Journal of Nematology 31(1):62–69. 1999.

Greenhouse Studies on the Effect of Marigolds (*Tagetes* spp.) on Four *Meloidogyne* Species[1]

Antoon T. Ploeg[2]

Abstract: The effects of preplanted marigold on tomato root galling and multiplication of *Meloidogyne incognita, M. javanica, M. arenaria,* and *M. hapla* were studied. Marigold cultivars of *Tagetes patula, T. erecta, T. signata,* and a *Tagetes* hybrid all reduced galling and numbers of second-stage juveniles in subsequent tomato compared to the tomato-tomato control. All four *Meloidogyne* spp. reproduced on *T. signata* 'Tangerine Gem'. Several cultivars of *T. patula* and *T. erecta* suppressed galling and reproduction of *Meloidogyne* spp. on tomato to levels lower than or comparable to a fallow control. Phytotoxic effects of marigold on tomato were not observed. Several of the tested marigold cultivars are ready for full-scale field evaluation against *Meloidogyne* spp.

Key words: control, marigold, *Meloidogyne arenaria, Meloidogyne hapla, Meloidogyne incognita, Meloidogyne javanica,* nematode, root-knot nematodes, *Tagetes erecta, Tagetes patula, Tagetes signata.*

Root-knot nematodes (*Meloidogyne* sp.) are economically the most important plant-parasitic nematodes in tropical and subtropical agriculture (Sasser, 1979). In California, control of these nematodes is dependent primarily on nematicides and resistant crop cultivars. However, as the use of nematicides is being severely restricted and resistant cultivars are available for only a limited number of crops (Roberts, 1990), development of alternative control strategies is urgently required. Marigold (*Tagetes* spp.) has long been known to possess nematicidal activity. Initial reports on suppression of root-knot nematodes by marigold (Steiner, 1941; Tyler, 1938) were later confirmed for *M. arenaria, M. hapla, M. incognita,* and *M. javanica* (Daulton and Curtis, 1963; Hackney and Dickerson, 1975; McSorley and Frederick, 1994; Motsinger et al., 1977; Rickard and Dupree, 1978; Suatmadji, 1969). However, results from these studies were often equivocal. Thus, *T. erecta* did not suppress *M. hapla* in one study (Suatmadji, 1969) but efficiently controlled it in two other studies (Bünte and Müller, 1996; Rickard and Dupree, 1978). In studies with *T. patula, M. arenaria* was suppressed (Motsinger et al., 1977; Suatmadji, 1969) or not suppressed (McSorley and Frederick, 1994; Rickard and Dupree, 1978). The reasons for these conflicting results are not known, but it is likely that intraspecific differences in the plants and in the nematodes play an important role (Motsinger et al., 1977; Suatmadji, 1969). Results with *M. incognita* and *M. javanica* were more consistent. Strong suppression of these nematodes, particularly by *T. patula,* was observed in several studies (Daulton and Curtis, 1963; Hackney and Dickerson, 1975; McSorley and Frederick, 1994; Siddiqi and Alam, 1988; Suatmadji, 1969).

Suppression of lesion nematodes (*Pratylenchus* spp.) by marigolds also has been reported (Hackney and Dickerson, 1975; Hutchinson, 1962; McKenry, 1988; Suatmadji, 1969; Visser and Vythilingam, 1959) and appears less variable than suppression of root-knot nematodes. Despite numerous reports on suppression of lesion and root-knot nematodes, few studies have included the effects of marigolds on nematode infestation or yields of subsequent crops. Oostenbrink et al. (1957) reported yield increases in roses and apple on lesion nematode-infested soils after marigolds comparable to nematicide treatments. Later, Oostenbrink (1960) suggested that marigolds increased yields of lesion nematode-susceptible crops on sandy and peaty soils by 10% to 40%. Significant yield increases in lesion or root-knot nematode-susceptible crops after mari-

