Additional Alternative Hosts of *Phakopsora pachyrhizi*, Causal Agent of Soybean Rust

JOANN L. RYTTER, Biological Laboratory Technician, and W. M. DOWLER and K. R. BROMFIELD, Research Plant Pathologists, Plant Disease Research Laboratory, Agricultural Research Service, U.S. Department of Agriculture, Frederick, MD 21701

ABSTRACT

Rytter, J. L., Dowler, W. M., and Bromfield, K. R. 1984. Additional alternative hosts of *Phakopsora pachyrhizi*, causal organism of soybean rust. Plant Disease 68:818-819.

Thirty-five species within 23 genera of legumes were tested for reaction to *Phakopsora pachyrhizi*, the soybean rust causal organism. Twelve species are reported as new alternative hosts, including *Coronilla varia, Lespedeza striata, Lupinus luteus, Sesbania sericea,* and *Trifolium repens*. Many of the hosts shown to be susceptible to *P. pachyrhizi* are common in the southern United States and could serve as overwintering hosts for this pathogen.

Soybean rust, causal organism *Phakopsora pachyrhizi* Sydow, is a serious soybean disease in Asia and Australia. Occurrence of this fungus in the United States is not known; however, it is a potential threat to the soybean crop of this country. In 1976, the rust was first observed on soybean in Puerto Rico by Vakili (14). This was the first observation of *P. pachyrhizi* on soybean in the Western Hemisphere. Since then, it has been reported on soybeans in Brazil (3), Colombia (4), and Costa Rica (1). The epidemiology of soybean rust is not well understood nor is the function of the teliospore known.

The purpose of this paper is to identify additional alternative hosts of this pathogen that could provide primary inoculum for soybean crops in the United States or serve as overwintering sources of the disease organism. Legumes chosen for screening were those commonly found in the southeastern and Gulf Coast regions of the United States. Some of these have been reported to be hosts in other areas of the world. An extensive list of previously reported hosts is found in the second edition of *Compendium of Soybean Diseases* (9).

This study was conducted within the Plant Disease Research Laboratory (PDRL) containment facility at Frederick, MD.

MATERIALS AND METHODS

Test plants. All legumes were planted in 10-cm-diameter clay pots in pasteurized soil. The number of plants tested varied because of seed size and germination capability and ranged between five and 40 plants per culture tested. Small seeds were broadcast on the soil surface. Seed of some species were treated to improve germination. Many responded to these treatments; others did not, and the number of plants available was small.

When the legumes were 2–4 wk old, they were divided into three groups; each group was inoculated with a selected culture of *P. pachyrhizi*. Wayne soybean (*Glycine max*) and red kidney bean (*Phaseolus vulgaris*) were inoculated as controls.

Inoculum sources. A culture from Puerto Rico and one from Brazil were chosen as representative test cultures. A virulent culture from Taiwan was also used to compare an Eastern Hemisphere culture with the two Western Hemisphere cultures. The three cultures were as follows: 1) PR COMP—progeny of urediniospores collected in 1975 at Limani, Puerto Rico, from hyacinth bean (*Lablab purpureus*), common bean, lima bean (*Phaseolus lunatus*), soybean, and scarlet runner bean (*P. coccineus*) by N. G. Vakili, USDA-ARS, Mayaguez, Puerto Rico. The collection was composited and increased on Wayne soybean and other hosts. 2) BRAZIL 82-1—progeny of urediniospores collected from lima bean by J. A. Deslandes, ESAL, Lavras, Brazil. The collection was received at PDRL in 1982 and subsequently increased on lima bean and red kidney bean. 3) TAIWAN 72-1—progeny of urediniospores sent from Taiwan in 1972 by Lung-Chi Wu, National Taiwan University, Taipei, and increased on Wayne soybean.

Inoculum of all three cultures consisted either of freshly collected urediniospores or of urediniospores that had been stored in sealed glass tubes held in a liquid-nitrogen refrigerator (−196 C).

Inoculum storage. To ensure adequate infectivity, it was necessary to predry urediniospores of cultures PR COMP and BRAZIL 82-1 before storage in liquid nitrogen. These were air-dried for 24 hr before tubing, then stored in liquid nitrogen. When inocula of the cultures were required, they were removed from liquid nitrogen, heat-shocked for 6 min in a water bath at 42 C, and hydrated in a saturated atmosphere for a minimum of 4 hr before application. Normal procedure for the Taiwan culture was removal of urediniospores from liquid-nitrogen storage and direct application to legume foliage.

