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Short communication

Effect of humidity on development of tomato powdery mildew (*Oidium lycopersici*) in the glasshouse

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Abstract

A series of experiments was carried out over four years in a glasshouse with computer control of humidity and temperature to investigate the effect of humidity on the development of tomato powdery mildew. Four relative humidities (RHs) (80%, 87%, 90% and 95%) at constant 19 °C were maintained over an eight-week experimental period during the Autumn. Disease was greatest at 80% RH and was progressively less with increasing RH to a minimum level at 95% RH on both inoculated plants, introduced to act as initial infection sources, and on adjacent uninoculated plants. The results indicate that high humidities may decrease severity of this disease in the glasshouse and may help management of this disease in the future.

Powdery mildew disease of tomato caused by *Oidium lycopersici* was first recorded in Europe in the 1980s and the same or similar powdery mildew has since spread to infect tomatoes around the world (Mieslerova and Lebeda, 1999; LaMondia et al., 1999; Whipps et al., 1998). Control is currently achieved with prophylactic fungicide sprays although resistant cultivars are beginning to be developed and released (Ciccarese et al., 1998; Huang et al., 1998).

Powdery mildew epidemics are largely influenced by the interaction of humidity and temperature, with different powdery mildew fungi requiring different optimum combinations of these environmental conditions for disease development (Aust and v. Hoyingen-Huene, 1986; Reuveni and Rotem, 1973; Yarwood, 1978). These environmental factors may influence germination, formation, release and survival of spores as well as mycelial development, and each process may have a different optimum combination of temperature and humidity (Reuveni and Rotem, 1974; Xu and Butt, 1998). Consequently, data on the effect of humidity on development of tomato powdery mildew in a crop situation, rather than on any one feature of the life cycle, could help growers to rationalise their management of this disease, particularly in relation to other glasshouse pathogens such as *Botrytis cinerea* (Dik and Elad, 1999; Elad et al., 1996). This paper reports a study of the development of tomato powdery mildew in the Autumn under a range of humidities known to occur in the glasshouse in northern Europe, at a constant temperature of 19 °C.

Four humidity levels were chosen to reflect the range of values known to occur commonly in UK glasshouses in the Autumn. Experiments were carried out four times from 1992 to 1995, and as the main results were similar in each case, experimental details and data are given from a single representative experiment in 1993 only. Eight compartments of a glasshouse with computer control of temperature and humidity were used to give 2 replicates of each relative humidity (RH) set at 70%, 78%, 86% and 95% RH (achieving 80%, 87%, 90% and 95% RH – 24 h means over the experimental period – at crop height) with the temperature controlled at 19 °C. Day and night RH varied by 0–4%.

This resulted in mean vapour pressure deficits of 0.71, 1.43, 1.77 and 2.88 mmHg, respectively. Temperature and RH data were collected using a Priva climate data system (Priva UK Ltd., Tewksbury, UK). The experiment was set up on 6 September 1993 and each compartment contained four double rows of 32 tomato plants (25-day-old, cv. Calypso) in a standard rockwool growing system, giving 1024 plants for the experiment. To introduce the pathogen, plants inoculated with *O. lycopersici* 10 days earlier by shaking infected leaves over the whole plant in a separate glasshouse, were introduced into the two central double rows at a rate of one per five uninoculated plants (six per double row). Each week, all inoculated and uninoculated plants in the central double rows, and 16 uninoculated plants in each outer double row were assessed for percentage leaf surface infection using standard keys. Analysis of variance of mean percentage infection of all inoculated and uninoculated plants was then carried out and significant differences at the $P < 0.05$ level determined from the F test.

With the inoculated plants, disease increased rapidly in all humidity treatments after one week and subsequently, significant effects of humidity were found in the last three weeks of the experiment, with the greatest disease at 80% RH and the least at 95% RH (Figure 1). With the uninoculated plants, powdery mildew was observed in all humidity treatments after two weeks and a significant effect of humidity was found in the last three weeks of the experiment, again with the greatest level of disease found at 80% RH and the least at 95% RH.

