INTEGRATED MANAGEMENT OF FUSARIUM CROWN AND ROOT ROT OF TOMATO IN FLORIDA

Robert J. McGovern, University of Florida, SWFREC-Immokalee

Fusarium crown and root rot (FCRR) caused by the fungus *Fusarium oxysporum* f. sp. *radicis-lycopersici* (FORL), has consistently been the most important soilborne disease of tomato in southwest Florida, and has also been a sporadic problem in transplant production houses. Preplant fumigation with methyl bromide/chloro-picrin is the most commonly used management practice for soilborne pests in Florida, but even it provides incomplete control of FCRR. However, the designation of methyl bromide as a Class-I ozone depleter by the EPA and its impending phase-out necessitates evaluation of alternative management strategies for FCRR and other soilborne pests. This report summarizes research conducted in southwest Florida on the integrated management of FCRR over the past three years.

Sanitation. FORL has the ability to survive for long periods in the soil presumably through its production of resistance structures called chlamydospores. The fungus can also contaminate the surface of transplant trays and wooden stakes. Populations of FORL were found to be higher on Styrofoam than on polystyrene transplant trays, and the fungus could be recovered for at least one year from wooden stakes previously used in field production of tomatoes. Water washes and surface disinfestation of trays with a quaternary ammonium salt solution failed to eliminate FORL, while steam disinfestation of Styrofoam trays at 71 C for 45 min was effective. On the other hand, steam treatment of stakes at 93 C for 45 min failed to eliminate the fungus from wooden tomato stakes. Surface disinfestation with a calcium hypochlorite solution for 24 hours was also ineffective. Thus far, only fumigation with high rates of methyl bromide/chloropicrin under a double layer of plastic mulch has eliminated the fungus from the surface of tomato stakes.

Resistance. Six commonly used tomato cultivars and one newly introduced cultivar have'been screened in laboratory and field tests for resistance/tolerance to FORL. Two laboratory tests were performed by placing surface-disinfested seeds of each cultivar on a medium containing the fungus. Cultivar performance was also evaluated in three trials in commercial tomato fields naturally infested with FORL. The newly introduced tomato cultivar, Conquest, was highly resistant to the fungus in both laboratory and field studies, and also appeared to be resistant to gray wall. Yields produced by 'Conquest' compared favorably with commonly used cultivars. The results of a tomato cultivar trial conducted during the Fall of 1992 in a naturally infested production field following application of methyl bromide:chloropicrin 67:33 (Ten-O-Gas 67, 392 kg/ha) are presented in Table 1.

Fumigants and Biological Control Agents. A number of fumigants have been screened during the last three years alone and in combination with commercial formulations of biological control agents for efficacy in reducing FCRR in multiple experiments using commercial tomato production fields in southwest Florida naturally infested by FORL. Metham sodium [Vapam (935 l/ha)], l-3 dichloropropene:chloropicrin, 87%:17% (Telone C-l 7,328 l/ha), chloropicrin (Chlor-0-Pit, 172 kg/ha) and a combination of Vapam and Telone C-17 were compared with Terr-O-Gas 67 (336 or 448 kg/ha). All fumigants were injected into the soil via chisels prior to bed formation. In some experiments, Vapam was also chemigated following bed formation through one or two irrigation tapes, or sprayed on the soil surface and rotovated prior to bedding.

In two of these experiments fumigants were also used in conjunction with *Trichoderma harzianum* (F-Stop, 1.0×10^4 conidia/cm^3), while Bacillus *subtilus* (Gus-2000, 1.0×10^7 CFU/cm^3) or *Streptomyces lycidus* (Actinovate, 2.0×10^5 CFU/cm^3) were evaluated in a single experiment. (Biocontrols were incorporated into the tomato transplant medium at seeding). Application of Telone C-17 and Chlor-O-Pic significantly decreased incidence and severity of FCRR in all experiments. The results of a representative fumigant experiment conducted during the Fall of 1993 are presented in Table 2. In general, Vapam failed to decrease FCRR except when it was rotovated into the soil (Table 3). Synergistic interactions were not observed between Vapam and Telone C-17, or between biocontrols and fumigants. Crown rot incidence was significantly decreased (-20.2%) by F-stop in one of two experiments and by Actinovate (-17%) but was unaffected by Gus-2000.