Inoculation and incubation. Twenty to 25 mg of urediniospores of a given culture was suspended in 10 ml of Freon 13 and sprayed onto the plants. Urediniospore germination varied when determined on water agar, but even at low levels (1–15%), application as described yielded infection that was adequate for rating purposes. Plants were removed from the dew chambers after 17–20 hr at 20–21 C and transferred to a greenhouse, where temperatures ranged from 18 to 30 C.

Reaction ratings. Host reaction was recorded 30 days after plants were placed in the greenhouse. The following modification of a scheme proposed by Vakili (11) was adopted to record reaction: NI = no infection; R = resistant, necrotic flecks, light brown to dark brown or purple, no uredinia; MR = moderately resistant, necrotic flecks, a few to many lesions, light to dark brown or purple, occasional sporulating lesions; S = susceptible, lesion distribution higher than MR, normal sporulation; and HS = highly susceptible, heavy distribution of lesions with prolific sporulation.

When a legume plant had lesions with sporulating uredinia, it was considered a host. Plants scored as MR, S, or HS were therefore hosts.

RESULTS AND DISCUSSION

Thirty-five species within 23 genera of legumes were tested for reactions to three cultures of *P. pachyrhizi*. Twelve species found to be hosts are reported for the first time (Table 1). Nine legume species previously reported to be hosts for at least one culture of *P. pachyrhizi* were found to be hosts to one or more of the other cultures used. Seventeen species did not support sporulation and are reported as nonhosts: *Canavalia ensiformis, Cassia fasiculata, C. obtusifolia, Crotalaria*

Accepted for publication 6 May 1984.

The publication costs of this article were defrayed in part by page charge payment. This article must therefore be hereby marked "*advertisement*" in accordance with 18 U.S.C. § 1734 solely to indicate this fact.

Table 1. Reactions of accessions of legume species to three cultures of *Phakopsora pachyrhizi*[a]

Plant species tested	Source	Culture[b] PR COMP	BRAZIL 82-1	TAIWAN 72-1	Remarks
Alysicarpus vaginalis	PI 189493	R	R	MR-S	New host
Cajanus cajan	PI 400212	MR	S	R-MR	(5,7,16)[c]
Cassia occidentalis	PI 292844	R	R-MR	NI-R	New host
Clitoria ternatea	PI 322364	NI-R	NI-R	MR	New host
Coronilla varia	T 2171	MR	MR	MR	New host
C. varia 'Emerald'	PI 278698	HS	S	R	New host
Crotalaria spectabilis	L. Walker, Stoneville, MS	R-MR	NI-R	NI	New host
Lablab purpureus	PI 288467	HS	HS	MR	(2,7,10,12)
Lespedeza stipulaceae	Valley Seed Co., Fresno, CA	S	MR	MR	New host
L. striata	PI 295940	S	S	R	New host
Lupinus albus	T 6959	MR	MR-S	MR	(9)
L. luteus	PI 316284	S	S	MR	New host
L. luteus	PI 384565	S	S	MR	New host
Macroptilium atropurpureum	PI 316462	HS	HS	MR	(5,9,16)
M. lathyroides	PI 276183	HS	HS	S	(3,9,12)
Melilotus officinalis	PI 314096	MR	MR	MR	New host
Pisum sativum	Burpee Seed Co., Warminsten, PA	MR	MR-S	MR-S	(8,9)
Pueraria lobata	A-50921	NI-R-MR	R-MR	R	(6,8)
P. phaseoloides	A-44904	NI-R-MR	R-MR	R-MR	(15)
Sesbania sericea	PI 284844	S	S	MR	New host
S. exaltata	Azlin Seed Co. Leland, MS	S	S	R-MR	(16)
Trifolium incarnatum	Autauga	S	S	MR	New host
T. repens	T 12039	R-MR	R-MR	R-MR	New host
T. repens	PI 304154	NI	MR	MR	New host

[a] Reaction ratings: NI = no infection, R = resistant, MR = moderately resistant, S = susceptible, and HS = highly susceptible.
[b] See text for explanation of origin of cultures.
[c] Previously reported host; numbers in parentheses indicate literature citations.

spectabilis (PI 316944), *Desmodium* sp., *Lathyrus hirsutus, Lespedeza striata* (TI 7586), *Leucaena leucocephala, Lotus corniculatus, Medicago arabica, M. lupulina, Melilotus officinalis* var. *Erector, Mucuna deeringiana, Trifolium pratense, T. vesiculosum, Vicia angustifolia,* and *V. lathyroides.*

Reaction ratings of the hosts varied. For example, *Crotalaria spectabilis* was rated MR, R, and NI (Table 1), but in repeated trials, inoculation with the PR isolates resulted in a few sporulating lesions. Mixed reactions were observed either on the same leaf, on different leaves, or on different plants of the same species. Similar variations from NI to R were observed on nonhosts. These differences may be due to variations within the plant species or the rust inoculum or to factors associated with inoculation and incubation.

