HOURLY AND DAILY CHANGES ON AIRBORNE UREDINIOSPORES OF *Phakopsora pachyrhizi*

VARIAÇÃO HORÁRIA E DIÁRIA DE UREDINIOSPOROS DE Phakopsora pachyrhizi NO AR

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ABSTRACT: The Asian rust (*Phakopsora pachyrhizi*) is one of the most destructive diseases of soybean in Brazil. Despite its importance, little is known about the airborne inoculum production dynamics of pathogen throughout the soybean cycle in Brazil. The objective of this study was to assess the temporal variation of air collected *P. pachyrhizi* urediniospores using a Burkard 7-day-spore-trap during 2006-2007 and 2007-2008, from November to March of each soybean (MSoy-8001) growing season. The disease severity was quantified on soybean planted in October 18, 2006 and in October 30, 2007. From November/06 through March/07 were collected over 175,000 urediniospores, and, over 131,000 from November/07 to March/08. In 06-07, most of the spores were collected from January 9, 2007 through February 1st, 2007 (±3,000 urediniospores day^{-1}), and, in 07-08 most urediniospores was collected from February 8, 2008 throughout March 2, 2008 (±2,000 urediniospores day^{-1}). The maximum amount of urediniospores collected in a single day in 06-07 (±15,000; 1/25/2007) was higher than in 07-08 (±12,000; 2/13/2008). In both soybean growing seasons most of the hourly urediniospores was collected from 10:00 am through 6:00 pm and the highest number from December to March, was at 3:00 pm (±16,000 in 06-07 and ±14,000 in 07-08). The disease started earlier in 2006-07 [38 days after planting (DAP)] than in 07-08 (58 DAP). The amount of collected airborne spores was positively correlated to disease severity, leaf wetness, and, precipitation along both soybean growing seasons. However, during a 24h-day evaluation, the major amount of hourly collected spores was negatively correlated to the leaf wetness and air relative humidity.

KEYWORDS: Airborne spore. 7-day-spore-trap. Burkard. Aerobiology.

INTRODUCTION

The Asian rust (*Phakopsora pachyrhizi* Syd. & P. Syd.) of soybean (*Glycine max* L.) is a destructive foliar disease found in many soybean-producing regions (YORINORI et al., 2005; ISARD et al., 2006; JARVIE 2009; ROSA et al., 2015; KELLY et al., 2015; MAUMARY et al., 2016; GODOY et al., 2016). Weather conditions influence directly in the cycle of the pathogen, which favors the development of rust epidemics on soybean (ISARD *et al*. 2005). Rainfall for 12-15 days is one of the main factors that explain the variations of disease severity in field condition (DEL PONTE et al., 2006; DUFAULT et al., 2010a). Marchetti et al. (1976), demonstrated that 6 hours of leaf wetness is the minimum time to ensure infection of soybean by the fungus. It is known that 18-26°C and leaf wetness duration determine the process of infection of urediniospores of *P. pachyrhizi* (ALVES et al., 2007).

The survey of airborne fungi spores by variable means has been done (LUO et al., 2007; OLIVEIRA et al., 2009a; KUDO et al., 2011; DAS; GUPTA-BHATTACHARYA, 2012; ALMAGUER et al., 2013; RIEUX et al., 2014; AHER et al., 2015). The assessment of air inoculum can contribute to understanding the potential risk of epidemics of diseases during the plant cycle (WAKEHAM; KENNEDY, 2010; WEST; KIMBER 2015; IGARASHI et al., 2016). Airborne spores can be sampled in many ways; one of them is the stationary Burkard volumetric spore trap (WEST; KIMBER, 2015; WEST et al., 2017). This trap has been used for detection of fungi and pollen of plants (INCH et al., 2005; PEEL et al., 2014). However, studies concerning the quantification of the air dispersed urediniospores of *P. pachyrhizi* are limited (DEL PONTE et al., 2006; BARNES et al., 2009; ISARD et al., 2011; NASCIMENTO et al., 2012). Iamamoto (2008) using a spore trap in soybean field in central Brazil, stated that was possible to anticipate the chemical control of the soybean Asian rust in 14 to 15 d. This author reported that air weekly collected spores from 100 to 600 could result in a rust outbreak.

