EVALUATION OF NEMATICIDES FOR CONTROLLING *MELOIDOGYNE INCOGNITA* AND *HOPLOLAIMUS COLUMBUS* ON KENAF (*HIBISCUS CANNABINUS*)†

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ABSTRACT

Mueller, J. D., and S. A. Lewis. 1992. Evaluation of nematicides for controlling *Meloidogyne incognita* and *Hoplolaimus columbus* on kenaf (*Hibiscus cannabinus*). Nematropica 23:91–97.

The effectiveness of aldicarb, fenamiphos, and 1,3-dichloropropene in controlling *Hoplolaimus columbus* and a combination of *H. columbus* and *Meloidogyne incognita* on kenaf (*Hibiscus cannabinus*) was evaluated in two similar field experiments. One experiment was conducted in a field with a Fuquay sand infested with *M. incognita* and *H. columbus*. The second experiment was in a field with a Dothan loamy sand infested with *H. columbus* but not *M. incognita*. In the first experiment, in-furrow application of aldicarb at planting at rates of 0.59 and 1.18 kg a.i./ha reduced root galling but also significantly reduced early season plant growth by 23% and 41%, respectively, based on plant weight 21 days after planting. The higher rate of aldicarb also reduced kenaf yield 7 months after planting. Fenamiphos and 1,3-dichloropropene significantly reduced galling caused by *M. incognita* and increased yield. In both experiments, *Hoplolaimus columbus* infected and reproduced on kenaf but in the field where only *H. columbus* occurred, no yield increases were obtained by nematicide treatment.

Key words: aldicarb, Columbia lance nematode, 1,3-dichloropropene, fenamiphos, *Hibiscus cannabinus*, *Hoplolaimus columbus*, kenaf, *Meloidogyne incognita*, nematicide, root-knot nematode.

RESUMEN

Mueller, J. D. y S. A. Lewis. 1992. Evaluación de nematicidas para el control de *Meloidogyne incognita* y *Hoplolaimus columbus* en kenaf (*Hibiscus cannabinus*). Nematrópica 23:91–97.

En dos experimentos de campo, se evaluó la efectividad de aldicarb, fenamifos y 1,3-dicloropropeno para el control de *Hoplolaimus columbus* solo y en combinación con *Meloidogyne incognita* en kenaf. El primer experimento se llevó a cabo en un campo con un suelo arenoso (tipo Fuquay) infestado con *M. incognita* y *H. columbus*. El otro experimento se realizó en un terreno de textura arena limosa (tipo Dothan) infestado con *H. columbus* sin *M. incognita*. En el primer experimento, la aplicación de 0.59 y 1.18 kg i.a./ha de aldicarb en el surco de siembra redujo el agallamiento de las raíces, aunque también redujo significativamente el crecimiento de las plantas un 23% y 41%, respectivamente, a los 21 días después de la siembra. La dosis alta de aldicarb también redujo el rendimiento de kenaf 7 meses después de la siembra. Fenamifos y 1,3-dicloropropeno redujeron significativamente el agallamiento de las raíces causado por *M. incognita* e incrementó el rendimiento de kenaf. *Hoplolaimus columbus* infectó y se reprodujo en kenaf en ambos experimentos, pero en el campo infestado solamente con *H. columbus*, la aplicación de nematicidas no resultó en un incremento de rendimiento.

Palabras clave: Hibiscus cannabinus, *Hoplolaimus columbus*, kenaf, *Meloidogyne incognita*, nematicida, nematodo agallador.

INTRODUCTION

Kenaf (*Hibiscus cannabinus*) is being examined as a potential new crop in the coastal plains of the southeastern United States (8). The stems and leaves of kenaf can be used for forage, silage, biomass

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production, and fiber extraction. Fiber from the bast of kenaf has various applications, particularly in the paper industry. Kenaf is highly susceptible to root-knot nematodes. In greenhouse tests, kenaf was susceptible to all races of *Meloidogyne incognita* (14), and to *M. arenaria* and *M. javanica* (7,8,14). In field tests, severe galling and yield losses occurred when kenaf was infected by *M. incognita* (1,10, 15). Adamson *et al.* (1) found reproduction and yield losses great enough to prohibit growth of kenaf in the same field 2 years in a row. Different levels of susceptibility to *M. incognita* have been reported but no cultivars are sufficiently resistant or tolerant to permit commercial kenaf production in *M. incognita*-infested fields without nematicides (8,10).

