# Factors Affecting Release of Ascospores by the Pear Scab Fungus (*Venturia pirina*)

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**ABSTRACT**

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Ascospores of *Venturia pirina* were monitored under field conditions in 1982 and 1983 with a Burkard 7-day recording spore trap adjusted to sample about 8 $m^3$ of air per hour at 55 cm above the ground. Ascospore productivity was determined weekly by sampling partially decomposed pear leaves near the spore trap. Ascospore emissions occurred mainly during daylight hours and fluctuated daily and seasonally (associated with periods of free moisture). The first mature ascospores were found when pear trees were in the green tip stage of fruit bud development (late August and early September). Maximum ascospore catches were recorded in September (white cluster to full bloom stage of fruit bud development), then progressively decreased until December. The lack of later liberation under Chilean conditions is apparently due to the absence of free moisture periods.

Pear scab, caused by *Venturia pirina* Aderh., is one of the most important diseases affecting pears (*Pyrus communis* L.) in Chile. It is particularly severe on Bartlett, Beurré du Bosc, Anjou, Packham's Triumph, and Winter Nelis. The fungus produces pseudothecia in fallen pear leaves. Mature ascospores are first released in late August or early September, when trees are at the green tip stage of fruit bud development (6). Thereafter, ascospores are normally released throughout the spring until late December. A similar ascospore discharge pattern has been reported for the apple scab fungus (*V. inaequalis* (Cke.) Wint.) in Chile (8). In some cultivars (eg, Winter Nelis), *V. pirina* may also survive as mycelium in infected twigs and produce conidia the following spring. Nevertheless, ascosporic inoculum appears to be a requisite for development of severe pear scab epidemics under Chilean conditions.

Factors affecting spore discharge have been well documented for the apple scab fungus. Ascospores of *V. inaequalis* are released only if pseudothecia are wetted (primarily by rains) and almost exclusively during daylight hours (2,4,5,7,9). Free moisture is also a major factor for ascospore release of *V. pirina* (1,10), but evidence for diurnal periodicity has not been conclusive. For instance in California, significant catches of ascospores were obtained during hours of darkness, suggesting that release of ascospores of *V. pirina* was not affected by light (1).

In this study, we report on seasonal fluctuation and diurnal periodicity of ascospore discharge of the pear scab fungus under field conditions.

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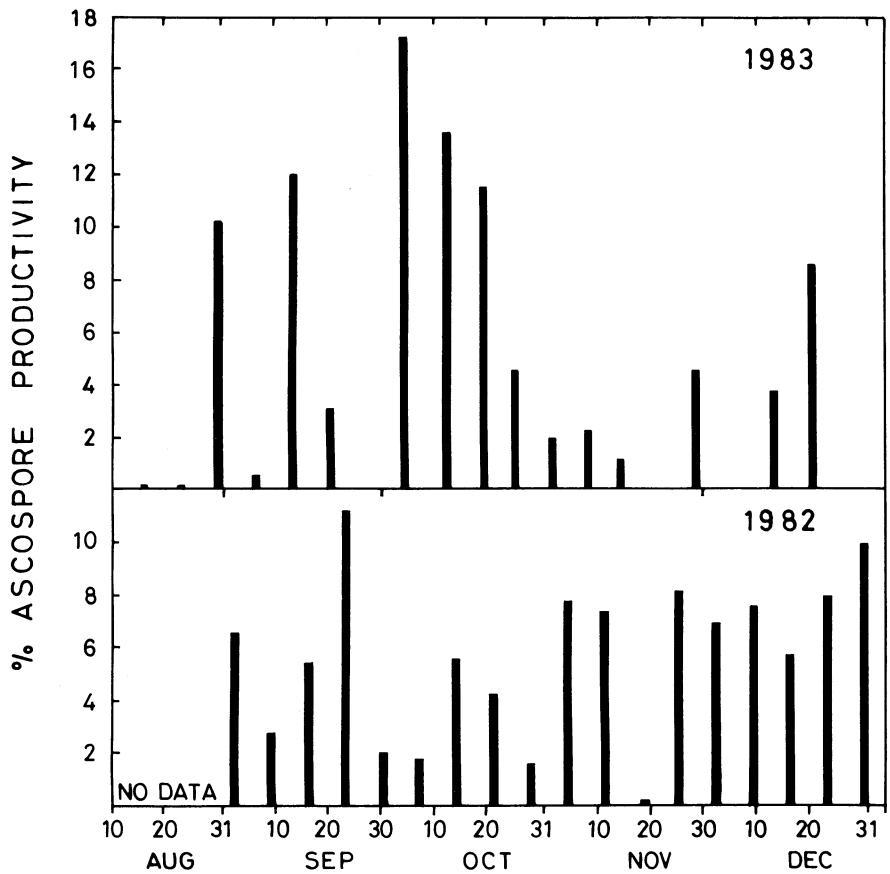


**Fig. 1.** Weekly ascospore productivity (percentage of seasonal total) of *Venturia pirina* in partially decomposed pear leaves, estimated by the procedure of Hirst and Stedman (5).