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In some places, qualitative studies are made, and the most common airborne fungi spore assessed are anamorphic fungi and a much smaller amount are Uredinales-like spore (AHER et al., 2015). Other studies, beyond qualitative evaluations, make quantitative monthly assessments, and, sometimes, hourly collected spore quantifications (OLIVEIRA et al., 2009b; ALMAGUER et al., 2013). The highest concentrations of daily collected spores are around 9:00 am and 7:00 pm (GRANKE et al., 2014; ALMAGUER et al., 2013; FALL et al., 2016). Thus, the objective of this work was to quantify the hourly and daily collected airborne urediniospores of *P. pachyrhizi* for two growing soybean seasons.

MATERIAL AND METHODS

The experimental trials were conducted at the Experimental Station of Biology of the 'Universidade de Brasília', Brasília, DF, Brazil. Local coordinates are 15º44´07.59" South latitude and 47º52´56.75" West longitude and an average altitude of 1009 m. Before planting, the acidity of the soil was corrected with dolomitic limestone applications, following technical recommendations (EMBRAPA, 2006). The tillage was done with a disk plowing and twice levelling harrow in the area. The mineral fertilizer used was the 4-30-16 (NPK) following technical recommendations (EMBRAPA 2006). The seeds were planted manually to a depth of 4 (±1) cm. The population of soybean was 250,000 plants ha^{-1} (10 plants m^{-1}), and the spacing between rows of 40 cm. Seed were treated with thiamethoxan (Cruiser^{TM} - 35 g a.i. 100 kg^{-1} of seed.) + (metalaxyl+fludioxinil) (Maxim XL^{TM}- 1.0 + 2.5 g a.i. 100 kg^{-1} of seed) and inoculated with 6 x 10^5 CFU of *Bradyrhizobium japonicum* seed^{-1}. The planting of the first trial was done in 10/18/2006 and chemical treatments applied in 11/30 and 12/8/2006. The planting of the second trial was in 10/30/2007 and fungicides applied in 12/27/2007, 12/1 and 1/28/2008 (Table 1).

Table 1. Planting (MSoy-8001), first symptoms (pustules) appearance (% of rusted leaf area), harvesting, soybean Asian-rust evaluations, and, fungicide (0.5 L ha^{-1}) treatment dates of field trials conducted in 2006-07 and 2007-08 at the University of Brasilia Experimental Station, Brasilia, DF, Brazil.

Information	Soybean growing season	
	2006-07	2007-08
Planting Date	10/18/06	10/30/07[3]
Final stand (Plants / ha)	250,000	250,000
Symptoms appearance (SA)	11/29/06	12/26/07
Soybean growth stage in SA	V3/V4[1]	V7/V8
% of rusted leaf area in SA	0.04%	0.10%
Tetraconazole (Domark 100 CE)	11/29/06 (V3/V4) [1]	12/27/07 (V7/V8)
Piraclostrobin+Epoxiconazole (Opera)	10/1/07 (R4/R5) [2]	1/12/08 (R1/R2)
Rust evaluation	11/22/06, 11/29, 12/6, 12/18 1/10/07, 1/17, 1/28	12/18/07, 12/26 1/5/08, 1/11, 1/17, 1/23, 2/1, 2/12, 2/22
Harvest	2/28/07	3/10/08

[1] Vn = (n) number of trifoliolate leaves unrolled, (n) + 1 number of nodes; [2] R1 = Beginning bloom - at least one flower is present on the main stem; R2 = Full bloom - flowers are found on any of the top two nodes; R4 = Full pod - pods are 2 cm long on one of the top four nodes; R5 = Beginning seed - seeds are 3 mm long on one of the top four nodes. [3] month/day/year.

Respectively, in the first and second experiments were used the fungicides Tetraconazole (Domark 100 CE) and Epoxiconazole+Pyraclostrobin (Opera®) (0,5 L ha^{-1}). The application of fungicides was made with a backpack sprayer (20L - Kingfisher PS4020 20 Liter Backpack Sprayer - Yellow). Fungicide application started with the observation of first symptoms of disease (V3/V4 – 29/11/06; V7/V8 – 27/12/07) (Table 1). To evaluate the variation of urediniospores and the progress of the rust on the field, a two-year work has been made in a 600m^2 (30x20m) soybean (cv. MSoy-8001) planting area. This area was subdivided 24 plots of 25m^2 (5x5m plot^{-1}) for disease evaluation.

The Burkard 7-day-spore-trap (Burkard Scientific Ltd PO Box 55, Uxbridge, Middlesex, UB8 2RT, UK) was set in the central portion of the experimental area. The trap has been set on metal support, and the aspiration orifice (2x14 mm) was positioned the 1.90 m in height from the ground. The air suction rate was 10 L/min (14.4 m^3 day^{-1}). Inside the trap there was and aluminum drum rotating at a speed of 2 mm h^{-1}, which contained a clear plastic tape (Melinex, Burkard Ltd., Rickmansworth Hertfordshire, England) covered with a thin layer of silicon grease that was placed around it to capture the spores. The tape set to trap drum was replaced weekly.

