Pathogenic Variation of *Phakopsora pachyrhizi* Populations in Brazil

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The obligate basidiomycete *Phakopsora pachyrhizi* Syd. & P. Syd. is the causal agent of soybean rust that has potential to cause severe yield losses of soybean [*Glycine max* (L.) Merrill]. The disease was originated from East Asia, and had been restricted mainly to Asia and Australia for several decades. After the disease occurrence in Hawaii in 1994, the rust has spread rapidly to Africa, South America and the continental United States. *P. pachyrhizi* can be found through most of soybean producing areas of Brazil. Soybean production in Brazil has been threatened by the rust, since the pathogen was first discovered in 2001.

The objective of this study was to understand pathogenic variation of the rust populations in Brazil. In this paper, we describe (i) development of evaluation system for soybean rust resistance, and (ii) evaluation of *P. pachyrhizi* populations sampled from Brazil in the 2007-2008 and 2008-2009 soybean cultivation seasons.

Soybean differentials below have been selected for evaluation.
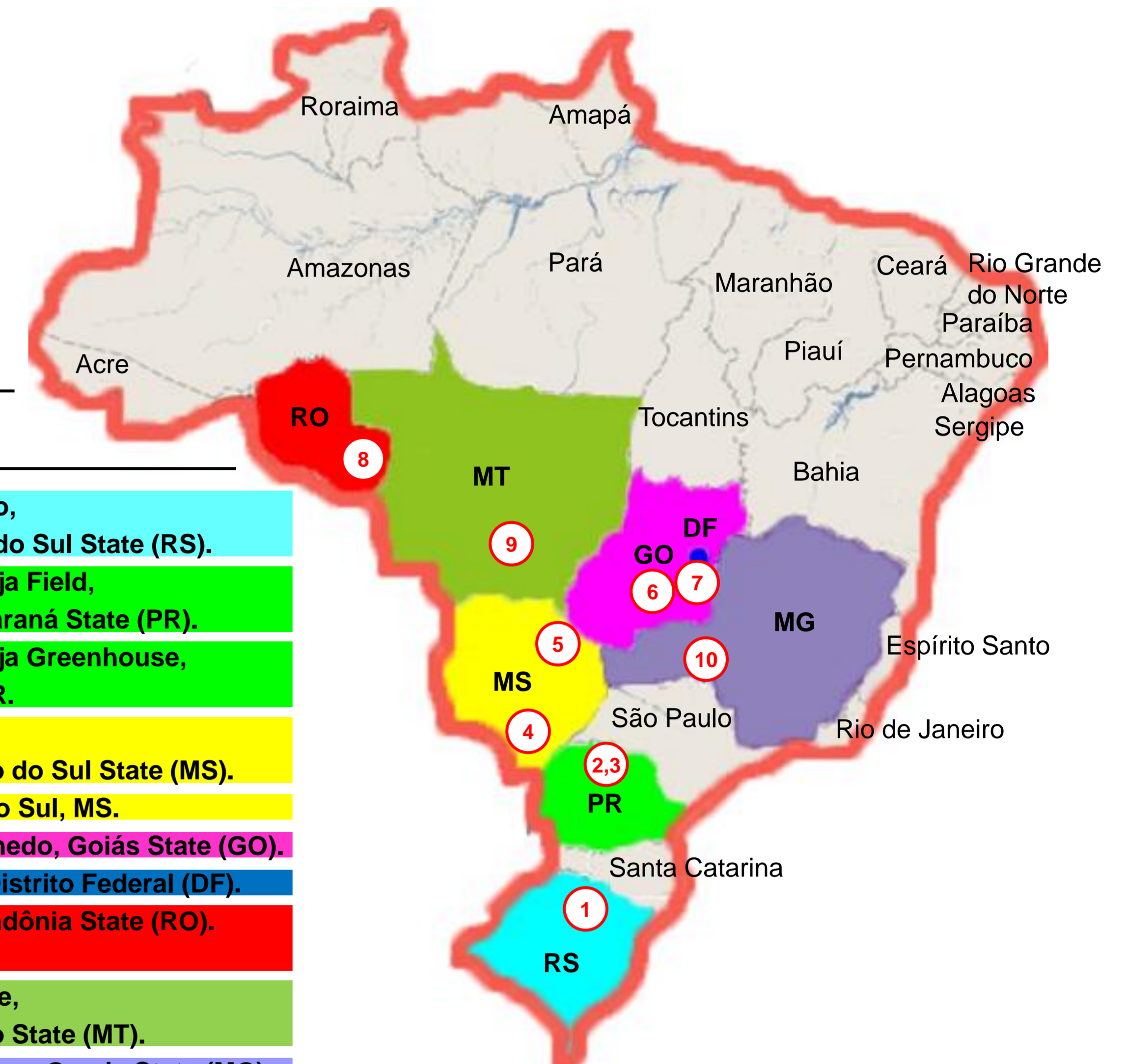
Soybean differentials (dif.) for evaluation

