Effect of Dew Period and Temperature on the Ability of *Exserohilum monoceras* to Cause Seedling Mortality of *Echinochloa* Species

W. M. Zhang, Graduate Research Assistant, and A. K. Watson, Professor, Department of Plant Science, Macdonald Campus of McGill University, Montréal, Québec, Canada H9X 3V9; and Research Scholar and Weed Scientist (seconded from McGill University), International Rice Research Institute, PO Box 933, 1099 Manila, Philippines

ABSTRACT

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In greenhouse and controlled environment experiments, disease development and mortality of *Echinochloa crus-galli*, *E. colona*, and *E. glabrescens* caused by *Exserohilum monoceras* were affected by duration, frequency, and timing of dew period, as well as by dew-period temperature and post-dew temperature. When adequate dew was provided, 100% mortality occurred for all three *Echinochloa* spp. over the broad dew-period temperature range of 20 to 30°C. The effect of post-dew temperature on disease development varied with the initial dew period. The minimum dew period to achieve 100% mortality was 16 h for *E. colona*, 12 h for *E. crus-galli*, and 8 h for *E. glabrescens*. Increasing dew period enlarged the range of temperature for maximum efficacy, whereas the use of optimum dew-period temperature decreased the dew period requirement. Delaying the initiation of the dew period by 24 h did not adversely affect disease development. Increased disease development occurred for inoculated seedlings treated with repetitive dew periods of shorter duration than the optimal period. These findings characterize one of the epidemiological requirements, i.e., dew requirement, needed to assess the potential of *E. monoceras* for the control of *Echinochloa* spp. in rice.

Additional keywords: barnyard grass, bioherbicide, jungle rice, weed control

Barnyard grass, *Echinochloa crus-galli* (L.) Beauv., ranked as the world's third worst weed, is one of the most serious weeds in rice (*Oryza sativa* L.) (2,7,18). Intense competition from *E. crus-galli* can reduce tillering in rice by up to 50% (7). Smith (17) reported that season-long competition from *E. crus-galli* reduced rice grain yields by 70%. Jungle rice, *E. colona* (L.) Link., ranked as the world's fourth worst weed, is another serious weed in rice, especially in upland rice (7,14). Yield reductions of 25% were observed in rice at *E. colona* densities of 80 plants/m² during the first 40 days of growth of this crop (12, 14). Although *E. colona* is a less vigorous competitor than *E. crus-galli*, *E. colona* poses serious problems in rice systems because populations typically far exceed 80 plants/m². *E. glabrescens* Munro ex Hook. f. is also an important weed species in rice, especially in tropical regions (2, 13). Average yield reductions in rice from transplanted *E. glabrescens* ranged from 6% at 5% infestation levels to 73% at 40% infestation levels (15).

Various management strategies are available for suppression of *Echinochloa* spp. in rice, including cultural techniques, hand-weeding, mechanical control, and chemical herbicides (10). Currently, the possibility of using indigenous plant pathogens as biological control agents to control these *Echinochloa* spp. in rice is being investigated (24,31). A fungus, *Exserohilum monoceras* (Drechs.) K. J. Leonard & E. G. Suggs, isolated from diseased *Echinochloa* spp. in the Philippines, caused blight symptoms on *E. crus-galli*, *E. colona*, and *E. glabrescens*, but was nonpathogenic to rice (31). An inoculum dose of 2.5 to 5.0 × 10⁷ conidia/m² killed seedlings of *Echinochloa* spp. at the 1.5-leaf stage under greenhouse conditions (30).

Since infection, disease development, and, subsequently, weed control efficacy of pathogens are usually suppressed under natural conditions (6,19,25), it is essential to determine optimal environmental conditions for disease development as well as limiting environmental factors that should be overcome or bypassed for effective field control of *Echinochloa* spp. by the fungus *Exserohilum monoceras*. Dew period and temperature have been recognized as two important environmental components that contribute to the efficacy of a bioherbicide (19,26). Various studies of the effects of dew period and temperature on the efficacy of commercial and other potential bioherbicides have been reported and provided

important information on epidemiological parameters (9,11,20,23). Thus, the objective of this study was to evaluate the effect of dew period, frequency, and timing on infection, disease development, and virulence of *Exserohilum monoceras* on *Echinochloa* spp. The effects of dew-period temperature as well as post-dew temperature on disease development were also investigated.

