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Special Research Report # 134: Understanding Coleus Downy Mildew

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BACKGROUND

Coleus (*Solenostemon scutellarioides*) has been prized by gardeners for its bright, colorful foliage since Victorian times. Recently, there has been a resurgence in popularity in the United States. Bedding plants (including coleus) rank 2nd in the United States for floriculture products with annual sales of ~$250 million. Downy mildew disease was first detected on coleus in New York and Louisiana in 2005 and throughout most of the U.S. by 2006. The pathogen was identified as *Peronospora* sp. and found to infect both seed- and vegetatively-propagated coleus. Downy mildew symptoms include: plant stunting, leaf distortion, spotting/blighting and leaf drop (abscission) (Fig. 1A). The brown or blighted areas on diseased foliage either have an irregular shape or may look square or angular when bordered by large leaf veins. Downy mildew may escape detection if only mild symptoms develop and can mimic common growing problems. Coleus seedlings or plants may appear healthy but develop the downy mildew symptoms later. The downy mildew pathogen, *Peronospora* sp., reproduces via specialized asexual spores called sporangia that grow on stalks emerging from infected plant tissue. When sporangia are mature, they are released into the air and carried by air currents with each sporangium having the potential to cause a new infection. Sporangia may sometimes be seen on the underside of leaves (Fig 1B,C). Often these sporangia are few in number and very difficult to see without a microscope; other times, they are produced in such high numbers that they form a fine carpet of grayish fuzz that is obvious to the naked eye. It is best to look for sporangia in the morning when the environment is cool and humid. Understanding how downy mildew infects coleus and the effects of environmental factors on downy mildew development contributes to an

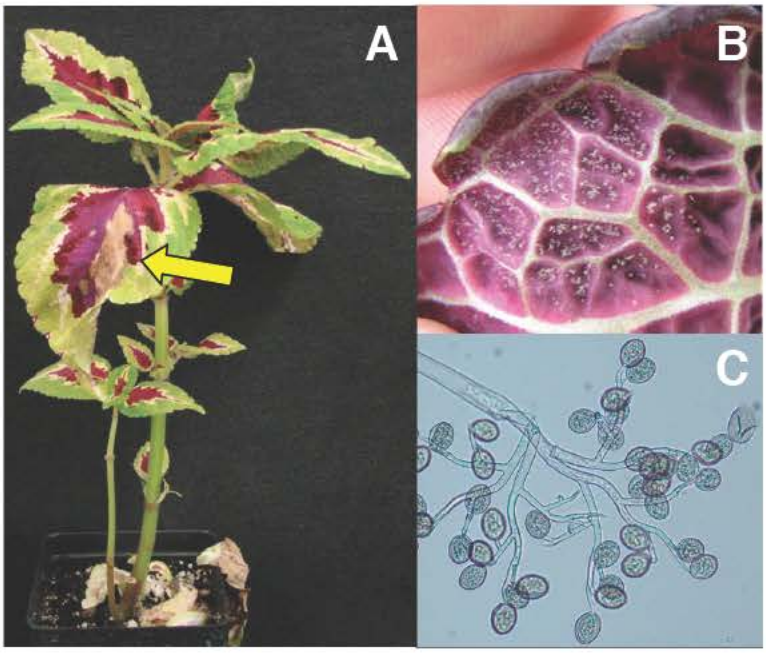

Fig. 1. A, spotting (arrow) and leaf drop on coleus 'Color Pride' infected with downy mildew. B, sporangia on the underside of an infected coleus leaf. C, Peronospora sp. under the microscope, showing sporangia growing on a stalk (sporangiophore).

integrated pest management approach for controlling this disease and producing a healthy coleus crop.

MATERIALS & METHODS

Spore Trapping: Concentrations of airborne sporangia of *Peronospora* sp. in a greenhouse of infected coleus were monitored using a Burkard 7-day volumetric spore trap (Fig. 2A) at Michigan State University. The trap continuously sampled the air and collected downy mildew sporangia where they were embedded on a transparent film tape coated with an adhesive mixture mounted on a reel (Fig. 2B,C). The tapes were removed and taken to the laboratory for identification and quantification. Tapes were cut into lengths representing 48 hour periods, stained, marked for hourly intervals, and mounted on microscope slides (Fig. 2D). Using a microscope (x100), numbers of sporangia in each hour were counted. Throughout the spore sampling experiment, temperature and relative humidity data were collected using a WatchDog 450 Data Logger (Fig. 2A). Data were statistically analyzed to determine if there were any correlations between temperature, humidity, and the numbers of airborne sporangia.

