

# Characterizing resistance of soybean accessions to soybean rust (*Phakopsora pachyrhizi*)

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## INTRODUCTION

Soybean rust, caused by *Phakopsora pachyrhizi*, has been detected in the continental U.S since 2004 and has the potential to cause significant yield losses. Four single dominant resistant genes have been identified as *Rpp1*, *Rpp2*, *Rpp3*, and *Rpp4*, and they condition resistance to a limited set of rust isolates (Bonde et al. 2006). Soybean germplasm has been screened for resistance to soybean rust in containment at the FDWSRU in Ft. Detrick and international locations. One of the international locations was the PPRI in Vietnam where the pathogen was identified in 1966. 57 accessions were evaluated in three consecutive seasons in 2005-2006 at PPRI. Three accessions identified as resistant in the Vietnam field trials were grouped with other sources of resistance and were challenged to each of 10 rust isolates at Ft. Detrick.

## OBJECTIVES

1. Characterize resistance of 57 accessions from USDA-ARS.
2. Characterize resistance sources to multiple rust isolates.

## MATERIALS AND EXPERIMENT DEDIGNS

### Experiment 1. Evaluation of 57 accessions in Vietnam

57 accessions provided by the USDA-ARS were evaluated at the PPRI in spring crop 2005. From this initial evaluation, 39 accessions were evaluated in the next two consecutive seasons. Accessions were blocked and replicated by maturity group. The local cultivars DT12 and DT2000 were planted as susceptible and resistant checks, respectively. Plants were inoculated twice at growth stages V6 and R1 with a local unpurified isolate. Disease severity of each maturity group was assessed five times from growth stages R2 to R6. Five plants of each accession were rated at three canopy positions: lower third, middle third, and upper third on each plant, using a 1-4 severity scale, in which 1 = no lesions, 2 = few number of lesions (1-100), 3 = moderate number of lesions (100-500), and 4 = greater than 500 lesions (Vuong et al., 2005). The disease scale in the last trial was based on the percentage of affected leaf area, with the ratings of 0 to 100%. The reaction type, Immune (I), resistant red-brown (RB), susceptible tan (TAN) and mix of TAN and RB (MX). Area under disease progress curve (AUDPC) for severity was calculated for each accession. Statistical analysis was done using the GLM procedure of SAS 9.1 (SAS Institute, Cary NY).

Rating the accessions in the field at PPRI



Table 1. Reaction types and AUPDC of thirteen of fifty seven accessions evaluated in three field trials conducted in 2005-2006 at the PPRI field station in Vietnam

Note: all accessions with Tan lesion type over three seasons are not reported

No	Entry	Evaluated	Spring 2005 (#=62)	Winter 2005 (#23)	Spring 2006 (#=43)
1	PI2100432 ( <i>Rpp1</i> )	Susceptible	160	Not tested	95
2	PI 230970 ( <i>Rpp2</i> )	Susceptible	139	226	44
3	PI 462312 ( <i>Rpp3</i> )	Susceptible	158	Not tested	85
4	PI 459025B ( <i>Rpp4</i> )	Resistant	158	480	71
5	PI 398998	Resistant	170	114	80
6	PI 437323	Resistant	110	86	54
7	PI 423972	Resistant	65	Not tested	56
8	PI 549017	Partial resistant	97	94	55
9	DT2000 (resistant check)	Resistant	74	87	55
10	Caobang U8253 (resistant check)	Resistant	158	Not tested	53
LSD <sub>avg</sub>			31	29	12

Reaction type

RB reaction	TAN reaction	Mixed (RB-TAN)	TAN with few lesions
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Table 2. Reaction type and mean rating with sporulation score of 20 accessions to 10 rust isolates at Fort Detrick, MD

