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Summary

For the first time in the UK, symptoms of *Phytophthora* on asparagus have been widespread in 2002, with at least 50 % of asparagus acreage affected or at risk. The disease is common in New Zealand and California, USA, where yield losses of 50 % have been reported.

The disease is characterised by soft, watersoaked lesions at soil-level on spears. Lesions may become slimy due to secondary bacterial infection. The disease is most likely to become a problem after heavy spring rainfall. Crop losses are due to failure of new stands to become established and from reduced yields or plant death in mature stands.

There are no fungicides approved for the control of asparagus *Phytophthora* in the UK or Europe. Given the perennial nature of the crop and that *Phytophthora* is soil-borne, there are serious concerns throughout the asparagus industry that without the option for chemical control, the disease will become a major production constraint in 2003. The aim of this review was to determine the best fungicide candidate(s) for control of *Phytophthora* rot on asparagus, together with the necessary information to support an application to the Pesticides Safety Directorate (PSD) for an appropriate emergency specific off-label approval (SOLA).

Based on approvals and recommendations from New Zealand and the USA (Table 1 and Appendix 1), it is recommended that Emergency off-label approval for use of SL 567A (480 g/litre metalaxyl-M) (Syngenta) on asparagus should be sought. The fungicide should be applied only once per year, prior to spear emergence and a minimum of 4 days before the start of harvest. A broadcast application should be made to cover the entire soil surface, using a rate of 1 – 1.3 litres/ha in at least 100 litres water/ha, to obtain good ground coverage. The higher application rate may be needed for soils with a high organic matter content and/or in fields where previous infections have been observed. Practices such as band-spraying and use of rates lower than those recommended should be avoided to minimise the risk of resistance development.

Aliette (fosetyl-aluminium) and Amistar (azoxystrobin) may have potential for control of asparagus *Phytophthora* and we recommend that trials are done to determine whether these products would provide useful alternatives or additions to metalaxyl use on asparagus under UK conditions.

Introduction

Before 2002, reports of *Phytophthora* rot on asparagus in the UK were rare. In grower surveys conducted by ADAS in 1989 and 1990, there were nil reports of the disease, while in 1997 and again in 2001, one major grower observed symptoms in several fields (W. Dyer, pers. comm.). In 2002, disease symptoms have been widespread, with responses to questionnaires distributed by the Asparagus Growers Association (AGA) and Horticultural Development Council (HDC) suggesting that at least 50% of asparagus acreage in the UK may be affected or at risk from the disease (V. Aveling, E. Garrod, pers. comm.). In 2002, a fungus isolated from asparagus spears with typical disease symptoms in one Cambridgeshire field, was confirmed by ADAS to be *Phytophthora*.

Phytophthora rot is a significant disease of asparagus in New Zealand, USA, Mexico, Chile, France and Australia (Falloon *et al*., 2001). The disease is also endemic in the Netherlands and Germany (P. Falloon, pers. comm.) but does not pose a major threat in these countries because of the different cultivation practices used to produce white asparagus. The majority of research on the biology and control of the disease has been done in New Zealand and USA (California), where yield losses in excess of 50 % have been attributed to the disease. Several species of *Phytophthora* attack asparagus, including *P. megasperma*, *P. megasperma* var. *sojae*, *P. cryptogea*, *P. cactorum* and *P. richardiae* (Erwin & Ribeiro, 1996; Falloon *et al*., 2001).

Snowdon (1991) describes the typical symptoms of *Phytophthora* rot as follows: the disease is characterised by soft, water-soaked lesions on shoots at, slightly above, or below the soil level (spear rot). The lesions elongate rapidly and become light brown. As the lesion collapses and shrivels, the affected side of the spear becomes flattened, and the shoot becomes extremely curved and may even collapse. This symptom is not, however, diagnostic as insect, slug and mechanical injury can also result in 'crooked' spears. As the spear rots, secondary bacterial infection may occur, imparting a disagreeable odour to the infected tissue. Crowns infected with *Phytophthora* spp. have yellow-orange coloured tissue. In severe infections, the tissue appears waterlogged and fibrous. The disease is most likely to become a problem after heavy and prolonged rainfall, particularly in the spring. Crop losses are due to failure of new stands to become established and from reduced yields or plant death in mature stands.

Infected spears, if hydro-cooled during packing for market, may contaminate the water and spread the pathogen to other spears, causing extensive rot during transit.

