# Host Range of Phakopsora pachyrhizi, the Causal Agent of Soybean Rust

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## Introduction

Phakopsora pachyrhizi, the causal organism of soybean rust, was first described in 1903 from leaves of *Glycine max* subsp. *soja*, or wild soybean in Japan. Since that time, there have been numerous reports of the uredinial stage of the pathogen on various leguminous species around the world. Prior to its introduction to North America in 2004, P. pachyrhizi was reported on approximately 90 host species (2). It is currently reported to occur on approximately 150 species in 53 genera of the legume family Fabaceae. All of the host species belong to a monophyletic group within the Papilionoideae subfamily of Fabaceae (Fig. 2). Approximately 120 of the known hosts of *P. pachyrhizi* grow in North America and may play a role in the epidemiology of the disease as overwintering hosts and/or sources of inoculum to soybean.

## **Materials & Methods**

A literature review of *P. pachyrhizi* host range studies followed by crosschecking known hosts through ILDIS, the International Legume Database and Information Service, resulted in the consolidation of approximately 95 previously reported hosts to 77 (1). Only papilionoid species that are native or naturalized to southern and major soybeanproducing states were tested in our trials. Seed was ordered from USDA-ARS National Plant Germplasm System repositories, and the 176 species available were initially tested in the containment facility in Ft. Detrick, MD (3). The 105 species that showed lesions prior to PCR or ELISA confirmation were tested in the field in Quincy, FL at the North Florida Research and Education Center (NFREC) for two seasons (4).



Fig. 1. Legume hosts infected with *P. pachyrhizi* and their reddish-brown lesions.

From top left: Lathyrus aphaca (stem), Neonotonia wightii, Vigna luteola, Caragana arborescens, Baptisia alba, Vigna adenantha, Macroptilium atropurpureum, Calopogonium mucunoides.

## Results

Sixty-five new hosts of *P. pachyrhizi* were identified in the greenhouse trial and five new hosts were identified in the field trial. There are now 142 known hosts, and 92 of these are either native or naturalized to areas in North America (Table 1). Many of these hosts, especially those more closely related to soybean, are capable of producing lesions with high levels of sporulation (Fig. 1).

**Table 1.** Complete list of *Phakopsora pachyrhizi* hosts as determined by the presence of uredinia and/or urediniospores with information on the location and year of first occurrence, the nature of the study (field or greenhouse), and the status in North America. Preference was given to the first published occurrence of a natural infection of *P. pachyrhizi*, even if a greenhouse study preceded the field occurrence.

