Aquatic Plant Control Research Program

Assessment of Fungal Pathogens as Biocontrol Agents of *Myriophyllum spicatum*

by J. L. Harvey, Harry C. Evans, 
*International Institute of Biological Control*

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Prepared for Headquarters, U.S. Army Corps of Engineers
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Prepared for U.S. Army Corps of Engineers
Washington, DC  20314-1000

Monitored by U.S. Army Engineer Waterways Experiment Station
3909 Halls Ferry Road, Vicksburg, MS  39180-6199
Waterways Experiment Station Cataloging-in-Publication Data

Harvey, J. L.
Assessment of fungal pathogens as biocontrol agents of *Myriophyllum spicatum* / by J.L. Harvey, Harry C. Evans; prepared for U.S. Army Corps of Engineers; monitored by U.S. Army Engineer Waterways Experiment Station.
35 p. : ill. ; 28 cm. -- (Miscellaneous paper ; A-97-1)
Includes bibliographic references.
1. Aquatic weeds -- Biological control. 2. Phytopathogenic fungi. 3. Eurasian watermilfoil -- Control. I. Evans, H. C. II. United States. Army. Corps of Engineers. III. U.S. Army Engineer Waterways Experiment Station. IV. Aquatic Plant Control Research Program (U.S. Army Engineer Waterways Experiment Station) V. Title. VI. Series: Miscellaneous paper (U.S. Army Engineer Waterways Experiment Station) ; A-97-1.
TA7 W34m no.A-97-1
Preface

The work reported herein was conducted as part of the Aquatic Plant Control Research Program (APCRP), Work Unit 32863. The APCRP is sponsored by the Headquarters, U.S. Army Corps of Engineers (HQUSACE), and is assigned to the U.S. Army Engineer Waterways Experiment Station (WES) under the purview of the Environmental Laboratory (EL). Funding was provided under Department of the Army Appropriation No. 96X3122, Construction General. The APCRP is managed under the Center for Aquatic Plant Research and Technology (CAPRT), Dr. John W. Barko, Director. Mr. Robert C. Gunkel was Assistant Director for the CAPRT. Program Monitor during this study was Ms. Denise White, HQUSACE.

The Principal Investigator for the study was Dr. Harry C. Evans, International Institute of Biological Control, Silwood Park, Ascot, United Kingdom. He was assisted in the research by postdoctoral candidate, Dr. J. L. Harvey. The study was conducted and the report prepared by Drs. Evans and Harvey. The research coordinator at WES was Dr. Judy F. Shearer.

This investigation was performed under the general supervision of Dr. John W. Keeley, Director, EL; Dr. Conrad J. Kirby, Chief, Ecological Research Division (ERD), EL; and Dr. Alfred F. Cofrancesco, Jr., Chief, Aquatic Ecology Branch, ERD.

At the time of publication of this report, Director of WES was Dr. Robert W. Whalin. Commander was COL Bruce K. Howard, EN.

This report should be cited as follows:


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1 Introduction

Myriophyllum spicatum L. (or Eurasian watermilfoil) is a member of the Haloragaceae family. It is a submersed aquatic plant that grows in a wide range of environmental conditions, in both fresh and brackish water. In weedy situations, it is fast growing, forming dense mats of foliage that interfere with the normal usage of water courses. Reproduction is by fragmentation of stems and the development of overwintering buds; seed formation also occurs but may play little part in the spread of the weed.

Myriophyllum spicatum is widely distributed throughout the United Kingdom, with records from Cornwall through to the Outer Hebrides, and occurs in most European countries from Scandinavia in the North to Sicily in the South (Kew Herbarium records). It also occurs in most of Asia as well as in East Africa (Harley and Forno 1990). Although locally common throughout the natural range, it is rarely dominant and has never been reported as a weed problem. It is most frequently found in the U.K. in still water, especially in lime-rich areas. Other Myriophyllum spp. (i.e., M. alterniflorum and M. proserpinacoides) share its habitat, while M. verticillatum grows in faster flowing water.

Myriophyllum spicatum has been a problem in the United States since the 1930s (Harley and Forno 1990). In the 1950s and 1960s, it became a serious ecological and economical weed in larger bodies of water in North America. As an ecological problem, M. spicatum can greatly reduce the numbers of naturally occurring aquatic plant species, with records of a fall in species number from 20 to 9 in a 2-year period, with M. spicatum coverage increasing from 2 percent to 20 to 45 percent over the same period (Madsen et al. 1990).

Attempts to control M. spicatum have involved both mechanical and chemical methods. Mechanical clearance can be cheaper than chemical alternatives, but needs to be carried out at least twice during the summer to produce a reasonable reduction in plant biomass. Herbicide applications have been successful; both underwater application made by boat and aerial application can give good control. However, because of environmental concerns, application of chemical herbicides needs careful consideration. Due to the dilution from a body of water, large amounts of herbicide need to be applied; if control is not sufficient, reinfestation can be rapid. In addition, the chemical has
to be specific and persistent enough to control the weed with no residual activity.

Many of the early investigations into biological control agents for *M. spicatum* concentrated on insects. Species on other *Myriophyllum* spp. from within the United States have been identified as possible control agents. A pyralid moth, *Acentria nivea*, found in stands of *Myriophyllum exalbescens* in the St. Lawrence River caused leaf loss and girdling of stems (Batra 1977). Surveys predominantly for insect agents have also been carried out in Pakistan, Bangladesh, and much of Eastern Europe and Asia (Commonwealth Institute of Biological Control (CIBC) 1970; Harley and Forno 1990). However, many of the insects found proved to be nonspecific to the target weed and hence of limited use as biological control agents.

Use of pathogens has long been regarded as a good potential method of biological control for *M. spicatum* (Freeman and Charudattan 1980). Work has been undertaken on isolating and assessing fungal pathogens from within the United States: *Acremonium curvulum* and *Fusarium sporotrichoides* were tested at Wisconsin, but though capable of causing lesions, both failed to control the weed in large-scale tests (Andrews and Hecht 1981; Andrews, Hecht, and Bashirian 1982; Charudattan 1990).

A fungal pathogen, *Colletotrichum gloeosporioides*, found on *M. spicatum* in Wisconsin, has been evaluated as a mycoherbicide, in combination with three possible chemical herbicides at down to 10 percent of their recommended concentration (Sorsa, Nordheim, and Andrews 1988). *Mycoleptodiscus terrestris*, from the southern States, has also been tested against *M. spicatum* and a series of aquatic plants and terrestrial crop plants and has been shown to be virulent and reasonably specific (Verma and Charudattan 1993). Endophytic fungi have been reported in the literature on *Myriophyllum* sp. in both Europe and the United States (Sparrow 1974; Luther 1979) and appear to be damaging.

