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Potential pathogens for control of leafy spurge

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Abstract:

Recent findings concerning the potential of plant pathogens of leafy spurge for the use as biological control agents are summarized and discussed. Variations in virulence and host range among strains of two soil-borne pathogens occurring on leafy spurge provide indications that effective pathogens with minimal impact on desirable plants is a strong possibility.

Introduction

Leafy spurge might properly be considered the most formidable noxious weed facing custodians of private and public rangelands in the Northern Great Plains. The weed has an aggressive, multifarious root system, which coupled with an adaptiveness to a variety of environments, poses a severe challenge to any class of feasible control strategy for leafy spurge, whether chemical, cultural, or biological. Though at present the employment of a variety of methods to control leafy spurge is necessary and advisable, the greatest potential for long term control of leafy spurge probably lies with biological means. Thus, biological control can be considered the most likely strategy to satisfy the need for cost effectiveness, environmental safety and concern for aesthetic values. The promise of and need for emphasis on biological control of leafy spurge is based on the observation by many workers, including the author, that the weed is under control in it's native range in Eurasia, and that this suppression can be directly related to a complex of insects and pathogens affecting *Euphorbia* spp. in these areas. The author has furthermore observed

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that the most effective agents acting on leafy spurge in it's native range are those that attack the roots (A. Caesar, unpublished). Plant pathogens that attack the roots of leafy spurge are probably the sole class of agent that may control the weed in the absence of root-feeding insects. Evidence for this are surveys for and studies of plant pathogens that are associated with ongoing stand declines of leafy spurge (in situations where insects have not been released) (5,7), or with stunting and chlorosis of patches of leafy spurge in otherwise apparently healthy stands (3,6). Pathogens that have been isolated from or closely associated with diseased leafy spurge are listed in Table 1 along with a description of their degree of pathogenic impact on the weed. Collectively, this indicates that soilborne pathogens or microorganisms have had the greatest effects in decreasing leafy spurge density or vigor.

Table 1. Pathogens and other microorganisms affecting leafy spurge. Microorganism are ranked in descending order based on their respective magnitude of pathogenicity or effects on leafy spurge density.

Pathogen or other microbes	location	biology	Symptoms and effects
Clavariaceae	Montana	soil fungus	coral fungus which promotes activity of soilborne fungi against leafy spurge
Rhizoctonia solani AG-4	Montana, Colorado, Nebraska	soil fungus	crown and systemic root rot, killing of root buds, co-infections with *Fusarium* spp.
Agrobacterium tumefaciens biovars 1 and 2	Montana, North Dakota	soil bacterium	crown gall, stunting and chlorosis through effects of secondary infections
Pythium spp.	Montana, North Dakota, Nebraska	soil fungus	killing and stunting of secondary roots, coinfection of crown galls (see above)
Rhizoctonia spp.	Montana, North Dakota	soil fungus	aerial stem rot and blight in moist weather
Alternaria spp.	Montana, Colorado	leaf and soil fungus	leaf, stem and blossom blights
Septoria spp.	Montana, Minnesota	leaf fungus	leaf spots
Pseudomonas spp.	Montana, North Dakota	leaf bacterium	blossom blight, limited systemic infection
Erwinia herbicola	several states	soil bacterium	blossom blight

Potential of plant pathogens for biological control

Assessment of the potential of plant pathogens for the biological control of leafy spurge: comparative virulence and host range. The author has noted that when several strains of the same pathogenic species are found, strains of the same pathogen species from different localities differ in the degree of pathogenicity which can be expressed against leafy spurge (comparative virulence). Studies on soilborne pathogens *Rhizoctonia solani* and *Agrobacterium tumefaciens* have shown this (3,4).

The concept of comparative virulence is an important practical consideration because of such findings. The discovery of a specific pathogen should be followed by further surveys of the same area to collect strains of the same pathogen. Comparison of the virulence of various strains of the same pathogen, if multiple strains are found, should be undertaken to select the most pathogenic among them. Figure 1 shows the comparative virulence to roots of leafy spurge of strains of *R. solani* isolated from leafy spurge, and indicates that there is variation in pathogenicity among even a small set of taxonomically identical strains from the same host. The strains of *R. solani* shown are of a single subspecies (4). There were also significant differences among *R. solani* strains with regard to virulence expressed as a result of inoculating stems of spurge (4). The host ranges of pathogens of leafy spurge are also of importance.