Dif. no.	Name/ Accession	Resistance gene	Reference	Classification
1	PI 200492	Rpp1	Hartwig and Bromfield (1983) Crop Sci	Those carrying major resistance genes
2	Tainung 4	Rpp1	McLean and Byth (1980) Aust J Agric Res	
3	PI 230970	Rpp2	Hartwig and Bromfield (1983) Crop Sci	
4	PI 417125	Rpp2	Laperuta et al. (2008) Pesqui Agropecu Bras	
5	PI 462312	Rpp3	Hartwig and Bromfield (1983) Crop Sci	
6	PI 459025	Rpp4	Hartwig (1986) Crop Sci	
7	Shiranui	Rpp5	Garcia et al. (2008) Theor Appl Genet	
8	PI 416764	unknown		Other PI lines in a numerical order
9	PI 587855	unknown		
10	PI 587880A	unknown		
11	PI 587886	unknown		
12	PI 587905	unknown		
13	PI 594767A	unknown		
14	BRS154	unknown		Susceptible
15	TK5	unknown		
16	Wayne	unknown		

A differential set in Asian Vegetable Research and Development Center.
Variety showing resistant reaction in Brazil and USA.
Variety showing different reaction between Brazil and USA.

Three characters on trifoliate leaves were recorded.

A: Lesion color

Color standard by Kato and Yorinori (2008) JIRCAS Work Rep

1 2 3 4 5 6

Example of lesion corresponds to each class
1 to 6: Reddish brown (RB) to Tan

B: Sporulation level

| 0 None | 1 Little | 2 Moderate | 3 Abundant |

Example of lesion corresponds to each class

C: Number of uredinia per lesion

Example: Enlarged image of single lesion

No. of uredinia/lesion on 30 lesions are counted.

The data was converted into the infection type.

Classification of infection type produced by soybean rust

Lesion	Mean no. (x) of uredinia	Sporulation	Infection type	
-	0	-	I	Immune
+	0	-	HR	Highly resistant
+	Less than 1	Less than 1	MR	Moderately resistant
+	1 ≤ x < 1.5	Less than 1	LR	Low resistant
+	Less than 1.5	More than 2	IM	Intermediate
+	More than 1.5	Less than 1	IM	Intermediate
+	1.5 ≤ x < 3	More than 2	MS	Moderately susceptible
+	More than 3	More than 3	HS	Highly susceptible

Soybean rust samples were collected in Brazil in two cultivation seasons.

P. pachyrhizi isolates in Brazil

Sample	Year	Location
1	2007/08 2008/09	Passo Fundo, Rio Grande do Sul State (RS).
2	2007/08 2008/09	Embrapa Soja Field, Londrina, Paraná State (PR).
3	2007/08	Embrapa Soja Greenhouse, Londrina, PR.
4	2007/08	Dourados, Mato Grosso do Sul State (MS).
5	2007/08	Chapadão do Sul, MS.
6	2007/08	Senador Canedo, Goiás State (GO).
7	2007/08	Planaltina, Distrito Federal (DF).
8	2007/08 2008/09	Vilhena, Rondônia State (RO).
9	2007/08	Campo Verde, Mato Grosso State (MT).
10	2008/09	Uberaba, Minas Gerais State (MG).

