Dissemination of Spores in a Glasshouse: Pattern or Chaos?

by

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ABSTRACT. — The dissemination of particles in a glasshouse with three united compartments was observed from experiments with *Lycopodium* sp. The experiments were performed in a glasshouse with open and closed ventilation openings, spore sources on two heights above soil surface, and in two consecutive time intervals. The spores were caught with self constructed spore traps placed at regular distances from each other. Air circulation was observed using smoke-puffs. High ventilation caused a rapid cleaning of the air while in a closed glasshouse spores remained suspended for quite a long time. Though the three compartments of the glasshouse were not separated by walls, a so-called “cell structure” of the individual compartments could be indicated.

INTRODUCTION

Although many fungal diseases in glasshouses are air-borne, published research in this field is not plentiful, despite the importance of glasshouse crops in countries of the temperate zones. Little is known about the mechanism by which spores are disseminated in glasshouses. Hirst (1959) was one of the first scientists to examine concentrations of spores in a glasshouse. His experiments showed a 30-fold increase of spore concentration in the air after sprinkling; one hour later it had dropped to one third of the initial concentration.

Frinking and Scholte (1983) showed that dissemination of air-borne spores in a glasshouse was very complex due to the numerous variables involved. Turbulence is one of the most important mechanisms of air-borne dissemination. Free convection by differential heating and forces due to pressure differences between the inside and outside of the glasshouse as well as human activities are common causes of turbulence.

CAUSES OF AIR MOVEMENT

CONVECTION. — Convection may occur on the one hand as a result of heating (either solar or by heating pipes), and on the other hand through cooling of air at the walls of the glasshouse. It is manifest as an upward movement of air above a relative warm surface such as heating pipes and plant leaves. The warm air rises, cools at the roof and descends at the
sides of a glasshouse compartment. This process causes a rather stable pattern of air circulation with air movements up to 0.1 m·s⁻¹, which are sufficient to transport spores over large distances. The terminal fall velocity of most spores is usually less than 0.02 m·s⁻¹ (Chamberlain, 1967).

PRESSURE DIFFERENCES. — These can be divided into static and fluctuating differences:

a. static differences originate from positive air pressure at the weather side of the glasshouse and negative pressure at the lee side, causing an air flow through cracks and holes;

b. fluctuating differences originate in the variability of wind speed outside the glasshouse.

Despite the fact that the mean pressure between two openings in the glass cover is the same, instantaneous pressures can differ significantly (Daws, 1967).

Fluctuating differences are far more important in causing air exchange than static differences. The amplitude of the fluctuations is the driving force for ventilation.

Ventilation can be expressed in terms of the number of times per hour a volume of air equal to that of the glasshouse is exchanged. This value can be calculated according to Bot (1983) with the formula

\[
\phi_v = G(\xi) \cdot \bar{u} \cdot A_o
\]  

(Eq. 1)

\( \phi_v \) = ventilation flux of fresh air (m³·s⁻¹)
\( G(\xi) \) = function depending on the ventilation opening (\( \xi \)) and type of glasshouse
\( \bar{u} \) = mean wind speed outside the glasshouse (m·s⁻¹)
\( A_o \) = total area of ventilation opening (m²)

The values of this ventilation factor vary from 0.2 for a well insulated glasshouse to up to 100 for a glasshouse with open windows. Measurements showed that the highest wind speeds in a glasshouse resulting from pressure differences vary from 0.5 to 2.0 m·s⁻¹ (Frinking, unpublished).

HUMAN ACTIVITIES. — Almost every glasshouse environment is repeatedly disturbed for maintenance, spraying and harvesting. These operations cause unpredictable disturbances to both plants and atmosphere in the glasshouse, and generate high concentrations of spores in the air.

All these physical processes and activities cause air turbulence and make it possible for spores, once disconnected from their substratum, to be transported from one place to another. The purpose of the present study was to determine how long spores may remain air-borne, and how far they may be transported, within a glasshouse.

MATERIALS AND METHODS

GLASSHOUSE AND CROP. — The experiments were performed in a glasshouse with three compartments united under a single roof, used for cultivation of roses. The glass cover could be opened at both sides of each roof gable (Fig. 1) for about 40% of the total roof surface.