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RESPONSE OF PINEAPPLE PLANTS GROWING IN NEMATODE-INFESTED SOIL TO AFTER-PLANTING NEMATICIDAL TREATMENTS [RESPUESTA DE LA PIÑA EN SUELO INFESTADO CON NEMATODOS A TRATAMIENTOS CON NEMATICIDAS DESPUES DE PLANTAR].

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ABSTRACT

Cvs Red Spanish, Smooth Cayenne and Sugar Loaf pineapple plants in nematode-infested plots which were fumigated before planting then received after-planting nematicidal treatments, grew faster, produced better root systems, showed less symptoms of nutrient deficiency and produced significantly higher yields than plants in plots which received the first nematicidal treatment 4, 8 or 12 months after planting than at 4-monthly intervals. There was little difference in the performance of the plants receiving the various after-planting treatments only or no treatment. For cv. Smooth Cayenne, plots receiving the before and after-planting treatments produced significantly more slips and suckers than the other plots. For all varieties, the benefits of the pre-planting treatment carried over to the ratoon crop. It appears that once pineapple plants have been damaged by nematodes, they derive little benefit from nematicidal treatments.

Key Words: Control, Ananas comosus, Pratylenchus, Helicotylenchus, DD, DBCP, Phenamiphos, Nemacur.

INTRODUCTION

Parasitic nematodes are considered to be the major limiting factor to production of pineapples, *Ananas comosus* (L.) Merr., in Jamaica (6,7). Nematode-damaged plants are recognised by their slow development, sparsity or lack of roots, general unthriftiness for which no cause is readily identified, lateness of production which is poor and the need for early replanting of the infested field. These plants also show nutrient deficiency symptoms such as yellowing or reddening of leaves, drying of leaves starting

at the tips, small fruits with large crowns, poor suckering, etc. (1,3,4) which are thought to be induced as the damaged roots cannot absorb nutrients effectively. On almost every occasion, when nematode damage to an established planting is confirmed, growers ask about the possible benefits of nematicidal treatments to the affected crop. Because information on this is lacking in Jamaica, a trial was carried out to investigate the response of nematode-damaged pineapple crops to nematicidal treatments.

MATERIALS AND METHODS

Pinapple cvs Red Spanish, Smooth Cayenne and Sugar Loaf were used. The trial area was a 77.0 x 12.2m bed recently taken out of pineapple and heavily infested with *Helicotylenchus multicinctus* (Cobb, 1893) Golden, 1956 and *Pratylenchus* sp. The soil was a heavy clay of pH 5.0-5.5.

The treatments were: T1- pre-plant fumigation of soil with a mixture of DD (1,3-dichloropropene and 1,2-dichloropropane) at 390 l/ha and DBCP (1,2-dibromo-3-chloropropane) at 16.8 l/ha, then post-plant treatment with Nemacur, (phenamiphos), (0-ethyl-o-(3-methyl-4-methyl-thiophenyl)-isopropylamido-phosphate) at 20 kg a.i./ha at four, eight and 12 months; T2- Nemacur (20 kg a.i./ha) four, eight and 12 months after planting; T3- Nemacur eight and 12 months after planting; T4- Nemacur 12 months after planting; T0- no treatment. The DD/DBCP mixture was applied with a hand injector. Nemacur 10G was sprinkled over the plants allowing some granules to fall into the leaf axils and some to the ground. Each treatment was replicated four times per variety. Plots were 6.4 x 2.0m. Two rows of suckers were planted in the middle of each plot; rows were 0.6m apart and plants 0.3m apart in the row. All cultural practices (fertilization, insect and weed control, etc.) observed were those normally carried out at Broom Hall Estate, Cave Valley, where this trial was sited. Experimental data taken were:

Plant Crop

Five, nine, 13 and 17 months after planting, a plant chosen at random was dug from each plot, weighed and the three longest roots measured; the number of plants per plot exhibiting nutrient deficiency symptoms was also estimated. The number and weight of fruits harvested from each plot were recorded and 20 months after planting, slips and suckers produced by Smooth Cayenne plants were counted. Three, seven and 11 months after planting, counts were made of the parasitic nematodes in soil and root samples from all plots.

Ratoon Crop

Twenty-eight months after planting, the plants per plot with nutrient deficiency symptoms were estimated. At 30 months, records were made of the number of plants per plot that bore fruit and fruit weight estimated and the Smooth Cayenne plants bearing suckers were counted.