MATERIALS AND METHODS

Inoculum production. A single-conidial isolate of *Exserohilum monoceras*, growing on half-strength potato dextrose agar (Difco, Detroit, MI) slants in small vials, was maintained under mineral oil at 4°C as the stock culture (22). Small pieces of mycelium from the stock culture were aseptically transferred to potato dextrose agar plates. Each plate was sealed with Parafilm (American National Can, Greenwich, CT) and incubated at 28°C for 7 days. Agar plugs (6 mm in diameter) containing mycelia were collected from the margins of these young colonies and used to inoculate lima bean agar plates. The lima bean agar plates were prepared by grinding 15 g of dry lima beans to a very fine powder, cooking in 1 liter of boiling water for 45 min, and adding 10 g of agar. Seeded lima bean agar plates were sealed with Parafilm and incubated at 28°C in the dark for 3 weeks. Conidia were harvested from plates by flooding the plates with 10 ml of distilled water and scraping the surface of the colonies with a glass slide. The resulting suspension was filtered through a layer of cheesecloth. The inoculum concentration was determined with the aid of hemacytometer and adjusted to the desired density by adding distilled water.

Plant production. A single batch of seeds of each of *E. crus-galli*, *E. colona*, and *E. glabrescens* collected from field populations at the International Rice Research Institute (IRRI), Los Baños, Philippines, was used in all experiments. Seeds of each species were incubated in petri dishes on moistened filter paper at room temperature for 48 h. Five germinated seeds (coleoptile and radicle visible) were planted in 10-cm-diameter plastic pots filled with water-saturated soil (Maahas clay, suborder Haplustic). Seeded pots were placed on a pushcart in the greenhouse, and a 2- to 3-cm water level was maintained throughout the experimental

Corresponding author: Alan K. Watson
E-mail: watsona@agradm.lan.mcgill.ca

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period. Greenhouse conditions were $35/23 \pm 5^\circ\text{C}$ day/night temperature, a 12-h photoperiod, and average light intensity of $350 \mu\text{E s}^{-1} \text{m}^{-2}$.

General inoculation procedure. Each treatment consisted of inoculating four pots of each of the three *Echinochloa* spp. (each pot containing five seedlings at the 1.5-leaf stage) with a conidial suspension at a rate of 5.0×10^7 conidia/m² containing 0.05% Tween 20 (polyoxymethylene sorbitan monolaurate, Sigma Chemical, St. Louis, MO) as a wetting agent, using a motorized sprayer at 100 kPa (A. H. Thomas Co. Scientific Apparatus, Philadelphia, PA). Immediately after inoculation, pots were transferred to a greenhouse section at $26 \pm 2^\circ\text{C}$ and $90 \pm 5\%$ relative humidity (27).

Assessment of disease development. Mortality of plants and dry weight of living aboveground biomass per pot were assessed 10 days after inoculation (DAI). Completely collapsed seedlings were considered dead. Dry weight was obtained by cutting aerial parts at soil level, drying the parts in paper bags for 4 to 5 days at 60°C , and weighing. Dead tissue was not included in dry weight measurements. The dry weight data were expressed as percent reduction in biomass compared with the biomass of noninoculated controls.

Effect of dew-period temperature. After inoculation, pots with inoculated seedlings were placed in a dark dew chamber at temperatures of 10, 15, 20, 25, 30, 35, or $40 \pm 1^\circ\text{C}$ for 24 h and then returned to the greenhouse.

Effect of post-dew temperature. Pots with inoculated seedlings were placed in a dark dew chamber at $25 \pm 1^\circ\text{C}$ for either 12 or 24 h. After the dew-period treatment, pots were transferred to growth chambers at temperatures of 15, 20, 25, 30, 35, or $40 \pm 1^\circ\text{C}$, with a photoperiod of 12 h and light intensity of $300 \mu\text{E s}^{-1} \text{m}^{-2}$ for 10 days.

Effect of dew period. Pots with inoculated seedlings were placed in a dark dew chamber at $25 \pm 1^\circ\text{C}$ for 0, 4, 8, 12, 16, 20, or 24 h. Except for the 24-h treatment, all pots were covered with cardboard for the remainder of the 24 h to simulate the dark period in the dew chamber. After the dew period treatment, pots were returned to the greenhouse.

Interaction between dew-period temperature and duration. After inoculation, pots with inoculated seedlings were placed in a dark dew chamber at 15, 20, 25, 30, or $35 \pm 1^\circ\text{C}$ and exposed to dew periods of 4, 8, 12, 16, 20, or 24 h. The experiment had a 5×6 factorial design. Except for the 24-h treatment at each temperature, pots were covered with cardboard for the remainder of the 24 h to simulate the dark period in the dew chamber. Following the dew-period treatment, pots were returned to the greenhouse.