*Myriophyllum spicatum* constitutes part of the background or natural aquatic flora throughout most of Europe and rarely reaches weed status. However, some of the ecosystems (in Central Western Europe) have recently been invaded by the North American exotic species *Myriophyllum heterophyllum* (Spanghehl and Scharrenberg 1986). Domination by the latter species would indicate that a different spectrum of natural enemies occurs in Europe and that a search for a fungal biological control agent for *M. spicatum* within Europe would be beneficial.
2 Material and Methods

Surveys

From plant records (Kew Herbarium, National Water Boards and the Terrestrial Ecological Surveys), sites of *M. spicatum* were selected to give a range of locations and environmental conditions. Sites were sampled over a 2-year period (1994-1995) during the growing season (May-October). Both *M. spicatum* and other *Myriophyllum* species were collected, and samples of water and soil were also taken in some cases. Samples were taken back to the weed pathology laboratories of the International Institute of Biological Control (IIBC), Silwood Park, Ascot Berks (U.K.)

Isolation

Isolation from diseased tissues of *M. spicatum* collected during the surveys was carried out following standard procedures; plants were washed under running tap water for 2 hr and rinsed in sterile distilled water before being placed on tap water agar (TWA). Samples of soil and water were also plated onto media selective for *Fusarium* (Komada 1975), and specific baits were employed for Oomycetes and aquatic fungi. Cultures were forwarded to the International Mycological Institute (IMI), Egham, Surrey (U.K.), for identification.

Screening

Isolates of species that are commonly pathogenic to plants and those species that were isolated constantly from several sites were screened against *M. spicatum*.

Sections of plants (with two nodes) were cut, weighed (after excess surface water was removed), and placed in 100 ml of sterile distilled water in a jar. These were inoculated with either two 9-mm agar plugs or a $10^6$ or $10^6$ spores per milliliter suspension (dependent upon sporulation of the isolate) and kept at a constant 25 °C with 12 hr light. Two uninoculated controls were
included. After 3 weeks, plants were visually assessed for any indication of infection. After a further 2 weeks, samples were again visually assessed, reweighed (after excess surface water was removed), and plated onto TWA with antibiotics for identification and proof of pathogenicity (Koch's postulates). Comparison of initial and final weights was used to give an indication of inhibitory effect in the absence of physical signs of infection (it was noted during field collecting that plants generally show few lesions or other signs of infection).
3 Results and Discussion

Surveys

Over the two seasons of the project, surveys have been carried out at nearly 200 sites in 12 European countries, covering most of England, Wales, and Scotland, eastern France, northern Italy, northern Spain, northern Switzerland, southern Germany, central Austria, central Ireland, Portugal, and Slovenia (Appendix A). Sites from which *M. spicatum* was collected have varied in character from ponds and drainage ditches to large lakes, rivers, and canals. Plants were found in both still and fast-flowing water, and at depths from 5-8 cm to 4-5 m (in the clear waters of some of the southern European lakes). Though normally found in water of a neutral to alkaline pH, in a few sites in Scotland, *M. spicatum* was found in water that, due to surrounding peat, was mildly acidic. As the acidity increased, *M. spicatum* was replaced by *M. alterniflorum*.

Growth characteristics of the plants often varied, depending upon site features. In fast-flowing, shallow rivers, plants had noticeable red stems that trailed up to 1 m downstream and rooted at several points. In slower moving rivers and canals, plants had more branched stems, larger leaves (up to 3 cm in the Royal Canal, Ireland), and more surface detritus. In lakes, the major change in character was dependent upon the depth at which the plant was growing. Along the shallow edges of lakes, stems could be only a few centimeters long, increasing to several meters in deeper water. Plants grew deeper in the clearer and warmer southern European lakes compared with the more cloudy colder northern lakes in England and Scotland. When returned to the standard laboratory conditions, all plant samples grew in similar fashion, indicating that these are ecotypes rather than biotypes.

Isolations

From the plant material (*M. spicatum* and related species), water, and soil samples collected, over 400 isolates (from normally pathogenic genera) have been isolated, comprising 56 identified species in 39 genera (Appendix B). There was no correlation between the species isolated and the collection site, either environmentally or geographically. The majority of isolates are
common colonizers of plant tissues and genera. *Fusarium* and *Acremonium* have been routinely isolated from all types of locations. Significantly, *Gliocladium roseum* has only been isolated from lakes and ponds, not from rivers. A few isolates are specific aquatic fungi; e.g., *Cylindrocarpon aquaticum* and *Nectria lugdunensis* from the Crinnean Canal in Scotland. Several isolates have been unusual records, such as the two *Embellisia* sp. isolated from Texel in Holland and Slapton Ley in England, which had only previously been recorded from desert soils in Wyoming. *Sclerotium hydrophilum*, isolated from Afriler See in Austria, has previously been recorded on *M. spicatum* in Yugoslavia (IMI Culture collection).

**Screening**

In total, 291 isolates have been tested; of these, 15 have shown some degree of pathogenicity or control, causing a reduction in growth (assessed by weight) and in more severe cases, loss of leaves, necrosis, or death (Appendix C). The majority of isolates damage the older tissue of the plant and have only a minimum effect on the newer growth. Of the isolates giving some degree of control, 12 of these were reisolated from plant tissues.

Of these 12 isolates that satisfy Koch's postulates, two are still unidentified Hyphomycetes (Mir 49a and Mir 80c) and two Coelomycetes (Mir 35 and Mir 36). Identification has been hampered by their very low and sporadic sporulation, though this does not appear to hinder either infection or reisolation from plant tissues.

Three of the isolates showing some degree of control are similar to those already screened in the United States (Andrews and Hecht 1981; Andrews, Hecht, and Bashirian 1982; Charudattan 1990; Verma and Charudattan 1993). *Acremonium* sp. (Mir 68c) has been screened twice giving good results and was reisolated both times. Results of reisolation of *Fusarium sporotrichoides* (MIR 96b) are still pending, but the isolate has been able to cause the death of inoculated plant sections. The native American isolates screened, *Acremonium curvulum* and *Fusarium sporotrichoides* (Andrews and Hecht 1981; Andrews, Hecht, and Bashirian 1982; Charudattan 1990), were successful in small-scale tests, but failed to control the weed in large trials. Though this may be the case with the European isolates, their closer evolution with the plants should allow for more consistent results. An isolate of *Colletotrichum gloeosporioides* (teleomorph: *Glomerella cingulata*) has been tested as a mycoherbicide in the United States (Sorsa, Nordheim, and Andrews 1988) while the European strain (Mir 51), though not reisolated from plant tissue, has been screened twice and reduced growth rate in both tests. Significantly, *Mycleptodiscus terrestris*, which has been isolated in both the United States and China and shown to be virulent and reasonably specific to *M. spicatum* (Verma and Charudattan 1993), was not found during any of the European surveys.
Several of the isolates that have shown a degree of control (*Cylindrocarpon destructans, Fusarium solani, Coniothyrium fuckelii, Geotrichum candidum*, and *Gliocladium roseum*) are generally not regarded as pathogenic or specific. Their ability to infect *M. spicatum* was probably opportunistic, aided by the small plant sections used in the screen, and may not be repeatable with whole plants.


