

## Biological Control of *Pythium* Root Rot of *Chrysanthemum* in Small-scale Hydroponic Units

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The capacity of several strains of root-colonizing bacteria to suppress *Pythium aphanidermatum*, *Pythium dissotocum* and root rot was investigated in chrysanthemums grown in single-plant hydroponic units containing an aerated nutrient solution. The strains were applied in the nutrient solution at a final density of  $10^4$  CFU ml<sup>-1</sup> and 14 days later the root systems were inoculated with *Pythium* by immersion in suspensions of  $10^4$  zoospores ml<sup>-1</sup> solution. Controls received no bacteria, no *Pythium*, or one of the *Pythium* spp. but no bacteria. Strain effectiveness was estimated based on percent roots colonized by *Pythium* and area under disease progress curves (AUDPC). In plants treated respectively with *Pseudomonas* (*Ps.*) *chlororaphis* 63-28 and *Bacillus cereus* HY06 and inoculated with *P. aphanidermatum*, root colonization by the pathogen was 83% and 72% lower than in the pathogen control, and AUDPC values were reduced by 61% and 65%. For *P. dissotocum*, the respective strains reduced root colonization by 87% and 91%, and AUDPC values by 70% and 90%. In plants treated respectively with *Ps. chlororaphis* Tx-1 and *Comamonas acidovorans* C-4-7-28, root colonization by *P. aphanidermatum* was 84% and 80% lower than in the controls and AUDPC values were reduced by 66% and 57%; these strains did not suppress *P. dissotocum*. *Burkholderia gladioli* C-2-74 and *C. acidovorans* OCR-7-8-38, respectively, suppressed colonization of roots by *P. dissotocum* by 74% and 86%, and reduced AUDPC values by 60% and 70%, but were ineffective against *P. aphanidermatum*. *C. acidovorans* OCR-7-8-39 reduced colonization and AUDPC values of *P. aphanidermatum* by 57% and 42%, respectively. *Pseudomonas corrugata* 13, *Ps. fluorescens* 15 and JZ12, and three additional strains of *C. acidovorans* were weakly or nonsuppressive against *P. aphanidermatum*. Strains that reduced AUDPC values for *P. aphanidermatum* or *P. dissotocum* when applied at  $10^4$  CFU ml<sup>-1</sup> were 11%–39% less effective at  $10^3$  CFU ml<sup>-1</sup>. Four tested strains (*Ps. chlororaphis* 63-28, *Ps. chlororaphis* Tx-1, *B. cereus* HY06, and *B. gladioli* C-7-24) in most instances suppressed root colonization and lowered AUDPC values of *P. aphanidermatum* when applied at 14, 7 or 0 days before inoculation, but reduction of the respective variables was generally greater when the strains were applied at 14 days (63%–87% and 75%–78%) or 7 days (44%–47% and 31%–88%) than at 0 days (14%–31% and 23%–62%) before inoculation. *Ps. chlororaphis* Tx-1, *Ps. chlororaphis* 63-28 and *B. cereus* HY06 significantly suppressed *P. aphanidermatum* whether the temperature of the nutrient solution was high (32°C) or moderate (24°C). Taken together, the observations suggest that *Ps. chlororaphis* 63-28, *B. cereus* HY06, *Ps. chlororaphis* Tx-1, *B. gladioli* C-2-74 and *C. acidovorans* OCR-7-8-38 have the potential for controlling *Pythium* root rot in hydroponic chrysanthemums.

KEY WORDS: Biological control; *Chrysanthemum morifolium*; hydroponic; *Pythium* root rot.

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