Effect of delaying initial dew period. Pots with inoculated seedlings were placed in the greenhouse for 0, 1, 2, 3, or 4 days before being placed in a dark dew chamber for 4, 8, 12, 16, or 20 h. The experiment had a 5×5 factorial design. Except for the 20-h treatment, pots removed from the dark dew chamber were covered with

cardboard for the remainder of the 20 h to simulate the dark period in the dew chamber. After treatment, pots were returned to the greenhouse.

Effect of repetitive dew periods. Pots with inoculated seedlings were provided one of the following dark dew periods at $25 \pm 1^\circ\text{C}$: (i) 6-h dew period/18-h dry period on 1, 2, 3, or 4 consecutive days; (ii) 12-h dew period/12-h dry period on 1 or 2 consecutive days; or (iii) a single 24-h dew period. All pots were kept in the dark for the remainder of the 24 h to simulate the dark period in the dew chamber by covering pots with cardboard. After treatment, pots were returned to the greenhouse.

Data analyses. All experiments were performed twice. A randomized complete block design with four replicates was used for all experiments. All percent data were arc sine-transformed prior to analysis (5). Factorial experiments were analyzed with an analysis of variance considering the effect of each factor individually and their interaction. Regression analysis was performed on all significant ($\alpha \leq 0.05$) dependent variables, using the PROC REG procedure in SAS (16). The best regression equation was selected with the step-wise model selection method (3). Results for the two trials of each experiment were pooled if homogeneity of variances was confirmed by the Bartlett test (5). However, for experiments in which the variances of trials were not homogeneous, results from one trial are presented given that a similar trend was observed in both trials. Mean values of five plants for each treatment were used for statistical analyses. Treatment means were separated by Duncan's multiple range test at the 5% level of significance.

RESULTS

Effect of dew-period temperature. All seedlings of *E. crus-galli*, *E. colona*, and *E. glabrescens* were killed at dew-period temperatures between 20 and 30°C . However, mortality declined sharply when dew temperatures were below 20°C or above 30°C (Fig. 1). For example, at 15°C dew temperature, *E. crus-galli*, *E. colona*, and *E. glabrescens* mortalities were 40, 10, and 56%, respectively, whereas with the 35°C dew-temperature treatment, *E. crus-galli*, *E. colona*, and *E. glabrescens* mortalities were 26, 13, and 36%, respectively. No mortality was observed at a dew temperature of 10 or 40°C for any of the three *Echinochloa* spp.

Effect of post-dew temperature. The effect of post-dew temperature varied with the initial dew period (Fig. 2). When provided a 24-h dew period, all seedlings of the three *Echinochloa* spp. were killed at temperatures ranging from 15 to 40°C . However, when provided a 12-h dew period, mortality of the three *Echinochloa* spp. varied with different post-dew temperatures. The highest level of mortality of

Fig. 1. Effect of dew-period temperature on disease development caused by *Exserohilum monoceras* on three *Echinochloa* spp., expressed as percent plant mortality 10 days after inoculation. Seedlings at the 1.5-leaf stage were sprayed with a conidial suspension of *E. monoceras* at rate of 5×10^7 conidia/m². Dew period was 24 h. Data from two trials were pooled because variances were homogeneous. Points represent means of eight replicates.

the three *Echinochloa* spp. was observed at the 30°C post-dew temperature treatment. Among the three *Echinochloa* spp., mortality of *E. glabrescens* appeared to be least influenced by post-dew temperature.

Effect of dew period. Mortality increased concomitantly as dew period increased (Fig. 3). No plant death was recorded for the 0- and 4-h dew period treatments. However, more than 8, 12, and 16 h of dew resulted in 100% mortality of *E. glabrescens*, *E. crus-galli*, and *E. colona* seedlings, respectively.

Interaction between dew-period temperature and duration. Mortality of all seedlings was observed with long dew period and dew-period temperatures of 20 to 30°C (Figs. 4 and 5). The minimum dew period for 100% mortality of *E. crus-galli* was 12 h at dew-period temperatures of 20 to 30°C (Fig. 4A). For *E. colona*, 100% mortality occurred with a minimum of 16 h of dew at dew-period temperatures of 20 and 25°C, while a 20-h dew period was needed for 100% mortality when the dew-period temperature was 30°C (Fig. 4B). For *E. glabrescens*, the ranges of dew period and temperature for achieving the highest levels of control were similar to those of *E. crus-galli*, except that a 100% mortality of *E. glabrescens* was obtained after only an 8-h dew period at 25°C (Fig. 4C).

