being the active ingredient spirotetramat). ***Translaminar*** products enter plant cells but not the vascular tissue. In general, they have limited systemic action and move from the upper leaf to the lower leaf (or vice versa), but not from leaf to leaf. Such products can be active against insects at application and upon ingestion. As with contact products, the residual period that each product is active within plants is highly variable (days to weeks or sometimes even months). Systemic products drenched into soil/growing media tend to be active for longer periods than when applied to foliage.

Do not apply *contact* pesticides to pests that inhabit protected areas of the plant. For pests that reside within leaves, growing tips and other protected areas, systemic or translaminar products are required. Translaminar products will only move a short distance across the leaf, therefore they may not be sufficient in some instances, e.g. stem-boring insects, pests producing very thick galls or those within multiple layers of a leaf roll.

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How Insecticides Cause Mortality

Insecticides are broadly categorised into five groups, depending on the physiological function they disrupt. These are: 1) nerve and muscle, 2) insect growth regulators, 3) respiration, 4) midgut, and 5) unknown.

Some nerve pesticides target sites that are also in vertebrates (including humans), leading to some products being taken off the market, not being able to be used near waterways or have been under significant review by the Australian Pesticides and Veterinary Medicines Authority (APVMA), e.g. organophosphates. Such products should be treated with great care. Newer nerve products often target sites that are not active (or not as active) against vertebrates. Products targeting *respiration, nerve and muscle* functions are relatively fast acting insecticides.

Insect growth regulators (IGRs) affect the development of insects, particularly moulting. They are moderately slow acting, though feeding may be inhibited and insect/mite development may cease. Adults are relatively unaffected and are likely to survive the application. However, their reproductive organs may be affected causing adults to become sterile or reducing egg survival. Only immature insects are killed and, depending what the product disrupts, it may not cause death until the insect next tries to moult. This is important when assessing efficacy of a product, as it may appear that the product is ineffective for some time after application. In addition, in cases where there is a large proportion of adults, these products may not be as effective as other MoA groups, unless applied in combination with another product.

The main *midgut* insecticides are *Bacillus thuringiensis* (B.t.) products for use against caterpillars or fly larvae (e.g. fungus gnats). These products are living bacteria that must be stored appropriately (cool and dry). Always check the manufacture date when purchasing these products as they have a relatively limited shelf life. Time of day of the application is important as the products are UV sensitive (broken down in sunlight) and must be ingested to cause insect death. These products are far more effective when applied against small larvae; ingestion of only a small amount of product causes death. Large larvae must ingest a large amount of product, causing greater damage in the process, and will survive a small dose. For nocturnal caterpillars, apply this product late in the afternoon, if possible (to reduce breakdown from UV radiation).

Cultural practices assist in reducing pest pressure passively, e.g. keeping clean growing areas free of weeds and having plants with good spacing.

What is Insecticide Resistance?

Insecticide resistance occurs from repeated use of products from the same MoA group. This causes a change in the sensitivity of a pest population resulting in a failure to achieve the expected level of control (at recommended label rates). Resistance can be passed on to offspring. Effectively this causes susceptible individuals to die, leaving behind resistant ones. Resistant individuals reproduce and result in a population with a relatively high proportion of resistant individuals.

Since the discovery of resistance in 1947, a pattern has developed often described as the 'pesticide treadmill'. Products are released and applied consistently, leading to insecticide resistance and more frequent applications of the product. This in turn leads to greater levels of resistance until the product fails altogether. A new product is used and the pattern starts again. Unfortunately, resistance to one pesticide MoA group can sometimes lead to resistance to pesticides of a different MoA.

Insecticide Resistance Management

The most effective method to reduce the likelihood of inducing insecticide resistance is to reduce the need to apply pesticides, by implementing as many cultural practices as possible. General practices include:

- Manage pest populations early by monitoring crop health regularly
- Check incoming stock for pests
- Manage weeds proactively
- Remove unsaleable stock and avoid holding old stock
- Grow resistant varieties
- Release biological control agents whenever possible
- Only apply pesticides when a pest population will result in damage
- Modify the growing environment to be favourable to plant growth, but unfavourable to pest development, e.g. reducing media moisture levels to manage fungus gnats.