	First Occurrence <sup>b</sup>				First Occurrence <sup>b</sup>				
Scientific Name <sup>a</sup>	Country		Location <sup>c</sup>	N.A. status <sup>d</sup>	Scientific Name <sup>a</sup>	Country			N.A. status <sup>d</sup>
Alysicarpus longifolius	India <sup>e</sup>	<b>Xear</b> 498	field greenhous	not present	Lotus pedunculatus	Australia <sup>f</sup>	^	dreenhous e	introduced
Alysicarpus vaginalis Amphicarpaea bracteata subsp.	United States <sup>f</sup>	198 197	greennous e	introduced	Lupinus albus	United States <sup>f</sup>	4	greenhous	introduced
edgeworthii	China <sup>e</sup>	999	field	native	Lupinus angustifolius	Japan <sup>f</sup>	^	greenhous greenhous	introduced
Amphicarpaea ferruginea	Nepal <sup>e,f</sup>	900	field greenhous	not present	Lupinus luteus	United States <sup>f</sup>	200	greenhous	introduced
Astragalus cicer	United States <sup>g</sup>	200 200	e	introduced	Lupinus perennis	United States <sup>9</sup>	^	greenhous	native
Astragalus glycyphyllos	United Statesh	200 200	field greenhous	introduced	Lupinus texensis	United States <sup>9</sup>	897	e	native
Baptisia alba	United States <sup>9</sup>	200 200	greenhous	native	Macroptilium atropurpureum	Australia <sup>e,f</sup>		field greenhous	native (Mexico)
Baptisia bracteata	United States <sup>9</sup>	897	е	native	Macroptilium lathyroides	Australia <sup>e,f</sup>	6 <sub>97</sub>	е	native (Mexico)
Cajanus cajan	Australia <sup>e,f</sup>	900	field greenhous	introduced	Macrotyloma axillare	Australia <sup>e,f</sup>		field greenhous	not present
Calopogonium caeruleum	United States <sup>9</sup>	8 97	е	native (Mexico)	Medicago falcata	United States <sup>9</sup>	0	greenhous	introduced
Calopogonium mucunoides	Malaysia <sup>e,f</sup>	198	field greenhous	native (Mexico)	Medicago laciniata	United States <sup>9</sup>	^	greenhous	uncertain
Canavalia gladiata	India <sup>f</sup>	997	greenhous	introduced	Medicago lupulina	United States <sup>9</sup>	^	greenhous	native (Mexico)
Canavalia rosea	Australia <sup>e,f</sup>	<del>2</del> 00	greenhous	native	Medicago orbicularis	United States <sup>9</sup>	8 <sub>98</sub>	greenhous	introduced
Caragana arborescens	United States <sup>g</sup>	8 198	greenhous	introduced	Melilotus officinalis	United States <sup>f</sup>	200	e	introduced
Centrosema pubescens	India <sup>f</sup>	200	greenhous	native	Mucuna pruriens	Argentina <sup>e</sup>	396	field	native (Mexico)
Centrosema virginianum	United States <sup>g</sup>	<b>8</b> 98	greenhous	native	Mucuna urens	Caledoniae	<del>ရ</del> 97	field	not present
Clitoria ternatea	United Statesf	200	greenhous	introduced	Neonotonia wightii	Australia <sup>e,f</sup>	ရ <del>ိ</del> 99	field	not present
Cologania angustifolia	United States <sup>9</sup>	<del>2</del> 00	greenhous	native	Ormocarpum cochinchinense	Japan <sup>e,f</sup>	191	field	not present
Cologania obovata	United States <sup>9</sup>	<sup>8</sup> 93	е	native	Pachyrhizus erosus	Taiwan <sup>e,f</sup>	<del>1</del> 99	field	native (Mexico)
Crotalaria albida	Philippines <sup>e,f</sup>	200	field greenhous	not present	Pachyrhizus tuberosus	Brazil <sup>e</sup>	<del>2</del> 00	field	not present
Crotalaria incana	United States <sup>9</sup>	<del>2</del> 00	greenhous	introduced	Phaseolus angustissimus	United Statesh	<del>2</del> 00	field	native
Crotalaria lanceolata	United States <sup>9</sup>	<sup>8</sup> 97	е	introduced	Phaseolus coccineus	United States <sup>e</sup>	ရ <del>ိ</del> 95	field	native (Mexico)
Crotalaria linifolia	Australia <sup>e,f</sup>	ရ <sub>96</sub>	field	not present	Phaseolus lunatus	India <sup>f</sup>	200	field	introduced
Crotalaria micans	Indonesia <sup>f</sup>	0	field	native (Mexico)	Phaseolus polystachios	United Statesh	8	field	native
