Prospects for Biological Control of *Heliotropium europaeum* by Fungal Pathogens

S. Hasan
CSIRO Biological Control Unit, 335 Avenue Abbé Paul Parguel, 34100 Montpellier, France.

**Abstract**

The summer annual, common heliotrope, *Heliotropium europaeum* (Boraginaceae), is a major weed in Australia causing severe stock poisoning. The weed is of Mediterranean and Middle Eastern origin. Surveys were therefore made in Europe, North Africa and the Middle East to discover organisms which could act as biological control agents of this species. Among these agents, the rust fungus *Uromyces heliotropii* and the leaf spot caused by *Cercospora* sp. damaged the plant. Evaluation has been made of the biology and host range of *U. heliotropii* with a view to its use as a biological control agent of common heliotrope in Australia. In addition some preliminary data on the *Cercospora* sp. is presented.

**Lutte Biologique contre *Heliotropium europaeum* par l’Utilisation de Champignons Pathogènes**


**Introduction**

*Heliotropium europaeum* L. (Boraginaceae), common heliotrope, is a summer-growing annual. The plant is native to the Mediterranean and Middle Eastern regions. Many species of *Heliotropium* other than *H. europaeum* are found in Iran and Iraq (Riedl 1967) suggesting that the genus may have evolved in the Palaearctic region. Common heliotrope was accidentally introduced into Australia where it has become an important weed (Everist 1974). It grows well in fallows and pastures especially after summer rains and causes poisoning due to the presence of pyrrolizidine alkaloids (Bull *et al.* 1956). The weed is also an effective competitor for moisture and consequently affects crop yield, especially in dry years (Delfosse and Cullen 1981). It multiplies only by seeds and these remain viable for many years in the soil.

Biological control seems to offer a promising alternative, as attempts to control common heliotrope by competition with other plants or with chemical herbicides have not been satisfactory. Surveys have been made in Europe, the Middle East and North
Africa and a number of insects and pathogens have been found to cause damage to *H. europaeum* and related species (Delfosse and Cullen 1981; Hasan and Cullen 1984). Among these, the flea beetle *Longitarsus albineus* Foudras (Coleoptera: Chrysomelidae) has already been studied in detail and introduced into Australia for the biological control of common heliotrope (Huber 1981). Drought prevented its establishment in the field (Delfosse 1985). Evaluation studies are now underway on the biological control potential of two fungal pathogens, *Uromyces heliotropii* Sredinski (Uredinales) and *Cercospora* sp. (Hyphomycetes).

**Uromyces heliotropii**

**Distribution**

*U. heliotropii* is a macrocyclic and autecious rust fungus which infects common heliotrope in the Mediterranean and Middle Eastern regions. It has also been recorded from southern Russia (Gäumann 1959). The rust occurs in a wide variety of climates from cold continental parts of central Anatolia to some of the warmest areas of North Africa. It has never been recorded in Australia (McAlpine 1906; J. Walker, pers. comm., 1983).

**Life Cycle**

Observations in the field in Turkey have revealed that *U. heliotropii* remains active throughout the heliotrope season and attacks all stages and all aerial parts of *H. europaeum*. In early spring it appears as small, short, cylindrical, yellow acedia in groups forming concentric rings, mostly on the lower surface of leaves of freshly germinated seedlings. Aecidia contain polygonoid to globoid, minutely, but densely verrucose, yellow aecidiospores. These aecidiospores in turn infect leaves and stems, producing dark brown, roundish uredinia exposed to the exterior by rupturing the epidermis (Fig. 1A). Uredinia are borne on both leaf surfaces but mostly on the upper surface. They are often large and abundant, giving rise to large quantities of powdery, brown, roundish to ellipsoid urediniospores (Fig. 1B). There are several generations of urediniospores throughout spring and summer, infection spreading rapidly on the already-infected plants and from plant to plant. In severe attacks, urediniospores cover entire leaves, causing rapid death of plant parts and, in the case of small plants and seedlings, the whole plant. Continuing production of uredinia on the stems and inflorescences of larger plants can also kill these or significantly retard their growth.

