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EPIDEMIOLOGY OF POWDERY MILDEW (*SPHAEROTHECA FULIGINEA*) OF SQUASH

1996.

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ABSTRACT

In laboratory tests, germination of conidia on glass slides of *Sphaerotheca fuliginea* was greatest at 25°C in high humidity, although the germination rate was generally low. No germination was observed below 15°C or above 30°C, or at relative humidity below 94%. Field studies of the development of powdery mildew on squash plants showed that symptoms first appeared on old leaves. Symptoms did not appear on first leaves until 7-8 weeks after emergence, but appeared progressively earlier on late formed leaves (2 weeks). Only a small proportion of the conidia germinated when placed on young leaves (2 weeks), but many germinated on older leaves (6 weeks). A field experiment indicated that the first symptoms of powdery mildew appeared approximately 1 week after a prolonged period of continuous leaf wetness (about 12 h) and high humidity (about 95%) in the summer when temperatures frequently rose above 22°C. The disease begins in isolated patches on leaves in dense canopies more than on exposed leaves.

Keywords: epidemiology, powdery mildew, *Sphaerotheca fuliginea*, squash

INTRODUCTION

Powdery mildew of squash, caused by *Sphaerotheca fuliginea* (Schlecht.) Pollacci, is a common and serious disease throughout New Zealand according to a survey by the Fresh Vegetable Research and the Development Committee of the New Zealand Vegetable and Potato Growers' Federation (unpublished). The disease can reduce photosynthetic area of leaves, and in severe cases causes defoliation of plants, effects that are likely to reduce yield and quality of fruit (Cohen *et al.* 1993).

Methods for disease control currently available to growers include repeated applications of sulphur or demethylation inhibitor (DMI) fungicides; however, these do not always provide adequate disease suppression (R. Wood pers. comm.). It is possible that the lack of control may be due to fungicide-resistant pathogen strains in squash crops. Fungicide resistance in populations of cucurbit powdery mildew has been reported in Australia (O'Brien 1994) and the USA (Paulus *et al.* 1976).

Alternative powdery mildew control methods with antagonistic micro-organisms (Heijwegen 1992), sodium bicarbonate (Homma *et al.* 1981) and plant extracts (Cheah and Cox 1995) have been reported. These cannot be effectively applied without a full understanding of the disease. Although powdery mildew is common in squash, the epidemiology and life cycle of the fungus are not fully understood (Butt 1978) and have not been studied in New Zealand. This paper reports the results on preliminary epidemiological studies of powdery mildew in New Zealand.

MATERIALS AND METHODS

Effect of temperature on conidium germination

Conidia of *S. fuliginea* from a diseased leaf were dusted onto glass microscope slides using a paint brush. Two slides were suspended on a rubber bung sited over water in a sealed plastic container (10 x 50 cm depth). Individual containers were placed in incubating rooms at a range of temperatures from 10°-35°C (Fig. 1), with five

replicate containers for each temperature treatment. After 3 days incubation, the percentage of conidial germination was determined using a microscope.

Effect of relative humidity on conidium germination

Saturated solutions of different chemicals were prepared to give a range of relative humidities in sealed containers (O'Brien 1948). Fifty ml of these solutions were poured into individual plastic containers (10 x 50 cm depth). Conidia of *S. fuliginea* were dusted onto microscope slides which were suspended over the solutions in plastic containers (as above). The containers were then sealed and placed in an incubator (25°C) to give the required relative humidities ($Mg(NO_3)_2$, 52%; NH_4NO_3, 63%; NaCl, 75%; KCl, 86%; KNO_3, 94%; H_2O, 100%). Percentage germination was determined with a microscope after 3 days incubation.

Disease development on individual plants

Disease development was monitored on five individual field-grown squash plants at the Levin Research Center. As the plants grew, each leaf was numbered and the date of emergence recorded. Leaf length measurements (from leaf base along the central vein) were made at 3-4 day intervals. Disease development was also monitored on individual leaves. These measurements were carried out over two growing seasons (1994/95 and 1995/96).

Effect of leaf age on conidium germination

Leaf discs (1 cm diam.) were cut from 2 week - and 6 week - old leaves from plants after planting. Leaf discs were arranged on fine gauze with upper leaf surfaces facing upward and placed on rubber bungs in plastic containers (as above). Conidia of *S. fuliginea* from a diseased leaf were dusted onto these discs. Containers were incubated at 25°C for 3 days and percentage germination of conidia on leaf discs was determined under a microscope.

Field experiment

Powdery mildew development on squash plants was assessed at two sites 1 km apart, at the Levin Research Center and in a commercial crop. Observations were made at 3 to 4 days intervals on the crops and spread of the disease was recorded. Weather data (relative humidity, temperature and leaf wetness) were recorded using a thermohydrograph and leaf wetness recorder (Belfort Instrument Company, Maryland, USA. Cat. No. 6098) placed at each site.

RESULTS

Effect of temperature on conidium germination

Greatest germination (up to 5%) was recorded at 25°C, although germination was generally low after 3 days of incubation (Fig. 1). Some conidia germinated at 20° and 30°C but no germination occurred at 10° or 35°C.

Effect of relative humidity on conidium germination

Germination (about 5%) only occurred at 100% relative humidity. No germination was observed at 94% relative humidity or below.