The kenaf cultivar Tainung 1 was reported susceptible to infection and reductions in root growth by *Hoplolaimus magnistylus* in a 60-day greenhouse test (7,8,9). No resistance to *H. magnistylus* or other *Hoplolaimus* spp. has been reported. Both *M. incognita* and *Hoplolaimus columbus* occur frequently in agricultural soils of South Carolina. Kenaf will most likely be planted in South Carolina on fields previously cropped to cotton (*Gossypium hirsutum*) or soybean (*Glycine max*). Recent surveys in South Carolina by S. B. Martin and C. E. Drye (personal communications) have shown damaging population levels of *M. incognita* in 10–15% of cotton and soybean fields. The incidence of potentially damaging population levels of *H. columbus* is even greater with 35% of cotton and 15% of soybean fields infested at these levels.

Limited information is available concerning the efficacy of nematicides on kenaf. Fumigant nematicides such as EDB (ethylene dibromide) and DBCP (dibromochloropropane) reduced yield losses due to *M. arenaria*; however, the nonfumigant carbofuran was ineffective (10).

The objectives of these experiments were to determine if *H. columbus* can infect and cause yield losses on kenaf, and to determine if nematicides can be used to control yield losses due to *H. columbus* or *M. incognita* in a cost-effective manner.

MATERIALS AND METHODS

Plots were established in two fields in Barnwell County, South Carolina, U.S.A. The first field, a Fuquay sand (90% sand, 6% silt, 4% clay) had a history of damage to watermelon (*Citrullus vulgaris*) and corn (*Zea mays*) by *M. incognita* and *H. columbus* and was planted on 17 June 1991. The second field, a Dothan loamy sand (84% sand, 10% silt, 6% clay), had a history of damage to corn and soybean by *H. columbus* and was planted on 13 June 1991. In both fields the following treatments were established in six randomized complete blocks: 1) nontreated check; 2) 0.20 kg a.i./ha acephate (Orthene 75S) broadcast on foliage 5 and 10 days after planting; 3) 0.59 kg a.i./ha aldicarb (Temik 15G) applied in-furrow at planting; 4) 1.18 kg a.i./ha aldicarb applied as in treatment 3; 5) 1.18 kg a.i./ha fenamiphos (Nemacur 15G) applied in-furrow at planting; 6) 26 L/ha 1,3-dichloropropene (1,3-D as Telone II) single chisel injected 31 cm under the seed furrow 14 days prior to planting); 7) 52 L/ha 1,3-D applied as in treatment 6; and 8) 26 L/ha 1,3-D + 0.59 kg a.i./ha aldicarb as in treatments 3 and 6. The acephate treatment was included to determine if thrips (*Frankliniella* spp.) control was contributing to yield increases observed in the aldicarb or fenamiphos plots.

All plots consisted of four 9.1-m rows on 96-cm centers. All plots were planted to

the cultivar Everglades 41 with 23 seeds/m row. All plots were treated with 0.84 kg a.i./ha trifluralin and received 56 kg/ha of N [as 3.5% NO_3, 6.6% NH_3, 14.9% $CO(NH_2)_2$] both preplant incorporated.