		200			Phaseolus polystachios var.		200		
Crotalaria ochroleuca	United States <sup>9</sup>	200 8	greenhous e	introduced	polystachios (=subsp. polystachios in GRIN)	United Statesh	200 8	field	native
		200	greenhous		Phaseolus polystachios var. sinuatus (=		200		
Crotalaria sagittalis	United States <sup>g</sup>	898	greenhous	native	subsp. sinuatus in GRIN)	United Statesh	<u>8</u> 00	field	native
Crotalaria spectabilis	United States <sup>f</sup>	496	е	introduced	Phaseolus vulgaris	South Africa <sup>e,f</sup>		field greenhous	native (Mexico)
Crotalaria trichotoma	Indonesia <sup>f</sup>	200	field greenhous	introduced	Pisum sativum	Japan <sup>f</sup>	_	greenhous	introduced
Crotalaria verrucosa	United States <sup>g</sup>	8 <sub>93</sub>	e	uncertain	Pseudovigna argentea	United States <sup>9</sup>	_	greenhous	not present
Derris philippinensis	Philippines <sup>e,f</sup>	200	field greenhous	not present	Psophocarpus tetragonolobus	India <sup>f</sup>	<b>2</b> 00	e	not present
Desmodium cuspidatum	United States <sup>g</sup>	<del>2</del> 00	greenhous	native	Psoralea pinnata	South Africae	497	field greenhous	not present
Desmodium perplexum	United States <sup>g</sup>	<sup>8</sup> 97	e	native	Psoralea tenax	Australia <sup>f</sup>	ရ <del>ိ</del> 97	e	not present
Desmodium rhytidophyllum	Australia <sup>e</sup>	900	field greenhous	not present	Pueraria calycina	China <sup>e,f</sup>	996	field	not present
Desmodium rigidum	United States <sup>9</sup>	<b>2</b> 00	e	native	Pueraria montana	Japan <sup>e,f</sup>	9 <sub>93</sub>	field	introduced
Desmodium tortuosum	United States <sup>e</sup>	6 <sub>98</sub>	field	introduced	Pueraria montana var. lobata	Taiwan <sup>e,f</sup>	<del>9</del> 97	field	introduced
Desmodium triflorum	Australia <sup>f</sup>	197	field	introduced	Pueraria montana var. montana	China, Taiwan <sup>e</sup>	999	field	not present
Desmodium varians	Australia <sup>e,f</sup>	ရ <sub>92</sub>	field	not present	Pueraria peduncularis	Nepal <sup>e,f</sup>	196	field	not present
Erythrina microcarpa	Indonesia <sup>f</sup>	<del>2</del> 98	field	not present	Pueraria phaseoloides	Cambodia <sup>e,f</sup>	<del>1</del> 93	field	not present
Erythrina senegalensis	Nigeria <sup>e,f</sup>	ရ <del>ိ</del> 96	field	not present	Pueraria pulcherrima	Philippines <sup>e,f</sup>	ရ <del>ိ</del> 98	field greenhous	not present
Erythrina subumbrans	Malaysia <sup>e,f</sup>	9 <sub>99</sub>	field	not present	Rhynchosia minima	Taiwan <sup>f</sup>	196	е	native
Erythrina variegata	Thailand <sup>e,f</sup>	<del>2</del> 98	field greenhous	introduced	Rhynchosia tomentosa var. mollissima	Indonesia <sup>e,f</sup>	900	field	native
Glottidium vesicarium	Taiwan <sup>f</sup>	198	greenhous	native	Robinia hispida	United Statesh	<del>2</del> 00	field greenhous	native
Glycine canescens	Australia <sup>e</sup>	196	е	not present	Robinia viscosa	United States <sup>9</sup>	<sup>8</sup> 98	greenhous	native
Glycine clandestina	Australia <sup>e,f</sup>	ရ <sub>98</sub>	field greenhous	not present	Securigera varia	United States <sup>f</sup>	<del>1</del> 98	greenhous	introduced
Glycine falcata	Australia <sup>e,f</sup>	198	greenhous	not present	Senna occidentalis	United States <sup>f</sup>	200	greenhous	native (Mexico)
Glycine latrobeana	Australia <sup>e,f</sup>	190	е	not present	Senna sophera	United States <sup>9</sup>	<sup>8</sup> 98	greenhous	uncertain
Glycine max	Japan <sup>e,f</sup>	<del>9</del> 90	field	introduced	Sesbania herbacea	United States <sup>f</sup>	<del>1</del> 98	greenhous	native
Glycine max subsp. soja	Japan <sup>e,f</sup>	398	field greenhous	not present	Sesbania sericea	United States <sup>f</sup>	<del>1</del> 95	е	introduced