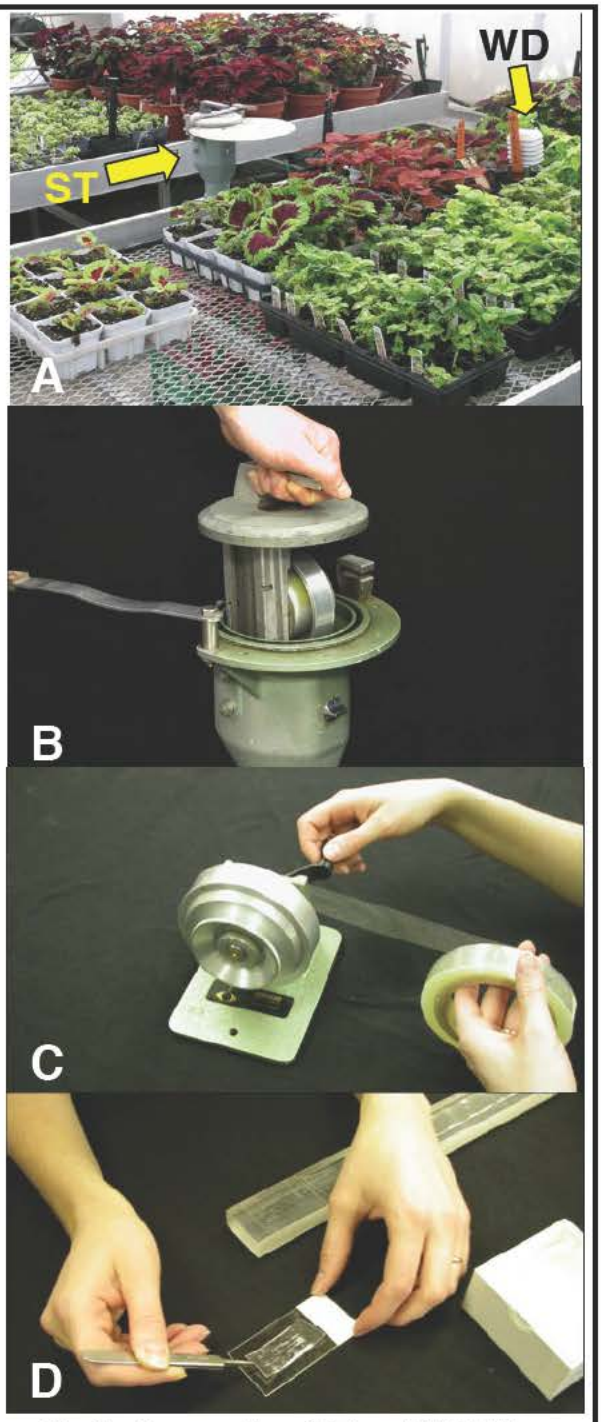

Fig. 2. A, spore trap (ST) and WatchDog (WD) in a greenhouse with infected coleus. B, removing the reel from the spore trap. C, preparing the reel with a week's worth of transparent film tape. D, mounting a length of tape representing 48 hours onto a microscope slide.

Temperature Studies-Infection: The effect of temperature on downy mildew infection of 'Volcano' coleus was investigated in growth chambers set at 59, 68, 77 and 86°F and a 16-hour photoperiod. Sporangia were collected from infected plants and suspended in water at a concentration of ~1,000 sporangia/ml. Subsequently, the inoculum was sprayed onto the foliage of coleus plants, which were immediately enclosed in plastic bags to maintain a high humidity while infection took place. They were placed in the growth chambers at different temperatures for days 1-7 (Fig 3A). Coleus were transferred to the greenhouse (average 64°F night and 77°F day temperatures) with the bags left open for days 8-14. Plants were placed

in wire mesh baskets enclosed in plastic bags to maintain high humidity while sporulation took place for days 15-21 (Fig. 3B) in the greenhouse. At the end of the

Fig. 3. A, inoculated coleus plants in bags ready for days 1-7 of infection. B, inoculated coleus in baskets within bags, ready for days 15-21 of sporulation.

experiment, the numbers of leaves per plant with sporulating downy mildew were counted and the leaf area (%) with sporulation was visually estimated.

Temperature Studies-Sporulation: The effect of temperature on downy mildew sporulation on 'Black Dragon' coleus was investigated in growth chambers set at 59°F, 68°F, 77°F, and 86°F and a 16-hour photoperiod. Inoculum was prepared and applied as described in the previous paragraph. Inoculated coleus plants were immediately enclosed in plastic bags to maintain high humidity for infection for days 1-7 (Fig. 3B) in the greenhouse (average 64°F night and 77°F day temperatures), then bags were left open for days 8-14 in the greenhouse. Plants were placed into baskets enclosed in plastic bags to maintain high humidity for sporulation and transferred to growth chambers at different temperatures for days 15-21 (Fig. 3C). At the end of the experiment, the numbers of leaves per plant with sporulating downy mildew were counted, and the leaf area (%) with sporulation was visually estimated.