# Appendix A
## Locations of Collection Sites

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<thead>
<tr>
<th>Code</th>
<th>Date</th>
<th>Site</th>
</tr>
</thead>
<tbody>
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<td>MIR 1-9</td>
<td>9/4/93</td>
<td>Slapton Ley, Slapton, Devon, England</td>
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<td>MIR 10-12</td>
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<td>Cherrybrook, High Dartmoor, Devon, England</td>
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<td>MIR 13</td>
<td>10/12/93</td>
<td>Streets Heath Pond, Chobham, Surrey, England</td>
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<td>MIR 14</td>
<td>10/12/93</td>
<td>Wood Street Pond, Guilford, Surrey, England</td>
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<td>MIR 15</td>
<td>posted</td>
<td>Southern Prague Lakes, Czech Republic</td>
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<td>MIR 16</td>
<td>11/3/93</td>
<td>Wicken Fen Canal, Cambridgeshire, England</td>
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<td>South Ferring Pond, Worthing, Sussex, England</td>
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<td>MIR 18</td>
<td>8/28/93</td>
<td>Angermünde, Germany</td>
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<td>9/1/93</td>
<td>Großer Buckowsee, Eberswalde, Germany</td>
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<td>Oder-Havel-Kanal, Eberswalde, Germany</td>
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<td>MIR 21</td>
<td>7/27/93</td>
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<td>Heider See, Bonn, Germany</td>
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<td>1/2/94</td>
<td>De Koog Pond, Texel Island, Netherlands</td>
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<td>Fedder Pond, Chatsworth Palace, Derbyshire, England</td>
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<td>Finger Pond, Priory Park, Bedfordshire, England</td>
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<tr>
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<td>Harold and Odell Lake, Harold, Bedfordshire, England</td>
</tr>
<tr>
<td>Code</td>
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<td>Site</td>
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<td>6/28/94</td>
<td>River Axe, Axminster, Devon, England</td>
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<td>6/28/94</td>
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<td>MIR 39</td>
<td>6/28/94</td>
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<td>Exeter Canal, Topsham Lock, Exminster Marshes, Devon, England</td>
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<td>7/5/94</td>
<td>Lake 32, Keynes Country Park, Gloucestershire, England</td>
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<td>7/5/94</td>
<td>Lake 56, Neighbour Country Park, Gloucestershire, England</td>
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<td>MIR 48</td>
<td>7/5/94</td>
<td>Lake Below 56, Neighbour Country Park, Gloucestershire, England</td>
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<td>7/6/94</td>
<td>River Hart, Bramshill, Hampshire, England</td>
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<td>MIR 50</td>
<td>7/6/94</td>
<td>Whitewater River, North Warnborough, Hampshire, England</td>
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<td>MIR 51</td>
<td>7/6/94</td>
<td>Basingstoke Canal, Broad Oak Bridge, Hampshire, England</td>
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<td>7/6/94</td>
<td>Basingstoke Canal, Dogmersfield, Hampshire, England</td>
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<td>MIR 93</td>
<td>10/5/94</td>
<td>Lac de Longmer, Langmer, Gerardmer, France</td>
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<td>MIR 94</td>
<td>10/5/94</td>
<td>Stream north of Schaenau, Rhinau, France</td>
</tr>
<tr>
<td>MIR 95</td>
<td>10/5/94</td>
<td>River Rhine, Rhinau, France</td>
</tr>
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<td>Code</td>
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<td>Site</td>
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<tr>
<td>MIR 96</td>
<td>10/5/94</td>
<td>Canal du Rhône au Rhin, Neunkirch, France</td>
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<tr>
<td>MIR 97</td>
<td>10/5/94</td>
<td>Etang de Stock, Diane-et-Kerpick, Gorraie, France</td>
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<td>MIR 98</td>
<td>10/6/94</td>
<td>River Moselle, Trier, Germany</td>
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<td>MIR 99</td>
<td>10/7/94</td>
<td>Feilinger See, west of Koblenz, Germany</td>
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<td>MIR 100</td>
<td>4/29/95</td>
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<td>MIR 101</td>
<td>4/30/95</td>
<td>Pond off River Moristin, Glen Moriston, Highland Region, Scotland</td>
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<td>MIR 102</td>
<td>4/30/95</td>
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<td>MIR 103</td>
<td>4/30/95</td>
<td>River Schiel, near Loch Duich, Highland Region, Scotland</td>
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<tr>
<td>MIR 104</td>
<td>5/1/95</td>
<td>Tarn off Road, Kilmalaug, Isle of Skye, Highland Region, Scotland</td>
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<tr>
<td>MIR 105</td>
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<td>Tarn at Staffin, north Skye, Isle of Skye, Highland Region, Scotland</td>
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<tr>
<td>MIR 106</td>
<td>5/2/95</td>
<td>River Schnizort, Dunvegen, Isle of Skye, Highland Region, Scotland</td>
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<tr>
<td>MIR 107</td>
<td>5/2/95</td>
<td>River at Bernisdale, Isle of Skye, Highland Region, Scotland</td>
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<td>MIR 108</td>
<td>5/2/95</td>
<td>River Drynock, Carbost, Isle of Skye, Highland Region, Scotland</td>
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<tr>
<td>MIR 109</td>
<td>5/3/95</td>
<td>River at Pentland Road, Isle of Lewis, Highland Region, Scotland</td>
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<td>MIR 110</td>
<td>5/3/95</td>
<td>River Greeta, Pentland, Isle of Lewis, Highland Region, Scotland</td>
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<td>5/3/95</td>
<td>River at Chanais, Boderer, Isle of Lewis, Highland Region, Scotland</td>
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<tr>
<td>MIR 112</td>
<td>5/3/95</td>
<td>River at Leinisical, Isle of Lewis, Highland Region, Scotland</td>
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<tr>
<td>MIR 113</td>
<td>5/3/95</td>
<td>River to Loch Lathainuel, Isle of Lewis, Highland Region, Scotland</td>
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<tr>
<td>MIR 114</td>
<td>5/4/95</td>
<td>River at Bahii Allen, Isle of Lewis, Highland Region, Scotland</td>
</tr>
<tr>
<td>MIR 115</td>
<td>5/4/95</td>
<td>River at Loch mouth, Tarbet, Isle of Lewis, Highland Region, Scotland</td>
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<td>MIR 116</td>
<td>5/4/95</td>
<td>River at Tarbet, Isle of Lewis, Highland Region, Scotland</td>
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<tr>
<td>MIR 117</td>
<td>5/5/95</td>
<td>River at Strathkiaard, Ullapool, Highland Region, Scotland</td>
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<tr>
<td>MIR 118</td>
<td>5/5/95</td>
<td>Loch at Knockau, Ullapool, Highland Region, Scotland</td>
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<tr>
<td>MIR 119</td>
<td>5/5/95</td>
<td>River at Benmore, Ledmore Junction, Highland Region, Scotland</td>
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<tr>
<td>MIR 120</td>
<td>5/5/95</td>
<td>River Oakley, Ledmore, Highland Region Scotland</td>
</tr>
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<td>Code</td>
<td>Date</td>
<td>Site</td>
</tr>
<tr>
<td>---------</td>
<td>---------</td>
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</tr>
<tr>
<td>MIR 121</td>
<td>5/23/95</td>
<td>Cleethorpes Country Park Lake, Cleethorpes, Humberside, England</td>
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<tr>
<td>MIR 122</td>
<td>5/23/95</td>
<td>Louth Canal, Tetney Lock, south of Cleethorpes, Lincolnshire, England</td>
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<tr>
<td>MIR 123</td>
<td>5/23/95</td>
<td>Trout Pond (1), Maltby le Marsh, Mabelthorpe, Lincolnshire, England</td>
</tr>
<tr>
<td>MIR 124</td>
<td>5/23/95</td>
<td>River at Yarburgh, Louth, Lincolnshire, England</td>
</tr>
<tr>
<td>MIR 125</td>
<td>5/23/95</td>
<td>Fishing Pond (1), Maltby le Marsh, Mabelthorpe, Lincolnshire, England</td>
</tr>
<tr>
<td>MIR 126</td>
<td>5/24/95</td>
<td>River Bain, Coningsby, Sleaford, Lincolnshire, England</td>
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<tr>
<td>MIR 127</td>
<td>5/23/95</td>
<td>Fishing Pond (2), Maltby le Marsh, Mabelthorpe, Lincolnshire, England</td>
