

EFFECT OF *MELOIDOGYNE INCOGNITA* ON WATERMELON YIELD

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ABSTRACT

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Field tests were conducted in 2004 and 2006 in Tifton, GA to document the effect of *Meloidogyne incognita* infection on watermelon yield. Experiments had 24 replications of two treatments: methyl bromide fumigated and non-fumigated. Each plot consisted of one row of nine plants: the first, fifth, and ninth plants in the row were pollinators (cv. Companion), and the other six plants were cv. Cooperstown seedless watermelons. Neither maximum vine length nor vigor rating three weeks after transplanting differed between methyl bromide-treated plots and non-treated plots in 2004. Both 'Cooperstown' and 'Companion' watermelons had significantly greater galling in non-fumigated plots than in the fumigated plots in both years. The level of galling on 'Companion' generally was the same as that on 'Cooperstown'. Significantly more fruit and greater total weight were harvested from methyl bromide-fumigated plots in both 2004 and 2006 due to more fruit and greater weight being harvested during the first harvest; fruit number and weight were not different between fumigated and non-fumigated plots for the second harvest in either year. Nematode parasitism reduced the weight of the first harvest by 30% in 2004 and 24% in 2006. Fumigation increased yields by increasing the number of fruit during the first harvest but not the weight of individual fruit.

Key words: *Citrullus lanatus*, *Meloidogyne incognita*, watermelon, yield loss.

RESUMEN

Davis, R. F. 2007. Efecto de *Meloidogyne incognita* en la producción de sandía. *Nematropica* 37:287-293.

Se llevaron a cabo ensayos de campo durante 2004 y 2006 en Tifton, GA para medir el efecto de *Meloidogyne incognita* sobre la producción de sandía. Los experimentos consistieron de 24 repeticiones de dos tratamientos: fumigación con bromuro de metilo y sin fumigación. Cada lote consistió de una fila de nueve plantas: la primera, quinta y novena planta fueron polinizadoras (cv. Companion), y las otras seis plantas fueron cv. Cooperstown sin semilla. No se observaron diferencias en la longitud y el vigor de las plantas tres semanas después del trasplante entre los lotes tratados con bromuro de metilo y los no tratados en 2004. Tanto 'Cooperstown' como 'Companion' tuvieron significativamente mayor agallamiento en los lotes no fumigados que en los lotes fumigados, ambos años. El nivel de agallamiento en 'Companion' generalmente fue igual al de 'Cooperstown'. Se cosecharon más frutos y mayor peso total en los lotes fumigados con bromuro de metilo tanto en 2004 como en 2006, debido a más frutos y mayor peso cosechado en la primera cosecha; no se observaron diferencias en la cantidad de frutos y el peso de los frutos entre los lotes fumigados y los no fumigados en la segunda cosecha de ambos años. La infección con nematodos causó una reducción del 30% en el peso de la primera cosecha en 2004 y una reducción del 24% en 2006. La fumigación aumentó la producción porque aumentó la cantidad de frutos durante la primera cosecha, pero no aumentó el peso de los frutos individuales.

Palabras clave: *Citrullus lanatus*, *Meloidogyne incognita*, sandía, pérdida de producción.

INTRODUCTION

Watermelon (*Citrullus lanatus* (Thunb.) Matsum. & Nakai var. *lanatus*) is a prolific host for root-knot nematodes (*Meloidogyne* spp.), including the southern root-knot nematode (*M. incognita* (Kofoid & White) Chitwood) (Montalvo and Esnard, 1994; Southards and Priest, 1973; Thies and Levi, 2003; Winstead and Riggs, 1959). Infection by *Meloidogyne* spp. results in copious galling of watermelon roots (Montalvo and Esnard, 1994; Sharma *et al.*, 1986; Southards and Priest, 1973; Thies and Levi, 2003; Thomason and McKinney, 1959; and Winstead and Riggs, 1959). Watermelon is often grouped with other cucurbit crops to simplify discussions of symptoms of nematode damage, crop loss due to nematodes, and nematode management recommendations (e.g., Thies, 1996). Yield loss due to root-knot nematodes in other cucurbit crops has been well documented (Thies *et al.*, 2004, 2005; Webster *et al.*, 2001). It is widely accepted by nematologists that root-knot nematode infection of watermelon causes yield reductions, but reports of reduced plant growth or yield in watermelons are primarily anecdotal.