The rust samples in Brazil were evaluated based on the infection type.

Season		2007/08									2008/09			
Dif. No.	Variety	1	2	3	4	5	6	7	8	9	1	2	8	10
		RS	PR	PR	MS	MS	GO	DF	RO	MT	RS	PR	RO	MG
1	PI 200492	MS	IM	HS	MS	MS	MS	HS	MS	MS	MS	HS	IM	MS
2	Tainung-4	MS	HS	MS	IM	MS	HS	HS	MS	MS	HS	MS	IM	MS
3	PI 230970	MR	IM	MS	LR	LR	HS	IM	MS	MS	IM	MS	IM	LR
4	PI 417125	IM	HS	IM	LR	MR	IM	MS	MS	MS	MS	MS	IM	MR
5	PI 462312	MS	HS	MS	HS	HS	HS	HS	MS	MS	I	HS	HS	I
6	PI 459025	MS	MR	HS	IM	IM	MS	MS	MR	MR	IM	IM	MR	LR
7	Shiranui	HR	MR	IM	MR	LR	LR	IM	LR	IM	MR	MR	HR	MR
8	PI 416764	MS	IM	HS	MS	MS	HS	IM	LR	IM	MS	MS	IM	MR
9	PI 587855	IM	nd	HS	nd	HR	MR	I	I	I	I	HS	I	I
10	PI 587880A	MS	MR	MR	I	I	I	I	HR	I	I	MS	HS	I
11	PI 587886	MS	HS	HS	HR	HS	MS	IM	MS	MS	MS	MS	MS	HS
12	PI 587905	IM	HS	LR	MR	HR	IM	HR	HR	I	I	MS	MR	I
13	PI 594767A	MR	nd	MR	nd	HR	LR	HR	HR	MR	HR	IM	I	HR
14	BRS154	MS	MS	HS	MS	MS	HS	HS	MS	MS	HS	HS	MS	MS
15	TK5	MS	MS	MS	IM	MS	MS	HS	IM	nd	HS	MS	IM	MS
16	Wayne	MS	MS	HS	HS	HS	HS	HS	MS	MS	HS	MS	MS	MS

Pathogenicity of *P. pachyrhizi* was compared using *Rpp*-carrying plants.

Season		2007/08									2008/09			
Rpp	Variety	1	2	3	4	5	6	7	8	9	1	2	8	10
		RS	PR	PR	MS	MS	GO	DF	RO	MT	RS	PR	RO	MG
1	PI 200492	MS	IM	HS	MS	MS	MS	HS	MS	MS	MS	HS	IM	MS
1	Tainung-4	MS	HS	MS	IM	MS	HS	HS	MS	MS	HS	MS	IM	MS
2	PI 230970	MR	IM	MS	LR	LR	HS	IM	MS	MS	IM	MS	IM	LR
2	PI 417125	IM	HS	IM	LR	MR	IM	MS	MS	MS	MS	MS	IM	MR
3	PI 462312	MS	HS	MS	HS	HS	HS	HS	MS	MS	I	HS	HS	I
4	PI 459025	MS	MR	HS	IM	IM	MS	MS	MR	MR	IM	IM	MR	LR
5	Shiranui	HR	MR	IM	MR	LR	LR	IM	LR	IM	MR	MR	HR	MR

Pathogenicity of *P. pachyrhizi* was compared between the two cultivation seasons.

