Integrated Control of *Meloidogyne incognita* on Tomato Using Organic Amendments, Marigolds, and a Nematicide

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ABSTRACT

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Control methods using chicken manure, compost, aldicarb 10G, and marigolds (*Tagetes patula* cv. Janie) were evaluated on nematode-resistant tomato cultivar Anahu R-2 and susceptible cultivar TK70. Significant differences among treatments were not observed on the resistant host. The resistance of Anahu R-2 was adequate to protect plants from nematode attack. None of the plants, treated or untreated, had a galling index higher than 0.5 (rating scale, 0–5). In contrast to Anahu R-2, TK70 demonstrated marked responses to the different combination schemes tested. Plants treated with manure; manure and aldicarb; and marigolds, aldicarb, and compost were identified as the three best yielders with significant increases in plant growth seen through top growth, root weights, and dry matter but not plant height. In treatments where aldicarb was involved, galling of the root system was completely controlled; where precrop marigolds were used without aldicarb as part of the follow-up treatment, significant reduction of root galling occurred but complete control was not effected. The field experiment using resistant and susceptible hosts confirmed previous observations that the combined treatment of manure and aldicarb could give good control of *M. incognita* and could result in significant increases in plant growth and yield.

Combinations of chemical and biological methods to control *Meloidogyne incognita* (Kofoid & White) Chitwood on susceptible tomatoes have given better control than either method alone (4). Use of dibromochloropropane and resistant soybean cultivars (2) and crop rotations and nematicides (3) suppressed nematode populations and increased crop yields. In Taiwan, an experiment using a nematode-trapping fungus (*Arthrobotrys oligospora* Fres.), chicken manure, compost, and aldicarb 10G was conducted under greenhouse conditions to control *M. incognita* on tomato (J. S. Ruelo, *unpublished*). When aldicarb and chicken manure were combined or were combined with other components, a significant increase in plant growth and yield and a trend for reduction of gall formation and nematode fecundity in roots occurred. The present study was designed to evaluate integrated control measures under field conditions.

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MATERIALS AND METHODS

Tropical soil marigold (*Tagetes erecta*) did not control *M. incognita* when planted between tomato plants (1). Therefore, the present study utilized marigolds as a precrop treatment. Plots were preplanted to 2-wk-old *T. patula* cv. Janie (Ta) seedlings spaced 25 cm apart. To maintain a high nematode population in plots not planted to Ta, tomato cultivar TK70 (susceptible to root-knot nematode) was planted 75 days before the experiment was initiated. To ensure uniformity of infestation, TK70 seedlings were cultured in plastic bags (15 × 3 cm), and seedlings in each bag were inoculated with three *M. incognita* egg masses 1 wk before being transplanted to the field. The susceptible tomato plants and Ta were grown in the field for 2 mo. The aboveground parts were then removed, and roots were left in the soil for an additional 2 wk before application of the treatments.

All plots were then reestablished for the next schedule of treatments. Including the precrop component (*Tagetes*), the treatments were Ta + aldicarb (Al); Ta + chicken manure (Ma); Ta + compost (Cp); Ta + Al + Ma; Ta + Al + Cp; Ma; Ma + Al; Al + Cp; fertilizer; and control. No attempt was made to include single component treatments utilizing Al, Cp, or Ta because in two previous experiments, they were consistently inefficient in controlling *M. incognita* when compared with combined treatments (4; J. S. Ruelo, *unpublished*). Individual plots were 1 × 7.4 m with 15 tomato plants per plot. The experiment was repeated four times. Watering of plants by furrow irrigation was done once every 2 wk.

Ma and Cp were dispensed at 450 and 750 g per tomato plant, respectively, and mixed thoroughly with the soil 15–25 cm deep. Plots treated with Al received 2 g per plant (30 g per plot), and the chemical was applied in the same way as Ma and Cp. Fertilizer treatment consisted of 4 g of NPK [N = 21% $(NH_4)_2SO_4$, P = 18% $CaH_4(PO_4)_2$, K = 60% KCl] per plant. A previous experiment had shown that 2 and 3 g of NPK per plant did not affect nematode control (J. S. Ruelo, *unpublished*).

Two tomato (*Lycopersicon esculentum* Mill.) cultivars, TK70 (susceptible to root-knot nematode) and Anahu R-2 (resistant) were used.

