Marigolds (*Tagetes* spp.) for Nematode Management[1]

R. Krueger, K. E. Dover, R. McSorley, K. -H. Wang[2]

Introduction

Nematodes are unsegmented roundworms that are usually microscopic in size. Many are found in terrestrial habitats. There are many different kinds of nematodes. Nematodes can be free-living, a term applied to nematodes that feed on fungi, bacteria, nematodes, or other microscopic organisms. Nematodes that feed on plants are called plant-parasitic nematodes. Plant-parasitic nematodes can seriously damage or even kill crops, turf, and ornamental plants. Plant-parasitic nematodes are difficult to control because they live underground or inside of plants. While some nematicides are available for use in commercial agriculture, there are no nematicides available for homegardners.

One of the most damaging groups of plant-parasitic nematodes are the root-knot nematodes (*Meloidogyne* spp.). These can attack a broad range of vegetable, fruit, and ornamental crops causing swellings or galls on the roots (Figure 1). If there is a severe infestation of root-knot nematodes, the plant may be stunted, wilt, or die. A plant that is already weakened can easily become infected with bacteria or fungi as well.

Once a plant is infected by nematodes, treatment options are very limited. Therefore, most nematode management strategies are pre-plant treatments. One such treatment is the planting of cover crops that can reduce nematode populations. A cover crop is a crop that is grown before the main cash crop is planted. This practice is used to either avoid soil erosion caused by fallowing land, or to reduce a pest that cannot reproduce on the cover crop for various reasons. Some cover crops release substances that are able to suppress other organisms. This is called allelopathy. Marigold (*Tagetes* spp.), which is a popular bedding plant, can be used as such a cover crop. Marigold produces a substance called alpha-terthienyl, which can aid in the reduction of root-knot nematodes and other disease promoting organisms, such as fungi, bacteria, insects, and some viruses (Hethelyi et al. 1986; Soule 1993). African (*T. erecta*) and French marigolds (*T. patula*) are the most commonly used species of these plants (Figure 2). Each consists of varieties that differ in characteristics such as bloom size, shape, and color, as well as plant size and leaf shape.

Figure 1. Damage caused by root-knot nematodes: Galls form within the roots and become part of the root tissue, which cannot be removed.

1. This document is ENY-056, one of a series of the Entomology and Nematology Department, UF/IFAS Extension. Original publication date August 2007. Revised November 2010, June 2013, and April 2016. Reviewed November 2019. Visit the EDIS website at https://edis.ifas.ufl.edu for the currently supported version of this publication.

2. R. Krueger; K. E. Dover; R. McSorley (retired), Entomology and Nematology Department; and K. -H. Wang, Department of Plant and Environmental Protection Services, University of Hawaii at Manoa; UF/IFAS Extension, Gainesville, FL 32611.

Reviewed: 01/2024

Figure 2. *Tagetes erecta* variety Moonstruck Yellow.

Nematode Suppression

Although they can be beneficial against a variety of pests, marigolds are best known for their ability to suppress plant-parasitic nematodes. In India, marigolds have been used for this purpose for hundreds of years (Khan 1971).

Marigold can suppress 14 genera of plant-parasitic nematodes, with lesion nematodes (*Pratylenchus* spp.) and root-knot nematodes (*Meloidogyne* spp.) the most affected (Suatmadji 1969). Different varieties of marigolds vary in their ability to suppress nematodes. In addition, nematode supression is influenced by crop plants, nematode species, and soil temperature (Ploeg and Maris 1999; Tables 1–2). Tyler (1938) investigated the effects of 29 varieties of marigolds on nematode populations. Although variation was observed, marigolds had an overall suppressive effect on nematodes.