Daily and hourly readings of the number of captured were taken every seven days, with seven slides for microscopy (one for each day of the week), with 48 mm tape piece per slide. In each 2-mm tape (1 hour of collection) was counted the number of spores with an optical microscope (400x). Therefore, was quantified the number of spores collected per hour and day of the week and the daily concentration of urediniospores m^{-3} of air, as described by Lima et al. (2009).

The severity of the rust was estimated by the percentage of diseased leaf area (% RLA) of each leaflet examined visually with a stereomicroscope. Three fully developed leaves from the inferior plant-third were randomly collected per plot in each evaluation date. The rust evaluations were made as follow: experiment 1 – 11/22, 11/29, 12/6, 12/18/2006, 1/10, 1/17, 1/28/2007; experiment 2 – 18/12, 26/12/2007, 1/5, 1/11, 1/17, 1/23, 2/1, 2/12, 2/22/2008.

In the center of the planting area was installed a weather station (Metos Compact, Pessel Instruments) with climatic sensors: air temperature (°C) and relative humidity (%) (Temperature and Relative Humidity Probe Model A660610), which recorded the average, maximum and minimum hourly temperatures and humidity on the air; precipitation (mm) (Tipping Bucket Rain Model M523CD); leaf wetness (minutes) (leaf wetness sensors Model IM521CD). The sensors were connected to the automatic data collection station. The data collection was done by transferring the information contained in the data platform for a laptop. Wind speed ($m\ s^{-1}$) data were collected from a Meteorological Station 200m far from the experiment. Correlation tests were carried out among the temporal collected urediniospores, disease severity, and climatic variables, using the Spearman rank correlation coefficient. The number of spores from a day was correlated to the percentage of damaged leaf area climatic and to the climatic variables the same day, as well as to the values taken up to 10 days before the rust evaluation.

RESULTS

Airborne urediniospores of *P. pachyrhizi* was collected mainly from 60 to 110 days after planting (DAP) in both growing seasons (Figure 1A). However, spores were collected in both growing seasons since 30 DAP. From November/06 through March/07 were collected over 175,000 urediniospores $season^{-1}$, and, over 131,000 from November/07 to March/08. In 2006-07, most of the spore were collected from January 9, 2007 through February 1st, 2007 (±3,000 urediniospores day^{-1} = 208 urediniospores m^{-3}), and, in 2007-08 most urediniospores was collected from February 8, 2008 throughout March 2, 2008 (± 2,000 urediniospores day^{-1} = 139 urediniospores m^{-3}). The maximum amount of urediniospores collected in a single day in 2006-07 (14,948 = 1,038 urediniospores m^{-3} January 25, 2007) was higher than in 2007-08 (±11,889 = 826 urediniospores m^{-3}; February 13, 2008) (Figures 1A; 2D). In 2006-07 from 70 to 110 DAP there were 9 spore peaks (≥ 2,000 urediniospores day^{-1} = 139 urediniospores m^{-3}), with an average of 5 days between them (Figure 1A). In the same period, in 2007-08, there were 5 spore peaks, with an average of 8 days between them. Most of the spores were collected until 100 DAP in the first season and 100 DAP in the second (Figure 1B). The disease started earlier in 2006/07 [38 days after planting (DAP)] than in 2007-08 (58 DAP). In 2006-07 the disease reached ~45% (%RLA) and in 2007-08 ~20%. After 110 DAP the %RLA was over 50 and ~30 in 2006-07 and 2007-08, respectively (Figure 1C).

Rust favorable (10-day period with leaf wetness ≥ 6 hours day^{-1}) amount of leaf wetness occurred from 60 to 85 days in 2006-07 and from 85 to 110 in 2007-08 soybean growing season (Figure 1D). Most favorable relative humidity (%) and minutes h^{-1} of leaf wetness, occurred from 70 to 85 DAP in 2006-07 and from 90 to 110 DAP (Figure 2A; B). From, 70 to 110 DAP, the average temperature in 2006-07 was higher (~21°C) than the one (~20°C) in 2007-08 (Figure 2C).