Received for publication 2 September 1998.
[1] This study was funded by grants from the Division of Agriculture and Natural Resources (DANR), University of California and the Slosson Foundation.
[2] Department of Nematology, University of California Riverside, CA 92521.
E-mail: antoon.ploeg@ucr.edu
The author thanks Sahin Seeds for providing seeds of marigold 'Single Gold' and S. Edwards and C. Caldwell for technical assistance.
This paper was edited by E. C. Bernard.

gold were also reported by Bünte and Müller (1996), Miller and Ahrens (1969), Siddiqi and Alam (1988), and Suatmadji (1969). Seinhorst and Klinkenberg (1963) obtained significant yield increases after marigold, but suggested that these results might not be attributed solely to nematode control as yields of onions and sugarbeets were 1.4× and 1.2× higher, respectively, after marigolds in fields without plant-parasitic nematodes. In contrast, McKenry (1988, 1991) achieved significant reductions in *P. vulnus* populations but did not observe expected yield increases in subsequent plum plantings. McKenry (1988) attributed the lack of yield increase to phytotoxicity of marigold that nullified the beneficial effects of nematode control, and concluded that marigold is unlikely to be of use for controlling nematodes in perennial crops.

Given the conflicting results on the suppression of *Meloidogyne* species by marigold and effect of marigold on nematode infestation and yield responses of subsequent crops, this study was initiated to identify marigold cultivars that would effectively suppress *Meloidogyne* populations, decrease infestation levels in a subsequent susceptible crop, and be non-phytotoxic.

Materials and Methods

Nematode inocula: Populations of four *Meloidogyne* spp. were used in the experiments: *M. incognita* race 3 from cotton in the San Joaquin Valley, California; *M. javanica* from cowpea, Chino, California; *M. arenaria* race 1, unknown origin; *M. hapla* from alfalfa in San Bernardino, California. Species and race identifications were done with isoenzyme electrophoresis and on differential host tests (Eisenback and Triantaphyllou, 1991). Populations were increased and maintained on tomato cv. Pixie grown in coarse sand in a greenhouse. Inoculum was prepared by collecting sand and roots from the tomato nematode cultures, cutting the tomato roots into 1-cm-long pieces, and thoroughly mixing infested sand and roots with sterilized sand (ratio infested:sterilized = 1:10).

Suppression of Meloidogyne spp. by marigolds: Three-week-old seedlings of *T. patula* cultivars Single Gold, Scarlet Sophie, Tangerine, Gypsy Sunshine, and Bonita Mixed, *T. signata* (=*T. tenuifolia*) cv. Tangerine Gem, *T. erecta* cultivars CrackerJack and Flor de Muerto, and the *Tagetes* hybrid Polynema were transferred to 200-ml plastic cones (Stuewe and Sons, Corvallis, OR) filled with 250 g of the inoculum sand. Cones planted with tomato cv. Pixie and cones without plants served as controls. Fifteen cones were prepared for each treatment and randomized in plastic holding trays on a greenhouse bench. Plants were fertilized with 3 g of N-P-K (17-6-10) and grown for 60 days. An additional 10 cones were prepared at the start

Table 1. Effect of marigolds, tomato, and fallow on *Meloidogyne hapla* population development 60 days after planting. Average inoculum at planting = 2,516 second-stage juveniles (J2).[a]

Species	Cultivar	Gall index	J2 in roots	J2 in soil	Total J2
Lycopersicon esculentum	Pixie	3.0 a	25,550 a	5,703 a	31,253 a
Tagetes erecta	CrackerJack	0.0 b	3 d	76 e	79 d
	Flor de Muerto	0.0 b	5 d	85 e	90 d
Tagetes hybrid	Polynema	0.0 b	2 d	105 e	107 d
T. patula	Bonita Mixed	0.0 b	33 c	96 e	129 d
	Gypsy Sunshine	0.0 b	1,011 b	136 e	1,147 bc
	Scarlet Sophie	2.6 a	1,150 b	552 b	1,702 b
	Single Gold	0.0 b	576 b	240 cd	816 bc
	Tangerine	0.0 b	2 d	155 de	157 d
T. signata	Tangerine Gem	0.0 b	868 b	293 bcd	1,161 b
Fallow	—	—	—	474 bc	474 c