The likely threat to important or endangered native species or major crops in areas adjacent to sites intended to be treated with fungal biocontrol strains should be assessed by studying the host ranges of such potential biological control agents. Even species of pathogens generally considered to be broad host range may be shown, upon closer examination of individual strains, to be somewhat limited in the number of species attacked. Tables 2 and 3 present data from studies of two soilborne pathogens of leafy spurge, *R. solani* and *A. tumefaciens*, illustrating that often strains are pathogenic to only a few other plant species beyond the original host (3,4). It may be necessary to balance the factors of high virulence and host range in choosing a strain to be applied as a biological control agent and studies described herein provide information relevant to this consideration. Figure 1 indicates that the most virulent strains to leafy spurge are those designated Lyman Creek and Sidney. These strains also possessed the widest host ranges among those studied, 6 of 23 crop species tested. Specific situations may dictate that a narrow-host-range strains be used, even if they are less pathogenic to the target weed. However, the significant variation among even

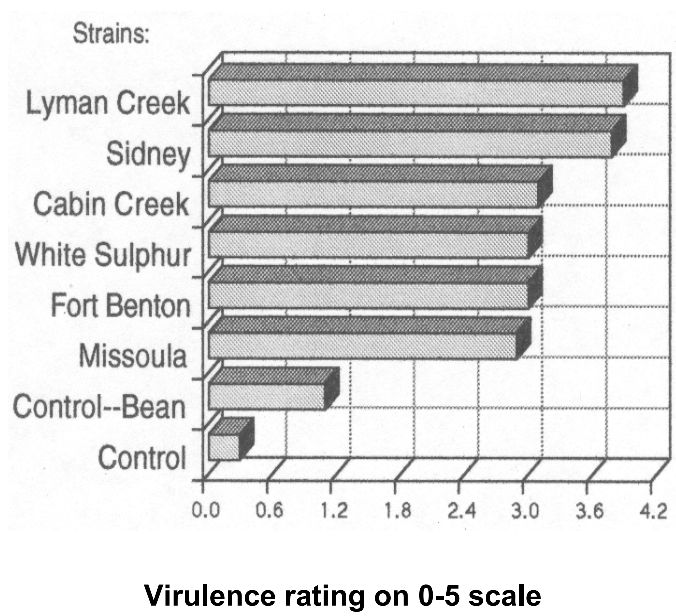


Figure 1. comparative degree of pathogenicity to roots of leafy spurge among six strains of *Rhizoctonia solani* of the same subspecies. The Lyman Creek and Sidney strains were significantly more pathogenic to roots of leafy spurge than four other strains, as confirmed with statistical tests.

a relatively limited set of strains observed in studies of two soilborne pathogens of leafy spurge, would indicate that highly virulent, narrow-host-range strains of plant pathogens are obtainable with continued screening.

Table 2. Reactions of nine species to Agrobacterium strains from leafy spurge and Russian knapweed.

	Cultivated species								
Strain	Artichoke	Flax	Mung Bean	Peanut	Snapbean	Sugarbeet	Soybean	Sunflower	Zinnia
Original host: Russian knapweed									
AG83A	–[a]	+[b]	–	–	–	+	–	+	+
D-45	–	–	–	–	–	–	–	–	–
Original host: leafy spurge									
91-25 #25	–	–	–	–	–	–	–	–	–
91-25 #23	–	–	–	–	–	–	–	–	–
91-30 #21	–	+	–	–	–	+	–	+	+
91-30 #38	–	–	–	–	–	–	–	+	–
Biovars									
BV1	–	+	+	–	–	–	–	+	+
BV2	–	–	–	–	–	–	–	–	–
BV3	–	–	–	–	–	–	–	–	–

[a]No disease following inoculation.
[b]Crown gall disease following inoculation.

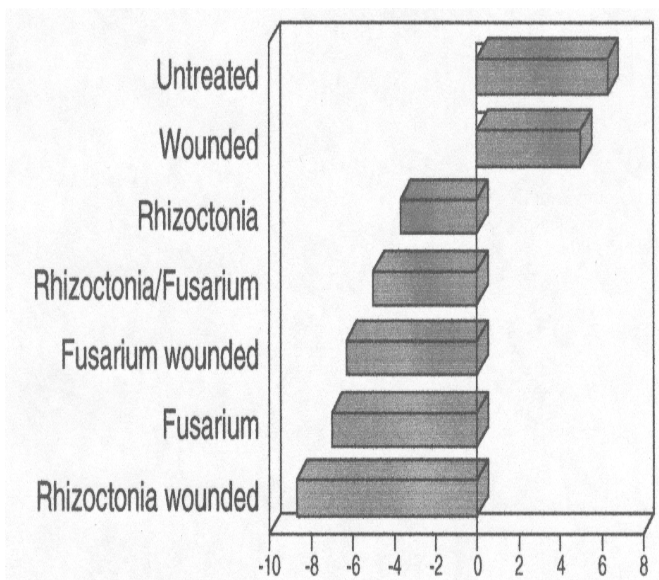
Table 3. Host ranges of *Rhizoctonia solani* AG-4 strains isolated from leafy spurge.