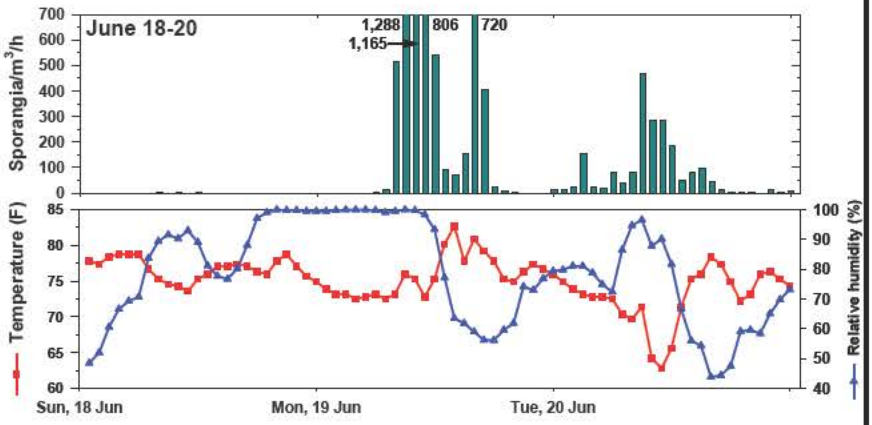

Fig. 4. High numbers of sporangia (bars in top graph) were trapped on 19 June after an extended period of 100% relative humidity (blue line in bottom graph) in a greenhouse with infected coleus. Note the peaks in sporangia numbers associated with drops in the relative humidity on 20 June.

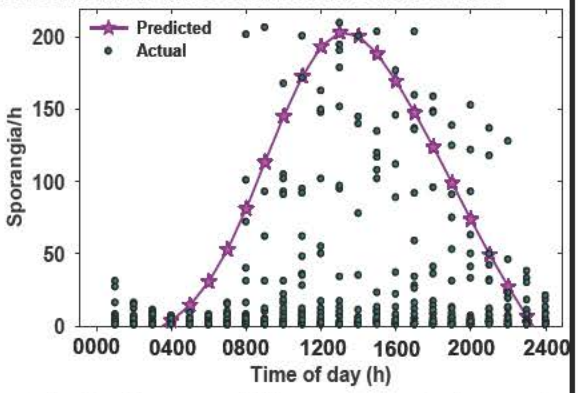

Fig. 5. Downy mildew sporangia trapped per hour of the day for one season.

RESULTS

Spore Trapping: Relative humidity levels greater than 95% and followed by a decrease prompted a sudden release of high numbers of sporangia into the air (Fig. 4). Extended periods of high relative humidity were followed by the highest sporangia numbers (Fig. 4) with the greatest numbers of sporangia occurring in May and June. The numbers decreased by August. Each day, the highest concentrations of sporangia were detected in the air of the greenhouse between 10 AM (1000 hrs) and 3 PM (1500 hrs) (Fig. 5).

Temperature Studies-Infection: Temperatures of 59°F and 68°F were most favorable for downy mildew infection (spotting, blighting, leaf drop) of 'Volcano' coleus (Fig. 6, top row). Minimal infections were noted at 77°F (spotting), and plants remained healthy at the highest temperature tested, 86°F (Fig 6, middle row).