Mode of Action

Host Status

Each species of nematode has certain plants it can feed and reproduce on and others it cannot. The ability of a plant to support reproduction of nematodes is referred to as host status. If a particular species of nematode is unable to reproduce on a crop, the nematode numbers will decline as nematodes die. A susceptible plant is one on which the nematode population will increase. A resistant plant is one on which the nematode population will decrease. An intermediate plant is one on which the nematode population will remain stable or be unpredictable. A summary of the susceptibility of the various marigold species or varieties to different types of plant-parasitic nematodes is listed in Tables 1, and 2. Table 1 shows susceptibility of marigold varieties to three species of root-knot nematodes that are common in Florida. Susceptibility of marigolds depends on the marigold species and variety or cultivar, as well as the species of nematode. Varieties designated "resistant" could be used as cover crops to suppress that nematode. Varieties designated "susceptible" can increase population levels of the nematode and actually make the problem worse. It is probably safest to avoid varieties termed "intermediate" in their response, since these can be unpredictable. *Meloidogyne incognita* is a common and widely distributed species of root-knot nematode in Florida (Table 1). However, additional species of root-knot nematodes are being discovered, which may be able to infect marigold cultivars listed as resistant to other root-knot nematodes species.

Marigolds may be resistant to some nematode species but may be very susceptible to others (Table 2). The lesion nematode (*Pratylenchus* spp.) is a problem is regions like Europe and other countries, but in Florida it is not considered to be a nematode of major concern and probably does not require management. However, French marigold cultivars (*T. patula*) appear to be most effective against the widest range of nematodes (Lehman 1979; Belcher and Hussey 1977; Motsinger et al. 1977; Rickard and DuPree, Jr. 1978; Suatmadji 1969; Pudasaini et al. 2006; Evenhuis et al. 2004).

Allelopathic Effect

Allelopathy is the ability of an organism to produce chemicals that are toxic to other organisms. Marigold roots release the chemical alpha-terthienyl, one of the most toxic naturally occurring compounds found to date (Gommers and Bakker, 1988). This compound is nematicidal, insecticidal, antiviral, and cytotoxic (Arnason et al. 1989; Marles et al. 1992).The presence of alpha-terthienyl inhibits the hatching of nematode eggs (Siddiqui and Alam 1988). However if in a field setting, it is unclear if marigolds producing alpha-terthienyl inhibit development because of the alpha-terthienyl itself or because marigolds are a non-host for certain nematodes. Nematodes may not feed or develop on non-host plants even when they do not contain allelopathic compounds. Furthermore, *Meloidogyne* spp. juveniles were unable to fully develop in the roots of *T. erecta* (Ploeg and Maris 1999).

Planting Tips

Marigold is a summer crop in most of the United States, but can be grown year-round in parts of Florida. Marigold can be grown ahead of time as a cover crop to suppress nematodes before planting a susceptible crop such as a vegetable crop. It also is a good choice to plant in ornamental

planting beds where root-knot nematodes are a problem on other annuals. In order to be an effective cover crop in nematode management, marigold should be planted at least two months before the desired vegetable crop. Furthermore, it must be planted at the same site in which the vegetable crop will be planted (see "Considerations" section below) otherwise no benefits can be gained from marigold root exudates. Marigolds can be disked or hoed into the soil in the fashion of a green manure to prepare the field for planting of the actual crop.

Providing proper nutrition and improved soil conditions can increase crop tolerance to nematodes. Follow the fertility and growing recommendations for marigold suggested by your County Cooperative Extension Office to ensure a healthy crop.

Planting should be dense to ensure the best nematode control. Vann et al. (2003) suggested limiting the row spacing and spacing between individual plants to less than 7 inches to help prevent weeds. This is very important, since nematodes can reproduce on weeds and thereby nullify the effects of marigold. This spacing may be practical if marigold transplants are used. If marigolds are direct-seeded in Florida, much higher seeding densities may be needed to obtain a dense stand.

Marigolds cannot eradicate nematodes. In order for marigold to have a continuous effect on nematode populations it must be grown every season before the actual crop is planted (Doubrava and Blake 1999), because nematode populations will increase over time in the presence of susceptible crops like most vegetables and bedding plants (McSorley et al. 1999).

