Evaluation of Potential Soybean Rust Resistant Sources in Paraguay During the 2005-06 Season

M. R. Miles, USDA-ARS, National Soybean Research Center, University of Illinois, Urbana, IL 61801; **W. Morel**, Centro Regional de Investigación Agrícola, Capitán Miranda, Itapúa, Paraguay; **J. D. Ray**, USDA-ARS, Crop Genetics and Production Research Unit, Stoneville, MS 38776; **J. R. Smith**, USDA-ARS, Crop Genetics and Production Research Unit, Stoneville, MS 38776; **R. D. Frederick**, Foreign Disease-Weed Science Research Unit, USDA-ARS, Ft. Detrick, MD, 21702 and **G. L. Hartman**, USDA-ARS, National Soybean Research Center, Department of Crop Sciences, University of Illinois, Urbana, IL 61801.

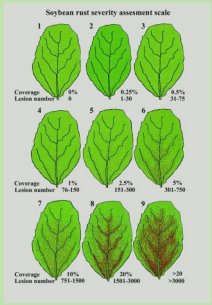
INTRODUCTION

Phakopsora pachyrhizi (H. Sydow & Sydow), the causal fungus of soybean rust, was discovered in Paraguay in 2001 and has since spread through most of the soybean producing areas of Brazil, Bolivia and Columbia with the first report in the continental U.S. in November 2004.

Four single dominant genes identified as Rpp_1, Rpp_2, Rpp_3 and Rpp_4 have been reported to confer resistance to *P. pachyrhizi*. However, each of the four genes conditions resistance to a limited set of specific *P. pachyrhizi* isolates and have not been durable when used in commercial cultivars. There are three reactions types associated with soybean rust: immune (I) and reddish-brown (RB), and the susceptible tan (TAN). The immune reaction, where no visible symptoms are observed, has only been reported with Rpp_1 when inoculated with a few *P. pachyrhizi* isolates, including India 73-1.

The USDA-ARS Soybean Germplasm Collection was evaluated for resistance to soybean rust by inoculating seedlings with a mixture of four *P. pachyrhizi* isolates in the USDA-ARS Foreign Disease-Weed Science Research Unit Biosafety Level 3 containment greenhouses. From over 16,000 accessions evaluated, 805 were reported to have low severity ratings or the presence of an RB lesion type. The objective of this study was to evaluate these soybean accessions for adult plant resistance in field trials conducted in Paraguay. The overall goal was to identify accessions with low soybean rust severities that may provide new sources of resistance genes for incorporation into commercial soybean cultivars.

Fig. 2. Soybean rust severity assessment scale



METHODS AND MATERIALS

Field evaluation 2005-06. Five hundred thirty soybean accessions from maturity groups (MG) III through IX were evaluated for resistance to *P. pachyrhizi* in a field trial during the 2005-06 growing season at the Centro Regional de Investigación Agrícola (CRIA) in Capitán Miranda, Itapúa, Paraguay (Fig. 1). The experimental design was a randomized complete block with accessions blocked by maturity group and four replications within each maturity group. Plots were single rows, 1 m in length and spaced 45 cm apart, with 1 m alleys between ranges. A pair of internal spreader rows were planted after every 10 rows and were inoculated with a liquid suspension of urediniospores, 0.5 g /L water with 0.1% Tween-20 (vol/vol), on 7 to 10-day intervals throughout the season. Overhead irrigation was applied throughout the course of the field trails. The field was surrounded with a susceptible, early maturing soybean cv. Pua ‘e, planted 4 weeks prior to the soybeans. The accessions from MG III, IV and V and the internal spreader rows were replanted in April 2006 using the same field design and protocols described above, and the plots were evaluated in June and July 2006.

Greenhouse and field evaluation of resistant accessions. Ten accessions from MG VI, VII, VIII and IX with severity ratings between 1.0 and 2.0 on the first assessment date in 2005 planting were evaluated in the greenhouse using six plants planted in 4 L pots under natural light. The plants were inoculated to runoff several times using 20,000 urediniospores per ml in distilled water with 0.1% Tween 20 (vol/vol) and placed in a dew chamber at 20-25 °C overnight. The severity of soybean rust infection, the presence of RB or TAN lesions, and the sporulation level within uredinia, were recorded from the first trifoliate on each plant. The accessions were also evaluated in the field under irrigation at CRIA using a replicated randomized complete block design. The accessions were planted in 1 m rows, 10 to 15 seeds per plot, in blocks 10 rows wide that were bordered by the susceptible cvs. Pua‘ e and Camila 6.4. All other field procedures were as described above.