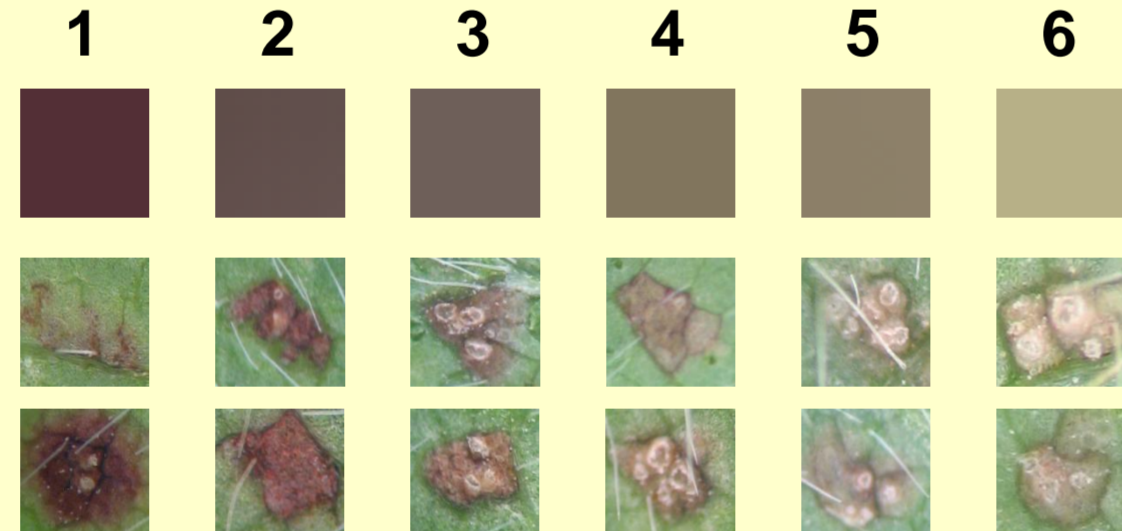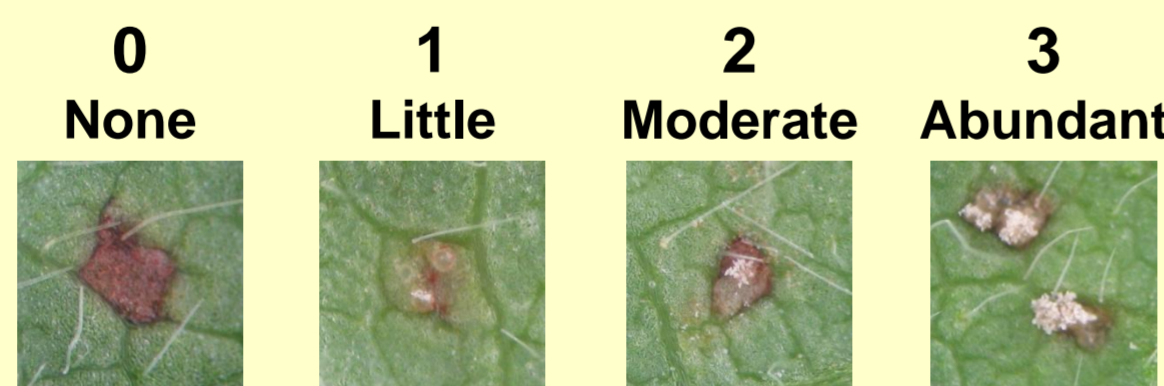| Isolate		1		2		8	
		RS		PR		RO	
Dif. No.		07/08	08/09	07/08	08/09	07/08	08/09
1		MS	MS	IM	HS	MS	IM
2		MS	HS	HS	MS	MS	IM
3		MR	IM	IM	MS	MS	IM
4		IM	MS	HS	MS	MS	IM
5		MS	I	HS	HS	MS	HS
6		MS	IM	MR	IM	MR	MR
7		HR	MR	MR	MR	LR	HR
8		IM	MS	HS	MS	LR	IM
9		IM	I	nd	HS	I	I
10		MS	I	MR	MS	HR	I
11		MS	MS	HS	MS	MS	MS
12		IM	I	HS	MS	HR	MR
13		MR	HR	nd	IM	HR	I
14		MS	HS	MS	HS	MS	MS
15		MS	HS	MS	MS	IM	IM
16		MS	HS	MS	MS	MS	MS

Conclusions

(1) Evaluation system for soybean rust resistance has been constructed using a set of 16 differential varieties.

(2) The evaluation system could detect pathogenic variation among the *P. pachyrhizi* populations in Brazil.

(3) In the first season, 2 rust samples showing similar pattern of the infection types might be the same or similar pathogen population. The other samples were likely different pathogenic populations.

(4) Pathogenic variation between the seasons was detected in the rust populations from RS and PR, but not remarkable in those from RO.