## MATERIALS AND METHODS

Ascospore emissions were monitored continuously in a heavily infected, 16-yr-old orchard of Winter Nelis pears, using a Burkard 7-day recording spore trap with the sampling orifice placed about 55 cm above the ground. The spore trap had a 200V power supply and was adjusted to sample about 8 $m^3$ of air per hour. It was placed between trees, surrounded by infected, overwintering pear leaves, and was operated from late winter (1 September 1982 and 20 August 1983) through early summer (December).

Hourly counts of trapped ascospores were made by examining the tape at 2-mm (60-min) intervals under a light microscope at ×400. Final counts were adjusted according to the tape area examined and the volume of air sampled. Data were recorded as numbers of ascospores trapped per cubic meter of air sampled per hour (5).

Ascospore production was assessed weekly in samples of partially decomposed, overwintering pear leaves collected near the spore trap and processed immediately. At each sampling, 120 leaf disks measuring 1.27 $cm^2$ each were cut with a cork borer. They were placed (alternating the upper and the lower surface) on a perforated zinc tray, sprayed twice with 20 ml of distilled water, and placed for 30 min in a wind tunnel built as described by Hirst and Stedman (5).

Ascospores were trapped as a single deposit line on a microscope slide coated with a thin layer of petroleum jelly containing 1% (v/v) phenol; those caught in the middle of the deposit line were counted under a light microscope. Ascospore productivity was defined as the number trapped per square centimeter of leaf within 30 min.

