Preliminary analisys of disease progress curves for Asian Soybean Rust epidemics in Entre Ríos Province, Argentina

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INTRODUCTION

The Asian soybean rust (ASR), caused by the *Phakopsora pachyrhizi* produces anticipated defoliation and reduction of the active photosynthetic area. At a world level, significant yielding loses associated to the decrease in the number of pods, grain weight and seed quality are recorded (Hartman *et al.* 2003).

Cited for the first time in the province of Entre Ríos (Argentina) in April 2004 (Formento, 2004), to date it is annually recorded in a generalized way in the main producing soybean region (*Glycine max*) of the country. However, there are scarce works at national level analyzing epidemic variables and the progress of the disease to comprehend the behavior of the disease during the last agricultural cycles (González *et al.* 2006, Scandiani *et al.* 2006 and Sillón *et al.*2006).

In a risk analysis that considered climatic variables Moschini *et al.* (2005) and Saluso *et al.* (2005) consider that conditions would present in Entre Ríos for the development of infective events during the culture cycle. Particularly, in Paraná the period February-May would be the one with greater risk for the soybean crops, which would indicate that a delay in the planting date and the use of late maturity groups in the region would expose the soybeans to environmental factors more favorable for the ASR development.

The aim of the present work was to carry out a preliminary characterization of ASR epidemics in different environments in the province of Entre Ríos.

MATERIALS AND METHODS

Field studies were conducted at two locations with different environmental conditions in Entre Ríos during the 2004-05 and 2005-06 growing seasons:

Paraná. Experimental station (EEA) Paraná of INTA (S 31º 51' 10.6'' O 60º 31' 59.1'')

La Paz. Comercial field crop (S 30º 45' 7.4'' O 59º 32' 19.7'')

In the first cycle an experimental plot of 4 rows and 5 m long was monitored in Paraná (planting date 05/01/05) and in the second cycle, 10 m x 10 m plots were valued in two localities: Paraná (November 03 and 28 and January 03, 2006) and La Paz (November 11 and 28 and December 20, 2005). In all the cases the soybean A 6411 RG, susceptible to *P.pachyrhizi*, was planting, 0.52 m apart.

48 plants were taken at random and were divided into three levels: Upper, Middle and Lower. Weekly, a central leaflet of each level of the plants selected was collected (total n = 48 x 3) and the determination of ASR was carried out in the laboratory.

The following variables was evaluated: Incidence (I = number of diseased plants / total number of plants observed x 100) and Conditional density (Cd = mean number of pustules/leaflet on the affected leaflets, according to de Souza et al. (2005).

In the EEA Paraná, a spore trap was installed next to the trial and evaluations were carried out twice a week according to the methodology proposed by de Souza and Formento (2005).

In Meteorological Stations next to the trials the following was registered: temperature in °C (t), hours of leave wetness (LW) and rainfalls in mm (pp).

The curves of progress and the absolute rate (dy/dt) were made and the logistic, exponential, and Gompertz models were valued and adjusted by no-lineal regression. The appropriateness of the model to the data was analyzed by the coefficients of determination (R^2), the graphic pattern of the residuals and the significance of the parameters estimated. The area under disease progress curve (AUDPC) was estimated by trapezoidal integration (Berger, 1988).

For the statistical analysis of the data the SAS statistical package (SAS, 1999) was used.

RESULTS AND DISCUSSION

In all the cases the appearance of the disease was produced delayed (R5.5 = beginning seed & R6 = full seed) and it was only registered in the last planting date of the two locations. This may be associated to the prolonged periods of hydric deficit registered during a great part of the crop cycle (January and February) during the two growing seasonss.

The logistic model, $y = â1 /(1 + â2 \exp(- â3t))$, where *y* represents disease level in proportion, â1 represents the asymptotic stabilization of the curve, â2 is related to the initial disease, â3 is the rate of disease progress and t is time in days, fit better to the data than the rest of the models analyzed (Table 1 and 2).

	Percent Incidence					
	Paraná 2004-05		Paraná 2005-06		La Paz 2005-06	
	Middle	Upper	Middle	Upper	Middle	Upper
â1	0.999	0.999	0.542	0.354	0.750	0.958
â2	-18.900	-16.527	-20.101	-19.826	-17.057	-22.003
â3	0.187	0.169	0.144	0.136	0.140	0.188
R^2	0.99	0.99	0.99	0.98	0.99	0.98
AUDPC	2144.240	2473.450	583.330	328.130	1356.250	1837.500
Epidemic duration	49 days		29 days		35 days	
Beggining of the epidemic	march 28, 2006 (R5)		april 21, 2006 (R6)		march 30, 2006 (R6)	

Table 1. Parameters (â1, â2 and â3) and coefficients of determination for the logistic model [$y = â1 /(1 + â2 \exp(- â3t))$] fitted to incidence progress curves, AUDPC and duration and beginning of the epidemics of *Phakopsora pachyrhizi* in Paraná during 2004-05 and 2005-06 and in La Paz during 2005-06.