Intercropping marigold with other crops to reduce plant-parasitic nematodes does not appear to be effective. Powers et al. (1993) showed that marigold intercropped with cucurbit was less productive than cucurbit monoculture and no effect on plant-parasitic nematodes was observed. On the other hand, El-Hamawi et al. (2004) showed that marigold used as an intercrop was effective in reducing *M. incognita* (Southern root-knot nematode). However, it should be pointed out that this experiment was conducted in pots, where root-knot severity might have been reduced because of soil dilution and a decreased density of host plants available for nematode reproduction.

Considerations

Not all marigold varieties control all types of nematodes. For example, Cracker Jack marigold may show good control of the southern root-knot nematode, but is a host for other nematodes such as stubby-root and reniform nematodes. Other nematodes that can increase on marigold are sting and awl nematodes (Rhoades 1980). Therefore, growers should determine which marigold variety to use based on nematodes present in the field. Knowledge of nematodes present within a field can be obtained by sending soil samples from that field to a nematode assay laboratory. Furthermore, populations of the same species can vary in their aggressiveness in different locations (Carpenter and Lewis 1991). Therefore it is important to verify the effect of marigolds on local nematode populations before attempting management on a large scale.

In addition, although marigolds may suppress nematode numbers, they might not be able to reduce severe infestations sufficiently, which will limit the success of the next cash crop (Lehman 1979). Therefore it is important to determine nematode population numbers before planting marigolds.

Research has shown that the nematicidal compound (alpha-tertheinyl) is only released by active, living marigold roots, because exposure to near-UV light inactivates alpha-tertheinyl when taken out of the soil. Thus there is no benefit in amending a planting site with marigold extracts of homogenized plant parts (Marles et al. 1992; Ploeg 2000).

Frequently Asked Questions

1. **Does marigold have an effect on plant-parasitic nematodes when grown in an intercropping setting?**

Probably not. Some research (El-Hamawi et al., 2004) suggests that interplanting marigolds with susceptible crops may reduce nematode numbers, but results are often complicated by soil dilution and other factors. No successful research on this topic has been done in Florida. Powers et al. (1993) showed that intercropping with marigold did not reduce plant-parasitic nematodes in Honduras. Typically root-knot nematodes will find and reproduce on roots of a susceptible crop or weed. So interplanting marigold and susceptible crops is very risky and may result in damage to the susceptible crops (Figure 3).

Figure 3. Marigold interplanted with coleus. Coleus will not be protected by marigold even though marigold is planted in close proximity.

2. **Does marigold suppress all plant-parasitic nematodes?**

No. It suppresses root-knot nematodes, lesion nematodes, and possibly reniform nematodes, but increases others such as, stubby-root, spiral, sting, and awl nematodes (Tables 1 and 2). In addition, different varieties of marigold may react differently to different root-knot nematodes. Furthermore, especially for root-knot nematodes, new species that have recently been discovered or remain undiscovered may increase on or damage marigold species/varieties that are proven to be resistant to other well-known nematode species.

3. **Can marigolds be used as a rotational crop?**

Yes, but in order for marigold to successfully suppress plant-parasitic nematodes, marigolds should be planted at least two months before the susceptible crop is planted. This succeeding crop must be planted in the exact same site as the marigold. In addition, a nematode assay should be conducted prior marigold planting in order to determine what species of nematodes are present in the soil. This will help to determine which species/varieties of marigold should be purchased.