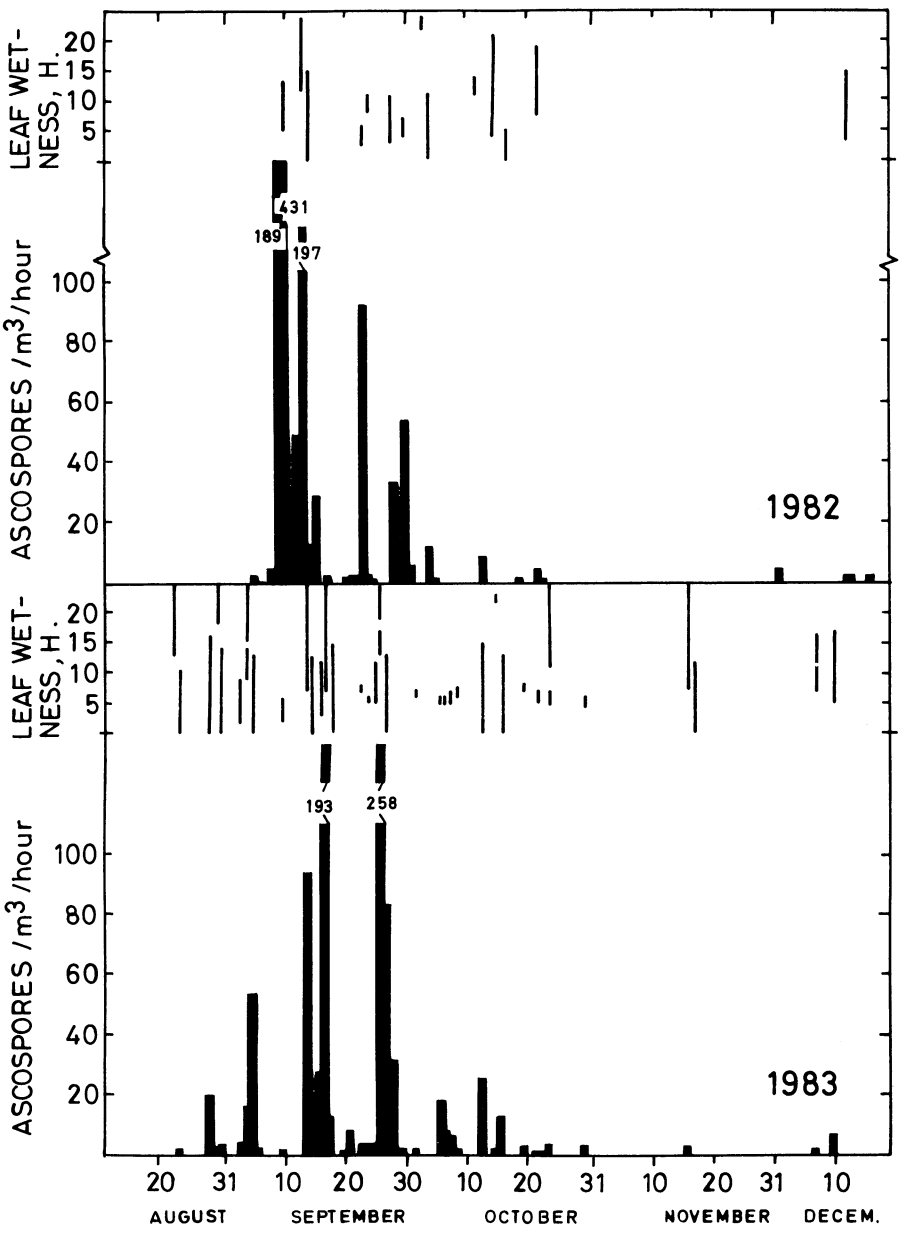


**Fig. 2.** Ascospores of *Venturia pirina* (per cubic meter of air per hour) trapped with a 7-day Burkard spore trap in the orchard.

Ascospore germinability was determined periodically in 1983. Ascospores were trapped on the surface of a sterile microscope slide in a wind tunnel (5,6,8). Six slides per sample time were aseptically coated with a thin layer of petroleum jelly without phenol. One or two drops of sterile distilled water were placed on top of the deposit line where the ascospores were trapped. The slides were then covered with a glass slip and incubated in a moist chamber at 18–22 C for 48–72 hr. At least $10^3$ ascospores were counted per sample. Spores categorized as germinated were those with an appressorium and/or a well-developed germ tube (two or three times the length of the ascospore) as observed at ×400 under a light microscope. Results were recorded as the percentage germinated at each assay time.

In the orchard next to the spore trap, temperature, relative humidity, and leaf wetness were recorded with a Belforst 7-day leaf wetness hygrothermograph placed 1 m above the ground. A leaf wetness balance (Hiltner type, Lambrecht Measuring Instruments) was placed about 15 cm above the ground for comparison. Rainfall data were obtained from a weather station 15 km from the orchard.

## RESULTS AND DISCUSSION

**Ascospore productivity.** The first mature ascospores were detected on 3 September 1982 and 17 August 1983, when trees were, respectively, at the green tip and swollen bud stages of fruit bud development. Mature ascospores represented about 6.6 and 0.2% of the overall ascospore productivity in 1982 and 1983, respectively (Fig. 1). Thereafter, ascospore productivity varied according to incidence and duration of free moisture.

High numbers of ascospores per square centimeter of leaf always occurred after periods of dryness, and relatively lower numbers followed periods of wetness. This apparently resulted from the continuing maturation and accumulation of mature ascospores within pseudothecia during periods of dryness. Because abundant ascospores were found even in late December (Fig. 1), the absence of ascospores in the air after December may be attributed to the lack of free moisture periods that induce liberation.

**Ascospore germination.** Ascospore germinability was observed throughout the season. Within 72 hr of germination, most ascospores produced a single, lateral germ tube (two or three times the length of the ascospore). Some germ tubes developed a thick, round appressorium at the tip of the germ tube. Germination varied from 22 to 99%. There was no association between germinability and time of year.

**Seasonal periodicity.** Spore discharge was always associated with a period of free moisture (primarily rainfall), but low

catches were recorded during five and eight dew periods in 1982 and 1983, respectively. The overall numbers of ascospores trapped after dew periods were 244 of 1,180 (20.7%) in 1982 and 172 of 934 (18.4%) in 1983. Of interest was the fact that dry weather, highly unfavorable for scab infections, always followed the dew periods. Consequently, ascospores liberated under those conditions may have little or no significance in development of pear scab epidemics.

The first ascospores were found in air samples on 3 September 1982 and 24 August 1983, when trees were, respectively, at the green tip and swollen bud stages of fruit bud development. In 1982 and 1983, the first catches consisted of one ascospore per cubic meter of air per hour. The number then increased rapidly, reaching maximum daily cumulative numbers of 431 ascospores on 9 September 1983 (white cluster stage) and 258 ascospores on 26 September 1983 (full bloom). Thereafter, frequent emissions but relatively small ascospore catches were recorded until December (Fig. 2).