Soil Solarization. The potential of heating the soil by solar radiation through clear plastic mulch to reduce FORL populations was evaluated in two experiments during the spring of 1993 and 1994. Inoculum of FORL was produced by growing the fungus in dried, finely ground, sterilized tomato shoots. One gram of FORL inoculum was placed in sealed packets formed by membrane filters permeable to water and gases. The membranes were enclosed in nylon mesh bags and buried at depths of 5, 15 and 23 cm in a field in southwest Florida. In 1993 flat soil surfaces were mulched with 3.6 m^2 sheets of 2 mil Polyon 201 clear stabilized polyethylene mulch. Population decreases in FORL were monitored for 2 months by serial dilution of inoculum on to a selective medium. In 1994 soil solarization was conducted over a four week period using a 81 cm wide, raised bed covered with Polyon 30 micrometer clear plastic mulch. Soil temperatures were monitored hourly in both experiments using a datalogger. Solarization significantly raised soil temperatures at all three depths and produced significant reductions in FORL populations at 5 cm in both experiments. Less consistent reduction of the fungal propagules occurred at 15 and 23 cm. Population reductions of FORL observed though solarization of a raised bed are presented in Figure 1.

These experimental results indicate that Fusarium crown and root rot of tomato can be effectively managed by integrating the use of pathogen-free transplants and stakes, resistant cultivars and preplant fumigation. Soil solarization and biological control show potential, but additional data is necessary to confirm their effectiveness in an integrated program to manage crown rot in Florida.

Table 1. Effect of Tomato Cuttfvar on the Incidence and Severfty of Fusarium Crown and Root Rot and Yleld

Tomato Cultivar	Moan Disease Incidence (%)'	Mean Disease Severity (%)'	Mean Fruit Yield (MT/ha)'	Mean % Gray Wall'
Olympic	77.8 a'	9.6 b	20.9 c	5.5 bc
PAP34263	73.3 a	10.2 ab	27.9 c	4.4 bc
Solarset	71.1 a	15.6 a	30.2 c	21.2 a
Merced	622 a	7.6 b	39.6 a	0.2 c
Sunny	62.2 a	10.0 ab	31.4 bc	7.2 b
Agriset-761	60.0 a	6.6 b	35.4 b	3.0 bc
Conquest	15.6 b	1.0 c	34.6 b	0.2 c

'Arc sine transformation was performed prior to statistical analysis: untransformed data is presented.
'Means within columns followed by different letters are significantly different (p=0.05) by LSD.
'Percentage of internal crown and root discoloration was evaluated following longitudinal sectioning of plant bases.
'Mean yields were based on the marketable fruit from two harvests of 10 plants/replicate. (Nine replicates were used) Following *mean* separation, yields were converted to metric ton/hectare (MT/ha) equivalents.
'Mean % of gray wall was based *on* the total number of fruit (marketable fruit + culls) from the first harvest only.

Table 2. Effect of Fumigants on the Incidence and Severfty of Fusarium Crown and Root Rot and Yleld In the Tomato Cultlvar Sunny

Fumigant	Mean Disease Incidence (%)	Mean Disease Severity (%)'	Mean Fruit Yield (MT/ha)
Untreated Control	96.7 a'	20.3 a	62.5 b
Chlor-O-Pic (172 kg/ha)	61.7 b	13.7 b	71.3 a
Telone C-17 (326 l/ha)	46.7 c	9.4 c	70.5 a
Terr-O-Gas 67 (336 kg/ha)	41.7 c	9.5 c	67.5 ab

'Arc sine transformation was performed prior to statistical analysis; untransformed data is presented.
'Means within columns followed by different letters are significantly different (p=0.05) by LSD.
'Percentage *of internal crown* end *root* discoloration was evaluated following longitudinal *sectioning of* plant bases.
'Mean yields *were* based *on* the marketable fruit from three harvests of eight plants/replicate. (Six replicates were used). Following mean separation, yields *were* converted to MT/ha equivalents.

Table 3. Effect of Fumigants on Incidence and Severity of Fusarium *Crown* and Root Rot and Yield in Tomato Cultivar Olympic

Treatment	Mean Disease Incidence (%)'	Mean Disease Severity (%)'	Mean Fruit Yield (MT/ha)'
Untreated Control	100.0 a'	30.5 a	90.0 a
Vapam (Chemigation. 935 l/ha)	91.6 ab	24.2 ab	61.5 a
Terr-O-Gas 67 (448 kg/ha)	85.4 b	20.1 bc	87.1 a
Vapam (Rotovation. 935 l/ha)	75.0 b	22.3 ab	66.4 a

'Arc sine transformation was performed prior to statistical analysis: untransformed data is presented.
'Moans within columns followed by different letters *are* significantly different (p=0.05) by LSD.
'Percentage of internal crown and root discoloration was evaluated following longitudinal sectioning of plant bases.
'Moan yields wero based on the marketable fruit from two harvests of 20 plants/replicate. (Six replicates were used). Following mean separation, yields were converted to MT/ha equivalents.

FIGURE 1. EFFECT OF SOIL SOLARIZATION ON FORL POPULA˜ ONS