Meloidogyne incognita infection reduced the weight of watermelon plants in the greenhouse (Dhankhar *et al.*, 1986) and in microplots (Xing *et al.*, 2006), but data on fruit weight from field-grown watermelons have not been reported in a peer-reviewed paper. An abstract reports a yield increase of 33% when a granular nematicide was applied (Román *et al.*, 1972), and two book chapters cite unpublished research showing yield increases of 50% and 75% when soil was fumigated prior to planting watermelon (Lamberti, 1979a, b), though none of these reports provides nematode population levels or degree of galling. This study was conducted to document the effect of *M. incognita* infection on watermelon yield.

MATERIALS AND METHODS

Field tests were conducted in 2004 and 2006 at the University of Georgia Blackshank Farm in Tifton, GA. The same field was used in 2004 and in 2006. Soil at the test location was a Fuquay loamy sand (loamy, siliceous, thermic, Arenic Plinthic Paleudults; 88% sand, 9% silt, 3% clay, and <1% organic matter; pH = 6.4), and was naturally infested with *M. incognita* race 1. The experiments were arranged in a randomized complete block design with 24 replications of two treatments: methyl bromide fumigated (224 kg a.i./treated ha) and non-fumigated. Rows were spaced 183 cm apart. Each plot consisted of one row of nine plants spaced 91 cm apart. The first, fifth, and ninth plants in the row were pollinators (cv. Companion), and the other six plants were cv. Cooperstown seedless watermelons, a cultivar commonly grown in this area. Both cultivars are produced by Seminis, Inc. (Oxnard, CA, USA). All plants were transplanted on 12 April 2004 and 29 March 2006.

Methyl bromide was applied with an implement which formed a raised planting bed (76 cm wide) and injected the fumigant approximately 30 cm deep behind two knives spaced 46 cm apart and centered on the bed; a single drip irrigation line was placed on the soil surface; and the bed was immediately covered with a black plastic mulch to seal in the fumigant. Non-fumigated beds were treated the same as fumigated plots in all respects (and at the same time) except that no fumigant was injected. The fumigant was applied on 5 April 2004 (seven days prior to transplanting) and 8 March 2006 (21 days prior to transplanting). Approximately 24 hours prior to transplanting, a row of holes for the transplants was punched through the plastic in the center of the bed to allow any residual fumigant to dissipate. Transplants

were placed into the holes by hand and immediately watered and fertilized. Approximately 10 to 15 plants each year died following transplanting and were replaced with new transplants within the first week; there was no apparent relation between plant death and fumigation treatment. Drip irrigation, fertilization, pesticide application (except for the methyl bromide treatment), and crop management were identical for all plots.

Soil samples for nematode analysis were collected before fumigation (2004) or at planting (2006), and at mid-season and harvest (2 April, 20 May, and 29 June 2004; and 7 April, 25 May, and 11 July 2006). Soil samples consisted of a composite of 8 to 10 cores per plot (2.5-cm diam. and approximately 20-cm deep) collected from the root zone. Nematodes were extracted from 150 cm³ soil by centrifugal flotation (Jenkins, 1964).

In 2004, maximum vine length measurements and subjective vigor ratings were made for all 'Cooperstown' plants in each plot on 3 May (21 days after transplanting). Vigor ratings were made on a linear 1 to 6 scale where 1 = a dead or nearly dead plant, 2 through 5 = progressively larger, more vigorous, healthier plants, and 6 = a large plant with good color which appears to be growing rapidly and appears completely healthy. Vine length and vigor ratings were not made in 2006.

Fruit were harvested twice each growing season, with approximately one or two weeks between harvests (21 and 29 June 2004, and 20 June and 6 July 2006). The number of 'Cooperstown' watermelons, and the weight of each individual fruit, was recorded for each plot. The number of fruit and the weight for each fruit from the pollinator plants ('Companion') also were recorded for each plot. From that data, the total fruit weight and the mean individual fruit weight for each plot were calculated.

Root-galling was evaluated immediately following the second harvest in 2004 and 2006. All watermelon plants in each plot were carefully excavated and examined. Gall ratings were assigned to each plant and the mean value for each plot for each cultivar was used for statistical analysis. Galling on 'Cooperstown' and 'Companion' were analyzed separately. A 0 to 10 scale was used in which 0 = no galling, 1 = 1-10% of the root system galled, 2 = 11-20% of the roots system galled, etc., with 10 = 91-100%.

Analysis of variance was used to determine if there were differences between fumigated and non-fumigated plots. Unless otherwise stated, statistical differences are with a probability ≤ 0.05 .