Nematode population densities were evaluated at planting (mid June), midseason (August 8), and harvest (January 31). Soil samples were composites of 12 cores (2.5 cm diam, 20 cm deep) from the rhizosphere of the center two rows of each plot. Nematodes were extracted from a 100-cm^3 random subsample using centrifugal flotation (6). At midseason, 10 root systems were removed at random from the first and fourth rows of each plot, and *H. columbus* and *M. incognita* were extracted for 7 days from a 15-g random sample from the 10 root systems using a modified mist apparatus (2). After nematode extraction, roots were dried for 72 hr in an oven at 80 °C and nematodes per gram dry weight of root were calculated. Root material within soil samples collected at harvest was separated from each 100-cm^3 soil sample with a 425-μm-pore sieve and nematodes were extracted from roots in the modified mist chamber described previously. Root systems from the *M. incognita-H. columbus* field were rated 21 days after planting and at harvest based on the percentage of the root system estimated to be galled, with 0 = none and 5 = 100% of the root surface galled. At midseason, 10 female *Meloidogyne* sp. were collected from roots and identified to species by examining perineal patterns (4,12) and isozyme electromorphs (5).

To evaluate early plant growth, 20 plants were collected from each plot and weighed 3 weeks after planting. Also at 3 weeks, stand counts from a 1.52-m section of each of the center two rows of every plot were recorded.

Harvest dates were 21 January for the *H. columbus* field and 8 January for the field infested with both *H. columbus* and *M. incognita*. At harvest, yields were estimated by collecting and weighing plants from a 3-m section of row from each of the center two rows of each plot. Five plants from each plot were then weighed, dried for 72 hr at 70 °C in a forced-air oven and reweighed to determine percentage dry matter. Using this value, the fresh weight of the 6 m of row harvested was converted to metric tons of dry matter per hectare.

RESULTS

Field with both H. columbus *and* M. incognita*:* All treatments except acephate reduced galling indices 21 days after planting (Table 1). At harvest, effects of nematicide treatments on root galling were generally similar to those observed at 21 days; however, the low rate of aldicarb did not differ from the nontreated

Table 1. Effects of the insecticide acephate and three nematicides on galling indices of kenaf 21 days after planting and at harvest in a field infested with *Hoplolaimus columbus* and *Meloidogyne incognita*.

Treatment	Rate (a.i./ha)	Galling index[y] At 21 days	Galling index[y] At harvest
Nontreated	—	1.78 a[z]	4.21 a
Acephate	0.20 kg	1.92 a	3.08 bc
Fenamiphos	1.18 kg	1.27 b	2.46 bc
Aldicarb	0.59 kg	0.78 bc	3.38 ab
Aldicarb	1.18 kg	0.53 c	3.00 bc
1,3-D	26 L	1.05 bc	3.08 bc
1,3-D	52 L	1.07 c	2.38 bc
1,3-D + aldicarb	26 L + 0.59 kg	0.70 c	2.08 c

[y]0 = no galling; 5 = 100% of root surface galled.
[z]Means within a column with a letter in common are not significantly different at $P \leq 0.05$ according to Duncan's new multiple range test.

check, and the acephate treatment had less galling than the nontreated check (Table 1). Recovery of both *M. incognita* and *H. columbus* from soil at midseason and at harvest was very low and did not differ between treatments (Table 2). Recovery of *M. incognita* from roots at midseason was greater in the acephate treatment than in all other treatments except the nontreated check (Table 2). Recovery of *H. columbus* from roots at midseason followed a pattern similar to that observed for *M. incognita*; however, these differences were not statistically significant (Table 2). Final populations of *H. columbus* in soil did not differ statistically among treatments. Plant stand 21 days after planting was unaffected by treatment (Table 3) and plant weight was not affected by 1,3-D or fenamiphos; treatment with aldicarb, however, reduced plant weights about 25%. The greatest final plant heights were in plots receiving 52 L/ha 1,3-D alone or a combination of 1,3-D + aldicarb. Biomass yield was also greatest for the 52 L/ha 1,3-D and the 1,3-D + aldicarb treatments.