RESULTS

Plant Crop

Plant weight - Five, nine, 13 and 17 months after planting, Red Spanish, Smooth Cayenne or Sugar Loaf pineapple plants from plots which received pre- then post-planting nematicide treatments (T1) were significantly heavier than plants from plots which received various post-planting nematicide treatments only (T2, T3, T4) or no

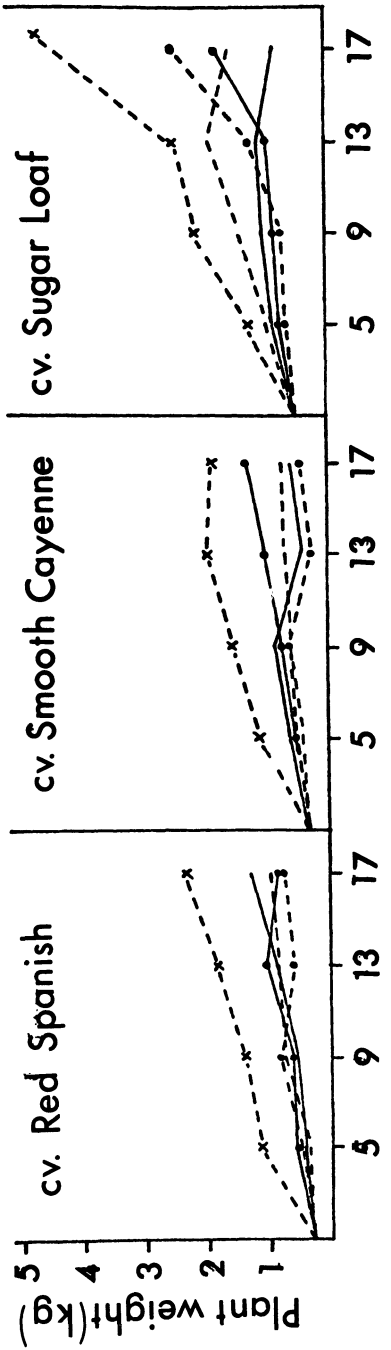

Fig. 1. Weight of pineapple plants * from plots treated with a nematicide 4,8 and 12 months after planting (T2) (●———●), 8 and 12 months after planting (T3) (————), 12 months after planting (T4) (●— — —●), from untreated plots (T0) (- - - - -) or from plots fumigated before planting then treated with a nematicide 4,8 and 12 months after planting (T1) (✕— — —✕).

*T1 significantly greater (1%) than T2, T3, T4 and T0 at all intervals.

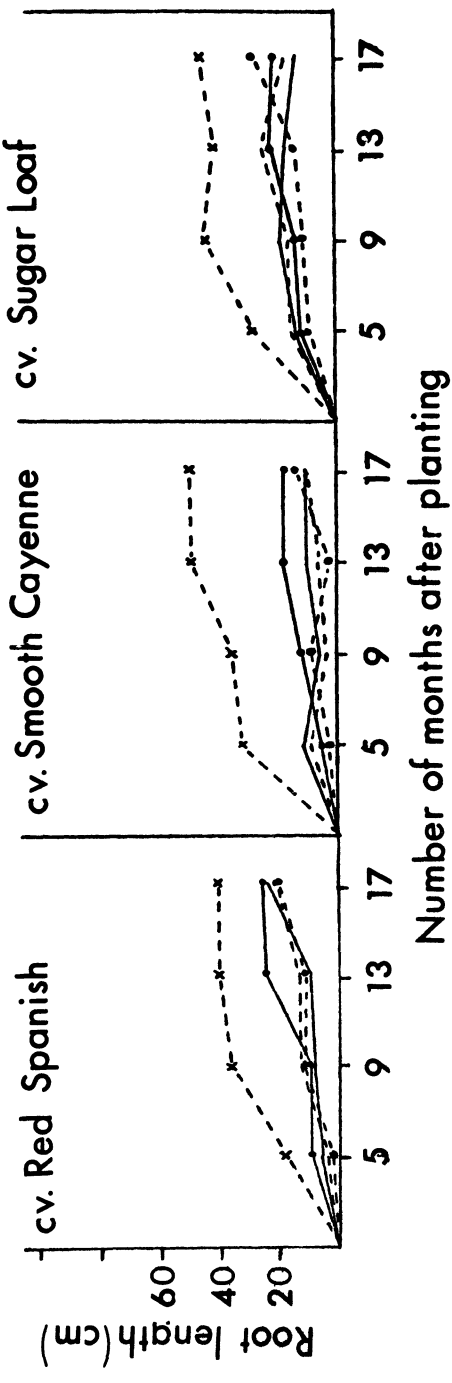

Fig. 2. Length of roots of pineapple plants* from plots treated with a nematicide 4,8 and 12 months after planting (T2) (●———●), 8 and 12 months after planting (T3) (———), 12 months after planting (T4) (●- - - -●), from untreated plots (T0) (– – – – –) or from plots fumigated before planting then treated with a nematicide 4,8 and 12 months after planting (T1) (×- - - -×).