RESULTS AND DISCUSSION

Mean maximum vine length three weeks after transplanting did not differ between methyl bromide-treated plots (29.7 cm) and non-treated plots (25.2 cm) in 2004. Subjective vigor ratings three weeks after transplanting also did not differ between fumigated (rating = 4.2) and non-fumigated plots (rating = 3.9). Though vigor and vine length were slightly numerically lower in non-fumigated plots, statistical differences could not be demonstrated despite the high number of replications (24). From this we infer that the subjective vigor ratings and maximum vine length early in the growing season are not indicative of nematode damage in watermelon. No above-ground differences were observed between fumigated and non-fumigated plots. No problems or diseases, other than galling induced by *M. incognita*, were observed on vines or roots during either year of this study, so yield differences should be attributable to nematode damage.

Meloidogyne incognita population levels were similar between treatments prior to

fumigation in 2004 and indicated a relatively high damage potential (Table 1). Population levels were low in both fumigated and non-fumigated plots on both post-fumigation sampling dates in 2004. All sampling dates in 2006 were after fumigation. Nematode counts generally were low, however, the non-fumigated plots had significantly greater nematode population levels at harvest.

In contrast to the low nematode counts, root galling was moderately severe (Table 1). Both 'Cooperstown' and 'Companion' watermelons in non-fumigated plots had mean gall ratings that were significantly greater than in the fumigated plots in both years. The level of root galling on 'Companion' and 'Cooperstown' were similar. Root-galling in fumigated plots was low. These results are consistent with previous reports that watermelon is a good host for *M. incognita* (Montalvo and Esnard, 1994; Southards and Priest, 1973; Winstead and Riggs, 1959) and reacts with copious galling to infection by this nematode (Montalvo and Esnard, 1994; Sharma *et al.*, 1986; Southards and Priest, 1973; Thomason and McKinney, 1959; and Winstead and Riggs, 1959). Galling has been

shown to decrease watermelon plant biomass in microplots (Xing *et al.*, 2006).

Galling is a measure of the amount of nematode parasitism and the subsequent damage suffered by a plant, whereas soil counts of nematodes are an indirect way of estimating the likely level of damage. Previous research (Xing *et al.*, 2006) showed that soil counts were a poor predictor of the damage potential of *M. incognita* to watermelon in microplots. Data in this study documenting low soil nematode counts in plots which suffered significant root galling suggest that soil counts also were a poor predictor of damage. Galling data clearly showed that fumigation reduced parasitism from *M. incognita* despite the fact that nematode counts were low and often did not differ between fumigated and non-fumigated plots.

Despite significant galling in non-fumigated plots, no above-ground symptoms such as stunting, yellowing, or poor growth were observed. Stunting, yellowing, and poor growth are commonly reported symptoms of root-knot nematode damage in other cucurbit crops such as cucumber (*Cucumis sativus* L.) and squash (*Cucurbita pepo* L.) (Thies, 1996). These results sug-

Table 1. Number of *Meloidogyne incognita* and root gall ratings in methyl bromide-fumigated (MBr) and non-fumigated (non-MBr) watermelon in 2004 and 2006.

Crop year	<i>M. incognita</i> /150 cm ³ soil			Root gall rating [§]	
	2 April	20 May	29 June	'Cooperstown'	'Companion'
2004					
MBr	284 a [‡]	0 a	24 a	1.0 a	1.2 A
Non-MBr	291 a	4 b	21 a	5.3 b	6.2 B
2006	7 April	25 May	11 July	'Cooperstown'	'Companion'
MBr	11 a	0 a	28 a	1.7 a	1.7 A
Non-MBr	18 a	3 a	120 b	4.5 b	5.0 b

[§]Root-galling was evaluated after final harvest.

[‡]LSD_(0.05) comparisons are for the methyl bromide-fumigated and non-fumigated plots within a column within a year. Samples on 2 April 2004 were prior to fumigation, and all other samples in both years were after fumigation.

gest that watermelon may be less likely than other cucurbits to express above-ground symptoms of damage from root-knot nematodes. Damage from root-knot nematodes may go unrecognized if above-ground symptoms are minimal or lacking.

Watermelon fields typically are harvested twice with approximately one week between harvests. Fruit that is sold wholesale is sold by weight rather than by the number of fruit. Fruit from the first harvest often sells for a higher price than fruit from the second harvest, so anything that delays fruit maturity has a negative economic effect even if yield is not reduced.