There are currently no fungicides approved specifically for the control of asparagus *Phytophthora* in the UK. Given the perennial nature of the crop and that *Phytophthora* is soil-borne (surviving as thick-walled oospores), there are serious concerns throughout the asparagus industry that without the option for chemical control, the disease will reach epidemic proportions in 2003 with inevitable effects on yield and profitability.

In the long term, the objective of the AGA should be to consider integrated strategies for the management of *Phytophthora* rot. However, in the interim, an option of fungicidal control for *Phytophthora* is now urgently required to safe-guard the asparagus industry in the coming season. The aim of this review is to facilitate the process of emergency fungicide approval for *Phytophthora* rot on asparagus.

Review terms of reference

Overall objective: To provide short-term recommendations on strategies required for the management of *Phytophthora* rot on asparagus.

Specific objective: To determine the best fungicide candidate(s) for control of *Phytophthora* rot on asparagus, together with the necessary information to support an application to the Pesticides Safety Directorate (PSD) for an appropriate emergency specific off-label approval (SOLA).

Approach: In consultation with experts in UK (including agro-chemical companies), Europe, USA and New Zealand, a list of 2-3 candidate fungicide products for which PSD approval could be sought, has been compiled. Information presented includes: products, active ingredients, manufacturer, modes of action, timing, rates and current approvals for use either in UK, Europe or elsewhere, and potential suitability for control of *Phytophthora* on asparagus.

Current recommendations for management of *Phytophthora* rot on asparagus

USA

California, Washington and Michigan State are the largest producers of asparagus in the USA (Anon, 2000), although it is only in California where *Phytophthora* rot is a major production constraint (Elmer, 2001).

Detailed studies of the disease were first undertaken in the 1980s when 30-54 % yield reductions were documented (Falloon *et al*., 1986). Initial trials in California on two soil types (including a peat soil) showed that treatment with metalaxyl in plots known to be infected with *Phytophthora* led to increases in the yield of marketable spears of between 35-141 % in 1983 and 17-44 % in 1984 (Falloon *et al*., 1985). It was found that an application of metalaxyl during the winter, while plants were dormant, had little effect on yield, indicating that winter infection does not constrain production. During the wet season of 1983 (conditions conducive for *Phytophthora* development), a single application of metalaxyl applied 7-14 days before harvest resulted in the most cost-effective control of *Phytophthora* rot.

Currently, there are two fungicides approved for the control of *Phytophthora* on asparagus in California; Ridomil Gold EC (metalaxyl-M) and Aliette WDG (fosetyl-aluminium). Ridomil Gold (manufactured by Syngenta) is reported to be the most effective of the two products and most frequently used by asparagus growers (B. Benson, pers. comm.). Specimen product labels can be viewed on an USA pesticide database, www.greenbook.net and application details (converted to metric units) have been summarised in Table 1. Ridomil Gold is the new formulation of metalaxyl, which consists of only mefenoxam (now known as metalaxyl-M), the most biologically active isomer of metalaxyl, whereas older formulations contained both the active and inactive isomer of metalaxyl.[1] Ridomil Gold is equivalent to SL 567A (manufactured by Syngenta) registered for use in the UK.

In California, development of resistance to metalaxyl within the pathogen population has been reported in asparagus crops. This is a particular problem where growers have band-sprayed the product to just the top of the asparagus beds, leading to a dilution effect at the edge of the spray band (B. Benson, pers. comm.). For this reason, it is recommended that the fungicide is applied to 100 % of the soil surface, resulting in effective control of *Phytophthora* with no problems of pathogen resistance.

Ridomil Gold should be applied when the soil is still dry enough for the fungicide to be leached into the soil with the advancing front of water from rain. If the product is applied to wet saturated soil, it is readily removed from the soil by surface drainage due to the high solubility of the compound. There is a possibility of ground water contamination where soils are permeable and the water table is shallow.

The label for Aliette states that the fungicide 'will provide effective control of Asparagus Spear Slime and Crown Rot caused by *Phytophthora* spp'. The fungicide is infrequently used in California because it has to be applied to the previous years' fern crop prior to the grower's knowledge of a 'wet winter or spring' which is impractical and unrealistic. In research trials, the winter and spring following applications of Aliette were not wet, (i.e. not conducive for *Phytophthora* development) and, therefore not a good test of Aliette control (B. Benson, pers.