[a] Values are means of five replicates. Nematode counts were transformed by $\log_{10}(x + 1)$ for analysis of variance. Values within a column followed by the same letter are not significantly different ($P > 0.05$) according to Duncan's multiple range test.

of each experiment for each *Meloidogyne* sp. to determine initial inoculum density. Nematodes from soil in these cones were extracted with sieving and decanting, and the resulting suspensions together with root pieces were left for 5 days on a filter paper supported by a coarse plastic sieve in a petri dish with water at room temperature. Second-stage *Meloidogyne* juveniles (J2) were counted following extraction at ×50. Sixty days after the start of the experiments, five cones from each treatment were randomly collected. The tops and roots of the plants were weighed, the roots were indexed for galling on a scale from 0 (no galls) to 10 (100% of roots galled) (Bridge and Page, 1980), cut into 1-cm-long pieces, and placed in a misting chamber (Seinhorst, 1950) for 5 days for nematode extraction. Numbers of J2 in the soil from each cone were determined by sieving and decanting as described above.

Infestation of tomato after marigold: The tops of the remaining plants (10/treatment) were cut, and a 3-week-old Pixie tomato seedling was planted into each cone. An additional 10 cones were filled with sterilized sand and remained uninfested (''fallow control'' treatment). Six weeks later the tomatoes were washed from the cones, tops and roots were weighed, roots were indexed for galling, and nematodes were extracted from the roots as described above.

Statistical analysis: Analysis of variance with SAS software (SAS Institute, Cary, NC) was carried out on plant weight and gall index data and on $\log_{10}(x + 1)$-transformed nematode count data. Treatment means were compared with Duncan's multiple range test at the 5% level of probability.

Results

Meloidogyne hapla: The inoculum density averaged 2,516 J2/cone. Sixty days after starting the experiment, the highest numbers of J2 were extracted from tomato and the fewest from Flor de Muerto. Galls were seen only on roots of tomato and Scarlet Sophie, with average gall indices of 3.0 and 2.6, respectively (Table 1). Effects of marigold cultivars on subsequently grown tomato were minor with regard to plant weight. Tomato after Tangerine Gem had the smallest tops and roots. Tops of tomato after fallow (infested or uninfested) were not significantly different from any of the other treatments.

Tomato after tomato had the highest gall index and number of J2 in the roots. Numbers of J2 in tomato roots following marigold cultivars Tangerine, CrackerJack, Flor de Muerto, Polynema, and Tangerine Gem were lower than numbers in the fallow treatment (Table 2).

Meloidogyne incognita: The average inoculum density per cone was 2,719 J2. Sixty days

TABLE 2. Effect of previous plantings of marigolds, tomato, and fallow on *Meloidogyne hapla* infestations and plant weight of tomato 6 weeks after planting tomato as a second crop.[a]

Previous crop	Cultivar	Top weight (g)	Root weight (g)	Gall index	Second-stage juveniles
Lycopersicon esculentum	Pixie	14.8 ab	7.3 a	5.8 a	45,025 a
Tagetes erecta	CrackerJack	15.1 ab	5.3 cd	0.8 c	796 f
	Flor de Muerto	16.4 a	5.9 bc	0.8 c	812 f
Tagetes hybrid	Polynema	15.6 a	4.7 cde	1.0 c	1,091 ef
T. patula	Bonita Mixed	16.6 a	5.7 bc	0.9 c	2,724 de
	Gypsy Sunshine	16.1 a	6.8 ab	2.2 b	18,300 ab
	Scarlet Sophie	15.3 ab	5.9 bc	2.6 b	16,920 ab
	Single Gold	17.0 a	5.8 bc	2.7 b	6,858 bc
	Tangerine	16.0 a	5.3 cd	0.6 c	843 ef
T. signata	Tangerine Gem	12.9 b	3.6 e	0.7 c	1,029 f
Fallow inoculated	—	15.3 ab	3.9 de	1.2 c	3,610 cd
Fallow control	—	15.0 ab	4.2 de	—	—

