Sodium Chloride, Nitrogen Source, and Lime Influence Fusarium Crown Rot Severity in Tomato

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Abstract. Media and nutrient variables were investigated to develop methods of reducing the incidence and severity of fusarium crown rot incited by *Fusarium oxysporum* Schlecht. f. sp. *radicis-lycopersici* Jarvis & Shoemaker (FORL), a disease problem of current importance with tomato *Lycopersicon esculentum* Mill. Root-dip inoculated seedlings were transplanted into trays of a 1 Canadian peat : 1 vermiculite medium that had been prepared with factorial combinations of CaCO_3 , (0.75 or 3.0 $\text{kg}\cdot\text{m}^{-3}$), $\text{Ca}(\text{NO}_3)_2$, or $(\text{NH}_4)_2\text{SO}_4$ (each at 225 mg N/liter), and NaCl at 0 or 2000 mg Na/liter as the experimental treatments. Crown rot was more severe with the lower CaCO_3 rate, with $(\text{NH}_4)_2\text{SO}_4$, and supplemental NaCl. Data on fresh weight of seedlings expressed as percentage values relative to the noninoculated controls supported observations on disease severity.

Fusarium crown rot of tomato incited by *Fusarium oxysporum* f. sp. *radicis-lycopersici* (FORL) has been a serious problem in the field in Florida (Jones et al., 1990) and in the greenhouse and field elsewhere (Bramall and McKeown, 1989; Jarvis and Thorpe, 1980; Vakalounakis, 1988). The development of crown rot is quite different from that of fusarium wilt of tomato. Crown rot decomposes cortical tissue, while fusarium wilt invades the vascular system, blocking or inhibiting upward movement of water. Fusarium crown rot attacks the crown, roots, and

hypocotyls of seedlings. Some crown rot isolates may attack the roots very strongly, while others are only weak pathogens of roots. Crown rot has also been referred to as foot and root rot (Jarvis and Thorpe, 1980).

The seedling culture medium selected for this research was intentionally very acid (pH 4.0 to 5.7). Our results from previous work (Jones et al., 1990) show that an acid reaction is essential to clear rapid expression of the disease. Also, field experience associated low soil pH with higher levels of severity and incidence of the disease incited by FORL. Florida pine-palmetto flatwood soils have an initial pH that is very acid (≈ 3.8), and the usual liming procedure does not adjust the pH upward quickly and uniformly. Sampling indicates that acid and moderately pH-elevated regions are present in the soil. Spot samples tested in addition to the customary samples show that both limed and unlimed conditions persist in the soil for some time after liming. Thus, an individual tomato plant will have some roots in strongly acid zones while others will be surrounded by re-

gions of moderately elevated pH. Although plant growth is satisfactory, nonuniform liming does not control fusarium diseases. Normal sampling procedures do not reveal the range of pH values that exist nor the relative proportion of the volume that is effectively limed. Optimally, conduct of research necessitates quick and uniform production of the disease at will, which is aided by the use of an acid medium. Lack of horticulturally acceptable cultivars with resistance to FORL accentuates the problem.

Sodium chloride was selected as a variable because commercial tomato growers and workers in agricultural fields reported to us that high soil NaCl was frequently associated with the development of more severe and extensive outbreaks of crown rot. Also, Davet et al. (1966) reported that fusarium wilt of tomato is aggravated by high NaCl content of irrigation water. Undesirably elevated soil NaCl levels are occasionally encountered by growers of tomatoes in areas of the United States.

Since earlier research led to a system of control or reduction in the tomato fusarium wilt disease (Davet et al., 1966; Woltz and Jones, 1968, 1973, 1981), we have attempted to apply and extend the findings with wilt to crown rot (Jones et al., 1990), inasmuch as the two *Fusaria* are of the same species.

Two-week-old seedlings of 'Walter' tomato were root-dip-inoculated in FORL inoculum prepared by blending potato glucose agar cultures in sterile deionized water and diluting to a final concentration of 5×10^6 spores per milliliter. The root dip also involved crowns and a portion of the hypocotyl. The inoculated seedlings, 15 per container, were transplanted into 18.5 $\times$ 24.5 $\times$ 2.5-cm plastic trays containing $\approx 2 \times 10^{-3} \text{ m}^3$ of a 1 Canadian peat : 1 vermiculite mix. The medium was amended with 1.5 kg of Perk micronutrient mix (Vigoro Industries, Fairview Heights, Ill.) and 3.0 kg of single superphosphate per cubic meter. Factorial combinations of powdered CaCO_3 (0.75 or 3.0 $\text{kg}\cdot\text{m}^{-3}$), solutions of $\text{Ca}(\text{NO}_3)_2$, or $(\text{NH}_4)_2\text{SO}_4$ (each at 225 mg N/liter), and NaCl at 0 or 2000 mg Na/liter were employed as the experimental treatments. Calcium carbonate was included in the dry mix while 200 ml of solutions of the N sources and

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Table 1. Effect of CaCO₃, N source, and NaCl on crown rot severity in tomato seedlings.