Significantly more fruit and greater total weight were harvested from methyl bromide-fumigated plots in both 2004 and 2006 (Table 2). These differences were due to more fruit being harvested during the first harvest; individual fruit weights

from the first harvest did not differ between treatments. Fruit number and weight did not differ between fumigated and non-fumigated plots for the second harvest in either year. Nematode parasitism reduced the weight of the first harvest by 30% in 2004 and 24% in 2006. Fumigation increased total yields by 29% in 2004 and 16% in 2006.

These responses are generally similar to the 33% increase in yield following nematicide application reported in an abstract by Román *et al.* (1972), but much less than the increases (50% and 75%) following fumigation cited as unpublished research by Lamberti (1979a, b). This difference could be due to different levels of nematode pressure in the studies, though Lamberti did not report nematode counts or gall ratings, or the difference could be due to differences in crop production sys-

Table 2. Effect of *Meloidogyne incognita* on yield of 'Cooperstown' seedless watermelon in methyl bromide-fumigated (MBr) and non-fumigated (non-MBr) plots 2004 and 2006.

Crop year and harvest		Number of fruit	Individual fruit weight (kg)	Total fruit weight (kg/plot) ^y
2004				
First harvest	MBr	7.8 a ^c	7.63 a	58.48 a
	Non-MBr	5.4 b	7.51 a	40.71 b
Second harvest	MBr	5.5 a	6.41 a	35.30 a
	Non-MBr	5.3 a	6.12 a	31.97 a
Total harvest	MBr	13.3 a	7.11 a	93.78 a
	Non-MBr	10.8 b	6.78 a	72.68 b
2006				
First harvest	MBr	14.8 a	7.80 a	114.57 a
	Non-MBr	12.1 b	7.21 a	87.42 b
Second harvest	MBr	3.9 a	7.29 a	28.21 a
	Non-MBr	4.7 a	7.60 a	35.54 a
Total harvest	MBr	18.7 a	7.71 a	142.78 a
	Non-MBr	16.8 b	7.27 a	122.96 b

^yMean weight of all fruit harvested from all 'Cooperstown' plants in each plot.

^cLSD_(0.05) comparisons are for the Mbr-fumigated and non-fumigated plots within a harvest within a year.

tems. In another melon crop (*Cucumis melo* L.), transplanting instead of direct-seeding significantly reduced the amount of damage caused by *M. incognita* (Ploeg and Phillips, 2001), which might explain why we observed less damage than Lamberti reported, though Lamberti did not report whether the watermelons were direct seeded or transplanted. Transplanting, which allows seedlings to grow a larger root system before any nematode parasitism occurs, has been shown to reduce damage from *M. incognita* in onion as well (Davis and Langston, 2003).

It is noteworthy that the increase in weight resulted from an increase in fruit number, not from an increase in the weight of individual fruit. Individual fruit weight did not differ between fumigated and non-fumigated plots for either individual harvest date or the total harvest in either year (Table 2). Similarly, yield loss caused by a reduction in the number of fruit rather than a decrease in average fruit weight occurred in *Cucumis melo* (Ploeg and Phillips, 2001) and tomato (Fortnum *et al.*, 1997). It appears that damaged vines either produce fewer flowers, which results in fewer fruits, or the vines abort flowers or developing fruit to compensate for the stress of nematode damage. Infection by *Meloidogyne* spp. causes plants to redirect nutrients to the site of nematode development, thereby creating a metabolic sink and reducing a plant's ability to support developing fruit (Bergeson, 1966; McClure, 1977). The fruit that are produced are of normal size and weight, thereby giving no indication that yield is being reduced. It also is possible that flowering may have been delayed and/or fruit may have taken longer to mature on nematode-damaged plants, though neither of these delays would reduce yield. In this study, data was not collected on when flowering began or on the period of time between flowering and fruit maturity.

In summary, reducing parasitism of watermelon by *Meloidogyne incognita* can increase total yield by increasing the number of fruit produced for the more valuable first harvest. Because above-ground symptoms of root-knot nematode parasitism such as stunting and yellowing may be minimal or lacking even when plants suffer moderately severe galling, and the weight of individual fruits is unaffected by nematode parasitism, damage from root-knot nematodes can easily go unnoticed. Though reduced yield of pollinator plants may not be important to growers, the fact that pollinator plants are very susceptible to root-knot nematodes may become important for nematode management strategies. If watermelon breeding programs are successful in developing *Meloidogyne*-resistant cultivars, resistance in pollinators becomes important and they also should be bred for resistance.

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