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<tr>
<td>MIR 128</td>
<td>5/22/95</td>
<td>Lakes at Ealand, Humberside, England</td>
</tr>
<tr>
<td>MIR 129</td>
<td>5/23/95</td>
<td>Trout Pond (2), Maltby le Marsh, Mabelthorpe, Lincolnshire, England</td>
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<tr>
<td>MIR 130</td>
<td>6/6/95</td>
<td>Rookley Lake, Rookley Country Park, Isle of Wight, England</td>
</tr>
<tr>
<td>MIR 131</td>
<td>6/7/95</td>
<td>Alvington Manor Pool, Carisbrooke, Isle of Wight, England</td>
</tr>
<tr>
<td>MIR 132</td>
<td>6/12/95</td>
<td>Bala Lake, Gwynedd, Wales</td>
</tr>
<tr>
<td>MIR 133</td>
<td>6/13/95</td>
<td>River Teme, Hereford and Worcestershire, England</td>
</tr>
<tr>
<td>MIR 134-135</td>
<td>6/13/95</td>
<td>River at Oversley Green, Alcester, Hereford and Worcestershire, England</td>
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<tr>
<td>MIR 136</td>
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<td>Lago di Maggiore, Barenno, Arona, Peidmont, Italy</td>
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<td>MIR 137</td>
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<td>Lago di Monate, Monate, Lombardi, Italy</td>
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<td>MIR 138</td>
<td>7/4/95</td>
<td>Lago di Varese, Biandronno, Lombardi, Italy</td>
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<tr>
<td>MIR 139</td>
<td>7/4/95</td>
<td>Lago di Como, Cernobbio, Lombardi, Italy</td>
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<tr>
<td>MIR 140</td>
<td>7/5/95</td>
<td>Lago di Endine, Sponone al Lago, Lombardi, Italy</td>
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<tr>
<td>MIR 141</td>
<td>7/5/95</td>
<td>Lago d’Idro, opposite Idro, Lombardi, Italy</td>
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<td>MIR 142</td>
<td>7/6/95</td>
<td>Lago di Garda, Maderno, Lombardi, Italy</td>
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<td>MIR 143</td>
<td>7/6/95</td>
<td>River Site, Quarto d’Altino, Veneto, Italy</td>
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<td>MIR 144</td>
<td>7/6/95</td>
<td>River at Oderzo, Veneto, Italy</td>
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<td>MIR 145</td>
<td>7/6/95</td>
<td>River at Blessaglia, Veneto, Italy</td>
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<td>MIR 146</td>
<td>7/6/95</td>
<td>River at Pordenone-&gt;Udine Road, Veneto, Italy</td>
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<td>MIR 147</td>
<td>7/7/95</td>
<td>Lake Bohinjskaje, Ribcev Laz, Slovenia</td>
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<tr>
<td>MIR 148</td>
<td>7/7/95</td>
<td>Lake Bled, Bled, Slovenia</td>
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<tr>
<td>MIR 149</td>
<td>7/8/95</td>
<td>Afrilzer See, north of Villach, Austria</td>
</tr>
<tr>
<td>Code</td>
<td>Date</td>
<td>Site</td>
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<tr>
<td>MIR 150</td>
<td>7/8/95</td>
<td>Brennsee, north of Villach, Austria</td>
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<td>7/8/95</td>
<td>Millstater See, Spittal, Austria</td>
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<td>MIR 152</td>
<td>7/8/95</td>
<td>Mondsee, east of Salzburg, Austria</td>
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<tr>
<td>MIR 153</td>
<td>7/8/95</td>
<td>Attersee, east of Salzburg, Austria</td>
</tr>
<tr>
<td>MIR 154</td>
<td>8/7/95</td>
<td>Lochgelly, northeast of Dumferlin, Fife, Scotland</td>
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<td>MIR 155</td>
<td>8/7/95</td>
<td>Loch Ore, Ballingry, Fife, Scotland</td>
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<tr>
<td>MIR 156</td>
<td>8/7/95</td>
<td>River Tay, Perth Racecourse, Tayside, Scotland</td>
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<tr>
<td>MIR 157</td>
<td>8/8/95</td>
<td>River South Esk, Brechin-Forfar, Tayside, Scotland</td>
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<tr>
<td>MIR 158</td>
<td>8/8/95</td>
<td>River Don, Inverurie, Grampian Region, Scotland</td>
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<tr>
<td>MIR 159</td>
<td>8/8/95</td>
<td>River Ythan, Methlick, Grampian Region, Scotland</td>
</tr>
<tr>
<td>MIR 160</td>
<td>8/8/95</td>
<td>River Deveron, Turriff, Grampian Region, Scotland</td>
</tr>
<tr>
<td>MIR 161</td>
<td>8/9/95</td>
<td>Loch Morlich, east of Aviemore, Highland Region, Scotland</td>
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<tr>
<td>MIR 162</td>
<td>8/9/95</td>
<td>Loch an Eilein, south of Aviemore, Highland Region, Scotland</td>
</tr>
<tr>
<td>MIR 163</td>
<td>8/9/95</td>
<td>Loch Insh, south west of Aviemore, Highland Region, Scotland</td>
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<tr>
<td>MIR 164</td>
<td>8/9/95</td>
<td>Loch Tay, Kenmore Tayside, Scotland</td>
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<tr>
<td>MIR 165</td>
<td>8/9/95</td>
<td>Loch on River Dohen, Benmore, Central Region, Scotland</td>
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<tr>
<td>MIR 166</td>
<td>8/10/95</td>
<td>Loch Lomond, Inveriglas, Strathclyde, Scotland</td>
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<tr>
<td>MIR 167</td>
<td>8/10/95</td>
<td>Loch above Loch Long, Strathclyde, Scotland</td>
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<tr>
<td>MIR 168</td>
<td>8/10/95</td>
<td>Crian Canal, Lochgilphead, Kintyre, Strathclyde, Scotland</td>
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<tr>
<td>MIR 169</td>
<td>8/10/95</td>
<td>River Add, Bridgend, Kintyre, Strathclyde, Scotland</td>
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<tr>
<td>MIR 170</td>
<td>8/10/95</td>
<td>Loch Coille-Bharr, Knapdale Forest, Kintyre, Strathclyde, Scotland</td>
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<td>MIR 171</td>
<td>8/10/95</td>
<td>Loch Eck, north of Donnor, Strathclyde, Scotland</td>
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<td>MIR 172</td>
<td>8/11/95</td>
<td>Loch Ascog, Isle of Bute, Strathclyde, Scotland</td>
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<td>MIR 173</td>
<td>8/11/95</td>
<td>River Leven, Renton, north of Dumbarton, Strathclyde, Scotland</td>
</tr>
<tr>
<td>MIR 174</td>
<td>8/11/95</td>
<td>Carman Reservoir, Renton, north of Dumbarton, Strathclyde, Scotland</td>
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<tr>
<td>MIR 175</td>
<td>8/9/95</td>
<td>Loch on B846, below Rannoch, Tayside, Scotland</td>
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<td>MIR 176</td>
<td>9/21/95</td>
<td>Embalsa del Ebro, Caniabrica, Spain</td>
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<td>MIR 177</td>
<td>9/22/95</td>
<td>Embalsa de Aguilar de Campo, Aguilar, Spain</td>
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<td>MIR 178</td>
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<td>Rio Rivero, Ruesaga, Spain</td>
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(Sheet 6 of 7)
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<td>Rio Carrion, Velilla del Carrion, Spain</td>
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<td>MIR 180</td>
<td>9/23/95</td>
<td>Rio Sil, Ponferrada, between Villa Patos and Toralde losv., Spain</td>
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<td>MIR 181</td>
<td>9/23/95</td>
<td>Rio Sil, Ponferrada, below Penarrubia dam and Salas de la Riberia, Spain</td>
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<td>MIR 182</td>
<td>9/24/95</td>
<td>Lago de Sanabria, above Puebla Sanabria, Spain</td>
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<tr>
<td>MIR 183</td>
<td>9/24/95</td>
<td>Rio Tera, Puebla Sanabria, Spain</td>
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<td>MIR 184</td>
<td>9/24/95</td>
<td>Rio Sabor, south of Rabal, Portugal</td>
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<tr>
<td>MIR 185</td>
<td>9/24/95</td>
<td>Rio Igrejas, Gamonde, Portugal</td>
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<tr>
<td>MIR 187</td>
<td>9/24/95</td>
<td>Rio Macas, Spanish Portuguese border, Portugal</td>
</tr>
<tr>
<td>MIR 188</td>
<td>9/25/95</td>
<td>Rio Coa, Vilar to Sabugal Road, Portugal</td>
</tr>
<tr>
<td>MIR 189</td>
<td>9/25/95</td>
<td>Rio Zezere, Caria to Teixosa Road, Portugal</td>
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<td>MIR 190</td>
<td>9/25/95</td>
<td>Rio Dao, N231 north of Constancia, Portugal</td>
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<td>MIR 191</td>
<td>9/26/95</td>
<td>Rio Tejo, south of Constancia, Portugal</td>
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<td>Chester Canal, Chester, Cheshire, England</td>
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<td>MIR 193</td>
<td>10/17/95</td>
<td>Llyn, Clwyd, Wales</td>
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</table>
Appendix B
Fungal Species Isolated From *Myriophyllum spicatum* During 2 Years of Surveying in Europe