[a] Values are means of 10 replicates. Nematode counts were transformed by $\log_{10}(x + 1)$ for analysis of variance. Values within a column followed by the same letter are not significantly different ($P > 0.05$) according to Duncan's multiple range test.

TABLE 3. Effect of marigolds, tomato, and fallow on *Meloidogyne incognita* population development 60 days after planting. Average inoculum at planting = 2,719 second-stage juveniles (J2).[a]

Species	Cultivar	Gall index	J2 in roots	J2 in soil	Total J2
Lycopersicon esculentum	Pixie	7.5 a	31,400 a	2,124 a	33,524 a
Tagetes erecta	CrackerJack	0.0 c	0 c	1 c	1 d
	Flor de Muerto	0.2 c	11 c	0 c	11 d
Tagetes hybrid	Polynema	0.0 c	0 c	3 c	3 d
T. patula	Bonita Mixed	0.0 c	0 c	7 c	7 d
	Gypsy Sunshine	0.0 c	1 c	7 c	9 d
	Scarlet Sophie	0.0 c	0 c	1 c	1 d
	Single Gold	0.0 c	0 c	4 c	4 d
	Tangerine	0.0 c	1 c	0 c	1 d
T. signata	Tangerine Gem	2.8 b	2,209 b	253 b	2,462 b
Fallow	—	—	—	132 b	132 c

[a] Values are means of five replicates. Nematode counts were transformed by $\log_{10}(x + 1)$ for analysis of variance. Values within a column followed by the same letter are not significantly different ($P > 0.05$) according to Duncan's multiple range test.

after transplanting, roots of tomato were heavily galled, those of Tangerine Gem had intermediate galling, and only very light galling was observed on Flor de Muerto roots, which corresponded with the number of J2 extracted from the roots. In all but the tomato and Tangerine Gem treatments the number of J2 was significantly lower than after fallow (Table 3). Correspondingly, galling and numbers of J2 in subsequently grown tomato were highest after Tangerine Gem and tomato. Three of 10 tomato plants after tomato died during the experiment. Roots of these plants were small and severely galled (gall index 10). These plants were not included in the calculation of mean top and root weight or number of J2 in the roots. Top weights of tomato after tomato were lower than after the uninfested control (Table 4).

Meloidogyne javanica: High numbers of J2 were collected from tomato. Fewer developed on roots of Tangerine Gem and Polynema, whereas no nematodes were recovered from any of the other marigold cultivars (Table 5). These results were reflected in the infestation of subsequent tomato: gall indices and J2 numbers were highest and top weights were lowest after tomato, Tangerine Gem, and Polynema. No J2 were ob-

TABLE 4. Effect of previous plantings of marigolds, tomato, and fallow on *Meloidogyne incognita* infestations and plant weight of tomato 6 weeks after planting tomato as a second crop.[a]

