Final Project Report to the NYS IPM Program, Agricultural IPM 2002 – 2003

Title:
Biological Control of Ground Ivy Using a Rust Fungus

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Type of grant:
Biological control and pest biology

Project location(s):
Central New York. Counties: Broome, Cayuga, Chemung, Cortland, Madison, Onondaga, Schuyler, Seneca, Tioga, Tompkins, Yates

Abstract:
Ground-ivy or creeping Charlie (*Glechoma hederacea*) is a creeping perennial in the Mint Family that forms dense prostrate patches in turfgrass, damp shady meadows, and disturbed sites. The control of ground ivy using chemical and mechanical methods has largely been unsuccessful in turfgrass where it is considered a major weed. Thus, there is a pressing need to develop and evaluate alternative approaches for the control of ground ivy in turfgrass that are effective and environmentally sound. Several rust fungi have been reported to infect ground-ivy in its native Eurasian range. In 1998, one of these rusts, *Puccinia glechomatis*, was found in North America including on ground-ivy plants growing in Syracuse, NY. Research to date has demonstrated that this rust fungus infects only plant species within the genus *Glechoma*. The goal of this study was to build on the initial data set collected during the 2001 growing season so as to better (1) determine the distribution of the *Puccinia glechomatis* rust on turfgrass ground-ivy populations in Tompkins County and surrounding counties, (2) assess the potential of the rust to effectively suppress ground-ivy in turfgrass, (3) determine whether the rust infects non-host plant species in turfgrass, and (4) determine optimal temperature and moisture conditions for disease development under controlled environment conditions. Field surveys during the 2002 growing season indicate that the rust has infected ground-ivy plants at locations in seven of the 12 Central New York counties surveyed. The slight increase in the number of counties having the rust in 2002 compared with 2001 is likely due to an increase in the number of locations surveyed within each county. In field

trials within naturally infected turf, the rust continued to reduce ground-ivy coverage. For instance, by mid-September 2002, 16 months after the start of trials, ground-ivy coverage had declined 80% in test plots. Interestingly, substantial decreases in weed cover were also observed in plots inoculated with the protectant fungicide, mancozeb, as well as in nearby adjacent "control" plots that had little disease in 2001. As in 2001, no disease symptoms were observed on turfgrass species or other non-target plants. Preliminary attempts to infect host plants with the selective rust, *Puccinia glechomatis*, under controlled environment conditions were not successful and warrant further work. Despite these difficulties, this rust may be a promising biocontrol candidate for suppressing ground-ivy in turfgrass.

Background and justification:

Ground-ivy (*Glechoma hederacea* L.) is a creeping perennial in the Labiaceae or Mint Family that forms dense prostrate patches in turfgrass, damp shady meadows, and disturbed sites. Reproduction is primarily by stolons and less commonly via seed and rhizomes. Ground-ivy is native to Eurasia but has been introduced and become widespread in North America, especially in the North-eastern and North-central USA (Uva et al., 1997). The control of ground-ivy using chemical and mechanical methods has largely been unsuccessful in turfgrass where it is considered a major weed (Mitich, 1994; Turgeon, 1994; Lamboy *et al*., 2000). Thus, there is an urgent need to develop and evaluate alternative approaches for the control of ground-ivy in turfgrass that are effective and environmentally sound. Biological control using selective fungal pathogens may be an effective and safe strategy for suppressing this troublesome weed.

Several rust fungi have been reported to infect ground-ivy in its native Eurasian habitat range. Recently, one of these rusts, *Puccinia glechomatis*, was found in North America (Scholler, 2000). The rust was detected on ground-ivy plants growing in Syracuse, NY in August 1998 and on plants growing in shady, frequently mowed private lawns west of Lafayette, IN in October 1999. Other U.S. States where this rust has been found include Pennsylvania, Virginia, West Virginia, Kentucky and Ohio (Boellmann and Scholler, 2001). The specific mode of introduction into North America is not known. Research to date has demonstrated that *P. glechomatis* infects only species within the genus *Glechoma* (Scholler, 2000, DiTommaso *et al*., 2002).