	Cultivated species[a]										Host range
Pathogen Strain	Alfalfa	Artichoke	Garden Beet	Mung bean	Oats	Okra	Peanut	Safflower	Snapbean	Soybean	(of 23 plant spp.)
CC#25L	+[b]	+	–[c]	–	–	+	–	+	+	+	6
FB6J	+	NT	+	–	–	-	+	–	+	+	5
LYMCRK	+	+	–	–	–	+	–	+	+	–	5
MISS-M	+	–	+	-	+	+	–	–	+	–	5
WSS-M	+	–	–	–	–	–	–	+	+	–	3
BB5E	+	–	+	+	–	+	–	–	+	+	6

[a] 13 other cultivated species were not susceptible to strains of AG-4
[b] Pathogenic
[c] Nonpathogenic

The potential of some soilborne pathogens for the biological control of leafy spurge: factors affecting field-effectiveness of candidate biocontrol agents. *R. solani* and *Fusarium* spp. possess the advantages of being applicable as bioherbicides while being capable of acting in a "classical" manner, i.e., they would not necessarily require repeated applications to be effective. This capability for a classical "mode of action", as biological control agents is based on evidence presented in several studies showing that *Rhizoctonia* and *Fusarium* spp. are favored in no-till or minimum-till cropping situations (1, 9, 10, 11) and furthermore that *Fusarium* species (and likely *Rhizoctonia* spp.) are pathogenically optimal when acting at the surface or the upper soil layers (2). This would be analogus to the action of *Rhizoctonia* or *Fusarium* or both applied to a stand of leafy spurge. The main points of analogy are the obvious lack of tilling in a stand of leafy spurge and the abundance of crop (spurge) residue, which these pathogens can utilize to proliferate and spread. Such an ability is confirmed by a study indicating that *R. solani* (and likely *Fusarium* spp.) was capable of spread from a single point-source (8). Field-testing of this *Fusarium/Rhizoctonia* combination began in 1992 and 1993. These trials investigated the effects of both species separately and in combination, wounded or unwounded. Results from the 1993 trail in which the species were applied as a granular formulation are shown in Figure 2. These data indicate that wounded plants are more susceptible to *Rhizoctonia solani* while *Fusarium* is effective without wounding, and the combination when formulated together is less effective.

Effect of two plant pathogens applied to leafy spurge



Mean Change in number of shoots per 3 sq ft over three months.

Figure 2. Effects on stand density of *Rhizoctonia solani* and *Fusarium* spp. applied in a granular formulation to leafy spurge in the field 1993.

Other strategies involving soilborne fungi and pathogens. An entirely novel strategy for the biological control of leafy spurge could lie within a heretofore obscure area of soil biology. Fairy rings caused by a basidiomycetes (mushrooms and allied and related species) have found to effectively eradicate leafy spurge by interacting with common soilborne fungi (5). The fungus that causes the rings is a coral fungus which, as is typical of fairy rings, grows through the soil, and alters the microbial flora and soil microenvironment to one favorable to soilborne pathogens which attack the root buds and crown of leafy spurge. The fungus does not persist once the active zone of fungal growth has proceeded. Furthermore, the fungus does not apparently infect the roots of leafy spurge. Other fairy rings have been observed by the author in Montana and North Dakota (5, and A. Caesar, unpublished) and others to substantially alter the associated flora. Such phenomena require further study with the goal of understanding the mechanisms involved, which may eventually lead to means of biological weed control for at least special sites where no augmentation of pathogens is advisable or possible.

Conclusion

The effective application of native plant pathogens of leafy spurge will require consideration of the likely most effective pathogen for a given site of weed infestation. For example, pathogens that are effective at cooler temperatures such as *Pythium* spp. may be required for shaded sites. As another example, the supplementation of insect release sites with *Rhizoctonia solani* has a potential impact on the rapidity of the control of leafy spurge in such sites. *Rhizoctonia solani*, *Fusarium* spp. and *Pythium* spp. have been isolated from larvae of *Aphthona* spp., whether surface-sterilized or not (unpublished). Additionally, greenhouse and field studies described above have shown that *Rhizoctonia* is most effective when acting upon wounded tissue, which the root-feeding insects provide. The selection of the most effective pathogen among several strains is necessitated by results showing that there is variation in virulence, and possibly in environmental requirements. Host ranges have also been shown to vary, and these variations offer the possibility that highly effective biological control agents with relatively narrow host ranges can be obtained. Also, strains that improve the impact of insect biological control agents should be investigated. These and other factors not discussed here provide glimpses of possible new strategies for biological control of leafy spurge that would be effective without adverse impact on desirable plants.

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