Glycine tabacina	Australia <sup>e,f</sup>	194	е	not present	Shuteria sp.	China <sup>e,f</sup>	900	field greenhous	not present
Glycine tomentella	Taiwan <sup>e,f</sup>	300	field greenhous	not present	Tephrosia cinerea	United States <sup>9</sup>	<del>2</del> 00	greenhous	native (Mexico)
Glycyrrhiza lepidota	United States <sup>9</sup>	<b>8</b> 97	е	native	Tephrosia purpurea	United States <sup>9</sup>	<del>2</del> 00	greenhous	uncertain
Hardenbergia violacea	Australia <sup>e,f</sup>	6	field	not present	Teramnus labialis	United States <sup>g</sup>	8	е	uncertain
Hylodesmum podocarpum subsp.	China <sup>e,f</sup>	195 0	fiold	not procent	Teramnus micans	United States <sup>9</sup>	200	greenhous	not procent
oxyphyllum Indigofera spicata	United States <sup>9</sup>	200 8	field greenhous	not present not present	Teramnus uncinatus	United States <sup>9</sup>	<sup>8</sup> 200	greenhous	not present native (Mexico)
Indigofera suffruticosa	United States <sup>9</sup>	<b>2</b> 00	greenhous	native (Mexico)	Trifolium aureum	United States <sup>9</sup>	^	greenhous	introduced
Kennedia coccinea	Australia <sup>f</sup>	<sup>ମ୍</sup> 97	greenhous	not present	Trifolium cernuum	United States <sup>9</sup>		greenhous	not present
Kennedia prostrata	Australia <sup>e,f</sup>	<sup>ရ</sup> 97	e field	uncertain	Trifolium incarnatum	United States <sup>f</sup>	898 4	greenhous	introduced
Kennedia rubicunda	Australia <sup>e,f</sup>	<sup>ရ</sup> 97 6	_	not present	Trifolium lappaceum	United States <sup>9</sup>	<b>2</b> 00	greenhous	introduced
Kummerowia stipulacea	United States <sup>f</sup>	ရှိ98 4	field greenhous	introduced	Trifolium repens	United States <sup>f</sup>	4	greenhous	introduced
Kummerowia striata	United States	<del>1</del> 98 ₄	greenhous	introduced	Trifolium resupinatum	United States <sup>9</sup>	<b>2</b> 00	greenhous	introduced
Lablab purpureus	Australia <sup>e,f</sup>	197 400	greenhous	introduced	Vicia faba	India <sup>f</sup>	_	greenhous e	introduced
Labiab purpureus Lathyrus aphaca	United States <sup>9</sup>	200	greenhous e	introduced	Vicia iaba Vigna adenantha	United States <sup>9</sup>	200 800	greenhous e	introduced
Lathyrus latifolius	United States <sup>h</sup>	200 800	field -	introduced	Vigna adenantria Vigna angularis	Japan <sup>f</sup>		greenhous e	not present
Latnyrus latifolius Lespedeza bicolor		998 2	field greenhous	introduced	Vigna anguiaris Vigna cylindrica	Philippines <sup>f</sup>	<del>1</del> 99	e field .	·
Lespedeza bicolor Lespedeza capitata	Japan <sup>†</sup> United States <sup>9</sup>	<b>ź</b> 00 8	greenhous e	native	Vigna luteola	India <sup>e,f</sup>	_	field greenhous	not present Native
Loopodoza bapitata	Jimeu Olales	J	е	HAUVÜ	vigita lateola	maia *	5	C	radivo
Lespedeza cuneata (=Lespedeza juncea	11.00.00	200	greenhous	. ,			198	greenhous	
var. <i>sericea</i> in ILDIS)	United States <sup>9</sup>	<sup>8</sup> 200	greenhous	introduced	Vigna mungo	India <sup>e,f</sup>		greenhous	not present
Lespedeza cyrtobotrya	United States <sup>9</sup>	8 197	greenhous	introduced	Vigna radiata	Japan <sup>e,f</sup>	95	e	introduced (Mexico)
Lespedeza juncea	Australiaf	<b>2</b> 00	greenhous	introduced	Vigna unguiculata	China <sup>e,f</sup>	96	field	introduced
Lespedeza thunbergii	United States <sup>9</sup>	<sup>8</sup> 200	greenhous	introduced	Vigna unguiculata subsp. sesquipedalis	Cambodiae	<del>1</del> 97	field	not present
Lespedeza virgata	United States <sup>9</sup>	997	greenhous	introduced	Vigna unguiculata subsp. unguiculata	Chinae	9	field	not present
Lotus corniculatus	Australia <sup>f</sup>	4	е	introduced					

