Enhanced metalaxyl breakdown and its implication in Australian horticulture

Final Report

Horticulture Australia Project VX00012
(Project completion 30/12/01)

by

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This is a final report of project VX00012 - Enhanced metalaxyl breakdown and its implication in Australian horticulture.

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Media Summary

This one-year project funded by Horticulture Australia Limited was to review and compile information on the implications of enhanced metalaxyl breakdown, and to recommend management practices to minimise the risks associated with the fungicide's use in Australian horticulture.

Metalaxyl is highly effective against serious diseases, such as potato late blight, downy mildew and damping-off of vegetables or cavity spot on carrots. As a result, it is often the only fungicide used in horticulture to control soil borne diseases caused by *Phytophthora* and *Pythium*.

Unfortunately, metalaxyl is susceptible to enhanced degradation by soil microorganisms, if used repeatedly over a short period. In soils with an enhanced degradation problem, metalaxyl breaks down so rapidly that it does not provide appropriate disease control.

Excessive use of metalaxyl as a soil fungicide will lead to a reduction in disease control. For example, in a sandy soil that had no prior history of metalaxyl application, its half-life was longer than 10 weeks. This was reduced to as little as 4 days in paddocks with enhanced degradation. A single metalaxyl application may create a potential problem.

Biodegradation by soil microorganisms is the most important factor in reducing metalaxyl persistence in soils, however other factors play a role. These include chemical degradation, adsorption onto soil particles, leaching, run-off, and photo-decomposition. Metalaxyl degradation also varies with soil type, environmental and management conditions.

Growers and agricultural advisers must be aware of the consequences of excessive metalaxyl use. A better understanding of the fungicide's properties, as well as effects of soils, irrigation, and cultural practices, will help to maintain metalaxyl products availability for use against major, economically significant soil borne diseases.

An information leaflet on enhanced metalaxyl degradation and other factors that may influence its persistence and efficacy, and recommendations for its sustainable use, was prepared for growers and industry use.

Technical Summary

This one-year project funded by Horticulture Australia Limited was to review and compile information on the implications of enhanced metalaxyl breakdown, and to recommend management practices to minimise the risks associated with the fungicide's use in Australian horticulture.

This report provides an overall perspective on enhanced degradation of metalaxyl, as well as other factors that affect metalaxyl persistence in agricultural systems.

Metalaxyl is highly effective against serious diseases caused by *Oomycetes* fungi, such as potato late blight, downy mildew and damping-off on vegetables, or cavity spot on carrots. As metalaxyl is a site-specific fungicide that is also very selective in its activity against target fungal pathogens, it is susceptible to both fungicide resistance and rapid degradation. The development and impact of metalaxyl resistance is well known. However, the phenomenon of rapid degradation of fungicides such as metalaxyl is relatively new, and there have been very few studies on its impact on *Oomycetes* disease control in horticultural crops.

It should be noted that although pesticide biodegradation in soil may adversely affect the control of soil pests, this process is also an important mechanism for degrading, detoxifying, or assimilating pesticides. This helps to prevent a build-up of pesticide residues, and soil and groundwater contamination.

Enhanced biodegradation

- Enhanced biodegradation by soil microorganisms was found to be the most important factor in reducing metalaxyl persistence in soils.
- Enhanced biodegradation can be defined as the accelerated degradation of a pesticide after repeated applications to soils.
- Enhanced degradation of metalaxyl has been reported in sites that have a history of consecutive years of metalaxyl soil applications.
- In soils with an enhanced degradation problem, metalaxyl breaks down so rapidly that it does not provide appropriate disease control. For example, in a sandy soil that had no prior history of metalaxyl application, its half-life was 82 days. This was reduced to as little as 4 to 10 days in paddocks with enhanced degradation.
- In laboratory studies, a single exposure of different soils with no history of metalaxyl treatment was sufficient to increase their subsequent capacity to degrade the fungicide. This may be due to the wide range of microorganisms (fungi, bacteria and actinomycetes) capable of degrading it.
- In comparison to the soil system, most plant canopies do not support high microbial activities. Hence, enhanced degradation is unlikely to occur on plant canopies following metalaxyl spray applications.
- High microbial activity in soil is usually associated with high organic matter levels. Therefore, metalaxyl tends to degrade faster in soils that are high in organic matter.

Technical Summary (Cont.)

- The rate of metalaxyl degradation in soils can also vary with soil depth. Organic matter levels are lower with increasing soil depth and hence conditions are believed to be less favourable for its degradation.
- Cultural practices may influence the persistence of metalaxyl in soil. Enhanced degradation was not detected in intermittently cropped red ferrosol soils in Tasmania. These soils had two or four years of pasture in between crops and metalaxyl soil applications.
- In contrast, rapid degradation was found in intensively cropped soils, where the fungicide had been applied to soil in carrot and potato crops in consecutive years.
- Further studies are required in order to better understand the effects of cropping practices, metalaxyl use, and types of crops, on metalaxyl persistence.
- It is not known whether affected soils can recover from enhanced metalaxyl degradation. Further investigations are required to determine the recovery potential of enhanced degradation affected sites.