In both soybean growing seasons most of the hourly urediniospores was collected from 10:00 am through 6:00 pm and the highest number from December to March, was at 3:00 pm (±16,000 in 2006/07 and ±14,000 in 2007/08) (Figure 3A). Numbers of hourly collected urediniospores were higher as lower were the hourly average of relative humidity (Figure 3B) and minutes of leaf wetness / hour (Figure 3C). The collected hourly airborne spore was higher as higher was the hour variation of temperature (Figure 3D).

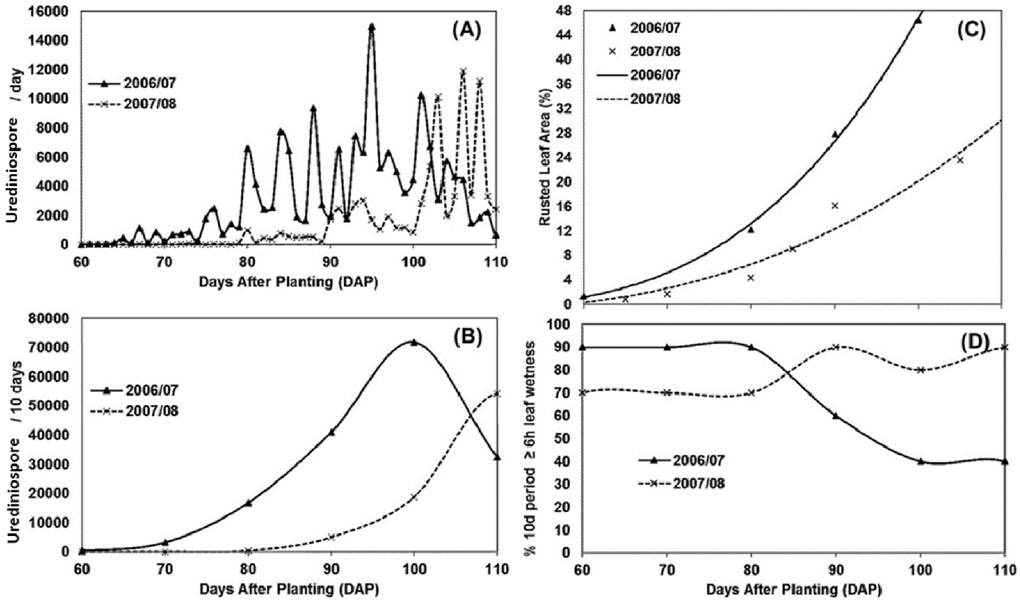

Figure 1. Total of urediniospores of *Phakopsora pachyrhizi* collected daily **(A)** and accumulated every 10 days (**B)** from December 2006 to March 2007 (black line) and from December 2007 to March 2008 (dotted line). (**C**) Asian Soybean Rust severity (% of rusted leaf area) progress in two growing seasons (2006/2007; 2007/2008) on soybean cultivar MSoy-8001. (**D**) Percentage of a 10-day period with leaf wetness ≥ 6 hours day^{-1}. [14,400 urediniospores day^{-1} = 1,000 urediniospores m^{-3}].