*Absidia cylindrospora* Hagem.
*Acroconium strictum* W. Gams.
*Acroconium persicinum* (Nicot.) W. Gams.
*Acrophaialophora levis* Samson and T. Mahmood.
*Alternaria infectoria* E. G. Simmons. Agg.
*Apiospora montagnei* Sacc.
*Ascochyta* sp. Lib.
*Aureobasidium* sp. Viola and Boyer.
*Byssoschlamys nivea* Westling.
*Botrytis cinerea* Pers.
*Chrysosporium* sp. Corda
*Cladobotryum* sp. Corda.
*Colletotrichum dematium* (Pers.:Fr.) Grove.
*Coniothyrium fuckelii* Sacc.
*Coniothyrium sporulosum* (W. Gams and Domsch) Aa.
*Corynascus sepedonium* (Emm.) Arx.
*Cryptosporiopsis* sp. Bub. and Kabat.
*Cylindrocarpon destructans* (Zinssm.) Scholten.
*Cylindrocarpon* sp. Morgan.
*Emericellopsis minima* Stolk.
*Fusarium acuminatum* Ellis and Everhart.
*Fusarium avenaceum* (Fr.) Sacc.
*Fusarium crookwellense* Burgess, P. E. Nelson and Touss.
*Fusarium culmorum* (W.G.Sm.) Sacc.
*Fusarium equisitii* (Corda) Sacc.
*Fusarium flocciferum* Corda.
*Fusarium graminearum* Schwabe.
*Fusarium oxysporum* Schlecht.
*Fusarium poae* (Peck) Wollenweber.
Appendix B  Fungal Species Isolated From Myriophyllum spicatum

Fusarium sambucinum Fuckel
Fusarium solani (Martius) Sacc.
Fusarium sporotrichioides Sherb.
Fusarium sp. Link.
Geotrichum candidium Link.
Gliocladium catenulatum J. C. Gilman and E. V. Abbott.
Gliocladium roseum Banier.
Gliomastix murorum var. felina (Marchal) S. Hughes.
Glomerella cingulata (Stoneman) Spauld. and H. Schrenk.
Microdochium tabacinum (T. H. Beyma) Arx.
Microsphaeropsis sp. Höhn
Mycocentrospora acerina (Hartig) Deighton.
Myrothecium cinctum (Corda) Sacc.
Myrothecium roidum Tode.
Nectria discophora (Mont.) Mont.
Nectria lugdunensis J. Webster
Phaeoseptoria sp. Speg.
Phoma complanata (Tode) Desm.
Phoma dennisii Boerema.
Phoma eupyrena Sacc.
Phoma exigua Desm.
Phoma hedericolora (Dur. and Mont.) Boerema.
Phoma leevillei Boer. and G. J. Bollen.
Phoma macrostroma Mont.
Phoma nebulous (Pers.:Fr.) Berk.
Phoma tropica R. Schnid. and Boerema.
Phoma sect. Paraphoma (Morgan-Jones and White) Boerema
Phoma sp. Desm.
Phomopsis sp. Sacc.
Pithomyces chartarum (Berk. and M. A. Curtis) M. B. Ellis
Plectosporaerella cucumerina (Lindf.) Gams.
Pythium sp. Pringsh.
Pythium sp. group F
Pythium sp. group HS
Pythium sp. group T
Pythium aquatil Höhnk.
Pythium acanthophoron Sideris.
Pythium periplcoco Drehrler.
Pythium sleroteichum Drehler.
Sclerotium hydrophilum Sacc.
Stagonospora sp. Sacc.
Saprolegnia parasitica Coker.
Trichosporiella sporotrichoides Oorschot.
Verticillium nigrescens Pethybr.
# Appendix C
Isolates That Have Been Screened Against Sections of *Myriophyllum spicatum*