Previous crop	Cultivar	Top weight (g)	Root weight (g)	Gall index	Second-stage juveniles
Lycopersicon esculentum	Pixie	11.7 c	8.7 bcd	7.9 a	2,003 a
Tagetes erecta	CrackerJack	24.3 a	9.8 abcd	0.5 c	11 c
	Flor de Muerto	26.7 a	9.5 abcd	0.7 c	10 c
Tagetes hybrid	Polynema	16.3 bc	5.6 e	0.7 c	3 c
T. patula	Bonita Mixed	20.8 ab	8.0 cd	0.6 c	8 c
	Gypsy Sunshine	25.0 a	10.0 abc	0.3 c	12 c
	Scarlet Sophie	26.6 a	11.7 a	0.1 c	7 c
	Single Gold	20.1 ab	8.2 bcd	0.0 c	0 c
	Tangerine	25.6 a	9.3 abcd	0.3 c	3 c
T. signata	Tangerine Gem	16.0 bc	5.3 e	3.0 b	283 b
Fallow inoculated	—	16.8 bc	7.3 de	0.1 c	4 c
Fallow control	—	21.7 ab	10.6 ab	—	—

[a] Values are means of 10 replicates except for tomato ($n = 7$). Nematode counts were transformed by $\log_{10}(x + 1)$ for analysis of variance. Values within a column followed by the same letter are not significantly different ($P > 0.05$) according to Duncan's multiple range test.

TABLE 5. Effect of marigolds, tomato, and fallow on population development of *Meloidogyne javanica* 60 days after planting. Average inoculum at planting = 2,150 second-stage juveniles J2.[a]

Species	Cultivar	Gall index	J2 in roots	J2 in soil	Total J2
Lycopersicon esculentum	Pixie	5.2 a	49,600 a	11,400 a	61,000 a
Tagetes erecta	Cracker Jack	0.0 b	0 c	1 b	0 c
	Flor de Muerto	0.0 b	0 c	1 b	1 c
Tagetes hybrid	Polynema	0.0 b	79 bc	1 b	80 c
T. patula	Bonita Mixed	0.0 b	0 c	0 b	0 c
	Gypsy Sunshine	0.0 b	0 c	1 b	1 c
	Scarlet Sophie	0.0 b	0 c	1 b	1 c
	Single Gold	0.0 b	0 c	0 b	0 c
	Tangerine	0.0 b	0 c	0 b	0 c
T. signata	Tangerine Gem	0.5 b	278 b	4 b	281 b
Fallow	—	—	—	0 c	0 c

[a] Values are means of five replicates. Nematode counts were transformed by $\log_{10}(x + 1)$ for analysis of variance. Values within a column followed by the same letter are not significantly different ($P > 0.05$) according to Duncan's multiple range test.

tained from tomato following any of the other marigold cultivars (Table 6).

Meloidogyne arenaria: Galling and nematode multiplication were highest on tomato, followed by Tangerine Gem and Polynema. The total number of J2 from tomato after the other marigold treatments was significantly lower than after fallow (Table 7). Correspondingly, galling on tomato after tomato, Tangerine Gem, and Polynema was greater than after the other marigolds. The number of J2 extracted from tomato roots 6 weeks after transplanting was lower than or similar to the number at planting, with the highest numbers on tomato following tomato, Tangerine Gem, Polynema, and fallow (Table 8).

Discussion

Tomato was a better host for all four *Meloidogyne* species than any of the tested marigolds. Correspondingly, gall indices and J2 numbers on tomato after tomato were higher than on tomato after marigold. Each of several marigold cultivars (e.g. Tangerine, Flor de Muerto, CrackerJack) had a consistent effect on all four *Meloidogyne* spp. on subsequent tomato compared to the fallow treatment. However, other marigold cul-

TABLE 6. Effect of previous plantings of marigolds, tomato, and fallow on *Meloidogyne javanica* infestations and plant weight of tomato 6 weeks after planting tomato as a second crop.[a]