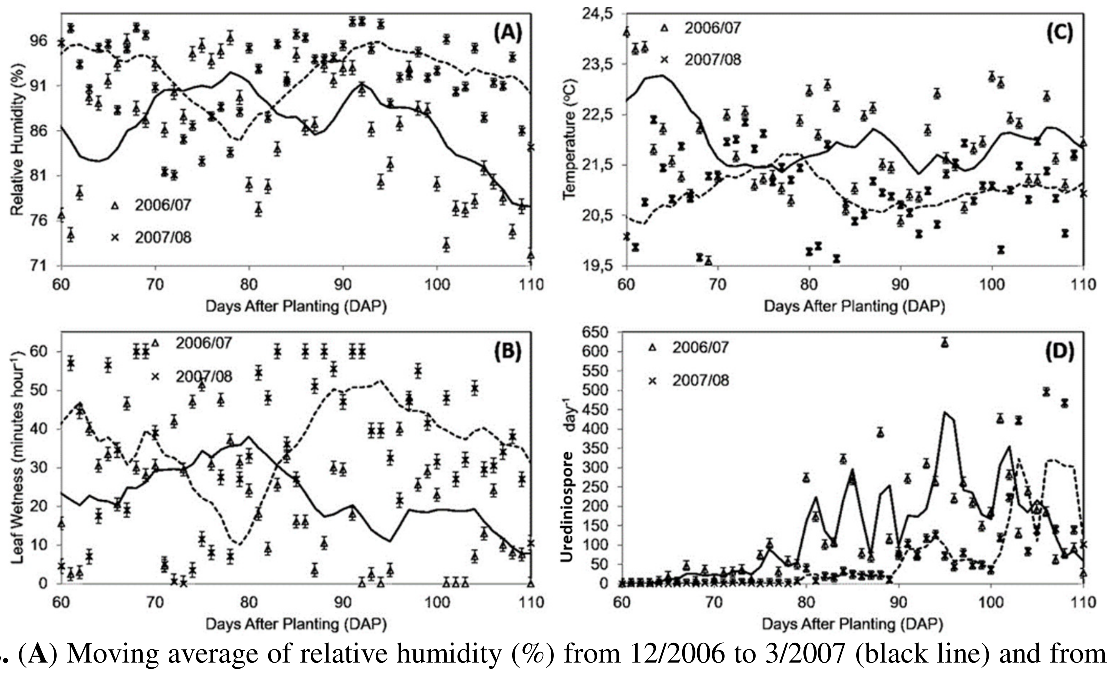

Figure 2. (**A**) Moving average of relative humidity (%) from 12/2006 to 3/2007 (black line) and from 12/2007 to 3/2008 (dotted line). (**B**) Moving average of leaf wetness (minutes / hour) from 12/2006 to 3/2007 (black) and from 12/2007 to 12/2008 (dotted). (**C**) Moving average of temperature (°C) from 12/2006 to 3/2007 (black) and from 12/2007 to 3/2008 (dotted). (**D**) Daly moving average of the number of urediniospores of *Phakopsora pachyrhizi* collected from 12/2006 to 3/2007 (black) and from 12/2007 to 3/2008 (dotted).

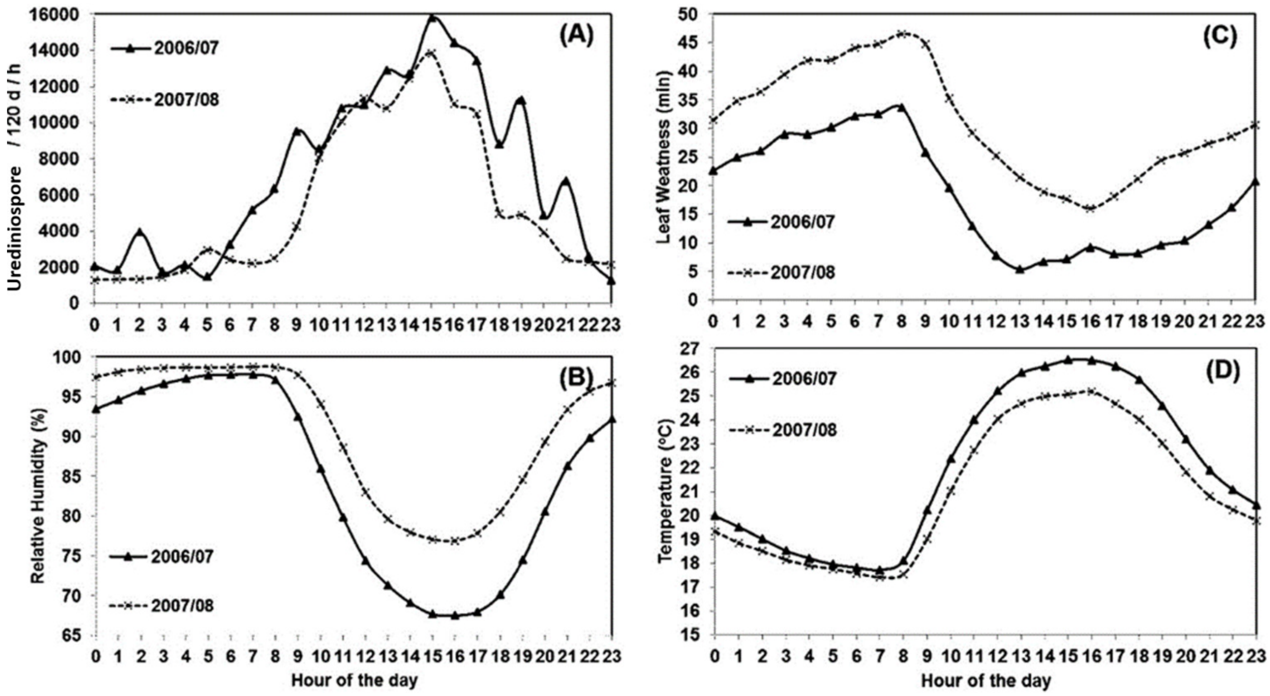

Figure 3. (**A**) Total of the hourly collected urediniospores of *Phakopsora pachyrhizi* from 12/2006 to 3/2007 (black line) and from 12/2007 to 3/2008 (dotted line). (**B**) Hourly average of the relative humidity (%) from 12/2006 to 3/2007 (black line) and from 12/2007 to 3/2008 (dotted line). (**C**) Hourly average of the leaf wetness (min) from 12/2006 to 3/2007 (black line) and from 12/2007 to 3/2008 (dotted line). (**D**) Hourly average of the temperature (°C) from 12/2006 to 3/2007 (black line) and from 12/2007 to 3/2008 (dotted line). [14,400 urediniospores day^{-1} = 1,000 urediniospores m^{-3}].