One day after the organic amendments and chemicals were applied to plots, fifteen 1-mo-old Anahu R-2 and TK70 seedlings were planted in each plot spaced 46 cm apart. Plants were allowed to grow until the end of fruiting time (about 90 days). The number and weight of mature fruits per weekly harvest were recorded. Plant heights were recorded at the first harvest. Shoot and root weights and dry matter were recorded at the end of the harvest period. The galling of the root system and nematode fecundity were measured by the rating system of Taylor and Sasser (6). Soil was assayed for nematodes before treatments were applied and after the final harvest. One 707-g sample of soil per plot was collected at each sampling and processed by the sieving Baerman-funnel method (5).

Data were subjected to analysis of variance, and significant differences were determined by Duncan's multiple range test.

Table 1. Effects of fertilizer, organic amendments, and nematicide on growth and yield of tomato cv. Anahu R-2 and nematode control[a]

Treatment[b]	Plant ht. (cm)	Shoot wt. (g)	Root wt. (g)	Dry matter (g)	Fruit/ha Tons	Fruit/ha No.	Nematode control: Galling/egg mass index[c]	Nematode control: Soil population[d]
Fr	67	98	11	30	12.53	262,838	0.0	34
Ma	79	212	19	61	22.36	408,784	0.3	41
Ma + Al	78	218	16	40	21.11	393,919	0.0	33
Al + Cp	72	107	10	39	13.14	281,081	0.0	35
Ta + Cp	77	168	15	41	18.72	317,905	0.0	35
Ta + Ma	77	162	14	43	18.07	354,054	0.5	29
Ta + Al	75	152	11	34	12.77	300,676	0.0	26
Ta + Al + Cp	74	110	10	31	13.85	305,068	0.0	48
Ta + Al + Ma	76	126	12	34	11.18	253,041	0.0	30
Control	74	106	10	31	15.78	271,622	0.3	22

[a]Means of 60 plants and four replicates. Treatment differences were determined by Duncan's multiple range test at the 5% level.
[b]Fr = fertilizer, Ma = chicken manure, Al = aldicarb 10G, Cp = compost, and Ta = marigold (*Tagetes patula* cv. Janie).
[c]0 = no galls or egg masses, 1 = 1–2 galls or egg masses, 2 = 3–10, 3 = 11–30, 4 = 31–100, 5 = more than 100 galls or egg masses.
[d]Data are means of 707-g soil samples per plot and four replicates.

RESULTS AND DISCUSSION

Anahu tomato as a host plant. Initial nematode populations in the soil ranged from 87 to 160/707 g of soil per plot.

Growth and yield differences among treatments were not significant (Table 1); however, some consistent trends were