Previous crop	Cultivar	Top weight (g)	Root weight (g)	Gall index	Second-stage juveniles
Lycopersicon esculentum	Pixie	7.4 e	8.0 ab	9.7 a	2,506 a
Tagetes erecta	CrackerJack	17.9 bcd	9.1 ab	0.0 d	0 d
	Flor de Muerto	33.1 a	9.3 ab	0.0 d	0 d
Tagetes hybrid	Polynema	11.7 ed	6.1 bc	3.4 c	63.3 c
T. patula	Bonita Mixed	21.5 bc	9.2 ab	0.0 d	0 d
	Gypsy Sunshine	21.6 bc	9.8 a	0.0 d	0 d
	Scarlet Sophie	24.2 bc	9.8 a	0.0 d	0 d
	Single Gold	21.4 bc	8.9 ab	0.0 d	0 d
	Tangerine	18.1 bcd	9.5 ab	0.0 d	0 d
T. signata	Tangerine Gem	17.2 cd	6.3 bc	7.0 b	528 b
Fallow inoculated	—	17.7 bcd	4.5 c	0.2 d	5 d
Fallow control	—	26.7 ab	8.6 ab	—	—

[a] Values are means of 10 replicates except for tomato ($n = 6$). Nematode counts were transformed by $\log_{10}(x + 1)$ for analysis of variance. Values within a column followed by the same letter are not significantly different ($P > 0.05$) according to Duncan's multiple range test.

TABLE 7. Effect of marigolds, tomato, and fallow on population development of *Meloidogyne arenaria* 60 days after planting. Average inoculum at planting = 4,321 second-stage juveniles (J2).[a]

Species	Cultivar	Gall index	J2 in roots	J2 in soil	Total J2
Lycopersicon esculentum	Pixie	7.5 a	50,563 a	4,575 a	55,138 a
Tagetes erecta	CrackerJack	0.0 c	0 c	0 e	0 c
	Flor de Muerto	0.0 c	1 c	1 e	2 c
Tagetes hybrid	Polynema	0.6 c	482 b	36 bc	518 b
T. patula	Bonita Mixed	0.0 c	0 c	1 e	2 c
	Gypsy Sunshine	0.0 c	0 c	4 de	4 c
	Scarlet Sophie	0.0 c	17 c	27 cde	43 c
	Single Gold	0.0 c	0 c	0 e	0 c
	Tangerine	0.0 c	0 c	8 de	8 c
T. signata	Tangerine Gem	1.8 b	3,274 b	41 cd	3314 b
Fallow	—	—	—	194 b	194 b

[a] Values are means of five replicates. Nematode counts were transformed by $\log_{10}(x + 1)$ for analysis of variance. Values within a column followed by the same letter are not significantly different ($P > 0.05$) according to Duncan's multiple range test.

tivars had nematode-specific effects. For example, Tangerine Gem suppressed galling and reproduction of *M. hapla* but not of *M. javanica, M. arenaria,* or *M. incognita* in subsequent tomato. In contrast, planting of Single Gold resulted in a total absence of galls or J2 on subsequent tomato with *M. incognita, M. javanica,* or *M. arenaria* but increased galling and J2 numbers of *M. hapla* on tomato compared to fallow.

All four *Meloidogyne* species were able to reproduce on *T. signata* Tangerine Gem. Similar results were obtained by Rickard and Dupree (1978) for reproduction of four *Meloidogyne* spp. on *T. signata.* In contrast, Siddiqi and Alam (1988) reported control of *M. incognita* by *T. signata.* Efficient suppression of *M. incognita* and *M. javanica* by *T. patula* and *T. erecta* varieties corresponds with results obtained by others (Daulton and Curtis, 1963; Hackney and Dickerson, 1975; McSorley and Frederick, 1994; Rickard and Dupree, 1978; Suatmadji, 1969). None of the four *Meloidogyne* spp. caused galls or reproduced on *T. patula* cv. Tangerine. This cultivar also was reported to be free of galls and J2 in a previous study with *M. incognita, M. arenaria,* and *M. hapla* as inocula (Motsinger et al., 1977). As in the present study, a rapid decline of *Meloidogyne* in-

TABLE 8. Effect of previous plantings of marigolds, tomato, and fallow on *Meloidogyne arenaria* infestations and plant weight of tomato 6 weeks after planting tomato as a second crop.[a]