The amount of collected airborne spores was positively correlated [Sperman's (ρ) correlation coefficient] to disease severity (0.82~0.83, p ≤ 0.05), leaf wetness (0.38~0.45; p ≤ 0.01), and, precipitation (0.26~0.30; p ≤ 0.01) along both soybean growing seasons (Table 2). However, during a 24h-day evaluation, the major amount of hourly collected spores was negatively correlated to the leaf wetness (-0.65~ -0.73; p ≤ 0.01) and relative humidity (-0.78~ -0.80; p ≤ 0.01) (Table 3; Figure 3A-D). The hourly collected spores were negatively correlated to hourly-precipitation, however, no significant correlation was established (Table 3).

Table 2. Spearman's (ρ) correlation coefficient among the number of daily collected urediniospores (Ured), rust severity (Rse), and daily evaluated climatic variables [Temperature (T), relative air humidity (RH), leaf wetness (LW) and precipitation (Ppt)].

Variable	Temperature			Relative Humidity			LW	Ppt	Rse
	Max	Min	Avg	Max	Min	Avg			
Ured 06-07	Ns	0.37**	0.25**	0.19*	0.30**	0.31**	0.45**	0.26**	0.82*
Ured 07-08	Ns	0.18*	Ns	0.40**	0.34**	0.39**	0.38**	0.30**	0.83*
Rse 06-07	Ns	Ns	Ns	Ns	Ns	0.87*	0.90*	0.83*	-
Rse 07-08	0.66*	ns	-0.77**	Ns	Ns	0.65*	0.63*	Ns	-

Ns = not significant; * significant (p ≤ 0.05); ** significant (p ≤ 0.01); Max = maximum; Min = minimum; Avg = average. For analyses was considered the last 9 days (lag period) before disease evaluation.

Table 3. Spearman's (ρ) correlation coefficient among the number of hourly collected urediniospores (Ured) and hourly evaluated climatic variables [Temperature (T), relative air humidity (RH), leaf wetness (LW) and precipitation (Ppt)].

Variable	T	RH	LW	Ppt
Ured 2006-07	0.80**	-0.80**	-0.73**	Ns
Ured 2007-08	0.79**	-0.78**	-0.65**	Ns

* Significant (p ≤ 0.05); ** significant (p ≤ 0.01); Ns = not significant; For analyses was considered the hourly average of 90 days (41-130 DAP).

DISCUSSION

Aerial spores of *P. pachyrhizi* might have a significant role in this fungal spread and distribution (HARTMAN; HAUDENSHIELD, 2009). The number of collected airborne spores varies from place to place and due to the hour of the day (OLIVEIRA et al., 2009a; 2009b). Most of these seasonal variations are associated to meteorological variables. Isard et al. (2005) has affirmed the role of environmental factors such as daylight, temperature, and humidity may affect the timing of spore release. Nascimento et al. (2012) stated that the number of airborne spores of *P. pachyrhizi* was related to the presence of soybean field crop, and there were positive correlations among the number of urediniospores, cumulative rainfall, disease intensity and favorable days for Asian rust (SAR). In addition, those authors defined the favorability to epidemic of SAR was associated to 18-26°C and 90-100% relative humidity.

In some studies, the highest number of airborne spores occurs from 9:00 am to 1:00 pm (Granke & Hausbeck., 2010). Faal *et al*. (2016) reported in Canada that most of airborne spores of *Bremia lactucae* were hourly collected from 11:00 am to 1:00 pm. Almager et al. (2013), in Havana, Cuba, reported that the most common taxa peaking at 11:00 am to 12:00 pm were *Cladosporium*, *Bipolaris*, *Nigrospora*, *Periconia*, *Alternaria,* Uredinales-type, *Pseudocercospora*, *Chaetomium*, *Curvularia*, *Monodictys*, *Stemphyllium* and *Pithomyces*. Blum & Dianese (2001) reported that most of the *Puccinia psidii* urediniospores were collected between 10:00 am to 1:00 pm, in Brasilia, DF, Brazil, during a survey made in 1988. In the present work, in both soybean growing seasons most of the hourly urediniospores was collected from 10:00 am through 6:00 pm and the highest number was at 3:00 pm (Figure 3A).