*T1 significantly greater (1%) than T2, T3, T4 and T0 at all intervals.

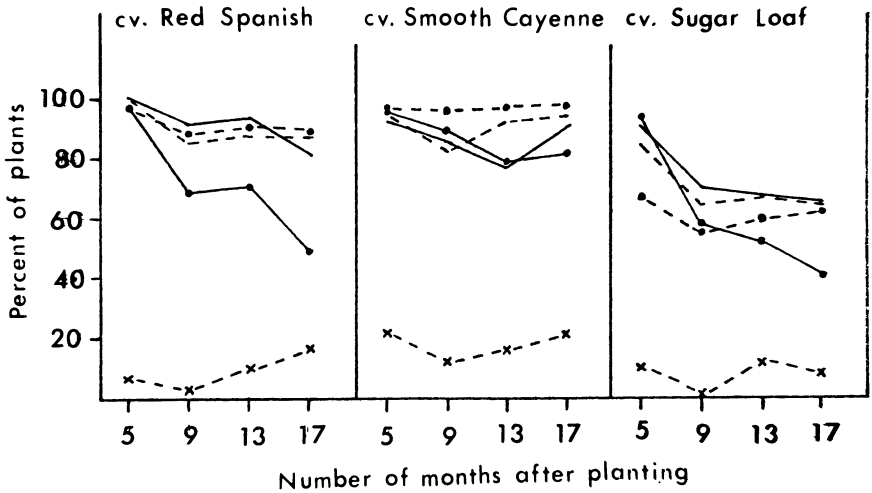

Fig. 3. Percentage of pineapple plants with nutrient deficiency symptoms from plots treated with a nematicide 4,8 and 12 months after planting (T2) (•———•), 8 and 12 months after planting (T3) (————), 12 months after planting (T4) (•– – – –•), from untreated plots (T0) (– – – – –) or from plots fumigated before planting then treated with a nematicide 4,8 and 12 months after planting (T1) (X– – – –X).

treatment (T0) (Fig. 1). Only at 13 months were T2-plants, i.e., those in plots receiving the earliest and most frequent after-planting nematicide treatments, significantly heavier than plants in plots receiving less frequent after-planting treatments (T3, T4) or no treatment (T0)

Root growth - Five, nine, 13 and 17 months after planting, roots of T1-plants of all the pineapple varieties were significantly longer than those of plants in plots receiving the after-planting nematicide treatments only or no treatment (Fig. 2). Only at 13 months were roots of T2-plants significantly longer than roots of T3, T4 and T0-plants.

Plants showing nutrient deficiency symptoms - During the first 17 months after planting, many more T2, T3, T4 or T0-plants exhibited symptoms of nutrient deficiency than T1-plants (Fig. 3). However, after four months, a high proportion of T2-plants of cvs Sugar Loaf and Red Spanish recovered from the unthrifty condition. There was always a high incidence of nutrient deficiency symptoms shown by T2, T3, T4 and T0-Smooth Cayenne plants.

Production - For each variety, T1-plots bore significantly more and heavier fruits than the other plots (Table 1). There was little or no significant difference in the percentage of bearing plants or in fruit weight between T2, T3, T4 and T0-plots. Statistical analysis showed that T1 produced a significantly greater increase in the percentage of bearing plants in cv. Smooth Cayenne than in cvs Red Spanish and Sugar Loaf. For the three varieties, overall production was greatest in T1-plots (Table 1).

Production of slips and suckers - Twenty months after planting, T1-plants of cv Smooth Cayenne had borne significantly more slips and suckers than plants in the other plots (Table 1). There was no significant difference in the production of slips and suckers between T2, T3, T4 and T0

Table 1. Response in the plant crop of pineapple plants in nematode-infested land fumigated before and treated at intervals after planting, in land always left untreated, or in land treated with a nematicide at various periods after planting.