Pesticides are the main method to reduce pest populations quickly and avoid economic loss from high pest populations. If a pesticide must be applied it is important to have a basic understanding of the pest lifecycle. The generation time is particularly important as is knowledge of vulnerable/tolerant life stages. The following recommendations will reduce pesticide resistance:

- Apply pesticides to the most vulnerable stage. In general, early stage immature insects are the most vulnerable to insecticides (just after hatching). For some groups late instar larvae are very tolerant to insecticides, e.g. scarab beetles, and for others all larvae are tolerant, e.g. gall midge flies. Do not assume that all stages of an insect can be effectively managed with an insecticide, even if the species is on the label without specifying a particular stage.
- Some labels have a pesticide resistance management strategy included. Always follow these instructions.
- Apply the full recommended rate. Using a low dose can increase pesticide resistance; individuals with low level resistance survive and may give rise to greater resistance in the future.
- Ensure good coverage to increase the chance of contacting the pest and achieve best efficacy.
- Maintain pesticide application equipment regularly, e.g. calibration of equipment, cleaning equipment, replacing nozzles as required.
- Apply pesticides using best management practice guidelines.
- Avoid applying broad spectrum pesticides that kill predators and parasites whenever possible.
- Do not continue to apply chemicals from a MoA group that has possibly failed due to pesticide resistance.
- Alternate/rotate between chemistries, as per section below.

Rotation/Alternation of Insecticides

Regular use of one pesticide chemistry (MoA) will increase the risk of resistance. Using products from multiple MoA can reduce this risk substantially and can be achieved in several different ways. It is critical to reduce exposure of consecutive pest generations to the same insecticide MoA. For this reason rotation scheduling can vary depending on the pest lifecycle.

For pests with a *short generation time*, it can be beneficial to employ a 'window' approach, in which the same product is applied on 2-3 consecutive occasions within the timespan of one pest generation. Depending on the pest and environmental conditions this could be over a week or month. Then for the next generation, apply an insecticide from a different MoA and continue this approach until pesticides are no longer required. However, exceptions occur. For two-spotted mite, *Tetranychus urticae*, the Croplife Australia resistance management strategy for ornamental crops recommends rotating to a different MoA after each application; to never apply sequential applications from any one MoA.

For pests with a relatively *long generation time*, e.g. months, it is critical to understand the lifecycle of the pest to apply insecticides during the vulnerable stage (which is often before damage is obvious). It is recommended to apply pesticides from different MoAs sequentially, if required. If the pest is continuously present in the nursery, do not use the same pesticide across multiple generations.

Monitoring for pests and diseases is very important. Infestations that are found at an early stage are much easier to manage and incur fewer losses.

Break the Lifecycle

If the same pest is continuously present in the nursery, even if at low levels, it becomes important to evaluate the management strategy employed. It is recommended to modify the approach such that the lifecycle of the pest is broken in the nursery. Find out how the pest is entering the nursery and put in place actions to reduce reinfestations. Where pests are flying into the nursery, consider appropriate monitoring to assist in its early detection, e.g. with traps. Pests coming into the nursery from agricultural areas also pose a higher risk of developing pesticide resistance.

CONCLUSION

Pesticide resistance poses a serious risk for all agricultural industries. However, by putting in place many simple management strategies, this risk can be mitigated. These include using cultural practices to reduce pest pressure, using predators, applying pesticides appropriately and rotating between chemicals of different MoA groups. The production nursery industry also has a large and growing volume of resources and best management practice guidelines to assist businesses in managing crop health, including pests.

MORE INFORMATION

Australian Plant Production Standard including factsheets, pest management plans and the best practice manual for pesticide application: ***http://nurseryproductionfms.com.au***

CropLife Australia resistance management strategies: ***https://www.croplife.org.au/resources/programs/resistance-management/***

Insecticide Resistance Action Committee MoA classification: ***https://irac-online.org/mode-of-action/***

PAST EDITIONS OF NURSERY PAPERS ARE AVAILABLE ONLINE on the Greenlife Industry Australia website: ***https://www.greenlifeindustry.com.au/Section?Action=View&Section_id=46***

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