4. **How much does it cost to plant marigolds?**

One source (Park Seed catalog, Spring 2007) lists different varieties of French and African marigold at prices ranging from $1.70 to $6.95 per 2 packets. A median price of $3.50 per 2 packets could provide about 50 seeds, assuming 25 seeds in one packet. Vann et al. (2003) recommend that plants should be planted with no more than 7 inches between plants. At that spacing, approximately 17 plants in each direction (10 ft x10 ft) would be needed to cover an area of 100 ft^2. This would equal about 289 flowers/100 ft^2. Costs for this type of planting would accumulate to over $20.00/100 ft^2. Costs extrapolated for plants covering 1 acre would be over $9000, since approximately 131,000 plants would be needed. As mentioned above, this spacing might be useful for transplants, but additional costs would be needed to raise seeds to seedling stage for transplanting. If marigolds were directly seeded in the field in Florida, it is likely that a much higher seeding rate may be needed to account for losses due to deep planting, seedling mortality, weed competition, or other factors. After the first crop of marigolds has been grown it can be harvested for its seeds, which can alleviate some future costs. In addition, some retailers and wholesale companies may sell seeds or plants for lower costs, particularly if large quantities are involved. However, planting large acreages with marigold could be an expensive treatment for managing nematodes.

References

Alam, M. M., Saxena, S. K., and Khan, A. M. 1978. Suitability of crops to certain ectoparasitic nematodes. Acta Botanical Indica 6 (supplement): 205-208.

Arnason, J. T. B., J. R. Philogene, P. Morand, K. Imrie, S. Iyengar, F. Duval, C. Soucy-Breau, J. C. Scaiano, N. H. Werstiuk, B. Hasspieler, and A. E. R. Downe. 1989. Naturally occurring and synthetic thiophenes as photoactivated insecticides. ACS Symposium Series 387: 164-172.

Belcher, J. V. and R. S. Hussey. 1977. Influence of *Tagetes patula* and *Arachis hypogaea* on *Meloidogyne incognita*. Plant Disease Reporter 61: 525-528.

Carpenter, A. S., and S. A. Lewis. 1991. Aggressiveness and reproduction of four *Meloidogyne arenaria* populations on soybean. Journal of Nematology 23: 232-238.

Caswell, E. P., J. deFrank, W. J. Apt, and C.-S. Tang. 1991. Influence of nonhost plants on population decline of *Rotylenchulus reniformis.* Journal of Nematology 23: 91-98.

Crow W. T. 2003/5. *Nematode Management for Bedding Plants*. ENY-052. Gainesville: University of Florida Institute of Food and Agricultural Sciences. http://edis.ifas.ufl.edu/IN470

Doubrava, N. and J. H. Blake. 1999. Root-knot nematodes in the vegetable garden. Publication number HGIC 2216. Home and Garden Information Center, Clemson University, Cooperative Extension Service, Clemson, SC. http://www.clemson.edu/extension/hgic/pests/plant_pests/veg_fruit/hgic2216.html. accessed 03-07-2007

Dover K. E., McSorley R., Wang K. -H, 2003. Marigolds as cover crops, http://agroecology. ifas.ufl.edu/Marigoldsbackground.htm accessed 06-12-2007.

El-Hamawi, M. H., Youssef, M. M. A., Zawam, H.S. 2004. Management of *Meloidogyne incognita*, the root-knot nematode, on soybean as affected by marigold and sea ambrosia (damsisa) plants, J Pest Sci 77: 95–98.

Evenhuis, A., Korthals, G.W., Molendijk, L.P.G., 2004. *Tagetes patula* as an effective catch crop for long-term control of *Pratylenchus penetrans*, Nematology, Vol. 6(6), 877-881.

Geo. W. Park Seed Co., Inc. 2007. Flowers and Vegetables. Spring 2007. p. 46-47.

Gommers, F. J. and J. Bakker. 1988. Physiological diseases induced by plant responses or products. Pp. 3-22 in: Diseases of nematodes. G. O. Poinar, Jr. and H. -B. Jansson, eds., Vol. I. CRC Press, Inc., Boca Raton, FL.

