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MELOIDOGYNE - FUNGAL COMPLEXES IN TOMATO ROOTS IN CALCAREOUS SOILS

by
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One of the major needs in the development of integrated pest management programmes is the determination of the population densities of individual pests that produce economic damage to crops (the economic threshold). However, most crops are affected by more than one pest simultaneously. In particular, there are several reports of soil-borne *Meloidogyne* - fungal complexes affecting tomato roots (Bergeson, 1972; Golden and Van Gundy, 1975; Powell, 1971 a, 1971 b) and there has been an indication of synergism between *Rhizoctonia* and *Meloidogyne* on tomato (Golden and Van Gundy, 1975), which produced more damage than *Meloidogyne* alone. The purpose of this study was to determine whether complexes occur in the calcareous soils of south Florida.

Three experiments were carried out on commercial farms in Dade county. Two trials (Site I and Site II) were conducted in the autumn 1979 tomato crop and one (Site III) in the 1980 spring crop. The soil type was a Rockdale fine sand to Rockdale fine sandy loam (pH = 7.4). Standard commercial practices were used to produce the crops (Marlowe and Montelaro, 1978). All fields had previously been cropped to tomatoes and had been used for continuous vegetable production for at least 5 years. 'FloraDade' tomato (*Lycopersicon esculentum* Mill.) was direct-seeded at Site I and III and 'MH-1' tomato at Site II.

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All plots were sampled for nematodes near planting time and shortly after harvest. Soil samples were collected with a hand trowel to a depth of 10-12 cm from 9 randomized locations in each plot. Each soil sample was passed through a 4 mm sieve to remove the larger stones, and a 100 cm^3 subsample then was processed by decanting and sieving, followed by suspension of the residue in modified Baermann funnels (Christie and Perry, 1951). On the later sampling date, 10 root systems were removed from each plot and thoroughly washed for 30 minutes in running tap water. Root systems then were rated for root knot galling on a 0-5 scale, where 0 = 0 galls per root system; 1 = 1-2 galls; 2 = 3-10 galls; 3 = 11-30 galls; 4 = 31-100 galls; 5 = more than 100 galls (Taylor and Sasser, 1978), and a mean rating of root galling was then calculated for each plot.

The same root systems were evaluated for root discolouration and decay, using the Horsfall-Barratt disease rating system (Horsfall and Barratt, 1945) with one overall rating for all 10 root systems per plot.

Attempts were made to identify associations between specific soil-borne fungi and the root discolouration and decay. Each of the root systems from all plots used for nematode and fungal damage ratings was blotted dry with sterile mimeograph paper. Four small sections were aseptically removed from each root system (40 root sections per plot) at the junction of healthy and discoloured tissue and surface-sterilized for 2 minutes in a fresh, aqueous solution of 0.26% sodium hypochlorite. They were then blotted dry and plated on water agar. Fungi growing from tissue sections 2-3 days later were transferred to potato glucose agar and identified over the next several weeks.

In addition, 5 paired fumigated and nonfumigated plots were established at Site I to estimate overall yield loss due to indigenous soil-borne complexes. Plots were single rows 4.6 m long on 0.9 m wide plastic-mulched beds. Soil fumigant, a mixture of 2 parts methyl bromide and 1 part chloropicrin, was applied to the fumigated plots at a rate of 225 kg/ha. It was injected at a depth of 15 cm with 3 chisels per bed. Mature-green fruit were hand-harvested twice from all plots beginning 3 months after seeding (Dec., 1979 - Jan., 1980) and graded according to USDA standards for fresh-market fruit (Anonymous, 1979). Calculations of gross revenue were made based on U.S.A. market conditions for the winter of 1980. All yield data were analyzed by the Student t-test for paired comparisons.

Table I - *Relative occurrence of fungi associated with discoloured and decayed roots of* Meloidogyne - *infected tomato plants grown on calcareous soils.*

Site	Percentage of root lesions infected by various fungi [a]					Frequency of fungi recovered from root lesions in relation to all other fungi recovered [b]				
	Rhizoctonia	*Fusarium oxysporum*	*Fusarium solani*	*Pythium*	Other [c]	*Rhizoctonia*	*Fusarium oxyporum*	*Fusarium solani*	*Pythium*	Other [c]
I	16.0	4.0	0.5	0.5	17.5	46.6	11.8	1.6	1.6	38.3
II	23.5	4.0	0.5	2.0	19.5	44.4	11.2	1.0	4.4	38.4
III	3.8	10.6	7.5	10.0	24.1	8.2	23.2	16.4	22.2	30.4

(a) Percent infection = no. of lesions infected by a given fungus/40 lesions plated per plot x100.

(b) Frequency = no. of lesions infected by a given fungus/total number of lesions from which fungi were actually isolated x100.

(c) Other fungi found include *Alternaria, Cephalosporium, Phoma, Pyrenochaeta,* and *Curvularia.* None of these individual genera was constistenly isolated in high percentages.