[1] Metalaxyl has systemic activity and is used exclusively for the control of oomycete fungi (*Phytophthora* spp., *Pythium* spp., and downy mildews). Aliette is a phosphonic acid fungicide with systemic activity, also used for the control of oomycetes, mainly in horticultural crops.

comm.). Pest management guidelines from the University of California state that control of *Phytophthora* on asparagus with Aliette is erratic (http://www/ipm.ucdavis.edu).

Concerns about metalaxyl resistance in California have prompted consideration of other strategies for management of *Phytophthora* on asparagus. Phosphorous acid (synonym = phosphonic acid) manufactured by Agrol as Phostrol is registered as a fungicide in other states of the USA and may be trialled in California for *Phytophthora* control. Asparagus breeding for resistance to *Phytophthora* rot is ongoing. Cultural practices include avoiding soil known to be infected with *Phytophthora*, use of disease-free transplants, and ensuring good drainage.

New Zealand

The same formulation of Ridomil Gold EC used in the USA (480 g/litre metalaxyl-M) is also approved for use on asparagus in New Zealand. Product label information from Syngenta is as follows: The product is applied at 1-1.3 litres per ha, with the higher rate being used if the disease was evident during the previous season. Apply in sufficient water to obtain good ground coverage. Apply as an annual broadcast application in early spring prior to spear emergence. During the cutting season, if disease pressure is severe, a repeat application can be made, provided it is made the same day immediately after a hard cutting. Apply no more than two applications in any one season. Ensure that the soil is free of weeds and trash. Light rain or irrigation is necessary to move the fungicide into the soil within 48 hours after application. The harvest interval ('withholding period') is 4 days. The product label is shown in Appendix 1.

Growers in New Zealand usually apply Ridomil Gold 1-3 weeks before the start of the harvest season to cover the entire soil surface, often in a tank mix with the pre-season herbicides. The harvest interval is 4 days so the fungicide can be applied after initial spear emergence. A repeat application may be made 6 weeks later if the latter part of the harvest season is wet. There is no benefit in terms of fungicide efficacy in adding mancozeb (Ridomil MZ) or copper oxychloride to the mix, for control of *Phytophthora* rot of asparagus (P. Falloon, pers. comm.). Many New Zealand growers still use an older formulation of Ridomil (metalaxyl) which is now off patent and less expensive. There is a 21- day harvest interval for this product, based on a generous safety factor rather than residue data.

After 10-15 years repeated use of metalaxyl on asparagus in New Zealand and associated problems of pathogen resistance and biodegradation (enhanced microbial breakdown), recent research efforts have focussed on alternative management strategies for asparagus *Phytophthora*. A breeding programme has been successful in developing durable resistance to *Phytophthora* rot and seed production of selected hybrids is underway (Falloon *et al*., 2001). Results from preliminary field trials suggest that inoculation of asparagus crowns with a biological control agent, *Pseudomonas aureofaciens*, led to a significant increase in the yield of plant material in the presence of *Phytophthora megasperma* var. *sojae* (Godfrey *et al*., 2000). There is also interest in the use of phosphorous (phosphonic) acid for *Phytophthor*a management.

Europe

The majority of asparagus grown in Europe is produced as the white type, which is not affected by *Phytophthora* spp.

In France, *Phytophthora megasperma* has caused problems on green asparagus, mainly in the Landes region. Its effect on yield can be significant (20 %) but only for a limited period such as 1 week during the harvesting season. No fungicides are approved (D. Adam, pers. comm.).

Phytophthora is not a problem on asparagus produced in the Netherlands and there are no fungicides approved (J. Poll, pers. comm.).

In Germany, Bardos (difenaconazole) and Ortiva (azoxystrobin) are approved for the control of *Stemphylium*, rust and *Botrytis* on asparagus, but not *Phytophthora* (www.syngenta.de).

There are no fungicides approved for the control of *Phytophthora* on asparagus elsewhere in Europe (W. Dyer, V. Powell, pers. comm.).

Short-term recommendations for the UK

SL 567A

We recommend that Emergency off-label approval for use of SL 567A (480 g/litre metalaxyl-M) as a soil application to asparagus fields prior to harvest should be sought. This product, manufactured by Syngenta, is equivalent to Ridomil Gold EC registered for control of asparagus *Phytophthora* in the USA and New Zealand. In the UK, this product already has full approval for the control of carrot cavity spot (soil application 6 weeks after drilling) and a specific off-label approval (SOLA 010770) as a soil application for the control of raspberry root rot.