For the temperature range tested, the relationship between dew-period temperature and duration for attaining 100% mortality was similar for all three species, but *E. glabrescens* was most susceptible and *E. colona* least susceptible (Fig. 5). The predicted minimum dew period required to produce 100% mortality was 12.4, 15.8, and 9.9 h for *E. crus-galli*, *E. colona*, and *E. glabrescens*, respectively.

Effect of delaying initial dew period. The greatest seedling mortality for all three species was obtained following the shortest delay in providing a dew period (Fig. 6). When the initial dew period was delayed 1 day after inoculation, the 12-h dew period treatment still resulted in 95% mortality of *E. crus-galli*, while the 16- and 20-h dew periods resulted in 100% seedling mortality. These mortality rates were not significantly different from those in which the 12- and 16-h dew period treatments were initiated immediately after inoculation. When the initial dew period was delayed by 2 days or longer after inoculation, *E. crus-galli* mortality decreased sharply (Fig. 6A). Similar patterns were observed for *E. colona* and *E. glabrescens*, with *E. colona* susceptibility more adversely affected by dew period delay than *E. glabrescens* susceptibility (Fig. 6B and C).

Effect of repetitive dew periods. When provided with a continuous dew period of 12 h or more, *E. monoceras* killed all *E. crus-galli* seedlings (Table 1). If two 6-h dew periods on consecutive days were pro-

vided, no mortality occurred, but when *E. crus-galli* seedlings were exposed to four 6-h dew periods, *E. monoceras* caused nearly 70% mortality (Table 1). Even

though *E. monoceras* did not cause 100% mortality when provided with a 6-h dew period on 2, 3, and 4 consecutive days, *E. crus-galli* dry weight was reduced from 43

Fig. 2. Effect of post-dew temperature on disease development caused by *Exserohilum monoceras* on three *Echinochloa* spp., expressed as percent plant mortality 10 days after inoculation. Seedlings at the 1.5-leaf stage were sprayed with a conidial suspension of *E. monoceras* at a rate of 5×10^7 conidia/m² and given a 12- or 24-h dew period. Data from two trials were not pooled because variances were not homogeneous. Bars represent means of four replicates. Bars within each temperature treatment in a dew period having the same letter are not significantly different according to Duncan's multiple range test at the 5% significance level.

Fig. 3. Effect of dew period on disease development caused by *Exserohilum monoceras* on three *Echinochloa* species, expressed as percent plant mortality 10 days after inoculation. Seedlings at the 1.5-leaf stage were sprayed with a conidial suspension of *E. monoceras* at a rate of 5×10^7 conidia/m². Dew temperature was 25°C (in dark). Data from two trials were pooled because variances were homogeneous. Points represent means of eight replicates.

to 90% (Table 1). Similar results were obtained with *E. colona* and *E. glabrescens* (data not shown).

DISCUSSION

Although the three *Echinochloa* spp. responded differently to *E. monoceras* at different dew-period temperatures, the optimum dew-period temperature range for achieving 100% mortality for all three

Echinochloa spp. was similar (i.e., between 20 and 30°C). Conflicting results have been reported with different bioherbicide pathosystems in which a single pathogen has been used to achieve control of more than one weed species. Boyette and Walker (1) reported that 25°C was the optimum dew-period temperature for the control of both *Abutilon theophrasti* Medik. (velvetleaf) and *Sida spinosa* L. (prickly sida) with *Fusarium lateritium* Nees:Fr., whereas the dew-period temperature that provided satisfactory control of *Malva pusilla* Smith (round-leaved mallow) by *Colletotrichum gloeosporioides* (Penz.) Penz. & Sacc. in Penz. f. sp. *malvae* was less than that necessary to control *A. theophrasti* (9). Similar dew-period temperature requirements for all three *Echinochloa* spp. should favor simultaneous, effective control on all three weedy *Echinochloa* spp. by *E. monoceras*. Moreover, the optimum dew-period temperature range and post-dew temperature for development of *E. monoceras* on *Echinochloa* spp. are within the temperature range that occurs during the rice-growing seasons in much of Southeast Asia (8), and are similar to temperatures required for conidial germination of *E. monoceras* (29). Therefore, dew-period temperature and post-dew temperature are not likely to be limiting factors for development of *E. monoceras* as a bioherbicide for the suppression of *Echinochloa* spp.

