BIOLOGICAL CONTROL OF FUSARIUM WILT OF TOMATO USING NONPATHOGENIC *FUSARIUM OXYSPORUM*.

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Fusarium wilt diseases, caused by pathogenic forma speciales of *Fusarium oxysporum*, can cause severe losses in tomato and a variety of other crop plants. For several crops, and particularly tomato, Fusarium diseases are generally controlled by fumigation with methyl bromide. We are investigating biological control as an alternative strategy for management of these diseases. The objective of this research is to develop effective biological control of Fusarium wilt of tomato and other crops of economic importance.

Previously, our research had identified several isolates of nonpathogenic *Fusarium oxysporum* that effectively controlled Fusarium wilt of tomato in greenhouse tests (TABLE 1). Selected isolates (CS-1, CS-20, CS-24, and Fo47) were further evaluated to determine the conditions, requirements, and ecological characteristics of this biological control. Characteristics studied included the mechanisms of action, antagonist-pathogen inoculum density relationships, efficacy in a variety of different soil types, and efficacy against different isolates and races of the pathogen. In addition, combinations of multiple antagonists were evaluated for their ability to improve control provided by *F. oxysporum* isolates alone.

The mechanism of action for isolates CS-1 and CS-20 was shown to involve induced systemic resistance, whereas isolate Fo47 appeared to function primarily through saprophytic competition with the pathogen. Inoculum densities of isolates CS-20 as low as 100 chlamydospores/g soil effectively controlled Fusarium wilt at all pathogen levels tested (up to 1×10^5/g soil) (Fig.1A), whereas CS-1 was effective only at antagonist densities of 500 or more cfu/g soil and at pathogen densities less than 1×10^4 cfu/g soil (Fig. 1B). Isolate Fo47 was generally effective only when the antagonist density was much higher ($\geq$ 5 times) than that of the pathogen (Fig 1C). Isolate CS-20 was effective in a variety of soil types, including a sandy loam with low organic matter (OM), a loamy soil with high OM, and a heavy clay soil, whereas isolate CS-1 was effective in all but the clay soil. Isolates CS-20, CS-1, and CS-24 were also effective in controlling disease caused by several different isolates of pathogenic races 1, 2, and 3 in all tests. In preliminary tests, combinations of multiple antagonists did not enhance the level of control provided by *F. oxysporum* isolates alone.

Our results indicate that these *F. oxysporum* isolates, and particularly CS-20, have potential for development as biological control agents. Isolate CS-20 was effective in controlling Fusarium wilt diseases at low antagonist inoculum densities, at up to very high pathogen densities, in a variety of soil types, and against all known pathogenic races. Research is continuing to improve the effectiveness and consistency of control by CS-20 and our other biocontrol agents through: 1) further evaluations of the mechanisms, conditions, and requirements for optimum biocontrol activity, 2) field tests to study the efficacy of biocontrol under natural field conditions, 3) integration of biocontrol with other control strategies, and 4) improved formulations and delivery systems.

TABLE 1. Isolates of nonpathogenic *Fusarium oxysporum* most effective in reducing Fusarium wilt of tomato, watermelon, and muskmelon in greenhouse tests.

Isolate	% Wilt[y]	% Reduction	Source
Pathogen only	58.7 a[z]	0	
CS-2	29.3 b	50.3	Florida, wilt-suppressive soil
CS-10	24.1 b	57.8	"
CS-6	23.1 bc	60.2	"
Fo47	20.4 bc	64.7	France, Fusarium-suppressive soil
CS-21	18.8 bc	67.4	Florida , wilt-suppressive soil
CS-24	17.3 bc	69.6	"
CS-20	10.7 c	81.5	"
CS-1	10.6 c	81.6	"

[y] Results represent combined data over all three hosts (isolate × host interactions were not significant). Disease (% wilt) is represented as the percentage of wilted plants over a 4-wk period. Disease reduction (% reduction) represents the percent reduction of disease relative to the pathogen-only control.
[z] Values followed by the same letter are not significantly different ($P<0.05$) according to Duncan's multiple range test.

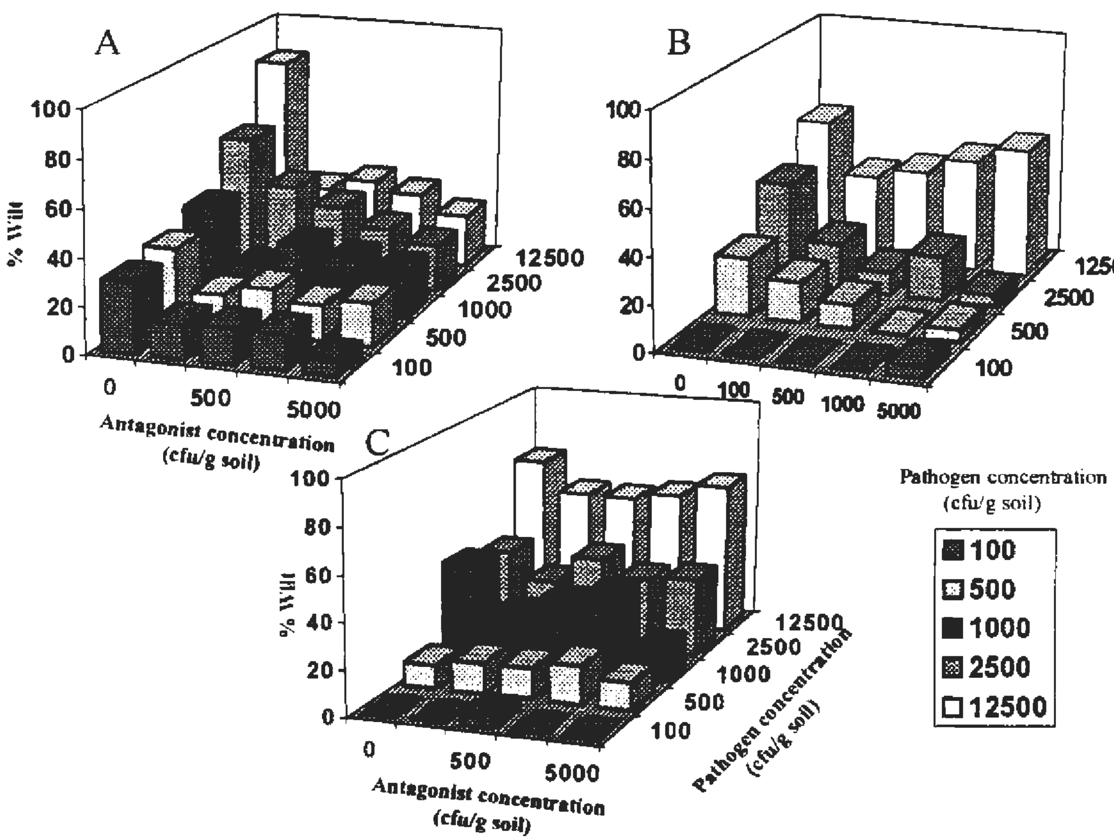

Figure 1. Effect of varying antagonist and pathogen inoculum densities on the development of Fusarium wilt of tomato using A) antagonist isolate CS-20, B) isolate CS-1, and C) isolate Fo47 of nonpathogenic *F. oxysporum*.