Pineapple varieties	Nematicide treatments* made before and/or at intervals after planting	Plants bearing up to 19 months after planting (%)	Average fruit weight (kg)	Calculated yield (tons/ha)	Slips/suckers produced per plot after 20 months
Red Spanish	Before, then 4,8 and 12 months after	88^{b}	0.85^{b}	21.2	
	Four, 8 and 12 months after	67^{a}	0.59^{ab}	11.4	
	Eight and 12 months after	62^{a}	0.49^{a}	8.8	
	Twelve months after	58^{a}	0.55^{a}	9.1	
	No treatment	58^{a}	0.51^{a}	8.5	
Smooth Cayenne	Before, then 4,8 and 12 months after	79^{c}	1.44^{b}	32.6	$23/25^{b}$
	Four, 8 and 12 months after	39^{b}	0.73^{a}	8.2	$1/7^{a}$
	Eight and 12 months after	32^{b}	0.63^{a}	5.7	$1/8^{a}$
	Twelve months after	16^{a}	0.76^{a}	3.5	$0/2^{a}$
	No treatment	27^{b}	0.68^{a}	5.2	$1/5^{a}$
Sugar Loaf	Before, then 4,8 and 12 months after	56^{b}	1.56^{b}	23.5	
	Four, 8 and 12 months after	41^{a}	0.79^{a}	8.7	
	Eight and 12 months after	43^{a}	0.67^{a}	7.8	
	Twelve months after	37^{a}	0.82^{a}	8.2	
	No treatment	50^{ab}	0.89^{a}	11.9	

* A mixture of DD (390 l/ha) and DBCP (16.8 l/ha) was used before and Nemacur (20 kg a.i./ha) after planting.

^{abc}For each pineapple variety, means in any colum followed by different letters are significantly different (5%; Duncan's Multiple Range Test).

Table 2. Counts[a] of parasitic nematodes found in soil about and roots* of pineapple plants in nematode-infested land fumigated before and treated at intervals after planting, in land left untreated, or in land treated with a nematicide at various intervals after planting.

Pineapple varieties	Nematicide treatments made before and/or at intervals after planting	Three months after planting Soil	Seven months after planting Soil/Root	Eleven months after planing Soil/Root
Red Spanish	Before, then 4,8 and 12 months after	48	91/0	215/6
	Four, 8 and 12 months after		131/62	108/0
	Eight and 12 months after	190		318/75
	Twelve months after		238/416	768/114
	No treatment			
Smooth Cayenne	Before, then 4,8 and 12 months after	59	218/126	14/7
	Four, 8 and 12 months after		124/327	226/0
	Eight and 12 months after	209		300/35
	Twelve months after		252/280	452/55
	No treatment			
Sugar Loaf	Before, then 4,8 and 12 months after	63	22/11	14/0
	Four, 8 and 12 months after		124/10	644/114
	Eight and 12 months after	181		306/180
	Twelve months after		204/17	283/235
	No treatment			

[a]Counts represent nematodes per 100ml soil or per gram root.

*Helicotylenchus multicinctus was present in every soil sample and Pratylenchus sp. in roots.

Table 3. Response in the first ratoon crop of pineapple plants in nematode-infested land fumigated before and treated at intervals after planting, in land left untreated, or in land treated with a nematicide at various intervals after planting.

Pineapple Varieties	Nematicide treatments* made before and/or at intervals after planting	Nutrient deficient plants at 28 months (%)	Plants bearing at 30 months (%)	Avg. fruit weight (kg)	Calculated yield (tons/ha)	Plants bearing suckers at 30 months (%)
Red Spanish	Before, then 4,8 and 12 months after	60[a]	53[b]	1.02	12.2	
	Four, 8 and 12 months after	85[a]	34[a]	0.62	4.8	
	Eight and 12 months after	74[a]	23[a]	0.62	3.2	
	Twelve months after	84[a]	28[a]	0.62	3.9	
	No treatment	76[a]	25[a]	0.57	3.2	
Smooth Cayenne	Before, then 4,8 and 12 months after	78[a]	36[b]	0.74	6.2	25
	Four, 8 and 12 months after	90[a]	38[b]	0.43	3.8	17
	Eight and 12 months after	88[a]	45[b]	0.54	5.7	9
	Twelve months after	100[a]	13[a]	0.37	1.1	3
	No treatment	100[a]	18[a]	0.30	1.3	2
Sugar Loaf	Before, then 4,8 and 12 months after	39[b]	48[b]	1.59	26.0	
	Four, 8 and 12 months after	69[a]	44[a]	0.91	13.9	
	Eight and 12 months after	68[a]	32[a]	1.02	11.2	
	Twelve months after	69[a]	41[a]	0.85	11.9	
	No treatment	85[a]	36[a]	0.82	10.1	

*A DD (390 l/ha)/DBCP (16.8 l/ha) mix was used before and Nemacur (20 kg a.i./ha) after planting.