Fungicide application

Recommendations for the UK should be developed in line with the New Zealand approval as follows: the fungicide should be applied only once per year, prior to spear emergence and a minimum of 4 days before the start of harvest. A broadcast application should be made to cover the entire soil surface, using a rate of 1 – 1.3 litres/ha in at least 100 litres water/ha, to obtain good ground coverage. The higher application rate may be needed for soils with a high organic matter content and/or in fields where previous infections have been observed.

Cost

The cost of SL 567A is relatively high (approximately £185 - £240 /ha). However, the information compiled suggests that this is the most effective product available, and its use may be warranted if symptoms of *Phytophthora* were observed in 2002 and if subsequent winter and spring rains are particularly heavy.

Pathogen resistance

Concerns about the development of pathogen resistance relating to repeated metalaxyl use have been highlighted in this report. Practices such as band-spraying and use of rates lower than those recommended should be avoided to minimise the risk of resistance development. However, in the case of asparagus, metalaxyl-M would be used to control soil-inhabiting fungi (similar to the use of SL 567A for the control of carrot cavity spot) rather than for the control of foliar oomycetes (e.g. potato late blight), for which the risk of rapid resistance development is higher. HDC-funded work on the use of metalaxyl-M for cavity spot control

(HDC Project FV 5f, 2002), showed that while fungicide efficacy was variable, this was not due to development of resistance in the pathogen population.

Microbial degradation

Metalaxyl degrades in soil but the rate of degradation varies greatly and in some fields it is very rapid (half-life < 7 days). Evidence from the recent HDC project on carrot cavity spot (HDC Project FV 5f, 2002) suggests that the degradation is microbial in origin and that rapid degrading fields assessed to date have had histories of intensive metalaxyl use. Neighbouring fields with similar soil type but not exposed to metalaxyl use, did not degrade metalaxyl as rapidly. These results suggest that established asparagus fields are probably not high risk for microbial degradation of metalaxyl. A soil test is now available at Horticultural Research International to determine metalaxyl degradation rate. Given the high cost of fungicide application, this test may be warranted prior to metalaxyl use in established crops and perhaps more importantly in new asparagus plantations where there may have been a history of metalaxyl use on previous crops.

Aliette

Information from the USA indicates that fosetyl-aluminium (for example, Aliette 80 WG, manufactured by Certis) may have potential for control of *Phytophthora* on asparagus, although reports on efficacy are variable. The fungicide is used widely in the UK for the control of oomycete fungi. Given its wide use on salad and vegetable crops, it is likely that obtaining an off-label approval for the product would be relatively straightforward. The required timing of application (before fern senescence and at least 110 days before harvest), however, suggests that *Phytophthora* infections occurring in early spring would not be controlled. The cost of the chemical (assuming an application rate of 5 kg/ha) would be approximately £168 per ha, which seems a risky investment for a chemical with only moderate efficacy reported.

We recommend that trials are done to determine whether this fungicide would provide a useful alternative or addition to metalaxyl use on asparagus under UK conditions.

Amistar

Although azoxystrobin is approved in Germany as Ortiva for control of rust, *Stemphylium* and *Botrytis* on asparagus, there is no information available on its efficacy against *Phytophthora* rot. As for Aliette, product application to the green fern is unlikely to control spring infections.

We recommend that if trials are conducted to determine the effects of Amistar on fern diseases of asparagus in the UK, product effects on *Phytophthora* should also be quantified.

Other management strategies

Possible cultural practices that could be implemented include avoiding soil known to be infected with *Phytophthora* for new plantations, use of disease-free transplants, and ensuring good drainage. Further research will be required to develop longer-term integrated management strategies for the disease.

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Table 1. Fungicides approved for the control of *Phytophthora* on asparagus in California, USA (www.greenbook.net)

Product	Active ingredient	Product application rate	Water vol (litres/ha)	Timing	Harvest interval
Ridomil Gold EC	Metalaxyl-M (48 %)	1.2 litre /ha as a broadcast spray	Min. 94.0	**Cutting beds:** Apply 30-60 days before the 1st cutting. For additional control, make another application just before the beginning of harvest. **New plantings:** Apply after planting seedlings or after covering one-year-old crowns	1 day
Aliette WDG	Fosetyl-aluminium (80 %)	5.6 kg/ha as a foliar spray	187.0-468.0	Apply once per season to fully expanded asparagus ferns. Do not apply to ferns that are beginning to senesce. Thorough coverage is required.	110 days

Appendix 1. Product label for Ridomil Gold EC in New Zealand

POISON
KEEP OUT OF REACH OF CHILDREN

Ridomil® GOLD EC

SYSTEMIC FUNGICIDE

Active Ingredient:
RIDOMIL Gold EC contains 480 g/litre METALAXYL-M in the form of an emulsifiable concentrate.