However, in a study made in Manitoba, Canada, monitoring airborne-ascospores of *Gibberella zeae*, the maximum amount was collected at 9:00 pm (INCH et al., 2005). Correia & Costa (2005), noted that the period of spore release *Lasiodiplodia theobromae* occurred during the hours of 6:00 am to 10:00 am. Schuh (1993) reported that *Cercospora kikuchii* released spores between 4:00 am and 8:00 am and between 6:00 pm and 9:00 pm. These, daily and hourly variations of collected spores are affected by environmental and type of the fungal spore (OLIVEIRA et al., 2009a; GRANKE et al., 2014). Fitt et al. (1989), informed that the release of spores that are scattered in dry air shows a diurnal periodicity, often, the spores are collected around 12:00 pm when the wind speed is higher, the temperature is higher, and the relative humidity is lower. Conversely, Correia & Costa (2005) observed that, with rain precipitations above 80 mm, the conidia of *L. theobromae* in coconut tree began to be precipitated from the air, and consequently resulted in the decrease of spores captured.

From 9:00 pm to 8:00 am, few spores of *P. pachyrhizi* were collected; this fact might be associated to the moisture on leaf (BECK et al., 2006). Therefore, the spore release would not start before leaf wetness dried out (BECK et al., 2006). Boudrot *et al*. (2016) reported that a high frequency of *Hemileia vastatrix* urediniospores capture occurred from 7:00 am to 7:00pm, and very little from 8:00 pm to 6:00 am. These authors also showed a strong effect of the hour of the day on the dispersal of urediniospores, and, this diurnal pattern of pathogen dispersal where the highest dispersal occurred late in the morning and in the early afternoon was linked to the decrease in relative humidity and the highest recorded wind speed. Vuorinen & Helander (1995) found that airborne collected urediniospores of *Melampsoridium betulinum* showed a circadian variation with a peak was observed from12:00 am to 4:00 pm. As in the present study, these authors also found that a high wind speed (Figure 4) significantly increased airborne urediniospores concentration; likewise, temperature affected the spore concentration positively.

The most favorable conditions to SAR epidemics reported are: (a) minimum leaf wetness (LW) of 6h per day; (b) optimum LW of 12-14h per day; (c) optimum temperature for spore germination of 18-26^{o}C; (d) optimum minimum temperature from 20 to 23^{o}C; (e) optimum maximum temperature inferior to 28^{o}C; (f) optimum minimum RH from 75 to 80%; (g) constant daily rain for 12-15 days (ALVES et al., 2007; BLUM et al., 2015; DEL PONTE et al., 2006; BONDE et al., 2007; DEL PONTE; ESKER, 2008; BONDE et al., 2013; DANELLI; REIS, 2016; DUFAULT et al., 2010b; ISARD et al., 2005; MARCHETTI et al., 1976; MELCHING et al., 1979; MELCHING et al., 1989; NASCIMENTO et al., 2012; YANEZ-LOPEZ et al., 2015). Under these conditions, from the urediniospores germination and hyphae penetration to new urediniospores formation, it takes 7-10 days (GARCÉS-FIALLOS, 2011). In this study, most favorable conditions (temperature, moisture, leaf wetness, rainfall) occurred in 2006-07 earlier than in 2007-08. Possibly, it is the main reason for higher levels of airborne spores and disease severity in

2006-07 than in 2007-08. Young *et al*. (2011) stated that precipitation was the main factor affecting SAR progress, where disease increased rapidly after rain occurrences.