The effect of post-dew temperature may be related to the degree of initial infection, which is dependent upon the initial dew period. A 24-h initial dew, at 25°C in the dark, appeared to allow *E. monoceras* to establish infections on *Echinochloa* spp. as shown by the similar degree of infection on the three *Echinochloa* spp. In this case, disease development does not appear to be affected by post-dew temperatures (from 15 to 40°C). However, when the initial dew period was reduced to 12 h, infection efficiency (28) on the three *Echinochloa* spp. differed and further disease development was influenced by post-dew temperature. Infection efficiency was greatest for *E. glabrescens* because this weed species was least susceptible to the influence of post-dew temperature. These findings suggest that temperature during the infection process (dew-period temperature) had a greater effect on the development of *E. monoceras* on *Echinochloa* spp. than did post-infection temperature (post-dew temperature). Although no similar study on the relationship between dew-period temperature and post-dew temperature has been reported in other commercial and/or potential bioherbicide pathosystems, results in this study support findings for crop diseases (4,21). These results also indicate that if a sufficient dew period was established after inoculation, or if the dew requirement was overcome or bypassed through artificial inoculation techniques,

Fig. 4. Effect of dew-period temperature and duration on disease development caused by *Exserohilum monoceras* on (A) *Echinochloa crus-galli*, (B) *E. colona*, and (C) *E. glabrescens*, expressed as percent plant mortality 10 days after inoculation. Data from two trials were pooled because variances were homogeneous. Points represent means of eight replicates. The relationships were best described by the following equations: (A) $Y = -45.82 - 15.71D + 1.97TD - 0.04T^2D - 0.01TD^2 + T^3$, $r^2 = 0.7342$; (B) $Y = -474.01 + 42.17T + 0.67D + 2.06TD - 1.93T^2 - 0.76D^2 - 0.05T^2D + 0.01TD^2 + 0.03T^3$, $r^2 = 0.8687$; and (C) $Y = -500.42 + 46.86T + 9.40D - 1.32T^2 - 0.22D^2 + 0.01T^3$, $r^2 = 0.7434$; where Y = mortality (%), T = dew-period temperature, and D = dew period. Percent mortality data were arc sine-transformed before analysis.

Fig. 5. Effect of dew-period temperature on the predicted dew period required to provide 100% disease severity on three *Echinochloa* spp. caused by *Exserohilum monoceras*, expressed as percent plant mortality 10 days after inoculation. The relationship was best described by the following equations: (i) *Echinochloa crus-galli*: $\ln D = (M + 15.1039)/(-36.1946 + 6.5039T - 0.1323T^2)$, ($P = 0.0001$, $r^2 = 0.7213$); (ii) *Echinochloa colona*: $\ln D = (M + 33.45)/(-47.14 + 7.44T - 0.145T^2)$, ($P = 0.0001$, $r^2 = 0.7828$); (iii) *Echinochloa glabrescens*: $\ln D = (M + 3.7930)/(-35.0961 + 6.5739T - 0.1344T^2)$, ($P = 0.0001$, $r^2 = 0.9254$); where M = mortality (%), D = dew period, and T = dew-period temperature. Percent mortality data were arc sine-transformed before analysis.

such as more efficient formulations or application methods (30), post-dew temperature would no longer be a limiting factor for the control of *Echinochloa* spp. by *E. monoceras*.

The minimum dew period to achieve 100% mortality was 12 h for *E. crus-galli*, 16 h for *E. colona*, and 8 h for *E. glabrescens*. These dew period requirements are similar to those reported for other bioher-

Fig. 6. Effect of delaying initial dew period on disease development caused by *Exserohilum monoceras* on (A) *Echinochloa crus-galli*, (B) *E. colona*, and (C) *E. glabrescens*, expressed as percent plant mortality 10 days after inoculation. Seedlings at the 1.5-leaf stage were sprayed with a conidial suspension of *E. monoceras* at a rate of 5×10^7 conidia/m². Data from two trials were not pooled because variances were not homogeneous. Points represent means of four replicates. The relationships were best described by the following equations: (A) $Y = -25.22 + 6.82P - 1.62PD + 0.38D^3$, $r^2 = 0.8462$; (B) $Y = -9.31 + 2.06P - 0.06P^2D + 0.01P^3$, $r^2 = 0.8506$; and (C) $Y = 9.68 - 7.47D + 5.17P - 0.81PD$, $r^2 = 0.7768$; where Y = mortality (%), D = days after inoculation, and P = dew period. Percent mortality data were arc sine-transformed before analysis.