The presence of the *P. glechomatis* rust on diseased ground-ivy plants collected in August 2000 from several locations in Dryden, Tompkins County, NY has been confirmed. Disease incidence and severity of affected populations was extremely high (DiTommaso, A., personal observation). Turfgrass species did not appear to be affected by the rust. It was expected that the rust would re-infect remnant ground-ivy populations in these same sites in 2001 and 2002 and possibly spread to adjacent areas in coming years. Before this research was undertaken, there was little information on the incidence of disease caused by this rust on host ground-ivy populations in Tompkins County and surrounding counties of Central New York. There was also limited data on the severity of disease caused by the rust or its impact on ground-ivy growth and development. Moreover, the host range of this rust would require a more accurate assessment before any consideration of this pathogen as a potential biological control agent for ground ivy is further evaluated.

Findings from research in 2001 indicated that although the selective rust, *Puccinia glechomatis* had a sporadic distribution in Central New York State, it was capable of substantially reducing ground-ivy cover while not affecting other plant species. The research carried out in 2002 built on the 2001 work and addressed one of the NYS IPM priorities in Ornamentals and Turfgrass, namely the development of enhanced methods of biological control of problem weeds in turfgrass.

Objectives:

1. Continue to determine the distribution of the *Puccinia glechomatis* rust on turfgrass ground-ivy populations in Tompkins County and surrounding counties of Central New York State
2. Continue to assess the effect of disease caused by *P. glechomatis* on ground-ivy growth and development
3. Further determine whether this rust infects non-host plant species in turfgrass
4. Determine optimal temperature and moisture conditions for disease development under controlled environment conditions.

Procedures:

Objective 1. ***Disease surveys***
During the 2002 growing season, we carried out surveys in Tompkins County and ten surrounding Central New York counties to further determine the extent of ground-ivy populations that were infected by the *Puccinia glechomatis* rust. Cornell Cooperative Extension educators in several of the counties aided in selecting locations for the surveys. Different habitats where ground-ivy was suspected to be present were sampled including private lawns and city parks. To be able to monitor disease progression in these natural populations, surveys were carried out on two separate occasions: 1) late July and 2) late August. A total of 33 sites, three in each of the 11 counties was sampled (Table 1). At each of the sites, the percentage ground-ivy coverage within three randomly located 0.25m^2 (50 x 50 cm) quadrats was visually estimated as was the percentage of ground-ivy leaf tissue that was diseased (Figure 1). Plant tissue suspected of being infected by *P. glechomatis* was collected and brought to Dr. Kathie Hodge of the Cornell Department of Plant Pathology for identification.

Figure 1. Turfgrass site heavily infested with ground-ivy (*Glechoma hedreacea*) **(left)**, and 0.25 m^2 quadrats used for sampling **(right)**.

Objectives 2 and 3. ***Field plot research***
To assess the impact of disease on ground-ivy growth and development, the same Dryden, NY private lawn site where *P. glechomatis* infection had been confirmed in 2000 and that was monitored in 2001, was used for the plot trial in 2002. At this site, the twelve 0.25m^2 (50 cm x 50 cm) quadrats established in mid-May 2001 were again used. Quadrats were separated by at least 0.5 m. As in 2001, 4 of the quadrats received applications of the protectant fungicide, mancozeb (Manzate® 75DF) at a rate of 10 lbs/175 gals/acre every 2 weeks from mid-May to mid-September to prevent rust infection of ground-ivy plants. In 4 of the quadrats, water was applied at the same spray volume as for the fungicide treatment such that rust infection of ground-ivy plants was allowed to progress naturally. The remaining 4 quadrats were located in an adjacent area infested with ground-ivy but which had shown no rust infection in 2000 and low levels of infection in 2001. These plots had been considered control plots in 2001 and thus received no fungicide application in either 2001 or 2002. At each of 5 sampling dates (i.e., May 30, June 15, July 15, August 15, September 15), the following data were collected from each of the 0.25 m^2 quadrats:

1) percentage ground area occupied by ground ivy

2) percentage ground ivy leaf area diseased
3) identification of other plant species infected by the rust
4) symptomology of infected ground ivy

Plots were mowed to a height of 10 cm after each sample period.