a Most current scientific name and authority from ILDIS. International Legume Database & Information Service. Retrieved February 2, 2008, from http://www.ildis.org.

c Location of the study: field/natural occurrence or greenhouse study

b Country and year of the first published occurrence with preference given to a natural, field infection of P. pachyrhizi, even if a greenhouse study preceded the field occurrence. Information came from various sources

Conclusions

The previously reported and newly identified hosts belong to a subgroup within the Papilionoideae subfamily (Fig. 2). Papilionoideae contains several major clades, and hosts of *P. pachyrhizi* are found in nearly all of them. No screened species from the Cladastris or Dalbergioid clades were found to be hosts. No species from the Mirbelioid clade were screened in our studies. The Millettioid clade contains the most severely infected hosts, as well as those that are most economically important. It is expected that there are many more hosts of the pathogen in the groups, i.e. clades and genera, in which hosts have already been identified.

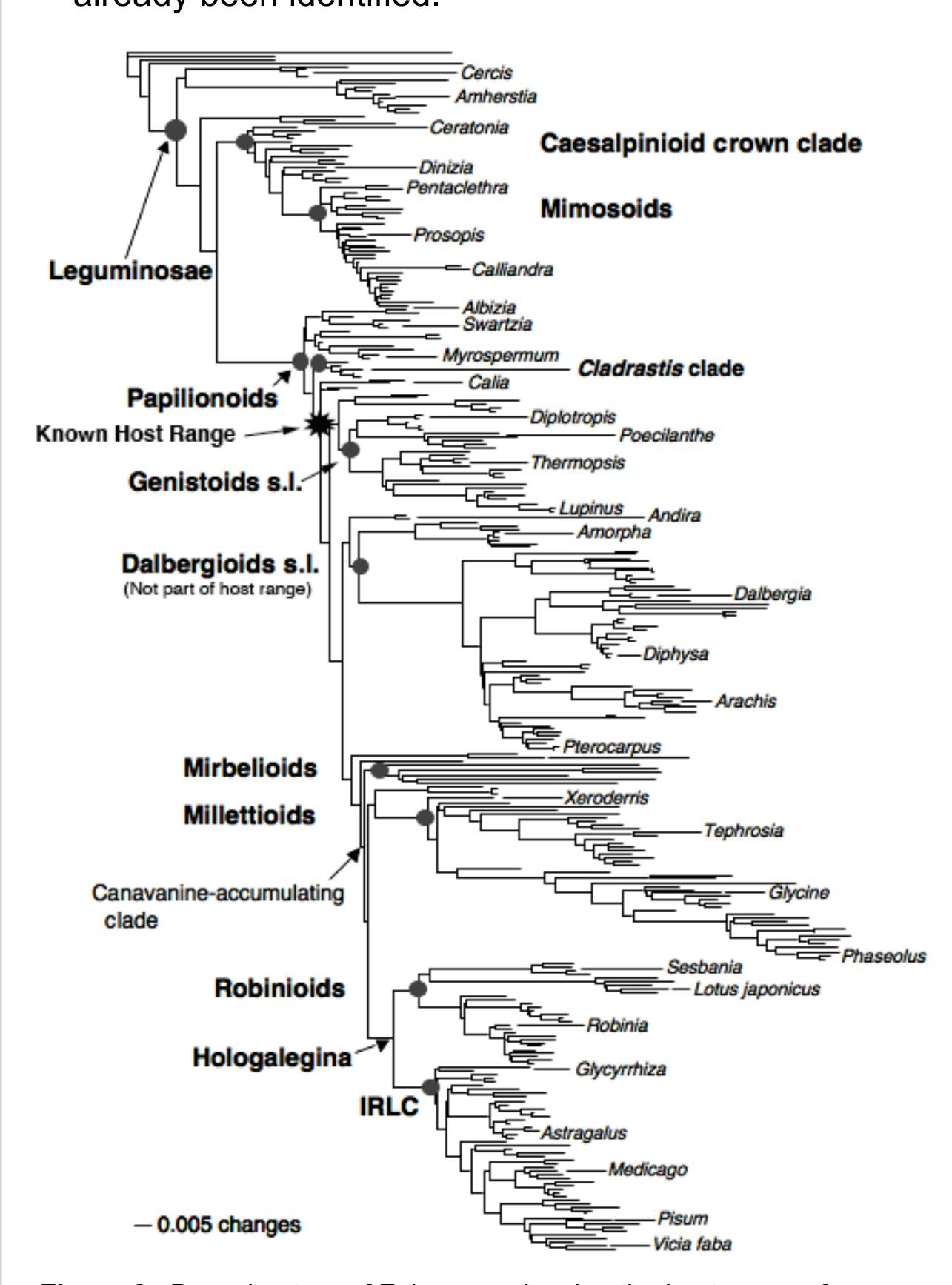


Figure 2. Bayesian tree of Fabaceae showing the host range of Phakopsora pachyrhizi. The known host range is indicated with an asterisk.

Adapted with permission from Wojciechowski, M. F., Lavin, M., and Sanderson, M. J. 2004. A phylogeny of legumes (Leguminosae) based on analysis of the plastid MATK gene resolves many well-supported subclades within the family. Am. J. Bot. 91:1846-1862.

### References

- 1.ILDIS. 2007. International Legume Database & Information Service: University of Reading, UK.
- 2.Ono, Y., P. Buritica, and J. F. Hennen. 1992. Delimitation of Phakopsora, Physopella and Cerotelium and their species on Leguminosae. Mycological Research 96 (10):825-850
- 3. Slaminko, T.L., M. R. Miles, R. D. Frederick, M. R. Bonde, and G. L. Hartman. 2008. New legume hosts of *Phakopsora* pachyrhizi based on greenhouse evaluations. Plant Disease 92:767-771.
- 4.Slaminko, T.L., M. R. Miles, J. J. Marois, D. L. Wright, and G. L. Hartman. Hosts of *Phakopsora pachyrhizi* identified in field evaluations in Florida. Plant Health Progress (in press).

### d North American native status e Farr, D. F., Rossman, A. Y., Palm, M. E., and McCray, E. B. 2007. Fungal Databases, Systematic Botany & Mycology Laboratory, ARS, USDA. Retrieved February 2, 2008, from http://nt.ars-grin.gov/fungaldatabases/ f Summarized in Ono et al. (2).