Soybean Rust Assessment. Soybean rust was evaluated on a row basis by examining five of the larger trifoliates from the middle third of the canopy within each plot. Severity was assessed using a 1 to 9 scale, where a rating of 1 was no soybean rust present on any leaflet (resistant) and a rating of 9 was greater than 20% of the leaflet surface infected by rust (susceptible) (Fig. 2). The presence of RB lesions or a mixture of RB and TAN lesions was recorded, as well as the sporulation level (1 to 5 scale) within the RB lesion.

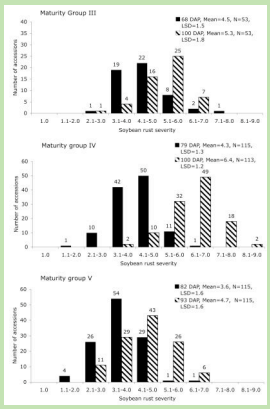
Fig. 1. Field evaluation during the 2005-06 growing season at the Centro Regional de Investigación Agrícola (CRIA) in Capitán Miranda, Itapúa, Paraguay

RESULTS AND DISCUSSION

Maturity Groups III, IV and V. Across the 281 accessions in MGs III, IV and V, soybean rust severity ranged from 2.0 to 9.0 (Fig. 3). Within the 53 accessions in MG III, PI 567351B was rated 4.3 in severity, while PI 437684 was rated 5.0 when evaluated 100 days after planting (DAP). Within the 113 accessions in MG IV, PI 506863 and PI 567341 were rated 4.0 or less in severity when evaluated at 100 DAP and seven additional accessions were rated 5.0 or less. Within the 115 accessions in MG V, PI 398288 and PI 408134B were rated 2.3 in severity when evaluated at 93 DAP. Twenty-nine accessions rated 3.8 or less in severity and were similar to PI 398288 and PI 408134B.

Maturity Groups VI, VII, VIII and IX. Soybean rust severity ranged from 1.0 to 9.0 in the 249 accessions in MGs VI, VII VIII and IX (Fig. 4). Within the 55 accessions in MG VI, PI 587886 was rated 1.0 in severity and was similar to PI 587880A and PI 587880B, which were rated 1.8 and 2.3, respectively. PI 605781E, PI 605781A and PI 615437 had severity ratings of 3.3 to 3.5. Within the 44 accessions in MG VII, PI 587905 was rated 2.5 in severity when evaluated at 129 DAP. No accessions within MG VII were similar in severity to PI 587905. Within the 78 accessions in MG VIII, PI 605779E was rated 4.0 in severity at 129 DAP. No accessions within MG VIII were similar in severity to PI 605779E. Five additional accessions had severity ratings of 4.0 or less at 108 DAP, but all had severity ratings greater than 5.0 at 129 DAP. Within the 72 accessions in MG IX, PI 594754 was rated 1.0 in severity, and PI 605833 and PI 594767A were rated 1.5 and 2.0, respectively, when evaluated at 130 DAP. The accessions PI 567104B, PI 567102B and PI 594767B were rated 3.3 to 3.5 in severity. The severity rating for all six accessions was less than 2.0 when evaluated at 112 DAP.

Fig. 3. Distribution of mean soybean rust severities for the accessions in maturity groups III, IV and V evaluated in a field trial at Centro Regional de Investigación Agrícola, Capitán Miranda, Itapúa, Paraguay in June and July 2006. Each maturity group was evaluated at different days after planting (DAP), and were of different sizes (N). Means were separated by Students' LSD, $P = 0.05$.



Greenhouse and field screen of selected lines. PI 549723, PI 549754, PI 594760B, PI 594767, PI 567099A, PI 567102B, PI 567145C, PI 587880A, PI 587886, and PI 605779E were selected as resistant, with severity ratings less than 2.0, from the first assessment in the 2005-06 growing season. Low soybean rust severity and presence of RB lesions with reduced sporulation was observed in subsequent greenhouse and field evaluations in the 2006-07 season and confirmed the resistance of these accessions (Table 1). The two accessions identified as immune in the 2005-06 field trial, PI 594754 and PI 587886, were highly resistant in the subsequent greenhouse and field assessments, but need to be evaluated against other *P. pachyrhizi* isolates or field populations to confirm their resistance as neither was immune as seedlings in previous greenhouse assessments.