Humidity clearly had an effect on the development of tomato powdery mildew but was less apparent on the inoculated plants than the uninoculated plants. As the period from infection to sporulation and obvious symptom expression is 5–7 days under the conditions used, the upper leaves of the inoculated plants were probably already infected by *O. lycopersici* when introduced into the glasshouse. Consequently, the effect of humidity only began to become apparent as the inoculated plants grew and new leaves developed under the influence of the humidity regimes. This was reflected in the non-inoculated plants which were spatially separated from the inoculated plants.

Lower humidity (80% RH) was more conducive to tomato powdery mildew development. Preliminary studies carried out under controlled environment conditions indicate that spore germination can take place at RHs between 65% and 100% but is optimal at 95% RH or greater, although at 100% RH, where water films may occur, spore germination is reduced (Ciccarese et al., 1998; Cirulli et al., 1997; Foster, 1992). This indicates that the effect of lower humidity enhancing disease development in the glasshouse must be expressed on parts of the life cycle of *O. lycopersici* other than spore germination. Optimum RH conditions for tomato powdery mildew development have been reported to lie between 60% and 80% RH (Corbaz, 1990; Gabler et al., 1990; Hannig, 1996), agreeing with the lowest RH tested in this paper. However, temperature was not always controlled, so the vapour pressure deficits could have varied widely, making direct comparison between results from these different countries difficult.

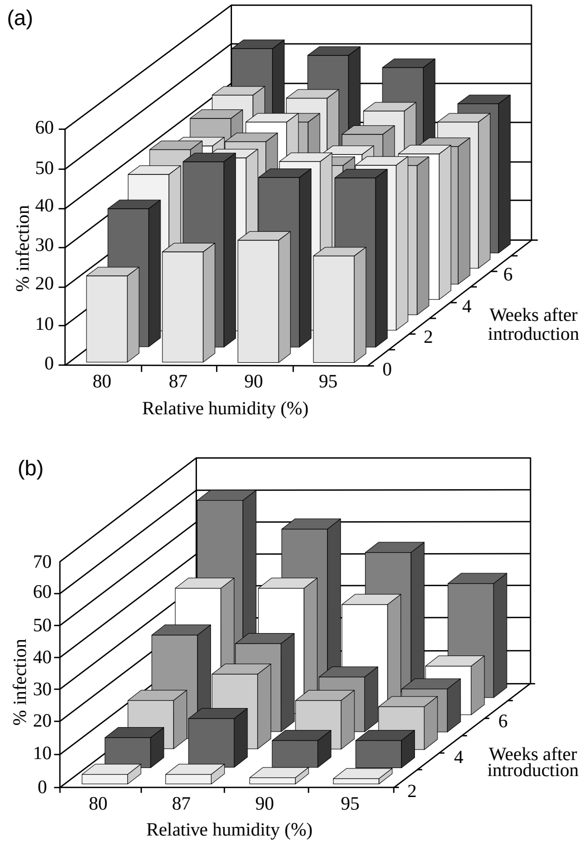

Figure 1. Development of tomato powdery mildew in the glasshouse under four humidity regimes on inoculated plants (a) and adjacent uninoculated plants (b). Significant effects of humidity were found 5–7 weeks after introduction for both sets of plants at $P \leq 0.05$ from analysis of variance and F test.

Raising humidity in the glasshouse may serve to decrease spread of tomato powdery mildew and provide some simple practical control of this disease. However, with this must go the proviso that the level of humidity is controlled so as to avoid enhancing the activity of *Botrytis cinerea*, which is favoured by high RHs (Elad et al., 1996). Under these circumstances, biological control agents of both powdery mildews and *Botrytis cinerea*, known to require higher relative humidity for optimal activity may prove particularly useful (Dik et al., 1998; Elad et al., 1996; Verhaar et al., 1998).

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