Objective 4. ***Determination of optimal temperature and moisture conditions for disease development***
Sixty stolon cuttings (having 3-4 nodes) taken from healthy ground-ivy plants were used for this portion of the study. A single cutting was planted to a depth of 2-cm in each of sixty 12.5-cm top-diameter plastic pots containing a standard Cornell soil mixture. The pots were placed under glasshouse conditions of 22/30 ± 3ºC day/night temperatures and a 14-hour natural photoperiod for 1 week. Plants were watered as required and fertilized twice with 125 ml of 20-20-20 (N-P-K) during this period. Subsequently, 12 of the pots were randomly selected and placed in each of five controlled environment chambers having a light (L) /dark (D) 14 /10 h photoperiod (500 umol $m^{-2}s^{-1}$) and different temperature regimes. The L/D temperature regimes used were 5/15, 10/20, 15/25, 20/30, 25/35ºC. In each of the controlled environment chambers, 8 of the target plants were exposed to a single detached rust-infected ground-ivy leaf using a paper clip (Figure 2a and 2b). Two of the remaining plants were exposed to rust spores using a paintbrush. Plants in two of the pots served as controls and were not exposed to either rust-diseased leaves of ground-ivy or rust spores. To assess the effect of moisture availability on disease development, half of the plants for each treatment were covered with a clear plastic bag (Figure 2c). Plants were grown fo a period of 3 weeks and were watered as required. Disease development was monitored every 2 days. The aboveground dry biomass of ground-ivy plants in each pot was determined by cutting all aboveground plant tissue at soil level, drying for 48 h at 65ºC, and weighing.

(a) **(b)** **(c)**

Figure 2. (a) Placement of a rust-infected detached ground-ivy (*Glechoma hederacea*) leaf on healthy plants, **(b)** close-up of this arrangement, and **(c)** plants covered with clear plastic bags.

Results and discussion:

Objective 1. ***Disease surveys***
Field surveys during the 2002 growing season indicate that the *Puccinia glechomatis* rust has infected ground-ivy populations in 6 of the 11 Central New York counties surveyed (Table 1). However, given that diseased populations were found in Dryden, Tompkins County but not in nearby towns of Lansing or Cortland and that additional sites were surveyed in 2002 compared with 2001, the current distributionof *P. glechomatis* in Central New York State continues to be heteregoneous and sporadic. In those sites where the rust was confirmed, the level of disease was relatively low with less than 50%of the ground-ivy leaf area diseased (Table 2). From

herbaria records, Boellman and Scholler (2001) estimated that the *P. glechomatis* rust has spread throughout the North-eastern and North-central United States at a rate of about 80 km per year. Additional field research is required however, to determine the constraints to disease development and spread of this rust both at the field and landscape scale.

Table 1. Locations in Central New York State where disease surveys were carried out in early June and August 2001 and late July and August 2002 to determine the presence of the rust *Puccinia glechomatis* on ground-ivy (*Glechoma hederacea*) plants

County	City/Town	Presence of rust (2001)[1]	Presence of rust (2002)[1]
Broome	Binghamton	Yes	No
Cayuga	Auburn	No	Yes
Chemung	Elmira	No	Yes
Cortland	Cortland	No	No
Madison	Cazenovia	No	No
Onondaga	Skaneateles	No	No
Schulyer	Watkins Glen	Yes	Yes
Seneca	Lodi	Yes	Yes
Tioga	Waverly	No	Yes
Tompkins	Lansing	No	No
Yates	Dundee	Yes	Yes

[1] In 2001, one site in each county was surveyed, whereas in 2002, three sites were surveyed in each county

Table 2. Mean percentage of ground-ivy (*Glechoma hederacea*) foliage infected with the rust *Puccinia glechomatis* in late July and late August 2002 at three sites in six Central New York State locations where the rust was detected

County	City/Town	Foliage infected (%) July 2002			Foliage infected (%) August 2002		
		Site[1]			Site[1]		
		1	2	3	1	2	3
Cayuga	Auburn	6	0	13	63	0	83
Chemung	Elmira	0	33	7	0	40	0
Schulyer	Watkins Glen	0	20	0	0	40	0
Seneca	Lodi	0	53	0	0	60	0
Tioga	Waverly	0	0	5	0	0	10
Yates	Dundee	37	0	0	60	0	0

[1] For each site, the value shown is the mean percentage of ground-ivy foliage that was infected by the rust in three $0.25m^2$ (50 x 50 cm) quadrats.