Other factors influencing persistence and efficacy

- Although, as a soil fungicide, metalaxyl is susceptible to biodegradation, there are additional factors that may influence its persistence and efficacy.
- Metalaxyl, with its high solubility, is easily transported in water. As a result, the mobility of metalaxyl is highest in sandy soils with low organic matter, and it may be leached down the soil profile with high rainfall or irrigation.
- Metalaxyl is less mobile in soils with high clay and/or organic matter due to higher adsorption onto soil particles. This makes less chemical available for degradation by soil microorganisms.
- Metalaxyl may also be susceptible to run-off, either mixed in with the run-off water or bound to eroding soil.
- The high solubility of metalaxyl offers one advantage; it is readily taken up by plants in solution. As a result, low dosages (~10ug/ml) often give effective control of *Oomycete*s fungi and good residual activity in soil. *Phytophthora erythroseptica* (pink rot) is sensitive at above 1ppm and completely inhibited at 10ppm metalaxyl, and the ED50 of *Pythium sulcatum* (cavity spot) is less than 5ug/ml metalaxyl.
- Metalaxyl degraded more rapidly at a pH of 8 or above. For example, less than 5% of the initial amount remained in solution after 12 weeks in sterile water at pH 10.
- Exposure to sunlight may also reduce the persistence of metalaxyl. Under simulated sunlight, the half-life of metalaxyl in soil was three to four times lower.
- The efficacy of metalaxyl for disease control is also influenced by the susceptibility of plant varieties and its effect on a fungal pathogen. Excellent disease control with metalaxyl can be obtained with the use of a *Phytophthora* resistant plant cultivar, while with a susceptible cultivar, disease symptoms can only be delayed as long as the fungicide persists in the soil.

Technical Summary (Cont.)

- Metalaxyl tends to inhibit the pathogen, thereby preventing or reducing new infections, and reducing disease severity on infected plants, but it does not eradicate or kill the pathogen.
- This is contrary to the misconception by growers that metalaxyl soil application will also kill fungi, and thus reduce pathogen levels. Metalaxyl appears to act mainly by inhibiting *Oomycetes* fungal growth and sporulation.
- In northern Tasmania, where most fields have a close rotation of potato crops, an increase in the incidence of pink rot has been observed in spite of metalaxyl soil applications. This suggests that there may have been a build-up of the pathogen's level in soil following several potato crops or volunteer potatoes. Again, this highlights the importance of reducing pathogen levels through appropriate cultural practices rather than relying on a suppressive fungicide alone.

Metalaxyl use

- Growers must become aware of the consequences of excessive use of modern pesticides for soilborne pest control. In recent years, there have been increasing numbers of reports of enhanced degradation of metalaxyl and other pesticides by soil microorganisms.
- The industry must take steps to promote better use of metalaxyl in order to ensure its long-term availability and effectiveness against the economically significant diseases.
- A long-term and sustainable approach for major diseases caused by *Oomycetes* pathogens must involve other measures, namely an integrated disease management program that includes appropriate cultural practices, improved soil management, and biological control methods.

Technology Transfer

An information leaflet on enhanced metalaxyl degradation and other factors that may influence its persistence and efficacy, and recommendations for its sustainable use, was prepared for growers and industry use.

Recommendations

- A long-term approach for a sustainable metalaxyl usage must involve the following measures for integrated disease management:
  - Use suitable crop rotations with plants that are not susceptible to *Oomycete*s fungal pathogens, thereby reducing the frequency of metalaxyl applications.
  - Do not plant one susceptible root crop soon after another.
  - Use crop cultivars with moderate to high resistance to *Oomycetes* pathogens.
  - Reduce metalaxyl leaching and run-off, by reducing the slope, avoiding over irrigating, constructing drainage ditches, and improving soil management to reduce compaction.
  - Encourage soil management practices that improve soil structure for better water infiltration, increased biological antagonists, disease suppression and reduced pathogen levels.
  - Develop alternative chemical methods for use in alternation or in addition to metalaxyl for *Oomycetes* soilborne disease control. For example, a new class of systemic fungicides that can activate plant natural defences may offer a new perspective in disease control.
  - Develop and introduce the use of biological control methods. As metalaxyl is selective in its activity, it is likely to be compatible with most biological control methods.

- Further studies are recommended in order to obtain a better understanding of the effects of cropping practices, types of crops, and intervals between metalaxyl applications and its persistence.

- Further investigations are required to determine the recovery potential of enhanced degradation affected sites.

Introduction

Background

Metalaxyl, a phenylamide fungicide, is currently used to control many major fungal diseases caused by *Oomycete*s fungi, such as *Pythium*, *Phytophthora*, and *Peronospora* (downy mildew) in vegetables, potatoes and field crops. Major diseases caused by *Oomycete*s fungi include cavity spot of carrots, and pink rot and late blight diseases of potatoes. In recent years, there have been increasing reports of enhanced metalaxyl breakdown by soil microorganisms. This process reduces the persistence of metalaxyl in soil, thereby affecting its efficacy for disease control.

Apart from microbial degradation, there are also other factors that may affect metalaxyl persistence in soils. Hence, this report will review and discuss all factors that are known to affect metalaxyl persistence and availability in soils.

As land use for agricultural production becomes more intensive, the use of metalaxyl is also expected to increase, as it has often been found to provide the most effective fungicide treatment for the control of diseases caused by *Oomycete*s fungi. Therefore, it is imperative that the horticultural industry has a good understanding of metalaxyl dissipation or loss in soil over time, and its implication for disease control. Unless the proper use of metalaxyl is promoted to the relevant industries, the long-term use of metalaxyl against the major target diseases may be severely affected.

Aims

The aim of this project is to obtain an overall perspective of metalaxyl persistence in agricultural systems. As there is a lack of detailed information on metalaxyl degradation in horticultural crops in Australia, much of the information presented in this report is drawn from overseas studies, as well as environmental studies on pesticide leaching and groundwater contamination.