Temperature Studies-Sporulation: Development of sporangia on the underside of

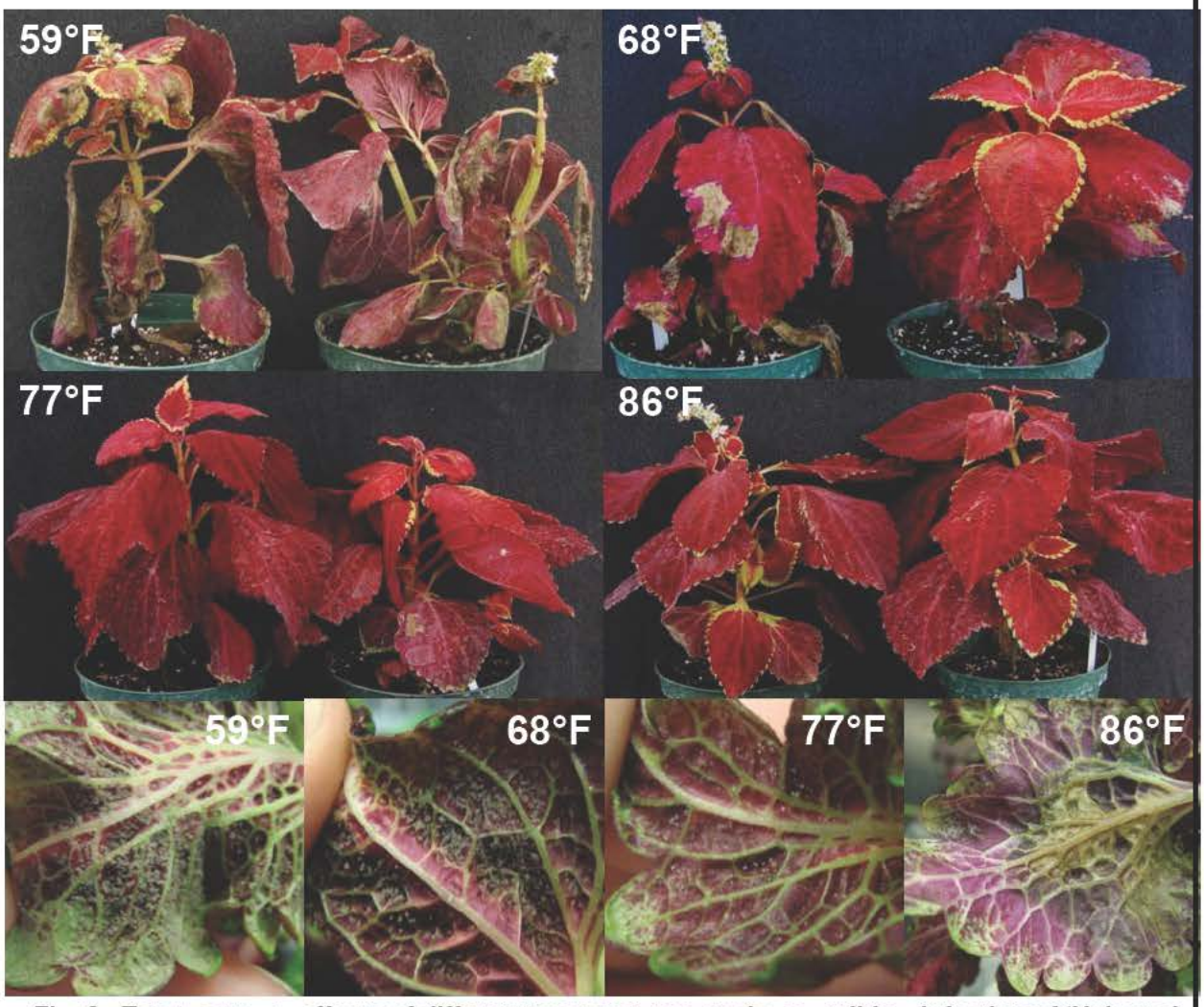

Fig. 6. Top two rows, effects of different temperatures on downy mildew infection of 'Volcano' coleus. Note spotting, blighting and leaf drop; plants remained healthy when temperature was 86°F during infection. Bottom row, effects of different temperatures on sporulation of downy mildew on 'Dragon Black' coleus. Note absence of sporulation at 86°F.

diseased coleus leaves was closely associated with temperature. Sporulation occurred at 59°F and 68°F (Fig. 6, bottom row); little sporulation was observed at 77°F and no sporangia were observed at 86°F.

CONCLUSIONS

For an epidemic of coleus downy mildew to occur, plants must be infected by the pathogen, which subsequently produce spores that are released into the air to initiate more cycles of infection and sporulation on other plants. The infection and sporulation stages of *Peronospora* sp. were favored by temperatures of 59°F and 68°F. Research has shown that once downy mildew has successfully infected a plant and the environment becomes hot (77°F, 86°F) and dry, conditions do not favor the disease. Thus, it may become 'quiet' or latent - neither growing further within the plant nor dying out. Plants with latent infections may appear perfectly healthy, but once the environment becomes favorable for pathogen growth, the disease may appear to develop overnight.

Periods of extended high relative humidity and periods of high relative humidity followed by a sudden decrease in relative humidity prompted the release of downy mildew sporangia into the greenhouse environment. Thus, limiting the relative humidity in the greenhouse through wider plant spacing and watering in the mornings may help to limit the development of downy mildew.

INDUSTRY IMPACT

An integrated pest management program which combines the manipulation of the greenhouse environment, scouting for the disease, selecting downy mildew-tolerant coleus cultivars, and prudent use of fungicides can help growers to produce quality coleus crops.

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