## Table C1

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<td><em>Plectosphaerella cucumerina</em></td>
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<td>MIR 2</td>
<td><em>Fusarium</em> sp.</td>
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<tr>
<td>MIR 2v</td>
<td><em>Acremonium strictum</em></td>
<td>No response</td>
</tr>
<tr>
<td>MIR 2iii</td>
<td><em>Gliocladium roseum</em></td>
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<tr>
<td>MIR 2ia</td>
<td><em>Pythium</em> sp.</td>
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<tr>
<td>MIR 3iii</td>
<td><em>Embellisia</em> nr. telluster</td>
<td>Good control</td>
</tr>
<tr>
<td>MIR 3a</td>
<td><em>Embellisia</em> nr. telluster (reisolated 3iii)</td>
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<td>MIR 4vi</td>
<td><em>Acremonium strictum</em></td>
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</tr>
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<td>MIR 4xa</td>
<td><em>Fusarium sporotrichoides</em></td>
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</tr>
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<td>MIR 5v</td>
<td><em>Fusarium crookwellense</em></td>
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<td><em>Apioспора montagnei</em></td>
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<td><em>Acremonium strictum</em></td>
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</tr>
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<td><em>Byssoschlamys nivea</em></td>
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<td><em>Fusarium crookwellense</em></td>
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<td><em>Fusarium sporotrichoides</em></td>
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<td><em>Fusarium sporotrichoides</em></td>
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<td>MIR 5iii</td>
<td><em>Acremonium persicinum</em></td>
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<td>MIR 6</td>
<td><em>Verticillum nigrescens</em></td>
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<td>MIR 6vi</td>
<td><em>Acremonium strictum</em></td>
<td>No response</td>
</tr>
</tbody>
</table>