Four genera of fungi generally were associated with root knot-damaged tomato plants in nonfumigated plots at the three sites (Table I). Mean root knot indices in the nonfumigated plots were 3.2, 1.8, and 3.9 at Sites I, II, and III, respectively. Horsfall-Barratt disease ratings were significantly correlated ($P = 0.05$) with root knot indices at each of the three sites, with $r = 0.803$, $r = 0.979$, and $r = 0.983$, respectively. At Sites I and II (Fall crop, 1979) *Rhizoctonia solani* Kuehn was the most frequently recovered fungus (Table I). These data establish *Rhizoctonia* as a soil-borne pathogen in the *Meloidogyne*-soil-inhabiting fungus complex affecting tomatoes on calcareous soils, as has been shown on sandy soils in California (Golden and Van Gundy, 1975). Other known pathogens (Walker, 1952) isolated at these two sites in consistent numbers were *Fusarium oxysporum* Schlecht., *F. solani* (Mart.) Appel *et* Wr., and *Pythium* spp.

At Site III (Spring crop, 1980) *Pythium* spp. and *Fusarium* spp. predominated. This shift from high *Rhizoctonia*-recovery rates at Sites I and II may be due to the increase in temperatures at the time of the samplings (late March for Site III, January for Site I and II). Rao *et al.* (1978) found that there was a marked increase in isolation of *Pythium* spp. from rotted corn roots in the warmest parts of the growing season.

Meloidogyne incognita (Kofoid *et* White) Chitwood was abundant in each of the three sites. At Site I, where paired fumigated and nonfumigated plots were maintained, there was significant reduction of both root knot galling and root browning in fumigated plots (Table II). A corresponding increase in total marketable yield was noted, although no significant differences in individual grades were evident. There was a trend towards increased yield of larger fruit in the fumigated plots. If the variability due to grading is removed by adding together weights of USDA $\neq 1$ and $\neq 2$ extra large and large fruit, the difference was significant ($P = 0.05$), with 11.94 kg/ha of extra large-large fruit in the nonfumigated plots and 16.87 kg/ha in the fumigated plots. There were no significant differences in weights of USDA very small fruit or culls by treatment; culls accounted for 13.5% and 13.0% of the total weight of fruit in the nonfumigated and fumigated rows, respectively. Fruit from both treatments were damaged by *Rhizoctonia* as plants leaned over between the rows in the nonfumigated areas which were not covered with plastic.

A significant increase ($P = 0.05$) of $3290/ha in the value of the marketable yield was recorded in the fumigated plots. At a cost

Table II - *The effect of soil fumigation on root knot index and disease ratings, yield, and crop value in tomato, Site I.*

Treatment [a]	Tomato yield (kg/ha)								Crop value (1000 $U.S./ha)	Root knot index	Horsfall Barratt disease rating [c]
	USDA size 1			USDA size 2			Total marketable yield	Total yield [b]			
	Extra large + large	Medium	Small	Extra large + large	Medium	Small					
Nonfumigated	9.52	6.68	0.82	2.43	1.74	0.38	21.57	26.45	11.87	3.2	4.0
Fumigated	12.40	6.94	0.92	4.47	2.12	0.43	27.28 *	32.14 *	15.16 *	0.1 **	2.0 **

(a) Mean of five replications. Significant difference from nonfumigated control at P = 0.05 (*) and P = 0.01 (**), respectively, according to t-test for paired comparisons.

(b) Includes USDA very small and total culled fruit.

(c) Log_{10} transformation applied to data before analysis.

of $ 1.76/kg, total fumigant expense was $ 294/ha, resulting in a net return of $ 2896/ha. *M. incognita* larvae were not detected in these plots at planting time. On the final sampling dates, however levels had risen to 9040 larvae/100 ml soil and 30/100 ml soil in the non-fumigated and fumigated plots, respectively. Thus while fumigation was economically feasible in this case, the fumigation decision could not be made on the basis of soil larval counts taken near planting time.

Reduction in yield, especially of large-size fruit, indicates that *Meloidogyne*/fungal complexes can be important in reducing yields and net returns for fresh-market tomatoes. The high frequency of discolouration and decay of nematode damaged roots by soil-borne fungi, especially *Rhizoctonia*, indicates that possible soil-borne complexes may have to be taken into account in integrated pest management programmes that include root knot nematodes.

SUMMARY

In calcareous soils, *Rhizoctonia solani* Kuehn, *Pythium* spp, *Fusarium oxysporum* Schlecht, and *F. solani* (Mart) Appel *et* Wr. were the most common tomato pathogens recovered from plant roots initially damaged by *Meloidogyne incognita* (Kofoid *et* White) Chitwood. In two of three tests, *R. solani* accounted for nearly 50% of the fungi isolated from decayed, nematode-damaged roots. Root disease ratings were significantly ($P = 0.05$) correlated with root knot indices ($r \geq 0.80$). Soil fumigation greatly decreased fungus/nematode damage to commercial tomato crops, resulting in significantly increased yield, average fruit size, and net return.

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