Hethelyi, E., B. Danos, and P. Tetenyi. 1986. GC-MS analysis of the essential oils of four *Tagetes* species and the anti-microbial activity of *Tagetes minuta*. Flavour and Fragrance Journal 1: 169-173.

Khan, A. M., S. K. Saxena, and Z. A. Siddiqi. 1971. Efficacy of *Tagetes erecta* in reducing root infesting nematodes of tomato and okra. Indian Phytopathology 24: 166-169.

Ko, M. P., and D. P. Schmitt. 1993. Pineapple inter-cycle crops to reduce plant-parasitic nematode populations. Acta Horticulturae 334: 373-382.

Lehman, P. S. 1979. Factors influencing nematode control with marigolds. Nematology Circular No. 50. Florida Department of Agriculture and Consumer Services, Division of Plant Industry, Gainesville, FL.

Marles, R. J., J. B. Hudson, E. A. Graham, C. S. -Breau, P. Morand, R. L. Compadre, C. M. Compadre, G. H. N. Towers, and J. T. Arnason. 1992. Structure-activity studies of photoactivated antiviral and cytotoxic thiophenes. Phytochemistry and Phytobiology 56: 479-487.

McSorley, R., M. Ozores-Hampton, P. A. Stansly, and J. M. Conner. 1999. Nematode management, soil fertility, and yield in organic vegetable production. Nematropica 29: 205-213.

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.

Ploeg, A. T. 2000. Effects of amending soil with *Tagetes patula* cv. Single Gold on *Meloidogyne incognita* infestation on tomato. Nematology 2: 489-493.

Ploeg, A. T. and P. C. Maris. 1999. Effect of temperature on suppression of *Meloidogyne incognita* by *Tagetes* cultivars. Journal of Nematology 31(4S): 709-714.

Powers, L. E., R. McSorley, and R. A. Dunn. 1993. Effects of mixed cropping on a soil nematode community in Honduras. Journal of Nematology 25: 666-673.

Pudasaini, M.P., Viaene, N., Moens, M. 2006. Effect of marigold (*Tagetes patula*) on population dynamics of *Pratylenchus penetrans* in a field, Nematology, Vol. 8 (4): 477-484.

Rhoades, H. L. 1980. Relative susceptibility of *Tagetes patula* and *Aeschynomene americana* to plant nematodes in Florida, USA. Nematropica 10: 116-120.

Rickard, D. A., and A. W. DuPree, Jr. 1978. The effectiveness of ten kinds of marigolds and five other treatments for control of four *Meloidogyne* spp. Journal of Nematology 4: 296-297.

Siddiqui, M. A. and M. M. Alam. 1988. Toxicity of different plant parts of *Tagetes lucida* to plant parasitic nematodes. Indian Journal of Nematology 18: 181-185.

Soule, J. 1993. *Tagetes minuta:* A potential new herb from South America. Pp. 649-654 in: Janick, J. and J. E. Simon (eds.), New Crops, Wiley, NY. http://www.hort.purdue.edu/newcrop/proceedings1993/ v2-649.html#BOTANY.

Suatmadji, R. W. 1969. Studies on the effect of *Tagetes* species on plant parasitic nematodes. Stichting Frond Landbouw Export Bureau publicatie 47. H. Veenman Und Zonen N. V., Wageningen, Netherlands. 132p.

Tyler, J. 1938. Proceedings of the root-knot conferences held at Atlanta. Plant Disease Reporter Supplement 109: 133-151.

Vann, S., T. Kirkpatrick, and R. Cartwright. 2003. Control root-knot nematodes in your garden. Publication number FSA7529-PD-5-02N. Division of Agriculture, University of Arkansas, Cooperative Extension Service, Little Rock, AR.

DeWaele, D., E. M. Jordaan, and S. Basson. 1990. Host status of seven weed species and their effects on *Ditylenchus destructor* infestation of peanut. Journal of Nematology 22: 292-296.