Fig. 4. Distribution of mean soybean rust severity for the accessions in maturity groups VI, VII, VIII and IX evaluated in a field trial at Centro Regional de Investigación Agrícola, Capitán Miranda, Itapúa, Paraguay in March 2006. Each maturity group was evaluated at different days after planting (DAP), and were of different sizes (N). Means were separated by Students' LSD, P = 0.05.

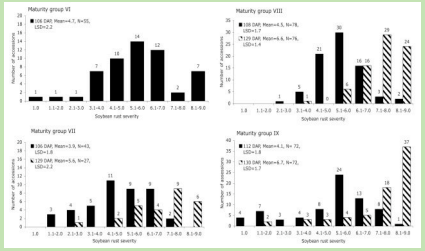


Table 1. Soybean rust severity, lesion type and sporulation level of ten accessions with severity ratings less than 2.0 in first assessment date of the adult plant field trial at Centro Regional de Investigación Agrícola, Capitán Miranda, Itapúa, Paraguay

		Greenhouse evaluation[a]			Field evaluation during the 2006-07 growing season		
Accession	MG	Severity[b]	Lesion type[c]	Sporulation[d]	Severity[b]	Lesion type[c]	Sporulation[d]
PI 587886	VI	2.0	RB	1.0	2.0	RB	2.0
PI 587880A	VI	2.0	RB	1.0	1.3	RB	3.0
PI 605779E	VIII	2.0	RB	1.0	3.0	RB	4.0
PI 594754	IX	2.0	RB	1.0	1.5	RB	1.0
PI 594760B	IX	2.0	RB	2.0	2.0	MX	2.0 or 5.0
PI 594767A	IX	2.0	RB	1.0	1.0	Rb[e]	2.0
PI 567102B	IX	2.0	RB	1.0	1.3	MX	2.0 or 5.0
PI 567099A	IX	2.0	RB	1.0	1.3	MX	1.0 to 5.0
PI 567145C	IX	2.0	RB	2.0	2.3	MX	2.0 to 5.0
PI 594723	IX	2.0	RB	1.0	2.3	MX	5.0
Pua‘ e	VI	9.0	TAN	5.0	9.0	TAN	5.0
Camilia 6.4	VI	7.0	TAN	5.0	9.0	TAN	5.0
LSD[f]		---		---	0.8		---

[a] The greenhouse evaluation consisted of six plants per accession, inoculated three weeks after planting, individual plants were evaluated for severity, lesion type and sporulation level two weeks after inoculation.

[b] The mean soybean rust severity was calculated from a sample of 3 to 5 trifoliates collected from within the mid-canopy of each replication using a 1 to 9 scale with 1 indicating no soybean rust present, 2 = up to 0.25% of the surface affected, 3 = up to 0.5% of the surface affected, 4 = up to 1% of the leaflet surface affected, 5 = to 2.5% of the surface affected, 6 = up to 5 % of the surface affected, 7 = up to 10% of the leaflet affected, 8 = up to 20% of the leaflet surface affected and 9 = over 20% of the leaflet surface affected.

[c] Lesion type classified as the resistant reddish-brown lesion (RB), the susceptible tan colored lesion (TAN), if no lesions were observed the lesion type was classified as an immune (I), where both RB and TAN lesions were observed on an individual leaflet the reactions was mixed (MX).

[d] Sporulation was evaluated visually on a 1 to 5 scale: 1 = no sporulation, 2 = sporulation less then 25% of a TAN lesion, 3 = 50% sporulation of a TAN lesion, 4 = sporulation was 75% of a TAN lesion, and 5 = sporulation comparable to a fully sporulating TAN lesion. When the sporulation ratings differed by replication or on plants within a row both ratings were presented.

[e] RB lesions were observed in the lower canopy, where as the severity rating was from mid-canopy.

CONCLUSION

This is the first report of adult plant resistance to *P. pachyrhizi* in a 530-line subset of 805 soybean accessions previously selected in seedling evaluations as potential sources of resistance. Of the 530 accessions evaluated in this study, approximately 25% had soybean rust severity ratings of 5.0 or less when evaluated as adult plants during the 2005-06 field season. These accessions with low adult plant severities may be new sources of resistance to *P. pachyrhizi*.

USDA United States Department of Agriculture
NCSRP NORTH CENTRAL SOYBEAN RESEARCH PROGRAM
USB