Effect of disease development on individual plants

There was a similar pattern of powdery mildew development on all squash plants (Fig. 2). Symptoms did not appear on the first leaves after planting until 7-8 weeks after emergence, but appeared progressively earlier, relative to the age of the leaf, on the later formed leaves (2 weeks). Symptoms rarely developed on leaves that had not grown to their full expansion and were never recorded on rapidly growing leaves.

Effect of leaf age on conidium germination

Only a small proportion (4.6%) of the conidia germinated when placed on leaf discs from young leaves (2 weeks old), but many germinated on leaf discs from older leaves (6 weeks old) (Table 1).

Field experiment

First symptoms of powdery mildew on squash crops did not appear until mid-January after a prolonged period of leaf wetness (about 12 h) when air temperatures rose above 22°C. The incubation period for the disease is 5-7 days. The disease always began in isolated patches under dense leaf canopies. Symptoms soon spread outward from these patches, and within a week the disease spread over a wide area within each crop.

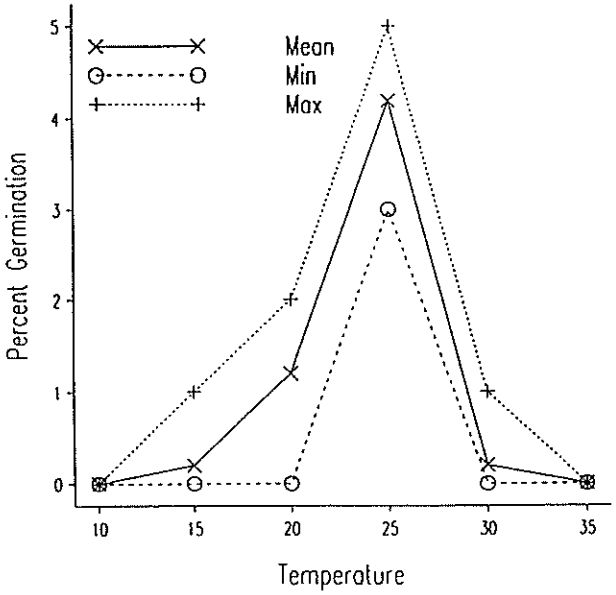

FIGURE 1: Percentage germination of *S. fuliginea* conidia on glass slides at different temperatures in saturated humidities.

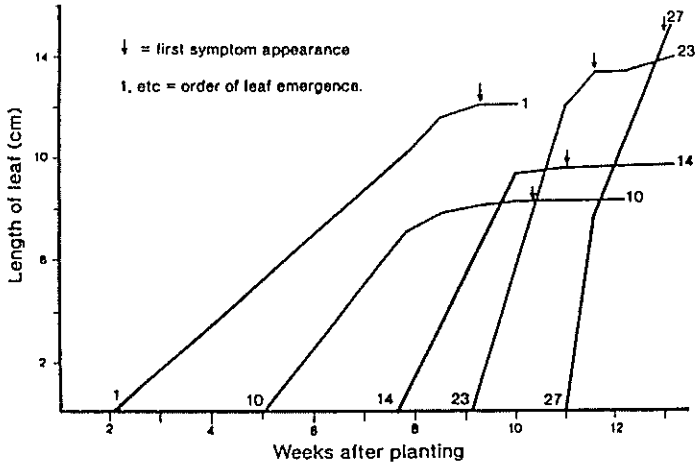

FIGURE 2: Typical development of powdery mildew symptoms in relation to the leaf growth of a field grown squash plant.

TABLE 1: Mean germination of *S. fuliginea* conidia on leaf discs cut from different aged leaves.

Leaf age (weeks)	Mean Germination (%)	Confidence Interval
2	4.6	(2 2; 9.7)
6	29.2	(22.5; 36.9)

* The confidence intervals (95%) were calculated for the percentages on the transformed (logit) scale and then back transformed.

DISCUSSION

It is generally accepted that germination of conidia of *S. fuliginea* occurs between 15° and 30°C, and is greatest at 25°C (Hashioka 1937; Manners and Hossain 1963). This temperature range falls within the summer range in the Horowhenua region, when powdery mildew starts to appear on squash crops. Conidia germinate best at relative humidity of 97-100% (Agrios 1969), but not below, indicating that they require moist air to germinate. Separate tests (unpublished data) confirm results of Butt (1978) who demonstrated that germination decreased or was delayed in the presence of free water. These laboratory results may partially explain our field observations that powdery mildew symptoms appear first on leaves under dense canopies where relative humidity is usually high. It has also been reported that cucurbit powdery mildew develops better in shade than in the full sunlight (Butt 1978; Dixon 1981).

There is general agreement that young leaves of cucurbits are more resistant to powdery mildew than older leaves (Uozumi and Yoshii 1952). In this study we did not compare conidium germination on the later-produced young leaves to the older leaves due to the later-produced leaves showing symptoms after 2 to 3 weeks of age coinciding with the end of the leaf expansion (Fig 2). Our field observations in Horowhenua indicate that the disease does not appear on squash crops until mid-January after prolonged periods (about 12 h) of leaf wetness when air temperatures were above 22°C. The disease spreads rapidly during this period. In view of the results we obtained from these epidemiological studies, trials are in progress to control of powdery mildew by spot application of fungicides with a Knapsack sprayer when the first symptoms appear.

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