Previous crop	Cultivar	Top weight (g)	Root weight (g)	Gall index	J2 in roots
Lycopersicon esculentum	Pixie	20.4 d	13.7 a	6.8 a	2,451 a
Tagetes erecta	CrackerJack	25.4 bcd	9.1 d	0.0 d	0 d
	Flor de Muerto	30.5 abc	9.5 d	0.0 d	0 d
Tagetes hybrid	Polynema	25.5 bcd	12.0 ab	4.4 bc	535 c
T. patula	Bonita Mixed	24.7 bcd	8.9 d	0.5 d	0 d
	Gypsy Sunshine	35.8 a	10.5 bcd	0.5 d	6 d
	Scarlet Sophie	31.4 abc	9.5 d	0.5 d	0 d
	Single Gold	25.6 bcd	11.9 abc	0.0 d	0 d
	Tangerine	23.5 cd	8.8 d	0.3 d	0 d
T. signata	Tangerine Gem	29.7 abc	10.0 bcd	4.7 b	1,529 b
Fallow inoculated	—	33.1 ab	10.2 bcd	3.5 c	65 c
Fallow control	—	28.2 abcd	9.8 cd	—	—

[a] Values are means of 10 replicates. Nematode counts were transformed by $\log_{10}(x + 1)$ for analysis of variance. Values within a column followed by the same letter are not significantly different ($P > 0.05$) according to Duncan's multiple range test.

oculum to near zero levels under fallow in greenhouse experiments has been observed by others (Hackney and Dickerson, 1975; Rickard and Dupree, 1978; Suatmadji, 1969), resulting in nonsignificant differences between the most suppressive marigold cultivars and fallow. Little is known of the effects of marigold compared to fallow in field experiments with *Meloidogyne* spp. However, Oduor-Owino and Waudo (1994) found significant increases in tomato growth and fruit yield and decreased root galling after *T. minuta* compared to fallow in a field infested with *M. javanica*.

Phytotoxic effects of marigold as reported by McKenry (1988, 1991) were not observed in this study on tomato. Top weights of tomato after 6 weeks in uninfested soil generally were not different from those after marigold. Whether the results obtained from these greenhouse experiments can be directly translated to field situations remains to be studied. It is possible that differences among marigold cultivars that are not relevant in a greenhouse study (e.g., in depth of rooting and in growth rate) become important under field conditions. This study provides an initial characterization of the differences among marigold cultivars with regard to the suppression of *Meloidogyne* species. In order to further evaluate the usefulness of marigolds in an integrated pest management system, field studies incorporating the effects of marigolds on *Meloidogyne* population development, yield responses, and economic outcome are required.

Literature Cited

Bridge, J., and S. L. J. Page. 1980. Estimation of root-knot nematode infestation levels on roots using a rating chart. Tropical Pest Management 26:296–298.

Bünte, R., and J. Müller. 1996. Einfluß resistenter Ölrettich-Genotypen auf die Abundanzdynamik von *Meloidogyne hapla* and *M. incognita*. Zeitschrift für Pflanzenkrankheiten und Pflanzenschutz 103:527–534.

Daulton, R. A. C., and R. F. Curtis. 1963. The effects of *Tagetes* spp. on *Meloidogyne javanica* in Southern Rhodesia. Nematologica 9:357–362.

Eisenback, J. D., and H. H. Triantaphyllou. 1991. Root-knot nematodes: *Meloidogyne* species and races. Pp. 191–274 *in* W. R. Nickle, ed. Manual of agricultural nematology. New York: Marcel Decker.

Hackney, R. W., and O. J. Dickerson. 1975. Marigold, castor bean, and chrysanthemum as controls of *Meloidogyne incognita* and *Pratylenchus alleni*. Journal of Nematology 7:84–90.