Wang, K.-H., B. S. Sipes, and D. P. Schmitt. 2001. Suppression of Rotylenchulus reniformis by *Crotalaria juncea*, *Brassica napus*, and *Tagetes erecta*, Nematropica 31: 237-251.

Wang, K.-H., B. S. Sipes, and D. P. Schmitt. 2002. Management of *Rotylenchulus reniformis* in pineapple, *Ananas comosus*, by intercycle cover crops. Journal of Nematology 34: 106-114.

Wang, K.-H., B. S. Sipes, and D. P. Schmitt. 2003. Intercropping cover crops with pineapple for the management of *Rotylenchulus reniformis*. Journal of Nematology 35: 39-47.

Winfield, A. L. 1985. Observations of the pin nematodes, *Pratylenchus nanus*, a possible pest of glasshouse lettuce, *Lactuca sativa*. Crop Research (Edinburgh) 25: 3-12.

Table 1. Susceptibility of marigold varieties to three root-knot nematode species common in Florida.

Marigold Variety	*M. incognita*	*M. arenaria*	*M. javanica*
African Marigold (*T. erecta*)			
Unknown variety [8]	--	--	Resistant
'Toreador' [7]	Resistant	Resistant	Resistant
'Diamond Jubilee' [3, 7]	Resistant	Intermediate - susceptible	Resistant
'Alaska' [7]	Resistant	Resistant	Resistant
'Crackerjack' [6]	Resistant	Resistant	Resistant
Flor de Muerto' [6]	Resistant	Resistant	Resistant
Triploid Hybrid Marigold (*T. erecta* x *T. patula*)			
'Red Nugget' [7]	Resistant	Resistant	Resistant
'Polynema' [5, 6]	Resistant	Resistant	Resistant
French Marigold (*T. patula*)			
'Bolero' [7]	Intermediate	Intermediate	Resistant
'Dwarf Primrose' [4]	Resistant	Resistant	Resistant
'Goldie' [7]	Resistant	Resistant	Resistant
'Petite' [7]	Resistant	Resistant	Resistant
'Petite Harmony' [3, 7]	Resistant	Intermediate - susceptible	Resistant
'Single Gold' [5, 6]	Resistant	Resistant	Resistant
'Tangerine' [1, 6, 7]	Resistant	Resistant	Resistant
'Bonita Mixed' [6]	Resistant	Resistant	Resistant
'Gypsy Sunshine' [6]	Resistant	Resistant	Resistant
'Scarlet Sophie' [6]	Resistant	Resistant	Resistant
Signet Marigold (*T. signata pumila*)			
'Golden Gem' [7]	Susceptible	Susceptible	Susceptible
'Tangerine Gem' [6]	Susceptible	Susceptible	Susceptible
Mexican Marigold (*T. minuta*) [1, 2]			
	Resistant	Susceptible	Resistant

1 = Motsinger et al., 1977.
2 = Belcher and Hussey, 1977.
3 = Lehman, 1979.
4 = McSorley and Frederick, 1994.
5 = Ploeg, 2002.
6 = Ploeg, 1999.
7 = Rickard and DuPree, Jr., 1978.
8 = Sipes and Arakaki, 1997.

Table 2. Susceptibility of three marigold species to various plant-parasitic nematodes.

Nematode	Nematode Species	Marigold Variety / Species		
		T. patula	*T. erecta*	*T. minuta*
Sting	*Belonolaimus longicaudatus*	Susceptible [4]	--	--
Awl	*Dolichodorus heterocephalus*	Susceptible [4]	--	--
Lance	*Hoplolaimus galeatus*	Intermediate [4]	--	--
Stubby-root	*Paratrichodorus minor*	Susceptible [4]	--	--
Reniform	*Rotylenchulus reniformis*	Resistant [2, 3]	Resistant [1]	--

1 = Alam et al., 1978.
2 = Caswell et al., 1991.
3 = Ko and Schmitt, 1993.
4 = Rhoades, 1980.