Journal of Nematology 16(4):396–398. 1984.

Cropping Effects of Marigolds, Corn, and Okra on Population Levels of *Meloidogyne javanica* and on Carrot Yields

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Key words: root-knot nematode, *Tagetes patula, Zea mays, Abelmoschus esculentus, Daucus carota,* rotation.

Root-knot nematodes, particularly *Meloidogyne javanica* (Treub.) Chitwood, 1949 and *M. incognita* (Kofoid and White) Chitwood, 1949, are among the most important pathogens of carrots (*Daucus carota* L.) in Brazil. They damage tap roots by galling, digitation, and constriction, resulting in lower market value (3). Even low soil densities of root-knot nematodes have been reported to reduce marketable root yields (3,11). Root-knot nematode control is important to increase the value of carrot production.

Crop rotation is an effective method to control *M. incognita* (8). Huang et al. (4) controlled the nematodes by growing *Crotalaria spectabilis* Roth for 8 months before planting carrot. Another cover crop used in rotation are marigolds (*Tagetes* spp.) (7,10) which contain a substance toxic to nematodes (9). Corn, a poor host to root-knot nematodes (1), is also used in rotation to suppress nematode populations (2,8). Because of the high economic value, corn would be valuable to use in rotation with carrots.

The effect of marigold and corn on suppressing *M. javanica* populations in soil, when used in rotation with carrot, and subsequent carrot yield were studied. Okra, highly susceptible to *M. javanica,* served as a control crop in this study.

Experimental plots were established at the National Vegetable Research Center/EMBRAPA, Brasília, D.F., in soil (12.3% sand, 27.1% silt, 60.6% clay, and pH 4.9) infested with *M. javanica.* Plots (each 4 × 5 m^2) were arranged in a randomized complete block with five replicates. Commercial fertilizer NPK (4-14-8) (120 kg/ha), $ZnSO_4 \cdot 7H_2O$ (15 kg/ha), and lime (1 t/ha) were applied at the beginning of the growing season of the first crop in October 1982. Fertilizer treatments were repeated at the start of the second season in February 1983.

Marigolds (*T. patula* cv. Happy Days), corn (*Zea mays* cv. Cubano), and okra (*Abelmoschus esculentus* cv. Santa Cruz 47) were planted in October 1982. Marigold plots consisted of 25 rows, each 20 cm apart and 4 m long; corn and okra plots were six rows, each 1 m apart and 4 m long. Plots were direct seeded; 4 months later, plant tops and roots were removed from the soil. All plots were then remade to five beds (4 m long × 80 cm wide) and seeded with carrot (cv. Nova Kuroda) in 20 rows, each 20 cm apart and 80 cm long, per bed in February 1983. Carrots were harvested 102 days after sowing.

At harvest, 24 2-cm-d soil samples were taken from the root zone (20-cm depth) in each plot. To extract nematodes, the samples were composited and 250 cm^3 per replicate processed by centrifugal flotation (6). Also, feeder root samples randomly taken from 15 plants per plot were cut into 2-cm long pieces and mixed. Nematodes were extracted from 300 grams of roots (5). Second-stage juveniles and eggs were counted. At carrot harvest, soil samples were also examined for nematode population levels.

During carrot thinning (32 days after sowing), gall number in young tap roots and seedling dry weights (70 C for 48 hours) were determined. To evaluate carrot yield, marketable root sizes (> 2 cm d and > 9 cm long) with or without galls, as described by Huang et al. (3), were classified and weighed.

Nematode population: At the end of the first crop cycle, final nematode numbers (Pf) recovered from corn plots were significantly lower than from okra plots and

Received for publication 3 November 1983.

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TABLE 1. *Meloidogyne javanica* populations and carrot response in plots previously planted with marigold, corn, and okra for 4 months followed by carrot in rotation.

Parameter	Crop sequence: Marigold ↓ Carrot	Corn ↓ Carrot	Okra ↓ Carrot
Nematode population			
Pi*: soil	191 a†	171 a	196 a
Pf in first crop: soil	19 c	99 b	570 a
roots	400 c	12,778 b	119,533 a
Pf in second crop: soil	126 c	292 b	379 a
Carrot seedlings			
No. of galls/tap root‡	0.59 b	0.91 b	1.49 a
Dry wt (mg)/seedling	55.3 a	45.3 b	40.5 c
Marketable carrot yield			
Root without galls: no.	180 a	109 b	66 b
wt (kg)	10.3 a	5.4 b	3.8 b
Root with galls: no.	50 b	64 b	80 a
wt (kg)	3.4 b	3.3 b	4.5 a

* Pi and Pf = initial and final nematode numbers per 250 cm^3 soil.
† Different letters in the horizontal level indicate significant difference according to Duncan's multiple-range test ($P = 0.05$).
‡ Average of 200 seedlings.

higher than from marigold plots (Table 1). The numbers of eggs and second-stage juveniles extracted from the feeder roots of marigolds, corn, and okra were also significantly different. Nematode numbers from soil samples taken after carrot harvest remained different for the three alternate crops.

Carrot seedlings: At thinning, gall numbers in young tap roots were higher from plots following okra than from plots following corn or marigolds. Seedling dry weights followed the same pattern.

Carrot yield: The total marketable root yields of carrots without galls in plots previously planted with marigolds were higher ($P = 0.05$) than those of the other two treatments in which root yields were not different. Numbers and weights of carrots with galls following marigolds were low. Numbers of carrots in plots following okra had more galls ($P = 0.05$) compared to those in plots following marigolds or corn.

These results indicated that marigolds were effective in reducing *M. javanica* numbers in field soil, thus increasing carrot numbers and yield. However, the final nematode population after carrots in plots previously planted with marigolds was close to the initial population before planting marigolds, indicating that *M. javanica* numbers increased rapidly on a good host. It is more than likely that reduction in nematode numbers after planting marigolds for 4 months will not give satisfactory results in the production of a third crop susceptible to the nematode. Nevertheless, rotation with marigolds serves not only to control root-knot nematodes but also to improve the Brazilian cerrado soil, especially during the rainy season (November–February). Rotation with corn suppressed the initial nematode population and lowered nematode infection in carrot seedlings but did not increase carrot yields.

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