As the disease advances, dark, roundish to irregularly shaped telia appear among uredinia on leaves and stems. These contain unicellular, dark brown to black, thick-walled teliospores (Fig. 1C). The mature teliospores are capable of germinating immediately after they are produced. However, teliospores produced towards the end of the heliotrope season seem to overwinter, along with urediniospores, on dead plants and infect young seedlings the following season, producing spermatia and aecidiospores. In turn, these infect more heliotrope and give rise to several generations of urediniospores.

**Spore Germination and Germ Tube Growth**

Urediniospores were seeded on the surface of water agar (1% Difco Bacto), plated on glass slides, in a spore settling tower (Chandreshekar and Heather 1981). Immediately
Fig. 1. Uromyces heliotropii Steindl., the heliotrope rust. A. Uredinia on an infected leaf of common heliotrope, *Heliotropium saracenum* L. B. Urediniospores (× 600). C. Teliospores (× 600).
afterwards the slides were enclosed in plastic Petri dishes and incubated at required conditions.

**Light and darkness.** Agar plates with urediniospores were incubated in a phytotron at 20°C with continuous light (9288 lux) and 85% r.h. for 1, 2, 3, 4, 6, 8, and 24 h. Half the number of total plates were wrapped in aluminium foil and thus kept in darkness. Three replicates were used for each incubation period.

Urediniospores germinated both in continuous light and darkness (Table 1). However, darkness seemed to accelerate germination as a small number of spores germinated within 1 h, while it took about 2 h for spores to germinate in the light. Also in the dark, percent germination increased sharply, attaining maximum within 6 h, while in the light, maximum germination was obtained somewhere between 8 and 24 h. On the other hand, the rate of germ tube growth was higher in darkness than in light for incubation periods up to 8 h, but progressively increased, reaching maximum and equal levels at 24 h incubation both in light and darkness.

<table>
<thead>
<tr>
<th>Hours of incubation</th>
<th>Light</th>
<th>Darkness</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% Germination</td>
<td>Avg. length of germ tube (μm)</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>7.8</td>
<td>24</td>
</tr>
<tr>
<td>3</td>
<td>20.3</td>
<td>76</td>
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<td>4</td>
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<td>6</td>
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<td>8</td>
<td>59.7</td>
<td>218</td>
</tr>
<tr>
<td>24</td>
<td>81.9</td>
<td>588</td>
</tr>
</tbody>
</table>

1 Average counts of 600 spores.
2 Average measure of 60 germ tubes.

**Temperature.** Agar plates were equilibrated at temperatures 5, 6, 8, 10, 15, 18, 20, 22, 25, 30, 32, and 35°C. Urediniospores were seeded on these equilibrated plates as described above and incubated for 5 and 24 h in darkness.

Good germination was obtained at temperatures between 18 and 30°C, being optimal at 25°C (Table 2). Urediniospores germinated at most of the temperatures but germination was inhibited at temperatures below 15°C. Only a few spores germinated at 6°C and 32°C. No germination occurred at 5° and 35°C.

**Host Range**

*U. heliotropii* has so far been recorded only on *H. europaeum* and related species, e.g. *H. eichwaldi* Steud. (= *H. ellipticum* Ledebl.) and *H. rotundifolium* Sieb. (Gäumann 1959). During surveys in Iran the rust was collected on *H. lasiocarpum* Fisch. & Mey. which is also considered to be a subspecies of *H. europaeum* (Brummitt 1972). Demonstration of the host specificity of *U. heliotropii* under laboratory conditions is being investigated in relation to Boraginaceae and related families (including plants of those families native to Australia) and crop plants. So far none of the test plants
Table 2. Percent germination and germ tube growth of urediniospores of *Uromyces heliotropii* Sredinski, at different temperatures in darkness.