Objectives 2 and 3. ***Field plot research***

In the 2002 plot trials within naturally infected turf, the rust reduced ground-ivy coverage by more than 50% from the first sample period in late May (mean coverage= 20%) to the last sample period in mid-September (mean coverage = 9%) (Figure 3). For the 16-month period beginning in May 2001 and ending in mid-September 2002, ground-ivy cover was reduced by 80%. As in 2001, ground-ivy plants within all four plots treated with fungicide also exhibited disease symptoms and suffered important declines in cover (Figure 3). In contrast to results in 2001 however, ground-ivy cover in the nearby plots that were not diseased in 2000 but showed intermedialte levels of rust infection late in 2001, decreased by nearly 80% during the late May to mid-September 2002 sampling periods (Figures 3 and 4). As for 2001, disease development was gradual through the season with the highest levels of foliar necrosis observed from mid-July to mid-August (DiTommaso *et al.,* 2002). Leaf tissue close to the soil surface appeared to be most severely infected and premature leaf senescence was common (Figure 5). Consistent with findings in 2000 and 2001, disease symptoms were not observed on turfgrass nor on other non-target plants. Areas within infected plots left vacant by the death or reduction in size of diseased ground-ivy plants were rapidly colonized by favorable turfgrass species (Figure 6). Once again, the poor control of the rust within fungicide-treated plots was likely due to the presence of the rust in these plots prior to the first fungicide application. Given that mancozeb is a protectant fungicide, disease present on host plants before it is applied will not be controlled. The dramatic reductions in ground-ivy cover in the nearby "control" plots in 2002 suggests that the rust can effectively disperse over short distances (i.e., 50 m) at least. The extremely dry conditions prevailing in July and August 2002 also appear to have contributed to the severity of infection and cover reductions in ground-ivy.

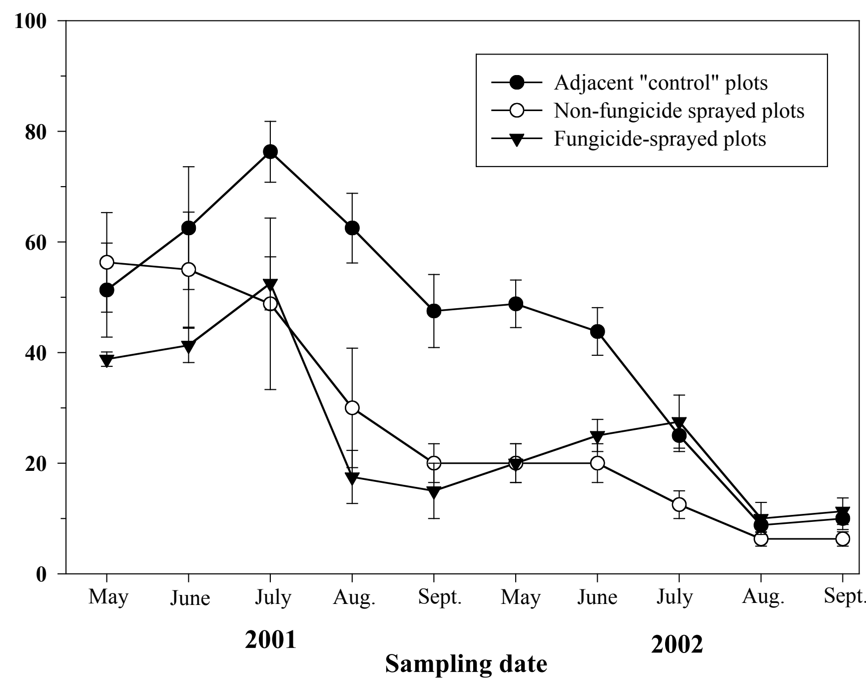

Figure 3. Percentage cover of ground-ivy (*Glechoma hederacea*) over two growing seasons in Dryden, NY turfgrass plots that were initially not infected with the rust *Puccinia glechomatis* and in plots either sprayed or not sprayed with the protectant fungicide mancozeb.

(a) **(b)**

Figure 4. **(a)** Ground-ivy (*Glechoma hederacea*) cover in an adjacent "control" plot (June 2002) that was not diseased in 2000 and was not sprayed with the protectant fungicide macozeb in both 2001 and 2002, **(b)** ground-ivy cover in the same plot in August 2002 following infection by the rust *Puccinia glechomatis*.