Some accessions of *Crotalaria spectabilis, Lespedeza striata,* and *Melilotus officinalis* were rated as hosts, whereas other accessions were rated as nonhosts for the same cultures of *P. pachyrhizi*, indicating possible strain differences within a given species.

Several accessions of legumes were susceptible (S) or highly susceptible (HS) to the Brazilian and Puerto Rican cultures. Urediniospores from these legumes were reisolated and tested to see if they would reinfect soybean. All isolates from these hosts yielded positive reinfection of soybean. Additional accessions were found moderately resistant (MR) but, by definition, still were considered hosts. It is unknown whether these legumes could be effective overwintering sources for *P. pachyrhizi* under field conditions. Sporulation under conditions tested was sparse.

Most legume species tested were more susceptible to the rust cultures from Brazil and Puerto Rico than to the culture from Taiwan. The Taiwan culture has been consistently more virulent on all soybean varieties tested to date at PDRL.

Many of the legumes shown to be susceptible to *P. pachyrhizi* are commonly found in the southern United States. Some of these remain in a vegetative condition throughout the year and thus could serve as overwintering hosts for the pathogen. Keogh (5) found *P. pachyrhizi* on *Kennedia rubicunda* year-round in Australia, and Vakili (13) found the rust on *Lablab purpureus* year-round in Puerto Rico. Alternative hosts such as these could provide inoculum to infect soybean when the season becomes favorable and should be a concern for the soybean production regions in the United States.

LITERATURE CITED

1. Bromfield, K. R. 1980. Soybean rust: Some considerations relevant to threat analysis. Prot. Ecol. 2:251-257.
2. Chaves, G. M., and DoVale, F. X. R. 1981. Research on soybean rust in Brazil. Soybean Rust Newsl. 4:6-10.
3. Deslandes, J. A. 1979. Ferrugem da soja e de outras leguminosas causada por *Phakopsora pachyrhizi* no est. Minas Gerais. Fitopatol. Bras. 4:337-339. (In Portuguese, English summary)
4. Hepperly, P. R., and Victoria, J. 1980. Soybean rust on soybean (in Colombia). Food Agric. Organ. Plant Prot. Bull. 28:77.
5. Keogh, R. C. 1974. Studies on *Phakopsora pachyrhizi* Syd.: The causal agent of soybean rust. M.S. thesis, Univ. Sydney, Australia. 95 pp.
6. Keogh, R. C. 1976. The host range and distribution of *Phakopsora pachyrhizi* in New South Wales. Austr. Plant Pathol. Soc. Newsl. 5:51-52.
7. Poonpolgul, S., and Surin, P. 1980. Study on host range of soybean rust fungus in Thailand. Soybean Rust Newsl. 3:30-31.
8. Sato, T., and Sato, S. 1982. Infective ability of soybean rust to several leguminous plants. Soybean Rust Newsl. 5:22-26.
9. Sinclair, J. B., ed. 1982. Compendium of Soybean Diseases. 2nd ed. American Phytopathological Society, St. Paul, MN. 104 pp.
10. Sudjandi, M. 1980. Host range study for soybean rust in Indonesia. Soybean Rust Newsl. 3:32-34.
11. Vakili, N. G. 1978. Field observations and host range of soybean rust, *Phakopsora pachyrhizi*, in Puerto Rico. Pages 4-15 in: N. G. Vakili, ed. Proceedings of the Workshop on Soybean Rust in the Western Hemisphere. U.S. Dep. Agric. 81 pp.
12. Vakili, N. G. 1979. Field survey of endemic leguminous hosts of *Phakopsora pachyrhizi* in Puerto Rico. Plant Dis. Rep. 63:931-935.
13. Vakili, N. G. 1981. Distribution of *Phakopsora pachyrhizi* on *Lablab purpureus* in Puerto Rico. Plant Dis. 65:817-819.
14. Vakili, N. G., and Bromfield, K. R. 1976. Phakopsora rust on soybean and other legumes in Puerto Rico. Plant Dis. Rep. 60:995-999.
15. Yang, C. Y. 1977. Past and present studies of soybean rust incited by *Phakopsora pachyrhizi* Syd. Bull. Inst. Trop. Agric. Kyusku Univ. 2:78-94.
16. Yeh, C. C. 1981. Rust and purple seed stain of soybeans. Ph.D. thesis. University of Illinois. 103 pp.