Hutchinson, M. T. 1962. Rehabilitating tea soils: 1. Susceptibility of plants now in use to the root-lesion nematode, *Pratylenchus loosi*. Tea Quarterly 33:138–140.

McKenry, M. V. 1988. Green manuring with marigold to control root lesion nematode in an orchard. Stone Fruit Tree Decline, 4th Workshop Proceedings, USDA-ARS.

McKenry, M. V. 1991. Marigolds and nematode management. Plant Protection Quarterly, University of California Kearney Plant Protection Group 1, (2):1–4.

McSorley, R., and J. J. Frederick. 1994. Response of some common annual bedding plants to three species of *Meloidogyne*. Supplement to Journal of Nematology 26:773–777.

Miller, P. M., and J. F. Ahrens. 1969. Influence of growing marigolds, weeds, two cover crops and fumigation on subsequent populations of parasitic nematodes and plant growth. Plant Disease Reporter 53:642–646.

Motsinger, R. E., E. H. Moody, and C. M. Gay. 1977. Reaction of certain french marigold (*Tagetes patula*) cultivars to three *Meloidogyne* spp. Journal of Nematology 9:278 (Abstr.).

Oduor-Owino, P., and S. W. Waudo. 1994. Comparative efficacy of nematicides and nematicidal plants on root-knot nematodes. Tropical Agriculture 71:272–274.

Oostenbrink, M. 1960. *Tagetes patula* L. als voorvrucht van enkele land- en tuinbouwgewassen op zand- en dalgrond. Mededelingen van de Landbouwhoogeschool en Opzoekingsstations Gent 25:1065–1075.

Oostenbrink, M., J. J. s'Jacob, and K. Kuiper. 1957. *Tagetes* als Feindpflanzen von *Pratylenchus*-Arten. Nematologica Supplement 2:424S–433S.

Rickard, D. A., and A. W. Dupree. 1978. The effectiveness of ten kinds of marigolds and five other treatments for control of four *Meloidogyne* spp. Journal of Nematology 10:296–297.

Roberts, P. A. 1990. Resistance to nematodes: Definitions, concepts and consequences. Pp. 1–15 *in* J. L. Starr, ed. Methods for evaluating plant species for resistance to plant-parasitic nematodes. Hyattsville, MD: Society of Nematologists.

Sasser, J. N. 1979. Economic importance of *Meloidogyne* in tropical countries. Pp. 256–268 *in* F. Lamberti and C. E. Taylor, eds. Root-knot nematodes (*Meloidogyne* species). Systematics, biology and control. London: Academic Press.

Seinhorst, J. W. 1950. De betekenis van de toestand van de grond voor het optreden van de aanstasting door het stengelaaltje (*Ditylenchus dipsaci* (Kühn) Filipjev). Tijdschrift over Plantenziekten 56:289–348.

Seinhorst, J. W., and C. H. Klinkenberg. 1963. De invloed van *Tagetes* op de bevolkingsdichtheid van aaltjes en op de opbrengst van cultuurgewassen. Netherlands Journal of Plant Pathology 69:153.

Siddiqi, M. A., and M. M. Alam. 1988. Control of plant parasitic nematodes by *Tagetes tenuifolia*. Revue de Nématologie 11:369–370.

Steiner, G. 1941. Nematodes parasitic on and associated with roots of marigolds (*Tagetes* hybrids). Proceedings of the Biological Society of Washington 54:31–34.

Suatmadji, R. W. 1969. Studies on the effect of *Tagetes* species on plant-parasitic nematodes. Wageningen, The Netherlands: H. Veenman en Zonen.

Tyler, J. 1938. Proceedings of the root-knot nematode conference held at Atlanta, Georgia, February 4, 1938. Plant Disease Reporter Supplement 109:133–151.

Visser, T., and M. K. Vythilingam. 1959. The effect of marigolds and some other crops on the *Pratylenchus* and *Meloidogyne* populations in tea soil. Tea Quarterly 30: 30–38.