CaCO ₃ (kg·m ⁻³) medium	N source ^z	NaCl ^y	Crown rot severity 0-4 ^x	Root rot severity 0-4 ^x	Fresh wt noninoculated seedlings (g/pot)	Relative fresh wt inoculated seedlings ^w	pH	Na ^v	Ca ^v
Main effects:									
0.75			1.56	1.93	12.4	37.2	3.98	285	80
3.0			0.83	1.06	11.5	58.5	5.68	136	96
	CN		0.90	1.08	13.9	55.1	4.81	209	99
	AS		1.50	1.91	9.9	40.7	4.85	212	77
		0	0.56	0.61	13.5	63.4	4.84	49	82
		2000	1.83	2.73	10.3	32.3	4.82	371	94
Significance									
Source		df							
CaCO ₃		1	**	**	NS	**	**	**	*
N source		1	**	**	**	**	NS	NS	*
NaCl		1	**	**	**	**	NS	**	*
CaCO ₃ × N		1	NS	NS	NS	NS	NS	NS	NS
CaCO ₃ × Na		1	NS	NS	NS	NS	NS	NS	NS
N × Na		1	NS	NS	NS	NS	NS	NS	NS
CaCO ₃ × N × Na		1	NS	NS	NS	NS	NS	NS	NS

^zCN = Ca(NO₃)₂, 225 mg N/liter; AS = (NH₄)₂SO₄, 225 mg N/liter.

^yNaCl as Na, mg·liter⁻¹.

^x0 = no disease, 1 = slight, 2 = moderate, 3 = severe, and 4 = dead.

^wExpressed as percentage values of the noninoculated controls (controls = 100).

^vValues based on a 2 water : 1 medium (v/v) extract; milligrams per liter of extract.

NS,*,***Nonsignificant or significant at *P* = 0.05 or 0.01, respectively.

NaCl were applied to trays before planting the inoculated or noninoculated seedlings, with solution applications (200 ml per tray) being repeated weekly to the end of the experiment.

The experiment was performed in the greenhouse in Nov. and Dec. 1990, with a completely randomized-block design. Day-time temperatures ranged from 18 to 26°C with night temperatures of 17 to 21°C. Lower temperatures, 22 to 24°C, are essential to the rapid, uniform development of crown rot (Jones et al., 1990). Statistical analysis was carried out with the analysis of variance *t* test (LSD) comparing equal cell sizes with pairwise *t* tests (SAS Institute, 1985).

Crown rot developed rapidly, being expressed at the earliest stage as a breaking over of the hypocotyl, followed by a wilting and necrosis of the leaves and death of the seedlings. Expression in young and small seedlings (10 to 14 days) was more of a collapse of the hypocotyls. Older (14 to 28 days) seedlings displayed a girdling of the crown, rated according to the severity of the effect. Calcium carbonate at the higher rate inhibited crown rot development (Table 1) as shown by disease ratings as well as by data for fresh weight of inoculated seedlings expressed as percentages of the appropriate noninoculated control plants.

As the N source, Ca(NO₃)₂ reduced crown rot severity compared to (NH₄)₂SO₄. Sup-

plemental NaCl increased disease severity in comparison with the lack of extra NaCl. Low CaCO₃, (NH₄)₂SO₄ as the N source, and added NaCl combined produced the most severe disease expression. A very low medium pH (≈4.0; Table 1) was associated with more disease. High Na and low Ca contents of a 1 part medium : 2 parts water extract were associated with higher severity of disease.

Dipping roots in comminuted potato glucose agar culture suspensions at high inoculum levels could be expected to overwhelm very young seedlings subject to root wounding by pulling from trays, inoculation, and replanting. We were surprised, therefore, that certain combinations of CaCO₃, N source, and NaCl could afford a high degree of protection against the crown rot disease. The data presented here for N source do not separate the effects of nitrate per se vs. ammonium, but include effects of Ca and sulfate. The effectiveness of fertilizing practices in preventing diseases likely would be much greater under normal conditions of low inoculum potential with no intentional wounding of roots, crowns, and hypocotyls, but confirmation requires application to commercial practice.

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