For the control of Phytophthora Spear Rot in Asparagus.

Net Contents: 1 litre

Registered pursuant to the Pesticides Act 1979 No. 4952.

Restricted Use Pesticide
This product must only be sold to and used by bona fide Asparagus growers.

Syngenta Crop Protection Limited
Tower 2, Level 7, 110 Symonds Street, Auckland
In a transport emergency dial 111, Police or Fire Brigade.
For specialist advice in an emergency only, call 0800 734 607 (24 hours).

N3, 454317
UN-Free

syngenta

PLEASE READ THE LABEL COMPLETELY BEFORE USE

WARNING
This product may be harmful if swallowed. Risk of serious damage to eyes from contact. May cause sensitisation from skin contact.

PRECAUTIONS
Store in original container away from foodstuffs.
When mixing or applying wear waterproof gloves with face and eye protection.
Avoid skin contact and wash hands and exposed skin before meals and after work.
Container disposal: Triple rinse empty container and add residue to spray tank. Burn if circumstances, especially wind direction permit, otherwise bury in a suitable landfill.
Avoid contamination of any water supply with chemical or empty container.

FIRST AID
If swallowed DO NOT induce vomiting. For advice, contact the National Poisons Centre 0800 POISON (0800 764766) or a doctor immediately. Begin artificial respiration if the victim is not breathing. Use mouth-to-nose rather than mouth-to-mouth. Obtain medical attention. If skin or hair contact occurs, remove contaminated clothing and flush skin and hair with running water. If splashed in eyes, wash out immediately with water. Obtain medical attention. If inhaled move the victim to fresh air immediately. Begin artificial respiration if breathing has stopped.

DISCLAIMER
Warning: RIDOMIL Gold EC contains a metalaxyl isomer.
Experience has shown that strains of fungus resistant to metalaxyl isomers have developed resulting in a reduction in the efficacy of the product and thus in yield losses. Since the occurrence of resistance cannot be foreseen, Syngenta accepts no responsibility for any loss of, or damage to, crops resulting from the failure of RIDOMIL Gold EC to control resistant strains. Where products have previously been found to be ineffective in controlling diseases, or if the user suspects that a tolerant or resistant strain is present, then RIDOMIL Gold EC should NOT be used. Advice as to alternative treatments should be sought in such cases.

GENERAL INFORMATION
RIDOMIL Gold EC is a systemic fungicide for the control of soil-borne Phytophthora Spear Rot of asparagus.

NOTE: RIDOMIL Gold EC must NOT be applied for any other use than that specified on the label.

9 414644 000264

DIRECTIONS FOR USE

Crop	Disease	Rates	Critical Comments
Asparagus	Phytophthora Spear Rot	1 to 1.3 litres per sprayed hectare	Use the higher rate if disease was evident during the previous season. Apply in sufficient water to obtain good ground coverage. Apply as an annual broadcast application in early spring prior to spear emergence. During the cutting season, if disease pressure is severe, a repeat application can be made provided it is made the same day immediately after a hard cutting. Apply no more than two applications in any one season. Ensure that the soil is free of weeds and trash. Light rain or irrigation is necessary to move the fungicide into the soil within 48 hours of application.

MIXING
When tank mixing with other products, add wettable powders, water dispersible granules and flowables first into the partly filled spray tank and agitate before the addition of the required amount of RIDOMIL Gold EC and then add the remainder of the water while agitating.

COMPATIBILITY
RIDOMIL Gold EC is compatible with the herbicides commonly used in Asparagus and can be applied with conventional ground and aerial spraying equipment.

WITHHOLDING PERIOD
Asparagus ..... 4 days

STORAGE
Store in a cool, dry place, avoiding temperatures below -10°C and above 35°C.

WARRANTY
This formulation is warranted to contain the specified active ingredient within accepted analytical tolerance when packed. The user bears the risk for damage resulting from factors beyond the manufacturer's control. The manufacturer declines all liability for damage resulting from improper storage or use of the product.

Distributed by Syngenta Crop Protection Limited,
Tower 2, Level 7, 110 Symonds Street, Auckland.

Appendix 2

Contacts during report preparation:

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