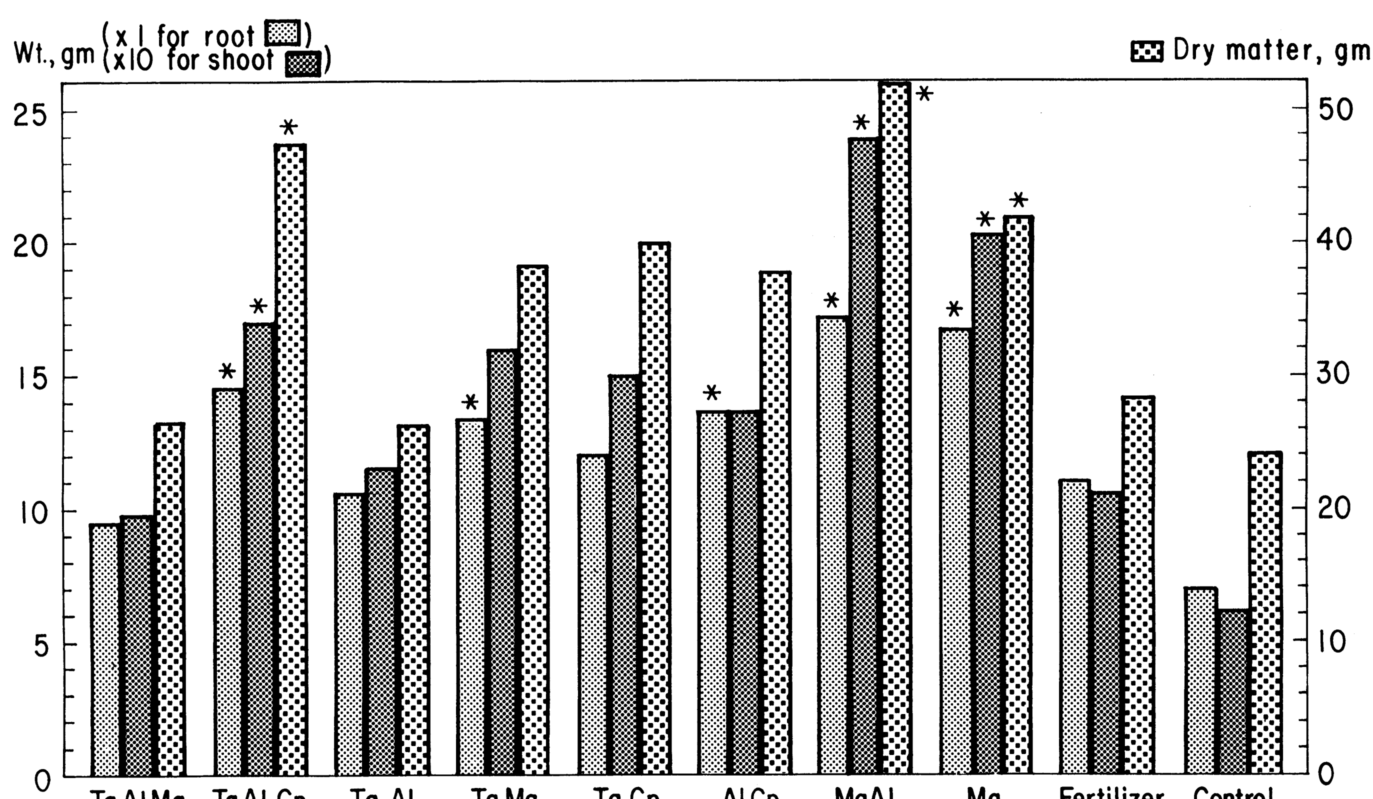

Fig. 1. Growth and development of tomato cv. TK70 in response to single and integrated treatments of fertilizer, chicken manure (Ma), aldicarb 10G (Al), compost (Cp), and marigold (Ta, *Tagetes patula* cv. Janie) to control *Meloidogyne incognita*. (Data are means of 60 plants and four replicates; * indicates significant difference from control at 5% level.)

Table 2. Effects of fertilizer, organic amendments, and nematicide on nematode root galling and fecundity on tomato cv. TK70[a]

Treatment	Galling/egg mass index
Fertilizer	2.5 +
Manure	3.3
Manure + aldicarb	0.0 +
Aldicarb + compost	0.0 +
Tagetes + compost	1.8 +
Tagetes + manure	1.0 +
Tagetes + aldicarb	0.0 +
Tagetes + aldicarb + compost	0.0 +
Tagetes + aldicarb + manure	0.0 +
Control	4.5

[a] Means of 60 plants and four replicates; 0 = no galls or egg masses, 1 = 1–2 galls or egg masses, 2 = 3–10, 3 = 11–30, 4 = 31–100, 5 = more than 100 galls or egg masses (+ = significantly different from the control at the 5% level).