H. columbus *field:* At midseason, differences among treatments in the recovery of *H. columbus* from soil were not detected (Table 4). Recovery of *H. columbus* from roots at midseason, however, was greater for the acephate treatment than for all other treatments except the low rate of aldicarb (Table 4). At harvest, recovery of *H. columbus* from soil was greater in acephate plots and in the nontreated check than in plots receiving fenamiphos or 52 L/ha of 1,3-D. As in the field where *M. incognita* was present, the numbers of *H. columbus* recovered from soil at harvest were greater than the numbers recovered at midseason.

Stand counts in plots receiving either fenamiphos or the high rate of aldicarb were lower than in the nontreated check (Table 5). Fresh weight 21 days after planting was lower for both rates of aldicarb than in the nontreated check (Table 5). Final plant height and yield of

Table 2. Recovery of *Meloidogyne incognita* and *Hoplolaimus columbus* from soil and roots of kenaf at midseason (52 days after planting) and at harvest in field plots treated with the insecticide acephate and three nematicides.

		Midseason				Harvest	
		M. incognita		*H. columbus*		*M. incognita*	*H. columbus*
Treatment	Rate (a.i./ha)	Soil[x]	Roots[y]	Soil	Roots	Soil	Soil
Nontreated	—	0 a[z]	4 909 ab	16 a	213 a	38 a	27 a
Acephate	0.20 kg	0 a	7 678 a	20 a	92 a	2 a	52 a
Fenamiphos	1.18 kg	1 a	2 221 b	12 a	37 a	22 a	20 a
Aldicarb	0.59 kg	0 a	2 606 b	13 a	110 a	45 a	52 a
Aldicarb	1.18 kg	0 a	2 368 b	25 a	35 a	25 a	35 a
1,3-D	26 L	4 a	2 595 b	8 a	106 a	32 a	32 a
1,3-D	52 L	0 a	3 198 b	15 a	91 a	28 a	53 a
1,3-D + aldicarb	26 L + 0.59 kg	8 a	1 629 b	11 a	60 a	32 a	45 a

[x]Nematodes extracted from 100 cm^3 soil.

[y]Nematodes extracted from 15 g root.

[z]Means within a column with a letter in common are not significantly different ($P \leq 0.05$) according to Duncan's new multiple range test.

Table 3. The stand and fresh foliar weight of kenaf 21 days after planting, and the height and dry matter yield of kenaf at harvest in a field infested with *Hoplolaimus columbus* and *Meloidogyne incognita* following treatment with the insecticide acephate and three nematicides.

Treatment	Rate (a.i./ha)	Seedlings at 21 days		Final height (cm)	Yield (MT/ha)
		Stand (plants/m)	Weight (g)		
Nontreated	—	19 a[z]	11.2 ab	165 c	1.94 b
Acephate	0.20 kg	18 a	11.0 ab	155 c	1.87 b
Fenamiphos	1.18 kg	18 a	10.0 bc	154 c	2.11 b
Aldicarb	0.59 kg	20 a	8.6 d	177 bc	2.61 b
Aldicarb	1.18 kg	18 a	6.6 e	202 abc	1.91 b
1,3-D	26 L	19 a	10.5 b	166 c	2.56 b
1,3-D	52 L	21 a	11.8 a	221 ab	4.17 a
1,3-D + aldicarb	26 L+0.59 kg	20 a	9.2 bc	254 a	4.86 a

[z]Means within a column with a letter in common are not significantly different at $P \leq 0.05$ according to Duncan's new multiple range test.

the treatments did not differ from the nontreated check (Table 5).

Insects: No thrips or any other damaging insects were detected in any plots of either field at 2 early-season sample dates, indicating that treatment effects were not influenced by early season insecticidal activity.

DISCUSSION

In the field where *M. incognita* was present, it reduced yields significantly. The low levels of nematode recovery from soil at midseason seems inconsistent with the high levels of galling and nematode recovery from the roots. How-

Table 4. Effects of the insecticide acephate and three nematicides on the recovery of *Hoplolaimus columbus* from soil and roots of kenaf at midseason (56 days after planting) and at harvest in a field infested with *Hoplolaimus columbus* but not with *Meloidogyne incognita*.

