DRIP-APPLIED SOIL PESTICIDES FOR NEMATODE CONTROL IN DOUBLE-CROPPED VEGETABLE SYSTEMS

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In the sub-tropical climate of the Southeastern US, polyethylene film mulched beds are commonly used for two or three crops before they are destroyed (double cropping). Soilborne pests and diseases usually become problematic on the second and third crops and practically can only be controlled by applying pre-plant pesticides through the drip tape. Among the most damaging pests in plastic mulch vegetable culture in the Southeastern US are the root-knot nematodes (*Meloidogyne incognita* or southern root-knot nematode, and *M. arenaria* or peanut root-knot nematode). Root-knot nematodes have a very wide host range. They typically become a problem in sandy soils, especially during summer and autumn when temperatures are high.

Two different tests, in fall 2002 and fall 2003, were conducted at the Coastal Plain Experiment Station (CPES) in Tifton, GA to evaluate the potential of drip-applied soil pesticides (fumigant and non-fumigant materials) for control of root-knot nematode in double-cropped plasticulture beds. Soil type is a Tifton sandy loam with 88% sand. In fall 2002, the efficacy of emulsifiable Telone concentrates (Telone EC and InLine) and metam sodium was evaluated on cantaloupe, which was planted on July 29 (Table 1). In fall 2003, the efficacy of InLine and metam sodium (pre-plant) with or without oxamyl (Vydate L) (at 0, 10 and 20 days after planting, DAP) was evaluated on squash, which was planted on August 15 (Table 2). In both years the first crop was eggplant, which left a high legacy of root-knot nematodes (>1000/150 cm^{-3} soil). Eggplant was not treated in 2002, but did receive different fumigant treatments (methyl bromide @ 300 lbs/acre and Telone C-35 @ 18 gal/acre) in 2003 (Table 2). Drip-applied fumigants were applied over 5 h using 40-50 gal water per plot (30 ft long x 30 in wide).

In 2002 drip-applied fumigants gave good control of root-knot nematode at 4 weeks after planting (flowering stage) (Table 1). Root gall indices and nematode soil populations at this stage were high in the non-treated beds and similarly low in any of the fumigated beds. By harvest root gall indices in the fumigated beds, especially with the metam sodium-InLine combination, were still lower than in the non-treated beds. Root gall indices were somewhat higher with metam sodium only and with the lower InLine rate. However, root-knot nematode soil populations at final harvest were high for all treatments, and differences were

limited. Stubby root nematodes were reduced at flowering stage of cantaloupe, but no longer by harvest. Cantaloupe yields were low, due to severity of airborne pests and diseases (melon worm, gummy stem blight, downy mildew and papaya ringspot virus). Among the drip-fumigated treatments, the metam sodium-Telone combinations and the higher application rates of Telone gave 20-35% higher yields than the lower application rates of Telone and the metam sodium drip only (Table 1). Yield was very low in non-treated beds, due to severe root-knot nematode damage during the crop's early growth, which caused severe stunting.

In 2003, at plant nematode soil populations were significantly reduced by metam sodium and InLine (Table 2). Early plant vigor of squash was improved by fumigation, but not by vydate drip applications. Plant vigor was better following metam sodium as compared to InLine. Root-knot nematode pressure was very high and most of the squash plants in the non-treated plots were severely damaged by the nematode. Gall indices at flowering and harvest of squash were significantly reduced both by fumigation and by vydate (Table 2). Root-knot nematode soil populations at harvest of squash were still significantly less in plots that were fumigated, as well as in plots in which vydate was dripped. Stubby root nematodes were not affected by fumigation, but were reduced following vydate applications. Ring nematodes were only found in non-treated plots. Very low yields were recorded in non-treated plots (Table 2), due to severe nematode infection. Yields in fumigated plots showed small differences between metam sodium and InLine. Vydate increased yields in fumigated plots with 30% following metam sodium and with 35-75 % following InLine.

Drip-applied soil fumigants did not provide complete control of root-knot nematode on double-cropped cucurbits. Combinations of different fumigants (metam sodium + Telone) or of a fumigant + Vydate significantly improved nematode control and increased yields. Drip-applied soil pesticides are the only option that growers have to control soilborne pests and diseases in double-cropped plasticulture vegetables. Advantages are the flexibility and relative ease of application. Disadvantages are the dependence on soil water movement and soil characteristics to achieve uniform fumigation of the bed. The sandy soils of the Southeastern US drain rapidly and horizontal water movement is often inadequate to achieve fumigation over the entire bed. In our tests drip-applied soil fumigants did not provide complete control of root-knot nematode on double-cropped cucurbits. Combinations of different fumigants (metam sodium + Telone) or of a fumigant + Vydate significantly improved nematode control and increased yields.

Table 1. Effects of drip-applied soil fumigants on root-knot nematode (*Meloidgyne incognita*, MI) population and gall indices, plant vigor and total marketable yield of double-cropped cantaloupe cv. Athena, fall 2002, Black Shank Farm Tifton, GA.

