BIOLOGICAL CONTROL OF FUSARIUM WILT DISEASES BY NONPATHOGENIC *FUSARIUM* SPP.: FORMULATIONS AND FIELD EFFICACY.

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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 identified several isolates of nonpathogenic *Fusarium* spp. (*F. oxysporum* and *F. solani*) that effectively controlled Fusarium wilt of tomato, watermelon, and muskmelon in greenhouse tests. The mechanism of action for selected isolates was shown to involve induced systemic resistance. These isolates were effective in significantly reducing wilt incidence at low antagonist inoculum densities, at high pathogen densities, and under varying environmental conditions, including in a variety of soil types, over a range of temperatures, against multiple races, isolates, and formae speciales of the pathogen, and on several different tomato cultivars. Additional research with the best biocontrol isolates (CS-20 and CS-1) was conducted to determine their efficacy under field conditions as well as to evaluate some potential formulations.

Field tests were conducted at two locations in Maryland on two different crops in 1997 and 1998. Isolates of *F. oxysporum* (CS-20) and *F. solani* (CS-1) were applied to seedlings in soilless potting mix as a drench and transplanted into field locations in Beltsville (tomato) and the eastern shore of Maryland (muskmelon). On muskmelon, biocontrol treatments significantly reduced disease incidence 40-43% and 49-59% relative to nontreated control plots in 1997 and 1998, respectively. However, due to the late development of disease, there were no significant effects on yield in either year. On tomato in 1998, CS-20 and a combination fungus (*Gliocladium*) plus bacterium (*Burkholderia*) treatment (G/B) significantly reduced disease incidence and significantly increased yield as measured by total weight and number of fruit per plot (Fig. 1). However, in 1997, disease was uniformly low among all treatments and no significant differences were detected.

In greenhouse formulation tests, fermentor-produced biomass of isolate CS-20 and another *F. oxysporum* biocontrol isolate (Fo47) was incorporated into a granular extrusion containing rice, Pharmamedia, vermiculite, and pyrophillite clay (ARRP7), or was grown on nutrient-enriched cellulose granules (Biodac). Both formulations of CS-20 effectively controlled Fusarium wilt of tomato at incorporation rates of 0.1 and 0.5% (w/v), reducing disease incidence by 66-69% (ARRP7) and 57-78% (Biodac) (Table 1). Formulations of Fo47 also significantly reduced disease incidence, but were consistently effective only at the higher (0.5%) incorporation rate. These formulations are inexpensive, easy-to-produce, easy-to-use, and are very stable (good shelf life).

Our results indicate that the *Fusarium* isolates, particularly CS-20, as well as the *Gliocladium*/*Burkholderia* combination, have potential for further development as biological control agents, and that practical implementation of biocontrol of Fusarium wilt diseases in the field is feasible.

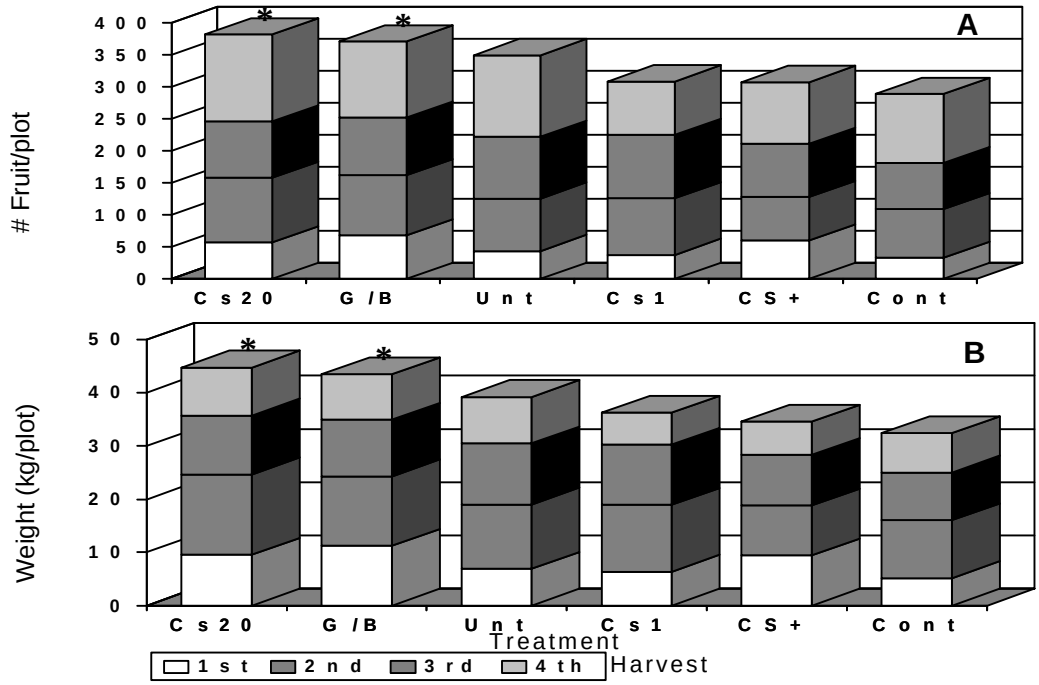

Figure 1. Effect of biocntrol treatments on the (**A**) number and (**B**) weight of tomatoes harvested per plot (12 plants) in 1998 Beltsville field test. Bars topped by an asterisk indicates a significant increase in yield relative to the pathogen control (Cont). Unt=No pathogen added, CS+=combination of CS-1 and CS-20.

Table 1. Effect of granular formulations (Biodac and ARRP7 at 0.1 and 0.5% (w/v) incorporation rates) of *Fusarium* spp. biocontrol isolates Fo47 and CS-20 on development and reduction of Fusarium wilt of tomato.

Treatment[a]	Disease incidence (%)		Disease reduction (%)[b]	
Pathogen control	78.4		0	
CS-20 ck (liq.)	26.2**[c]		66.0**	
Biodac	0.1%	0.5%	0.1%	0.5%
check(no biomass)	50.8*	66.7	34.1*	15.0
Fo47	51.1*	18.1**	34.8*	76.3**
CS-20	33.0**	17.3**	56.9**	78.0**
ARRP7				
check(no biomass)	59.2	73.5	21.9	6.2
Fo47	76.0	43.8**	3.1	43.2**
CS-20	26.6**	23.5**	65.8**	69.0**

[a] Each granular formulation (Biodac and ARRP7 with and without fermentor-produced biocontrol isolate biomass) was compared with the nontreated pathogen control and a liquid inoculum of CS-20 ($1x10^6$cfu/ml) as a standard control.

[b] Percent reduction of disease incidence relative to the pathogen control.

[c] Values followed by asterisks represent a significant reduction of disease compared to the pathogen control at the P=0.05 (*) and P<0.01 (**) according to Fisher's LSD test. Values represent combined results of two similar tests.