*(Sheet 1 of 10)*
<table>
<thead>
<tr>
<th>Code</th>
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</tr>
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<tbody>
<tr>
<td>MIR 7a</td>
<td>Aureobasidium sp.</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 7xii</td>
<td>Acremonium strictum</td>
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</tr>
<tr>
<td>MIR 7xiii</td>
<td>Fusarium avenaceum</td>
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</tr>
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<td>MIR 8b</td>
<td>Acremonium sp.</td>
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</tr>
<tr>
<td>MIR 13ii</td>
<td>Fusarium sambucinum</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 13i</td>
<td>Fusarium sambucinum</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 16ii</td>
<td>Fusarium graminearum</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 16i</td>
<td>Fusarium sambucinum</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 16ii</td>
<td>Fusarium avenaceum</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 16iii</td>
<td>Fusarium culmorum</td>
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</tr>
<tr>
<td>MIR 16vii</td>
<td>Fusarium culmorum</td>
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</tr>
<tr>
<td>MIR 16</td>
<td>Fusarium solani</td>
<td>Good control</td>
</tr>
<tr>
<td>MIR 16b</td>
<td>Fusarium oxysporum</td>
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</tr>
<tr>
<td>MIR 16a</td>
<td>Fusarium acuminatum</td>
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</tr>
<tr>
<td>MIR 17j</td>
<td>Acremonium strictum</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 17</td>
<td>Fusarium graminearum</td>
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</tr>
<tr>
<td>MIR 18</td>
<td>Mucor hiemalis</td>
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</tr>
<tr>
<td>MIR 18</td>
<td>Alternaria alternata</td>
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</tr>
<tr>
<td>MIR 18a</td>
<td>Coniothyrium sporulosum</td>
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</tr>
<tr>
<td>MIR 18c</td>
<td>Coniothyrium sporulosum</td>
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<tr>
<td>MIR 22i</td>
<td>Verticillium sp.</td>
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<tr>
<td>MIR 22</td>
<td>Fusarium polyphialides</td>
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<td>MIR 22r</td>
<td>Fusarium oxysporum</td>
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</tr>
<tr>
<td>MIR 23</td>
<td>Embellisia indefessa</td>
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<td>MIR 23</td>
<td>Ascochyta sp.</td>
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</tr>
<tr>
<td>MIR 23</td>
<td>Fusarium crookwellense</td>
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<td>MIR 24</td>
<td>Cylindrocladium sp.</td>
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<tr>
<td>MIR 24i</td>
<td>Mucor hiemalis</td>
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<tr>
<td>MIR 25</td>
<td>Cylindrocladium sp.</td>
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</tr>
<tr>
<td>MIR 25ii</td>
<td>Gliocladium roseum</td>
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</tr>
<tr>
<td>MIR 25iii</td>
<td>Gliocladium roseum</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 25i</td>
<td>Gliocladium roseum</td>
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(Sheet 2 of 10)
<p>| Code    | Isolate                          | Result         |
|---------|=================================|----------------|
| MIR 25iv | Gliocladium roseum              | No response    |
| MIR 26  | Oomycete                        | No response    |
| MIR 26a | Fusarium graminearum            | No response    |
| MIR 26a | Acremonium sp.                  | No response    |
| MIR 27e | Gliocladium roseum              | No response    |
| MIR 27d | Gliocladium roseum              | No response    |
| MIR 27f | Acremonium sp.                  | No response    |
| MIR 27i | Trichosporiella sporotrichoides | No response    |
| MIR 27g | Pythium aquatic                 | No response    |
| MIR 27i | Epicoccum nigrum                | No response    |
| MIR 28  | Pythium sclerotrichium          | No response    |
| MIR 29b | Acremonium sp.                  | No response    |
| MIR 29c | Cylindrocarpon sp.              | No response    |
| MIR 30  | Phomopsis sp.                   | No response    |
| MIR 30b | Cylindrocarpon sp.              | No response    |
| MIR 30a | Cylindrocladium sp.             | No response    |
| MIR 30  | Phoma sp.                       | No response    |
| MIR 30i | Stagonospora sp.                | No response    |
| MIR 30  | Pythium sp.                     | No response    |
| MIR 31a | Fusarium oxysporum              | No response    |
| MIR 32  | Phoma sp.                       | No response    |
| MIR 32d | Indeterminate Hyphomycete       | No response    |
| MIR 32  | Acremonium sp.                  | No response    |
| MIR 32a | Cylindrocarpon sp.              | No response    |
| MIR 32b | Verticillium sp.                | No response    |
| MIR 32c | Fusarium culmorum               | No response    |
| MIR 34  | Gliocladium roseum              | Good control   |
| MIR 34a | Fusarium sp.                    | No response    |
| MIR 34b | Corynascus sepedonium           | No response    |
| MIR 35  | Fusarium sambucinum             | No response    |
| MIR 35  | Fusarium graminearum            | No response    |
| MIR 35  | Indeterminate Coelomycete       | Good control   |</p>
<table>
<thead>
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<th>Code</th>
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<th>Result</th>
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<tr>
<td>MIR 35a</td>
<td>Oomycete</td>
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<td>MIR 36e</td>
<td>Indeterminate Ascomycete</td>
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<td>MIR 36</td>
<td>Gliocladium roseum</td>
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</tr>
<tr>
<td>MIR 36b</td>
<td>Mortierella sp.</td>
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<td>MIR 36</td>
<td>Gliomastix murorum var. felina</td>
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<td>MIR 36ii</td>
<td>Indeterminate Hyphomycete</td>
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<tr>
<td>MIR 37b</td>
<td>Phomopsis sp.</td>
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</tr>
<tr>
<td>MIR 37d</td>
<td>Acremonium sp.</td>
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</tr>
<tr>
<td>MIR 38b</td>
<td>Phomopsis sp.</td>
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<td>MIR 38</td>
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<td>MIR 38a</td>
<td>Absidia cylindrospora</td>
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<td>MIR 42</td>
<td>Cledobotryum sp.</td>
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<tr>
<td>MIR 43a</td>
<td>Fusarium sambucinum</td>
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<td>MIR 43</td>
<td>Fusarium sambucinum</td>
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<td>MIR 43c</td>
<td>Fusarium pallidoroseum</td>
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<td>Emericellopsis minima</td>
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<tr>
<td>MIR 43</td>
<td>Acremonium sp.</td>
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</tr>
<tr>
<td>MIR 43</td>
<td>Phoma exigua</td>
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<tr>
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<td>Phomopsis sp.</td>
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<tr>
<td>MIR 43</td>
<td>Fusarium sambucinum</td>
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<td>MIR 44</td>
<td>Indeterminate Hyphomycete</td>
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<tr>
<td>MIR 44</td>
<td>Saprolegnia parasitica</td>
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<td>Cylindrocladium sp.</td>
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</tr>
<tr>
<td>MIR 44</td>
<td>Oomycete</td>
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</tr>
<tr>
<td>MIR 45e</td>
<td>Oomycete</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 45f</td>
<td>Cylindrocarpon destructans</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 45a</td>
<td>Cylindrocarpon destructans</td>
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<td><em>Cylindrocarpon destructans</em></td>
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<td>MIR 45b</td>
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<tr>
<td>MIR 45d</td>
<td>Oomycete</td>
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<td>MIR 45h</td>
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<td>MIR 47a</td>
<td>Cladosporium sp.</td>
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<td>MIR 48</td>
<td>Oomycete</td>
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<tr>
<td>MIR 49</td>
<td><em>Cylindrocarpon sp.</em></td>
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<tr>
<td>MIR 49a</td>
<td>Indeterminate Hyphomycete (reisolated MIR 49d)</td>
<td>Good control</td>
</tr>
<tr>
<td>MIR 49b</td>
<td>Gliocladium roseum</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 49g</td>
<td>Acremonium sp.</td>
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<tr>
<td>MIR 49d</td>
<td>Indeterminate Hyphomycete</td>
<td>Good control</td>
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<tr>
<td>MIR 50</td>
<td>Acremonium sp.</td>
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<td>MIR 50</td>
<td>Acremonium sp.</td>
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</tr>
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<td>MIR 51</td>
<td><em>Glomerella cingulata</em></td>
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<td>MIR 58</td>
<td>Oomycete</td>
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<td>MIR 59</td>
<td>Chrysosporium sp.</td>
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<tr>
<td>MIR 59d</td>
<td>Geotrichum candidum (reisolated MIR 59e)</td>
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<tr>
<td>MIR 59e</td>
<td>Geotrichum candidum</td>
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<tr>
<td>MIR 59</td>
<td>Geotrichum candidum (reisolated 59c)</td>
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</tr>
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<td>MIR 59c</td>
<td>Geotrichum candidum</td>
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<td>Chrysosporium sp.</td>
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<td>MIR 59</td>
<td>Indeterminate Hyphomycete</td>
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<td>MIR 60a</td>
<td>Fusarium equiseti</td>
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<td>Cylindrocladium sp.</td>
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<td>Coniothyrium fuckelii (reisolated 64d)</td>
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</tr>
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<td>Coniothyrium fuckelii</td>
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<tr>
<td>MIR 65a</td>
<td>Gliocladium roseum (reisolated 65b)</td>
<td>Slight effect</td>
</tr>
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<td>Gliocladium roseum</td>
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</tr>
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<td>MIR 67a</td>
<td>Pythium periplocum</td>
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<td>MIR 68a</td>
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(Sheet 5 of 10)
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<td>Gliocladium roseum</td>
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</tr>
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<td>MIR 68h</td>
<td>Gliocladium roseum</td>
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<td>MIR 68c</td>
<td>Acremonium sp.</td>
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<td>MIR 68a</td>
<td>Fusarium sambucinum</td>
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<td>Phomopsis sp.</td>
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<td>MIR 73c</td>
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<td>MIR 76a</td>
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<td>MIR 77a</td>
<td>Fusarium coeruleum</td>
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<td>MIR 78b</td>
<td>Cylindrocladium sp. (reisolated 78g)</td>
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<td>MIR 78a</td>
<td>Fusarium ciliatum</td>
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<td>MIR 79a</td>
<td>Fusarium sambucinum</td>
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<td>MIR 80a</td>
<td>Fusarium graminearum</td>
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<td>Cylindrocarpon destructans</td>
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</tr>
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<td>MIR 80f</td>
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<td>MIR 83a</td>
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<td>MIR 84a</td>
<td>Mycocentrospora acerina</td>
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<td>MIR 86b</td>
<td>Fusarium sp.</td>
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<td>MIR 86a</td>
<td>Lemonniera sp.</td>
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<td>MIR 87c</td>
<td>Leptosphaerulina sp.</td>
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<td>Fusarium sporotrichoides</td>
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<td>MIR 89b</td>
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<td>MIR 89e</td>
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<tr>
<td>MIR 93c</td>
<td>Gliocladium roseum</td>
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</tr>
<tr>
<td>MIR 93b</td>
<td>Gliocladium roseum (reisolated 93g)</td>
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</tr>
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<tr>
<td>MIR 94d</td>
<td>Indeterminate Coelomycete</td>
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</tr>
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<td>MIR 96b</td>
<td>Fusarium sp.</td>
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<td>MIR 97c</td>
<td>Colletotrichum sp.</td>
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<td>Fusarium equiseti</td>
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<td>Cylindrocladium sp.</td>
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</tr>
<tr>
<td>MIR 103c</td>
<td>New Hyphomycete</td>
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</tr>
<tr>
<td>MIR 104a</td>
<td>Macrotricha sp.</td>
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<tr>
<td>MIR 108a</td>
<td>Phaeoseptoria sp.</td>
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<td>MIR 113a</td>
<td>Coniothyrium sp.</td>
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<tr>
<td>MIR 114a</td>
<td>Phoma sp.</td>
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</tr>
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<td>MIR 115b</td>
<td>Phaeoseptoria sp.</td>
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<td>Ascochyta sp.</td>
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<tr>
<td>MIR 123b</td>
<td>Acremonium sp.</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 124b</td>
<td>Indeterminate Hyphomycete</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 124a</td>
<td>Phoma sp.</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 125b</td>
<td>Acremonium sp.</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 125a</td>
<td>Cladosporium cladosporioides</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 126a</td>
<td>Phomopsis sp.</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 126b</td>
<td>Phoma sp.</td>
<td>No response</td>
</tr>
<tr>
<td>Code</td>
<td>Isolate</td>
<td>Result</td>
</tr>
<tr>
<td>----------</td>
<td>--------------------------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>MIR 126c</td>
<td>Acremonium sp.</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 126d</td>
<td>Fusarium equiseti</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 127b</td>
<td>Acremonium sp.</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 128a</td>
<td>Acremonium sp.</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 128b</td>
<td>Fusarium sp.</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 129c</td>
<td>Fusarium sp.</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 129d</td>
<td>Fusarium sp.</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 129j1</td>
<td>Sclerotial isolate</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 131b</td>
<td>Fusarium sp.</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 131a</td>
<td>Oomycete</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 132a</td>
<td>Pythium acanthophoron</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 133a</td>
<td>Acrophialophora levis</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 134a</td>
<td>Cryptosporiopsis sp.</td>
<td>Good control</td>
</tr>
<tr>
<td>MIR 134c</td>
<td>Coniothyriopsis sp.</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 135j1</td>
<td>Coniothyrium sp.</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 136a</td>
<td>Phoma sect. Paraphoma</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 138b</td>
<td>Indeterminate Hyphomycete</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 139c</td>
<td>Mucor sp.</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 139a</td>
<td>Alternaria sp.</td>
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</tr>
<tr>
<td>MIR 139b</td>
<td>Myrothecium roridum</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 140b</td>
<td>Fusarium sambucinum</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 140a</td>
<td>Phoma sp.</td>
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</tr>
<tr>
<td>MIR 140j1</td>
<td>Gloeocladium sp.</td>
<td>No response</td>
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<tr>
<td>MIR 141c</td>
<td>Fusarium sp.</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 141a</td>
<td>Phoma sp.</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 142a</td>
<td>Pithomyces chartarum</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 142b</td>
<td>Acremonium sp.</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 143c</td>
<td>Fusarium sp.</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 143a</td>
<td>Fusarium sp.</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 144b</td>
<td>Indeterminate Hyphomycete</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 144b</td>
<td>Acremonium sp.</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 144j1</td>
<td>Alternaria sp.</td>
<td>No response</td>
</tr>
<tr>
<td>Code</td>
<td>Isolate</td>
<td>Result</td>
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<tr>
<td>---------</td>
<td>-----------------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>MIR 144j2</td>
<td><em>Fusarium culmorum</em></td>
<td>No response</td>
</tr>
<tr>
<td>MIR 145c</td>
<td><em>Fusarium</em> sp.</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 145a</td>
<td><em>Coniothyrium</em> sp.</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 147a</td>
<td><em>Alternaria</em> sp.</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 147c</td>
<td><em>Myrothecium</em> sp.</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 148a</td>
<td>Indeterminate Coelomycete</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 148b</td>
<td><em>Ascochyta</em> sp.</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 148c</td>
<td><em>Fusarium</em> sp.</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 149a</td>
<td><em>Sclerotium hydrophilum</em></td>
<td>No response</td>
</tr>
<tr>
<td>MIR 149b</td>
<td><em>Sclerotium hydrophilum</em></td>
<td>No response</td>
</tr>
<tr>
<td>MIR 150a</td>
<td><em>Ascochyta</em> sp.</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 151a</td>
<td><em>Ascochyta</em> sp.</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 152a</td>
<td><em>Fusarium</em> sp.</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 156a</td>
<td><em>Alternaria</em> sp.</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 157a</td>
<td><em>Fusarium graminearum</em></td>
<td>No response</td>
</tr>
<tr>
<td>MIR 158a</td>
<td><em>Acremonium</em> sp.</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 158b</td>
<td><em>Ascochyta</em> sp.</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 158c</td>
<td><em>Ascochyta</em> sp.</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 158d</td>
<td><em>Ascochyta</em> sp.</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 159a</td>
<td><em>Cylindrocladium</em> sp.</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 159b</td>
<td><em>Cylindrocladium</em> sp.</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 159c</td>
<td><em>Phoma</em> sp.</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 160a</td>
<td><em>Acremonium</em> sp.</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 161a</td>
<td>Indeterminate Hyphomycete</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 162a</td>
<td>Oomycete</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 163a</td>
<td>Oomycete</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 163b</td>
<td>Oomycete</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 163c</td>
<td>Indeterminate Hyphomycete</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 164j1</td>
<td><em>Ascochyta</em> sp.</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 164j2</td>
<td><em>Phaeostalagmus</em> sp.</td>
<td>No response</td>
</tr>
</tbody>
</table>