Treatment	Rate (a.i./ha)	Midseason		Harvest
		Soil[w]	Roots[x]	Roots and soil[y]
Nontreated	—	23 a[z]	109 b	68 ab
Acephate	0.20 kg	19 a	356 a	72 a
Fenamiphos	1.18 kg	13 a	94 b	17 c
Aldicarb	0.59 kg	17 a	199 ab	46 abc
Aldicarb	1.18 kg	13 a	65 b	36 abc
1,3-D	26 L	15 a	73 b	21 bc
1,3-D	52 L	28 a	61 b	11 c
1,3-D + aldicarb	26 L+0.59 kg	4 a	98 b	21 bc

[w]Nematodes extracted from 100 cm^3 of soil.
[x]Nematodes extracted from 15 g roots.
[y]Nematodes extracted from 100 cm^3 soil plus those extracted from associated roots.
[z]Means within a column with a letter in common are not significantly different at $P \leq 0.05$ according to Duncan's new multiple range test.

Table 5. Effects of the insecticide acephate and three nematicides on the stand and fresh foliar weight of kenaf 21 days after planting, and on the height, and dry matter yield of kenaf at harvest in a field infested with *Hoplolaimus columbus* but not with *Meloidogyne incognita*.

Treatment	Rate (a.i./ha)	Seedling stand (plants/m)	Weight (g)	Height (cm)	Yield (MT/ha)
Nontreated	—	22.3 a[z]	11.8 ab	386 ab	10.0 ab
Acephate	0.20 kg	21.8 ab	12.9 a	402 a	9.9 ab
Fenamiphos	1.18 kg	18.4 c	11.3 abc	394 a	10.6 ab
Aldicarb	0.59 kg	21.4 ab	9.4 c	395 a	10.6 ab
Aldicarb	1.18 kg	19.3 bc	6.0 d	364 b	8.5 b
1,3-D	26 L	20.6 abc	12.4 a	394 a	9.2 ab
1,3-D	52 L	22.2 a	12.9 a	384 ab	9.9 ab
1,3-D + aldicarb	26 L+0.59 kg	20.1 abc	9.9 bc	407 a	11.0 a

[z]Means within a column with a letter in common are not significantly different at $P \leq 0.05$ according to a Duncan's new multiple range test.

ever, Minton *et al.* (10) saw similar low recovery rates from soil during much of the growing season. In the presence of *M. incognita*, the high rate of 1,3-D and the 1,3-D + aldicarb treatment provided yield responses sufficient to more than offset the cost of treatment. However, if a market value for kenaf of $62 U.S./MT dry weight is assumed, yields of 12 MT/ha are needed to offset the inputs involved in crop production, not including nematicide application (M. J. Fuller, personal communication). Therefore, none of the treatments in either field allowed cost efficient production of kenaf. In-furrow application of aldicarb in particular may be unsuitable for use on kenaf considering the high level of phytotoxicity observed in our tests. Other methods of application could be examined.

Hoplolaimus columbus clearly can infect and reproduce on kenaf, and populations can be reduced with nematicides. Since no yield increases were obtained, *H. columbus* appeared to be a relatively weak pathogen on kenaf. However, weather conditions during the 1991 growing season were ideal for kenaf production and the possible effects of *H. columbus* under less favorable growing conditions should be studied.

Root-knot nematodes appear to be a major limiting factor in kenaf production in infested fields and current management strategies are inadequate. Appreciable host plant resistance is not available in agronomically acceptable kenaf cultivars (7,11,14) and crop rotations are limited due to the wide host range of *M. incognita* and the susceptibility of kenaf to fungal pathogens such as *Macrophomina phaseolina* (13) and *Sclerotium rolfsii* (3). Root-knot nematodes appear to exacerbate damage due to either of these fungi. In our tests, nematicides did not provide an economic return. Therefore, if kenaf is to be grown in the coastal plains of the southeastern United States, it will be important to sample candidate fields prior to deciding to plant kenaf to avoid losses due to *M. incognita* and possibly other nematodes.

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