	Uredinia / leaflet					
	Paraná 2004-05		Paraná 2005-06		La Paz 2005-06	
	Middle	Upper	Middle	Upper	Middle	Upper
â1	0.001	0.003	0.001	0.001	0.003	0.005
â2	-18.478	-28.007	-12.214	-12.014	-14.997	-19.203
â3	0.084	0.147	0.046	0.052	0.068	0.103
R^2	0.99	0.98	0.99	0.99	0.99	0.98
AUDPC	190.440	73.170	322.560	804.160	527.520	653.430
Epidemic duration	49 days		29 days		35 days	
Beggining of the epidemic	march 28, 2006 (R5)		april 21, 2006 (R6)		march 30, 2006 (R6)	

Table 2. Parameters (â1, â2 and â3) and coefficients of determination for the logistic model [$y = â1 /(1 + â2 \exp(- â3t))$] fitted to conditional density progress curves, AUDPC and duration and beginning of the epidemics of *Phakopsora pachyrhizi* in Paraná during 2004-05 and 2005-06 and in La Paz during 2005-06.

In all the cases, the Cd values were incipient (< 100 uredinia / leaflet) (Fig. 1). The â1 parameter presented very low values (< 0.01 = < 1%) in all the epiphytes analyzed. The levels of I were from medium to moderate (> 35%).

The epidemic rate (â3) varied from 0.136 to 0.188 for I. The variable Cd fluctuated between values of 0.046 to 0.147, similar to those cited by other authors for mild epidemics phytes and/or delayed appearance (González, *et al.* 2006, Scandiani *et al.* 2006 and Yang *et al.* 1990). The greater rates of Cd were registered in the upper level.

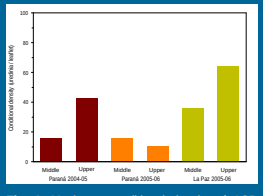

Fig. 1. Maximum conditional density of ASR (uredinia/leaflet) versus plant level for Paraná and La Paz, during 2004-05 and 2005-06.

Table 3. Maximum, minimum and mean temperatures, cumulative rainfall, number of days with rainfall and cumulative hours with leaf wetness for different locations during epidemics of ASR (*Phakopsora pachyrhizi*) in Entre Ríos, Argentina.

Weather variables	Location (year)		
	Paraná 2004-05	Paraná 2005-06	La Paz 2005-06
Max. temp (ºC)	21.9	20.9	24.8
Min. temp (ºC)	11.3	9.6	11.9
Mean. temp (ºC)	16.8	15.2	18
Rainfall (mm)	119.1	23	39.2
Rainfall (nº days)	12	4	21
Leaf wetness (h)	398.4	269.5	285.1

The major levels of final I and Cd were reached in Paraná during the cycle 2004-05 and in La Paz 2005-06 and they also exhibited the greatest apidemic rates and AUDPC. These epidemics began earlier and presented a more favorable environment during their progress, with higher temperatures, more rainfalls and more leaf wetness hours (Fig. 2, 3, 4 and Table 3) compared to the epidemics in Paraná 2005-06.

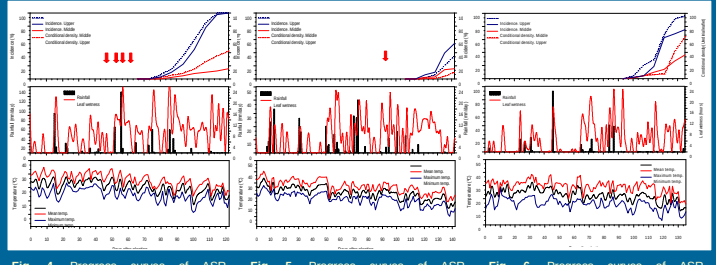

Fig. 4. Progress curves of ASR, maximum, minimum and mean temperatures (ºC), rainfall (mm) and number of daily hours of leaf wetness in Paraná during 2004-05 growing season. Red arrows indicate when inoculum was collected on spore trap.

Fig. 5. Progress curves of ASR, maximum, minimum and mean temperatures (ºC), rainfall (mm) and number of daily hours of leaf wetness in Paraná during 2005-06 growing season. Red arrow indicates when inoculum was detected on spore trap.

Fig. 6. Progress curves of ASR, maximum, minimum and mean temperatures (ºC), rainfall (mm) and number of daily hours of leaf wetness in La Paz during 2005-06 growing season.

These are the first reports of ASR temporal evaluation for the Entre Ríos. They present late and mild epidemics and they express the effect that fall environmental conditions of the region may have (with more rainfalls, more hours of leave wetness and moderate to cool temperatures) on the progress of the disease in the field.

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