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>% Germination</th>
<th>Avg. length of germ tube (µm)</th>
<th>% Germination¹</th>
<th>Avg. length of germ tube (µm)²</th>
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<tbody>
<tr>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>6</td>
<td>0</td>
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<td>8</td>
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<td>10</td>
<td>4.7</td>
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</tr>
<tr>
<td>15</td>
<td>12.9</td>
<td>195</td>
<td>15.3</td>
<td>289</td>
</tr>
<tr>
<td>18</td>
<td>26.7</td>
<td>193</td>
<td>33.3</td>
<td>356</td>
</tr>
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<td>20</td>
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<td>463</td>
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<td>57.7</td>
<td>290</td>
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</tr>
<tr>
<td>35</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

¹ Based on 600 spore counts in 3 replicates.
² Mean of 60 measures of germ tube in 3 replicates.

Fig. 2. Leaves of common heliotrope, *Heliotropium europaeum* L., bearing lesions caused by *Cercospora* sp.
including the ornamental *H. peruvianum* L. and the wild *H. curassavicum* L., which is found in the Mediterranean region, have been attacked by the rust fungus.

**Cercospora spp.**

Several *Cercospora* spp. have been recorded on *Heliotropium* in the Mediterranean region and elsewhere (Chupp 1953). One of these fungi has been found widely in heliotrope infestations in the Mediterranean and Middle Eastern regions (Hasan 1974). The pathogen multiplies only by asexual conidia and thus belongs to the group Hyphomycetes. It causes brown and circular to irregular lesions on leaves, sometimes covering the major portion of the leaf surface (Fig. 2). In these lesions are found brown stromata with pale, olivaceous conidiophores and conidia, mostly on the lower surface of the leaf. Conidia are multiseptate, hyaline, cylindric with subtruncated base and bluntly rounded tip.

The fungus has been grown on the culture medium Potato Dextrose Agar (Difco Bacto) with 0.5% yeast extract (Oxoid) and produces a non-sporulating mycelium mat. This, when fragmented in water and sprayed onto *H. europaeum*, produces sporulating lesions on leaves in the glasshouse. Similarly, infection was also obtained by spraying plants with a water suspension of conidia collected from the glasshouse or spontaneous field infections. The infected plants quickly lose their leaves and show poor growth or premature death.

**Discussion**

Observations in the field and glasshouse studies on the life cycle of *U. heliotropii* have confirmed that all four spore stages of the rust are produced on *H. europaeum*. This excludes the possibility of the pathogen having an alternate host. Also it seems to be highly damaging to the seedlings which is of great advantage as the weed begins to flower very early, and death of seedlings will reduce production of seeds, which is important for infestations of the weed.

Occurrence of common heliotrope depends very much upon conditions such as soil disturbance, absence of interspecific plant competition and adequate rainfall. This makes its distribution and abundance very unpredictable. In such a case a biological control agent has to be rapidly effective as well as able to survive and easily dispersed. The dry and powdery urediniospores are well adapted for easy dispersal by wind and thus have the capacity to reach heliotrope infestations even if these are far apart.

Better urediniospore germination in dark, and over a wide range of temperatures such as commonly prevail in common heliotrope infestations during the night, in presence of dew, are likely to be conducive to infection. Studies are, however, under way on effects of dew period and temperatures on infection of *H. europaeum*. Field experiments are also being conducted on the overwintering of the pathogen especially as the host weed is then absent in nature. If no environmental limitations are found and *U. heliotropii* proves to be host specific, its introduction to Australia for the biological control of the common heliotrope would be worthwhile.

It is too early to make predictions on the *Cercospora* sp. Studies are at present under way on the identification of this fungus, as three species of *Cercospora* are known to attack *Heliotropium* (Chupp 1953) and one of these, *C. taurica* Tranz., is already present in Australia (Delfosse 1985).

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References