Treatment [a]	Rate / acre	MI (150 cm^{-3} soil) 28 August	MI (150 cm^{-3} soil) 28 October	Early Root gall index [b] 28 August	Final Root Gall Index 28 October	Vigor Rating[c] 20 August	Total marketable fruit weight (lbs/plot) [d]
1. Telone EC	13.5 gal	11b	203b	0.5b	2.7bc	6.8ab	20.4 b
2. Telone EC	18 gal	0	1108ab	0.8b	3.0bc	7.6ab	27.7 ab
3. Telone InLine	13 gal	9b	206b	0.9b	4.4 b	6.0a	21.8 ab
4. Telone InLine	20.5 gal	6b	1632a	0.9b	3.1bc	7.6ab	28.8 ab
5. Vapam	75 gal	2b	598ab	0.7b	3.8bc	8.2a	22.2 ab
6. Telone InLine + Vapam	13 gal 37.5 gal	9b	441ab	0.1b	1.8c	7.8ab	29.3 ab
7. Telone EC + Vapam	13.5 gal 37.5 gal	0	398ab	0.3b	2.9bc	8.6a	32.2 a
8. Non-Treated	N/A	372a	648ab	8.7a	9.2a	3.1c	2.7 c

[a] Fumigant treatments were applied on 1-4 July. [b] Root Gall Index 0-10 scale whereby, 0 = no galls, 1 = very few small galls, 2 = numerous small galls, 3 = numerous small galls of which some are grown together, 4 = numerous small and some big galls, 5 = 25 % of roots severely galled, 6 = 50 % of roots severely galled, 7 =75 % of roots severely galled, 8 = no healthy roots but plant is still green, 9 = roots rotting and plant dying, 10 = plant and roots dead. [c] Vigor was done a 1-10 scale with 10= live and healthy plants and 1=dead plants. [d] Plots were 30 ft long and 30 in. wide, only the central 15 ft were harvested.

Data are means of five replications. Means in the same column followed by the same letter are not different (P = 0.05) according to Duncan's multiple range test. No letters indicate non-significant difference.

Table 2. Effects of soil fumigation with and without oxamyl drip applications on root-knot nematode (*Meloidgyne incognita*, MI) population and gall indices, plant vigor and total marketable yield of double-cropped crookneck squash, fall 2003, Black Shank Farm Tifton, GA.

Treatments on first crop	MI initial (150 cm^{-3} soil)	Treatments on second crop	MI at plant (150 cm^{-3} soil)	MI at harvest (150 cm^{-3} soil)	Early Root gall index [c] 27 DAP	Final Root Gall Index 52 DAP	Vigor Rating[d] 21 DAP	Total marketable fruits (No/plot) [e]
Methyl bromide (67-33) + Vydate [b]	108 b	InLine [a] + Vydate [b]	0 b	4 c	0.0 c	1.1 d	5.8 ab	51.4 ab
Methyl bromide (67-33)	52 b	InLine	6 b	82 b	1.5 b	4.3 bc	4.4 bc	29.2 b
Telone C-35 + Vydate	24 b	InLine + Vydate	0 b	16 bc	0.3 c	1.7 cd	6.2 ab	59.0 a
Telone C-35	162 a	InLine	1 b	58 bc	0.7 bc	4.3 b	6.5 ab	43.4 ab
Telone C-35 + Vydate	2 b	Metam sodium + Vydate	0 b	6 c	0.1 c	0.9 d	6.6 ab	62.6 a
Telone C-35	54 b	Metam sodium	0 b	100 b	1.7 b	4.8 b	7.3 a	47.6 ab
Non-Treated + Vydate	3118 a	InLine + Vydate	6 b	78 b	0.2 c	2.2 cd	6.4 ab	51.8 ab
Non-Treated	2876 a	Non-treated	1052 a	551 a	6.5 a	9.1 a	2.0 c	3.2 c
*F*probability fumigation	<0.01			<0.01	<0.01	<0.01	<0.01	<0.01
F probability oxamyl	NS			<0.01	<0.01	<0.01	NS	0.01

[a] Fumigant treatments on the 2nd crop were applied on 24-25 July, InLine @ 18 gal/acre, metam sodium @ 50 gal/acre;
[b] Vydate L was applied at a rate of 2qts/A through the drip tape at planting (August 15) and 10 and 20 days afterwards.
[c] Root Gall Index 0-10 scale whereby, 0 = no galls, 1 = very few small galls, 2 = numerous small galls, 3 = numerous small galls of which some are grown together, 4 = numerous small and some big galls, 5 = 25 % of roots severely galled, 6 = 50 % of roots severely galled, 7 =75 % of roots severely galled, 8 = no healthy roots but plant is still green, 9 = roots rotting and plant dying, 10 = plant and roots dead. [d] Vigor was done a 1-10 scale with 10= live and healthy plants and 1=dead plants. [e] Plots were 30 ft long and 30 in. wide, only the central 15 ft were harvested. Data are means of five replications. Means in the same column followed by the same letter are not different (P = 0.05) according to Duncan's multiple range test. NS = non-significant difference.