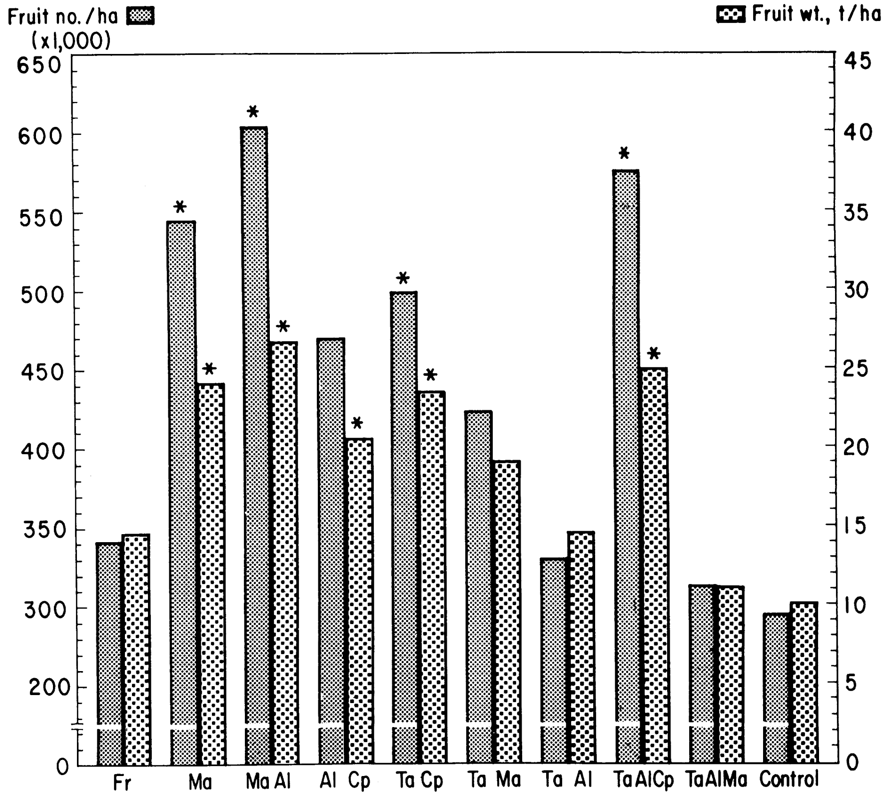

Fig. 2. Yield of tomato cv. TK70 from single and integrated treatments of fertilizer (Fr), chicken manure (Ma), aldicarb 10G (Al), compost (Cp), and marigold (Ta, *Tagetes patula* cv. Janie) to control *Meloidogyne incognita*. (Data are means of 60 plants and four replicates; * indicates significant difference from control at 5% level.)

noted. All treatment combinations except Ta + Al + Ma generally resulted in growth and yield values greater than the untreated control. The greatest yield, plant height, and shoot and root weight occurred in plots treated with Ma alone and with Ma + Al.

Plant height, dry matter, and root weight were consistently greater in plots treated with Ma than with Ma + Al, but differences were not significant.

T. patula cv. Janie failed to completely rid the soil of *M. incognita*. These results were surprising because in a previous experiment (4), *T. patula* cv. Hiliput Sunkist almost completely eliminated *M. incognita* from the soil. Despite the presence of the nematodes in the soil before treatments in all plots, the gall indices of Anahu R-2 roots in treated or untreated plots recorded after harvest were ≤0.5 on a 0–5 scale. The resistance of Anahu R-2 appeared to be adequate to protect plants from *M. incognita* attack. Previous field trials with Anahu R-2 at the Asian Vegetable Research and Development Center in Taiwan gave similar results (J. S. Ruelo, *unpublished*). Data from soil assays indicate that none of the treatments completely eliminated *M. incognita* from the soil.

TK70 tomato as a host plant. Unlike Anahu R-2, marked responses to the different treatments were recorded for TK70. Top growth, root weight, dry matter, and yields were greater from plants in plots treated with Ma, Ma + Al, and Ta + Al + Cp than controls (Fig. 1). Plants in untreated plots were stunted and yielded poorly.

Before treatments were applied, the number of nematodes ranged from 99 to 235/707 g of soil in plots planted to TK70. There were no galls on roots of plants in plots treated with aldicarb as a component (Table 2). These results confirm the effective nematicidal action of aldicarb in soil infested with low numbers of *M. incognita*. Where Ta was a precrop treatment without Al, as in Ta + Cp and Ta + Ma, a significant reduction in root galling occurred, but not complete elimination. In all treatments, numbers of egg masses were similar to numbers of galls.

Advantageous effects of integrated treatments were observed in the following treatments: Ta + Cp gave significant but partial control of *M. incognita* and significant increases in yield, number, and weight of fruit; the addition of Al completely controlled *M. incognita* and increased top growth, root weight, and dry matter. In the Al + Cp treatment, root galling was reduced completely, and fruit weights and root weights were significantly increased. The results of the Al + Cp + Ta treatment were similar but also showed an increase in top growth, dry weight, and fruit number. Ma alone did not protect plants from nematode attack, but Ma + Al prevented galling of roots and improved growth and yield compared with the Ma treatment (Figs. 1 and 2). The practical benefits of the Ma + Al combination in this field trial confirm similar results obtained with this combination in greenhouse experiments. More studies are needed to test the stability of this combination in different localities where *M. incognita* is a problem.

Further investigations are needed to determine the causative factors of the drastically reduced growth of TK70 and reduced yields of TK70 and Anahu when the precrop Ta treatment is followed by Al or Ma + Al treatments.

NPK fertilizer significantly suppressed galling but did not prevent it completely. Perhaps the next experiment on NPK fertilizer at the same experimental site, using the same nematode and host plant but different concentrations, will explain the suppressing action of this component at 4 g per plant on nematode populations. Fertilizer was not as effective as Ma in increasing plant growth and yield.

Plant height was not affected by treatments.

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