Lines / Isolate	TW72-1	IN73-1	TW80-2	BZ01-1	TH01-1	ZM01-1	PG01-2	AL04-1	LA04-1	AL04-3
DT2000	3.0	2.5/1	3.5/2	3.3	3.7/2	3.0/2	3.2	2.8/2	2.5/1	2.5
Caobang U8253	2.8	2.5	3.3	3.2/2	3.0/2	2.7/2	3.2/1	3.3/2	3.3	2.8
NTHL LangSon	3.5	2.5/2	3.2/2	3.7/2	3.7/2	3.2/2	3.3	3.3/2	3.8	2.3
GC 84058-18-4	3.0	2.5/1	3.0/2	3.2/2	4.2/2	3.2/2	2.6	2.8/2	2.0/1	3.2
DT95	3.0/3	2.5	4.0	4.0/2	4.5/2	3.8/2	3.5/2	4.3/2	2.2/1	3.2
DT96	3.0	2.0	4.0	4.3	4.2	3.5	3.3	3.3	3.0/2	2.8
VX93	3.0	3.0	4.5	3.8	3.8	3.0	3.4	3.8	4.0/2	3.5
M163	3.8	3.2	3.8	4.0	4.2	3.5	3.8	3.7	4.4	3.8
DT12	3.5	3.0	3.7	4.0	4.2	3.3	3.8	3.8	3.8	3.2
PI 437323	3.4	3.0	3.3/3	3.2	3.0/3	3.3	2.7/3	3.7	3.8/3	3.2
PI 423972	3.7	2.8	4.0/3	3.7	4.2/2	3.7/2	4.0	4.2	4.2	3.5
PI 581886	3.8/2	1.8	3.2/2	3.2/2	3.2/2	2.5/1	3.7/1	2.2/1	3.7	3.2
PI 587905	3.7/2	2.3/1	3.3/2	3.0/2	3.3/2	2.8/1	3.8/2	3.0/1	3.2	3.0/2
PI 605833	3.0/2	2.3/1	3.3/2	3.7/2	3.3/2	2.8/2	3.2/3	3.3/2	3.2	3.0/2
PI 594754	3.0	Immune	1.8/1	3.0/1	2.0/2	2.6/1	3.2/1	2.0/1	3.7	2.8/1
PI 200492 ( <i>Rpp1</i> )	3.0	Immune	3.8	3.3	4.5	3.5	4.2	4.2	2.7/2	3.2
PI 230970 ( <i>Rpp2</i> )	1.7/1	2.3/1	3.7	4.0/3	3.8/2	3.3/2	2.7/2	3.8/3	2.7/2	2.5/1
PI 462312 ( <i>Rpp3</i> )	3.0	3.0/2	3.8	4.2	3.8	3.2	4.2	3.8/2	2.2/2	3.3
PI 459025B ( <i>Rpp4</i> )	3.8/3	3.0/3	3.5/3	3.7/2	3.5/3	3.2/2	3.8/2	3.5/2	4.0/3	2.7/2
Williams82	3.3	3.0	3.8	3.8	3.3	3.7	3.3	3.7	4.3	3.5
LSD <sub>avg</sub>	0.6	1.4	0.6	0.6	0.8	0.6	1.1	0.6	1.8	0.6

Reaction type

RB reaction	TAN reaction	Mixed reaction	Immune reaction
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Rating for rust resistance in Containment at Ft. Detrick, MD



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Resistant accessions PI 437323 with RB lesions



Mixed reaction on PI 423972



Susceptible check Williams 82 with typical TAN lesions



## Experiment 2. Greenhouse evaluation of resistant sources identified in the field.

Twenty accessions, including 15 identified as resistant in Paraguay and Vietnam, the sources of four known single genes and Williams 82 (a susceptible check), were inoculated with each of ten rust isolates in containment at Fort Detrick. Plants, 14 to 18 days old, were inoculated with 40 ml water containing 20,000 spores/ml using an atomizer at 20 psi. The flats were placed in a dew chamber at 20-22°C, in the dark for 24 hours. Each of the ten isolates was inoculated separately using two replications. The most severely infected trifoliolates were rated for severity using a 1-5 scale in which 1 = no visible lesions, 2 = few scattered lesions present, 3 = moderate number of lesions on at least part of the leaf, 4 = abundant number of lesions on at least part of the leaf, and 5 = prolific lesions develop over most of the leaf. Reaction type, Immune (I), RB, TAN and mixed was recorded. Sporulation within RB lesions was rated on a 1 to 5 scale: 1 for no sporulation, 2, 3, 4 and 5 when the sporulation was equal to 25, 50, 75 and 100% of the sporulation of a susceptible TAN lesion, respectively (Miles et al., 2005). Data were analyzed using GLM procedure of SAS 9.1

## RESULTS AND DISCUSSION

**Vietnam.** Three accessions, PI 459025B (*Rpp4*), PI 398998, and PI 437323 had RB reactions in all three seasons (Table 1). These accessions also had low AUDPC. PI 200492 (*Rpp1*) and PI 462312 (*Rpp3*) had TAN reactions in all three seasons whereas PI 459025B (*Rpp4*) had a RB reaction. PI 230970 (*Rpp2*) had a RB reaction the first two seasons and a mixed reaction the third season. PI 549017, had a TAN reaction but had a reduced AUDPC which was equal to the resistant check DT2000. PI 549017 may have partial resistance due to reduced infection frequency or longer latent period. The mixed reaction type was observed more frequently in the third season, suggesting that there was a shift in the virulence of the pathogen.

**Fort Detrick.** PI 459025B had an RB lesion type with high levels of sporulation to all ten isolates, but differed for severity by isolate. This result was similar to that observed in Vietnam. The remaining accessions produced a TAN lesion type with at least one isolate. Three accessions (PI 594754, PI 605833 and PI 587905) identified as resistant in Paraguay, had RB reactions with a low sporulation to all isolates except the U.S isolate LA04-1. In the contrast, VX93, a resistant source identified in Vietnam, was the only entry that had a RB reaction to LA04-1, but had TAN reactions with the remaining nine isolates. PI 594754 was immune to IN73-1, the isolate used to identify *Rpp1*, however, PI 594754 had a mixed reaction with TW72-1 and an RB reaction to the remaining rust isolates, suggesting that it may carry additional resistance compared to PI 200492. PI 437323 identified in Vietnam, was resistant to the four most aggressive rust isolates (TW72-1, TH01-1, PG01-2 and LA04-1). In conclusion, all of the sources of resistance were found to be isolate specific, differing by reaction type, severity or level of sporulation. We also found that the newly purified U.S. isolates may have a high degree of virulence based on the lesion type, especially AL04-3.

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