(a) **(b)** **(c)**

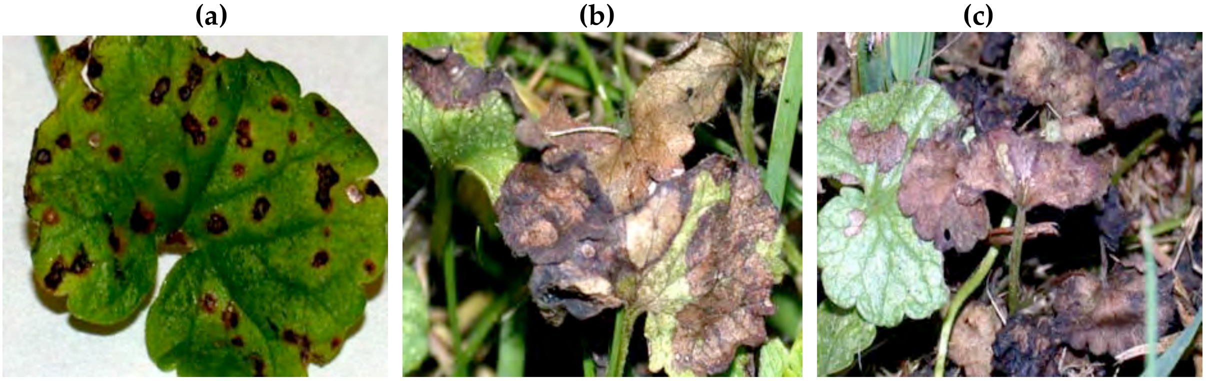

Figure 5. **(a)** Characteristic necrotic lesions on the upper surface of a ground-ivy (*Glechoma hederacea*) leaf caused by the rust *Puccinia glechomatis*, **(b) and (c)** severely diseased ground-ivy plants in the turfgrass trials (August 2002).

Figure 6. Colonization and regrowth of turgrass species in areas left vacant by the death of rust-infected ground-ivy (*Glechoma hederacea*) plants.

Objective 4. ***Determination of optimal temperature and moisture conditions for disease development***

No disease symptoms were observed on ground-ivy plants exposed to the rust either by direct contact of healthy tissue with a detached rust-infected leaf or by the brushing of spores using a paintbrush. It had been hoped that at least one of these tactics would have been successful in causing infection of healthy tissue. Increasing moisture availability by covering pots with a clear plastic bag in order to favor disease development also did not result in rust infection of ground-ivy plants. Thus, it was not possible to determine optimal temperatures and the influence of moisture availability on disease development. However, ground-ivy aboveground dry biomass was found to peak at day/night temperatures of 15/25ºC. Future research efforts should focus on developing more effective strategies that favor disease development of this rust under controlled environment conditions.

Conclusions

Findings from this research indicate that the selective rust, *Puccinia glechomatis* is present in Tompkins County and surrounding counties of Central New York State although its distribution continues to be intermittent. More extensive surveys should provide more detailed and reliable information on the distribution of this recently introduced rust pathogen. Results from the turfgrass plot trial showed that *Puccinia glechomatis* is not only host specific to ground-ivy, but can substantially reduce coverage of this troublesome weed in turfgrass within two growing seasons (up to 80%). This finding is especially relevant and timely because of the limited number of safe and effective non-herbicidal options available in turfgrass for managing problem weeds. Additional research on this promising biological control candidate is required however to more fully assess the impact of disease on ground-ivy growth under different growing conditions and to finding strategies for infecting plants under controlled environment conditions.

References:

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Samples of materials:

A website (http://ppathw3.cals.cornell.edu/CUPpages/rust.html) has been created that expands on this research and also provides the public with colored images of both the host plant and the rust fungus. Visitors to the website are also encouraged to send suspected diseased ground-ivy plants to either the co-investigators of this Cornell research team (for NY State residents only) or to our colleague, Dr. Markus Scholler, at Purdue University.

Publications:

DiTommaso, A., L.A. Weston, V.R. Walker, and K.T. Hodge. 2002. Occurrence and impact of the rust *Puccinia glechomatis* on ground ivy in New York State. Northeastern Weed Science Society of America Abstracts 56: 52.