In 1982, 97% (1,140 of 1,180) of the ascospores were trapped in September, distributed in 10 discharge periods (at least one ascospore per cubic meter of air within at least three consecutive hours). A similar trend was observed in 1983 in the same orchard. Of 934 ascospores trapped throughout the 1983 growing season, 811 (87%) were caught during September in 11 discharge periods.

The fact that high concentrations of ascospores occurred during the beginning of the growing season (September and October) in Chile (Fig. 2) emphasizes the need for an effective control program to prevent primary infections. This is usually accomplished by weekly fungicide applications between green tip and petal fall.

**Daily periodicity.** Ascospores trapped during various hours of the day (normalized as percentages of the total count of each year) showed a strong diurnal periodicity. Ascospores were trapped almost exclusively during daylight hours (Fig. 3). Significant releases began at about 0600 hours and ended between 1900 and 2000 hours (Figs. 4 and 5). The concentration of airborne ascospores increased rapidly in the morning, with a peak at 1000 hours. A subsidiary peak occurred at 1700 or 1400 hours in 1982 and 1983, respectively. Thereafter, ascospore numbers gradually declined, reaching minimum concentrations at about 2000 hours. Frequency (as a percentage of the overall number of hours when ascospores were found) followed similar patterns (Fig. 3).

Only minimal ascospore counts, 6 of 1,180 (0.5%) in 1982 and 5 of 934 (0.5%) in 1983, were recorded during darkness. These occurred within only 6 of 121 (5%) hours when ascospores were trapped in 1982 and within 4 of 199 (2%) hours in 1983 (Fig. 3). Night trappings were scattered and at the most occurred during two consecutive hours; this was considered insufficient evidence for a true discharge period.

Daily plots of ascospore numbers (normalized as a percentage of the total number of ascospores per day) against daily hours demonstrated three patterns of emission according to the time when the free moisture period occurred: pattern A, with free moisture starting during the hours of darkness but ascospores being released during daylight; pattern B (Fig. 4B), with free moisture starting and ending during daylight and the ascospores being released between about 0600 and 1900 hours; and pattern C (Fig. 5), with free moisture starting during daylight of the first day and ending during daylight of the second day. In pattern C, ascospores were found only during daylight hours. More than 94% of the ascospores were released the first day (Fig. 5). This reinforces our belief that ascospores accumulate within pseudothecia under dry conditions but deplete relatively rapidly under wet conditions.

We conclude that free moisture and light are the major factors triggering ascospore liberation of *V. pirina*. Our results are consistent with previous reports associating ascospore release with free moisture periods (1,10) but are

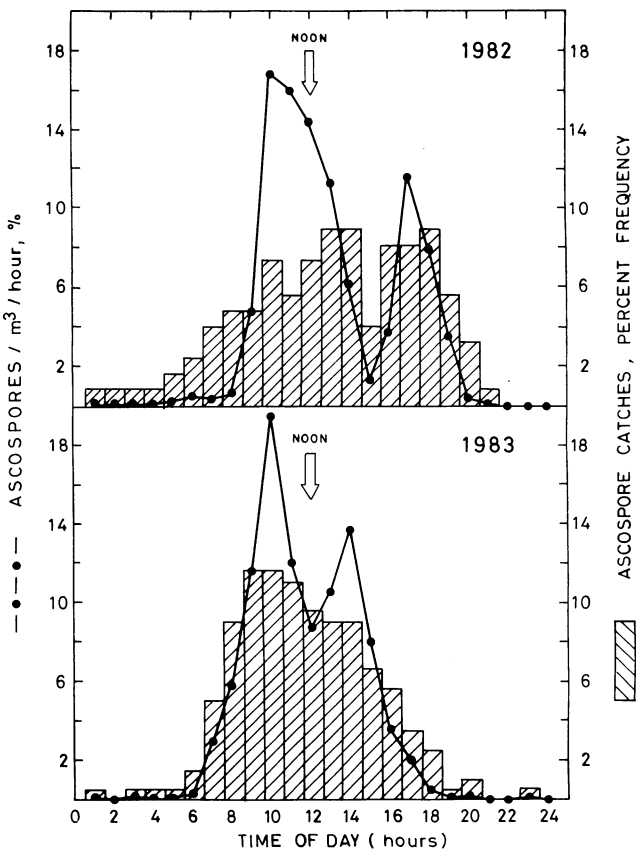


**Fig. 3.** Diurnal periodicity of ascospore release of *Venturia pirina* (percentage of total catch in relation to percentage frequency of hourly catches).

