BIOLOGICAL CONTROL OF FUSARIUM WILT OF TOMATO UNDER VARYING ENVIRONMENTAL CONDITIONS.

R. P. Larkin* and D. R. Fravel, USDA-ARS, Biocontrol of Plant Diseases Laboratory, Beltsville, MD 20705.

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 identified several isolates of nonpathogenic Fusarium spp. *(F.* oxysporum and *F.* solani) that effectively controlled Fusarium wilt of tomato in greenhouse tests. The mechanism of action for some of these isolates was shown to involve 'induced systemic resistance. Selected isolates were effective at low antagonist inoculum densities, at high pathogen densities, in a variety of soil types, and against multiple races, isolates, and pathogenic formae, speciales. Additional tests with these isolates (CS-20, CS-1, CS-24) were conducted to determine their efficacy under different environmental conditions, particularly temperature, as well as the influence of tomato cultivars of varying degrees of resistance to Fusarium wilt.

Growth chamber (GC) studies were conducted at three different temperature regimes, ranging from cool (22°C day, 16°C night), warm (27°d, 22°n), to hot (32°d,26°n) conditions. Plants were also grown under normal greenhouse (GH) conditions (20-28°C) for comparison. Disease development was strongly affected by temperature. In the pathogen-infested control treatments. wilt incidence was low (~10%) at cool temperatures. high (73-82%) at warm temperatures, and moderate (37%) at hot temperatures (Fig. 1). Isolate CS-20 effectively reduced disease incidence at all temperature regimes tested (60- 100% disease reduction relative to the pathogen controls). Isolates CS- I and CS-24 were effective under GH conditions and at high GC temperatures, but were less effective at warm GC temperatures where optimal conditions for disease development occurred. Overall, the effective temperature range of the Fusarium antagonists was the same as the effective range of the pathogen. However, disease protection provided by some antagonists broke down under conditions of very high disease pressure (>80% wilt incidence).

Isolates CS-20 and CS- I were also effective at reducing Fusarium wilt on eight different tomato cultivars of varying resistance to the disease (Table 1). All cultivars were susceptible to race 3 of the pathogen, and CS-20 and CS- I were equally effective in reducing disease across all cultivars (80% and 69% disease reduction, respectively). These isolates also were equally effective in controlling race 2 of the pathogen on the five cultivars susceptible to race 2 (66% and 67% reduction). Thus. the inherent genetic resistance or lack of resistance in tomato cultivars did not affect the efficacy of biological control by these antagonists.

Our results indicate that these Fusarium isolates, and particularly CS-20, have potential for development as biological control agents. Research is continuing to improve the effectiveness and consistency of control by CS-20 and 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.

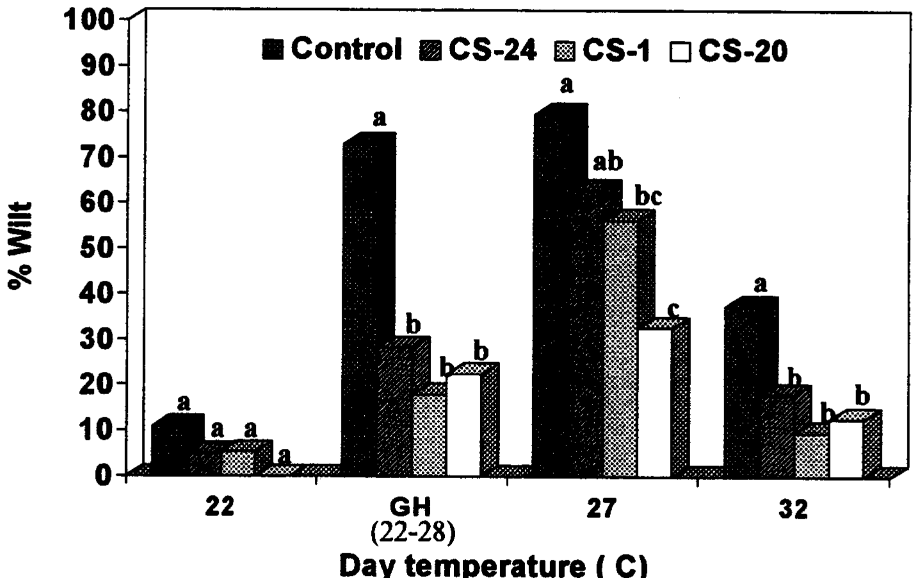

Figure 1. Development of *Fusarium* wilt of tomato as affected by treatments with nonpathogenic *Fusarium* antagonists and varying temperature regimes. Bars topped by the same letter for each temperature regime are not significantly different (P<0.05) according to Duncan's multiple range test.

TABLE 1. Incidence of Fusarium wilt (%) caused by race 2 and race 3 isolates of *F. oxysporum* f. sp. *lycopersici* on eight tomato cultivars with varying disease resistance and as affected by biocontrol treatments with antagonistic *Fusarium* spp. (CS-20 and CS-1)

Tomato		-- Race 2[x]			Race3[x]		
Cultivar	Resistance[w]	CS-20	CS-1	Control	CS-20	CS- I	Control
Bonny Best	0	31.8	26.6	71.4	20.0	28.2	90.0
Marglobe	0	20.0	13.2	63.4	17.4	35.0	76.8
Rutgers	1	5.0	5.0	30.0	5.0	5.0	76.8
Better Boy	1	21.6	30.0	60.0	16.6	35.0	80.0
Miracle Sweet	1	40.6	36.8	93.4	21.6	15.0	80.2
Early Girl	1-2	R[y]			15.0	42.0	81.6
Celebrity	1-2	R			0.0	23.2	66.6
Big Beef	1-2	R			34.0	11.6	85.0
Mean		23.8 a[z]	22.3 a	63.6 b	16.2 a	24.4 a	79.4 b

[w] Cultivar resistance to Fusarium wilt pathogens. O=susceptible to all races, 1 =resistant to race 1, 1-2=resistant to races 1 and 2.
[x] Soil infested with race 2 or race 3 of *F. oxysporum* f. sp. *lycopersic*i. CS-20 and CS- 1 represent antagonist treatments with nonpathogenic *Fusarium* spp. Control represents pathogen-infested control treatment.
[y]Resistant to race 2. Disease incidence <5% for all treatments.
[z]Means followed by the same letter for each race are not significantly different (P<.05) according to Duncan's multiple range test (cultivar x antagonist treatment interaction not significant).