bicides and potential bioherbicides including *Colletotrichum gloeosporioides* f. sp. *aeschyromene* (20), *Fusarium lateritium* (1), *Alternaria cassiae* A. M. M. Jurair & A. Khan (23), and *C. gloeosporioides* f. sp. *malvae* (9). TeBeest (19) suggested that dew period requirements of 16 h or longer could limit the practical use of fungi as biological control agents for weeds. Therefore, as in other bioherbicide pathosystems, dew period is a limiting factor for the control of *Echinochloa* spp., especially *E. colona*, by *E. monoceras*. Fortunately, the limitation of dew period for development of *E. monoceras* on *Echinochloa* spp. can be overcome or bypassed by formulating inoculum as an oil emulsion or by the application of a dry-powder formulation that floats conidia on the water surface (30).

The interaction between dew-period temperature and duration demonstrated that the dew period requirement was moderated by dew-period temperature. The predicted curves (Fig. 5) of minimal dew period for 100% mortality for each species flattened out over the temperature range of 20 to 30°C. Dew periods of 12 to 16 h for *E. crus-galli*, 16 to 21 h for *E. colona*, and 10 to 12 h for *E. glabrescens*, respectively, were required for *E. monoceras* to achieve 100% mortality over this relatively broad temperature range. However, at dew-period temperatures below 20°C or above 30°C, the dew requirement increased significantly for all three *Echinochloa* spp. The majority of bioherbicide studies place an emphasis on the application of biocontrol agents at times that favor the onset of dew formation (11,19,23). The findings in this study strongly suggest that application of biocontrol agents should also take into account the ambient temperature at the time the biocontrol agents are applied. For *E. monoceras* to control *Echinochloa* spp., application of the fungus should not be carried out when night temperatures are

expected to be below 20°C or above 30°C.

A few infections occurred on inoculated *Echinochloa* seedlings that did not receive a dew period. Similarly, dry periods of up to 24 h beginning immediately after inoculation did not adversely affect the weed control efficacy of *E. monoceras* if sufficient dew subsequently occurred. Similar results were reported on the biocontrol of *Senna obtusifolia* (L.) H. Irwin & Barneby (sicklepod) by *Alternaria cassiae*, in which a delay of 2 days in the occurrence of dew was tolerated without adversely affecting the efficacy of the pathogen (23). Therefore, field application is not restricted to late afternoons or early evenings as is usually recommended for bioherbicide pathogens (11,19).

Repetitive dew periods have been reported to shorten the optimal dew period required for efficient control of *Senna obtusifolia* by *Alternaria cassiae* (23). Similar results were observed in our study, i.e., shorter repetitive dew periods (6 h rather than 16 or 24 h of continuous dew), more closely simulating field conditions than a single long dew period, enhanced the control of all three *Echinochloa* spp. These results were confirmed by field observations in which foliar applications of conidial suspensions of *E. monoceras* containing 0.05% Tween 20 reduced plant dry weight by approximately 5% at 7 DAI and 50% at 28 DAI (data not shown).

Yang and TeBeest (26) proposed a model for control efficacy of bioherbicides in which efficacy was composed of primary infections established by the application of inoculum and secondary or post-application infections. *E. monoceras* has poor dispersal ability and the precise role of secondary infections for control of *Echinochloa* spp. by *E. monoceras* is yet unknown (29). When the inoculum was formulated as an oil emulsion or when applied as a dry powder, the level of primary infection increased significantly and 90% mortality was achieved at 14 to 20 DAI (29). Therefore, an adequate formulation can greatly reduce the environmental dependency of *E. monoceras* and increase its potential as a bioherbicide.

Table 1. Effect of repetitive dew periods on mortality and reduction in dry weight of *Echinochloa crus-galli* inoculated with *Exserohilum monoceras*^y

Dew period (h/day)	Mortality (%)	Dry weight reduction (%)
0	0 c ^z	10.0 d
6	0 c	23.8 c
6; 6	0 c	42.6 b
6; 6; 6	5 c	59.1 b
6; 6; 6; 6	70 b	90.0 a
12	100 a	100.0 a
12; 12	100 a	100.0 a
24	100 a	100.0 a

^y Seedlings at the 1.5-leaf stage were sprayed with a conidial suspension of *E. monoceras* at 5×10^7 conidia/m². Data from two trials were not pooled because variances were not homogeneous. Data represent means of four replicates.

^z Values having the same letter are not significantly different according to Duncan's multiple range test at the 5% significance level.

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