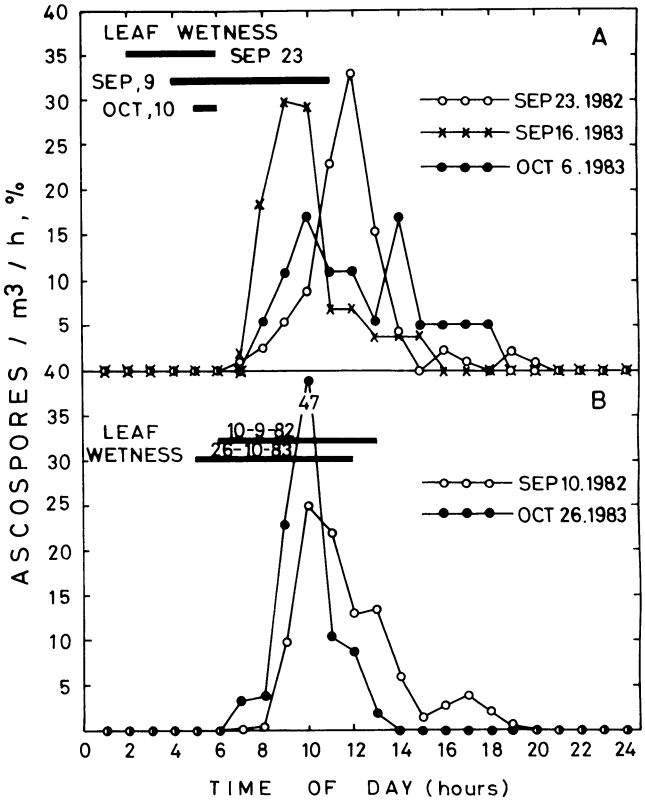


**Fig. 4.** Daily periodicity of ascospore discharge of *Venturia pirina* in relation to leaf wetness. **(A)** Discharge periods with free moisture starting during darkness but ascospores being released during daylight. **(B)** Discharge periods characterized by periods of free moisture that start and end during daylight hours.

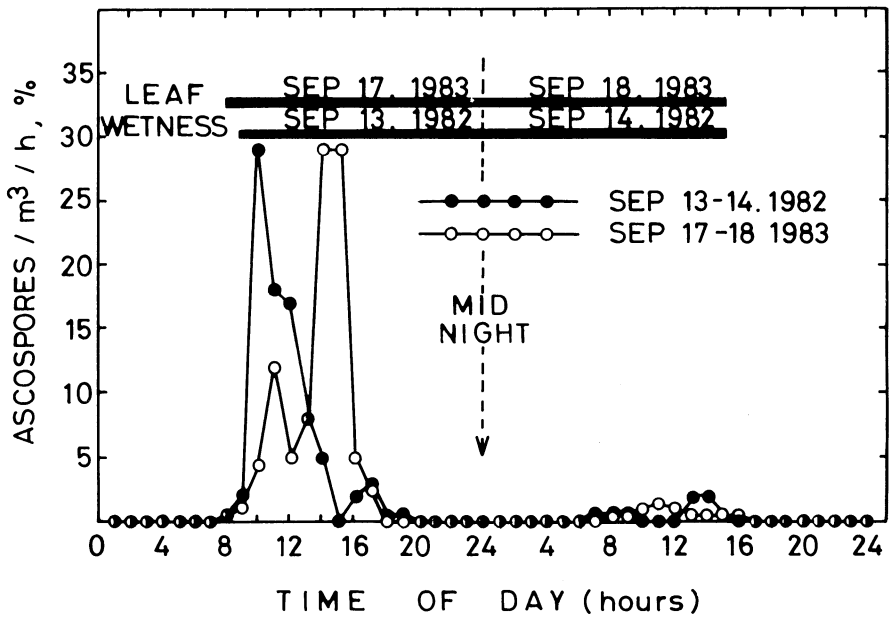


**Fig. 5.** Hourly concentration of ascospores of *Venturia pirina* during two consecutive days, with a continuous moisture period starting during daylight of the first day.

inconsistent with reports from California (1), where significant ascospore catches were recorded during night hours. We found only minimal ascospore concentrations at night and presumed that these were discharged during daylight hours and were moved around the spore trap by air turbulence during the night. We found no evidence for a real discharge period at night, even under favorable moisture conditions. Our results agreed with reports of the factors affecting liberation of ascospores of *V. inaequalis*. Emissions of ascospores of the apple scab fungus are affected by free moisture periods and light (apparently infrared light) (2,3). Additional controlled-environment studies with *V. pirina* are needed to clarify the influence of light on ascospore discharge from pseudothecia.

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