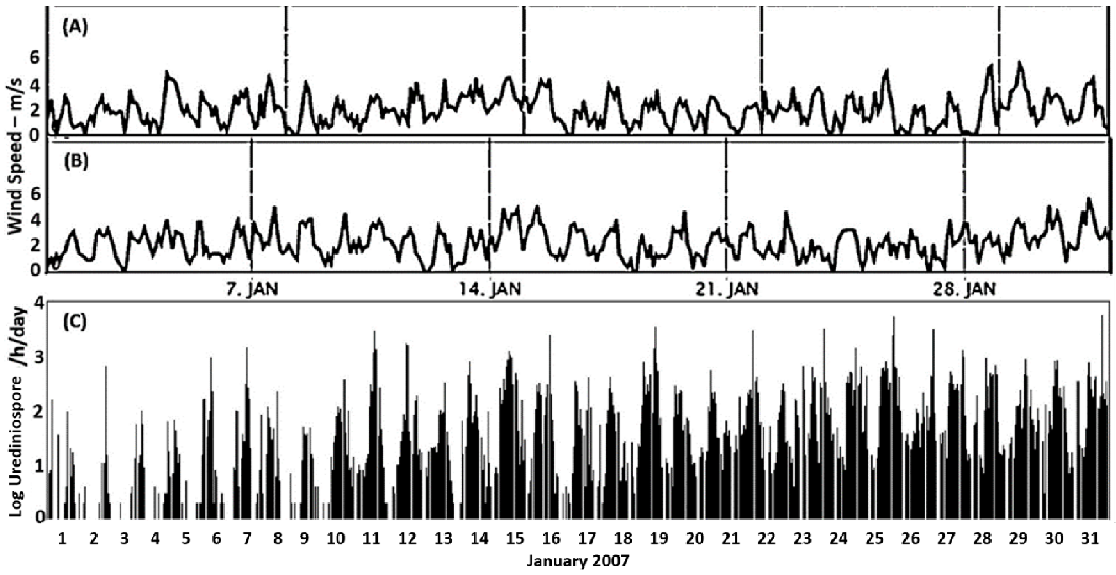

Figure 4. Circadian variation of January daily wind speed (2007; 2008) and collected urediniospores (2007). (**A**) Wind speed (m s^{-1}) in January 2007, and (**B**) January 2008. (**C**) Urediniospores of *Phakopsora pachyrhizi* collected hourly and daily during January 2007.

CONCLUSIONS

The maximum amount of urediniospores collected in a single was around 15,000 in 1/25/2007) and, around 12,000 in 2/13/2008.

In both soybean growing seasons most of the hourly urediniospores was collected from 10:00 am through 6:00 pm.

The highest amount of airborne-collected-urediniospores from December to March, was at 3:00 pm.

The disease started earlier in 2006-07 [38 days after planting (DAP)] than in 07-08 (58 DAP).

The amount of airborne spores was positively correlated to disease severity, leaf wetness, and, precipitation along both soybean growing seasons.

During a 24h-day evaluation, the major amount of hourly collected spores was negatively correlated to the leaf wetness and air relative humidity.

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RESUMO: A ferrugem asiática (*Phakopsora pachyrhizi*) é uma das doenças mais destrutivas de soja no Brasil. Apesar de sua importância, pouco é conhecido sobre a dinâmica de distribuição de inóculo no ar do patógeno em todo o ciclo da soja no Brasil. O objetivo deste estudo foi avaliar a variação temporal de urediniósporos de *P. pachyrhizi* coletados do ar com uma armadilha de esporos Burkard de 7 dias de captura em 2006-2007 e 2007-2008, durante o cultivo da soja (cv. MSoy-8001) entre novembro e março. A severidade da doença foi quantificada em soja plantada em 18 de outubro de 2006 e em 30 de outubro de 2007. De novembro/06 até março/07 foram coletados mais de 175.000 urediniósporos, e, mais de 131.000 de novembro/07 a março/08. Em 06 / 07, a maioria dos esporos foram coletada de 9 de janeiro de 2007 a 1º. de fevereiro de 2007 (± 3.000 urediniósporos dia^{-1}), e, em 07-08 a maioria dos urediniósporos foi coletada entre 8 de fevereiro de 2008 e 2 de março de 2008 (±2,000 uredosporo dia^{-1}). A quantidade máxima de urediniósporos coletados em um único dia em 06-07 (±15,000; 25/1/2007) foi superior a 07-08 (±12,000; 13/2/2008). Em ambas as safras de soja a maioria dos urediniósporos em cada hora foi coletado entre 10:00 e 18:00 de dezembro a março e o maior número foi às 15:00 (±16,000 em 06-07 e ±14,000 em 07-08). A doença iniciou mais cedo em 2006-07 [38 dias após o plantio (DAP)] do que em 07-08 (58 DAP). A quantidade de esporos no ar coletados correlacionou-se positivamente a severidade da doença, umidade foliar, e precipitação ao longo de ambos os ciclos de soja. No entanto, durante a avaliação diária, a quantidade de esporos coletados por hora foi negativamente correlacionada com umidade foliar e a umidade relativa do ar.

PALAVRAS-CHAVE: Esporos no ar. Armadilha de esporos do ar. Burkard. Aerobiologia.

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