*Appendix C  Isolates Screened Against *Myriophyllum spicatum*
<table>
<thead>
<tr>
<th>Code</th>
<th>Isolate</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIR 164a</td>
<td>Indeterminate Hyphomycete</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 166j2</td>
<td><em>Phoma tropica</em></td>
<td>No response</td>
</tr>
<tr>
<td>MIR 166j3</td>
<td><em>Phoma</em> sect. Paraphoma</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 166j1</td>
<td><em>Phoma dennisii</em></td>
<td>No response</td>
</tr>
<tr>
<td>MIR 167j2</td>
<td><em>Phoma</em> sp.</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 168j2</td>
<td><em>Nectria</em> lugdunensis</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 168j1</td>
<td><em>Cylindrocarpon aquaticum</em></td>
<td>No response</td>
</tr>
<tr>
<td>MIR 169j1</td>
<td>Indeterminate Coelomycete</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 169j2</td>
<td>Indeterminate Coelomycete</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 169j3</td>
<td>Indeterminate Coelomycete</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 170j1</td>
<td>Indeterminate Coelomycete</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 171j1</td>
<td><em>Phoma leveillei</em></td>
<td>No response</td>
</tr>
<tr>
<td>MIR 172j1</td>
<td><em>Phoma hedericola</em></td>
<td>No response</td>
</tr>
<tr>
<td>MIR 173j1</td>
<td><em>Phomopsis</em> sp.</td>
<td>No response</td>
</tr>
<tr>
<td>MIR 174j1</td>
<td><em>Coniothrium</em> sp.</td>
<td>No response</td>
</tr>
</tbody>
</table>
Assessment of Fungal Pathogens as Biocontrol Agents of Myriophyllum spicatum

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United Kingdom

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U.S. Army Corps of Engineers
Washington, DC 20314-1000

Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

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In the 2 years of this project (1994-95), nearly 200 sites in the United Kingdom and mainland Europe were surveyed for fungal pathogens that could be used as biocontrol agents against Myriophyllum spicatum. Over 400 potential pathogens in 38 genera were obtained in pure culture. Isolates have been screened for pathogenicity on sections of plants; of these, 13 have been shown to possess some control capabilities. These include two isolates of Gliocladium roseum, two indeterminate Hyphomycetes (producing only chlamydospores), Acremonium sp., Cylindrocarpon destructans, Embellisia nr. teluster, Fusarium solani, Geotrichum candidum, Coniothyrium fuckelii, Cryptosporiopsis sp., Glomerella cingulata, and an indeterminate Coelomycete.

Biocontrol agents
Fungal pathogens
Myriophyllum spicatum