[ab]For each pineapple variety, means in any column followed by different letters are significantly different (5%; Duncan's Multiple Range Test).

Parasitic nematodes in soil and roots - Three months after planting, higher numbers of parasitic nematodes were present in the plots which were yet untreated (T2, T3, T4 and T0) than in plots which were fumigated before planting (T1) (Table 2). At seven and 11 months, few nematodes were found in soil and root samples from T1-plots (except for cv, Smooth Cayenne at seven months and cv. Red Spanish at 11 months) while high numbers were present in plots which had received some post-planting nematicidal treatments (T2 at four and eight and T3 at eight months) and the untreated plots (T4 and T0). Although high numbers of nematodes were found in soil in untreated plots or those receiving post-planting treatments only, there is some indication that 11 months after planting T2 caused suppression of nematodes in roots of the three pineapple varieties (Table 2).
Helicotylenchus multicinctus was found in all soil samples and *Pratylenchus* sp. in roots.

Ratoon Crop

Plants showing nutrient deficiency symptoms - For the three pineapple varieties, less T1-plants showed nutrient deficiency symptoms than T2, T3, T4 and T0-plants. However, only for cv. Sugar Loaf was the difference significant (Table 3). More T1-ratoon plants of each variety showed deficiency symptoms than T1-plants of the plant crop.

Production of fruits and suckers - After 30 months, only cv. Red Spanish had significantly more T1-plants which bore fruit than T2, T3, T4 and T0-plants (Table 3). For cv. Smooth Cayenne, more T2 and T3-plants bore fruit than T1-plants. However, for all three varieties, T1-plants bore the largest fruits resulting in the highest overall yield (Table 3). For cv. Smooth Cayenne, more T1 and T2-plants bore suckers than plants getting T3, T4 or no treatment (Table 3).

DISCUSSION

In this trial, the most beneficial method for controlling nematodes damaging cvs Red Spanish, Smooth Cayenne or Sugar Loaf pineapple plants was pre-plant fumigation of soil followed by after-planting nematicide treatments to soil and plants (T1). This treatment was far superior, for every parameter measured, to after-planting treatments only. In the plant crop, T1 suppressed nematode populations from the outset allowing early development of good root systems and good-sized plants few of which showed nutrient deficiency symptoms. Most of these plants bore a large fruit and for cv. Smooth Cayenne, suckered satisfactorily. Plants in the plots receiving the various after-planting treatments only or no treatment had poorly developed root systems and were stunted. Less of these plants bore fruits and these fruits were smaller compared to T1-plants. Soil about and roots of these plants were always heavily infested with parasitic nematodes.

Four months after planting, the majority of plants in unfumigated plots were stunted, had poorly developed root systems and showed symptoms of nutrient deficiency, all indicative of nematode damage. In fact, high soil populations of parasitic nematodes were associated with these plants. At 17 months, none of the post-planting regimen of nematicidal treatments had encouraged a significant response in plant weight, root length or in fruit weight at bearing for any of the pineapple varieties. Furthermore, none of these treatments suppressed soil populations of the parasitic nematodes but there was some indication that the treatment applied four and eight months after planting (T2) suppressed nematodes in roots of the three pineapple

varieties by 11 months after planting. Some T2-plants of cvs Sugar Loaf and Red Spanish recovered to reduce the high incidence of symptoms of nutrient deficiency observed on these varieties early in the plant crop; this was reflected in the increased number of plants which bore fruit and slightly heavier fruit weight. However, this response was of little economic significance. In the plant crop, cv. Smooth Cayenne showed no response to any post-planting regimen of nematicidal treatment.

For the three pineapple varieties, the benefits of preplanting fumigation carried over to the ratoon crop where T1-ratoon plants showed the least symptoms of nutrient deficiency, bore the largest fruits, gave highest overall yields and for cv. Smooth Cayenne, bore most suckers. However, the ratoon crop of cv. Smooth Cayenne showed some response to post-planting nematicidal treatments only as higher percentages of T2 and T3-plants bore fruit than T1-plants. However, T1-plants bore the heaviest fruits. Previous work with cvs Red Spanish and Smooth Cayenne showed that preplanting fumigation alone can benefit ratoon crops (6).

Considering results in the plant and ratoon crops, it seems clear that of the three pineapple varieties used in this trial, cv. Smooth Cayenne was most susceptible to damage by *Helicotylenchus multicinctus* and *Pratylenchus* sp.; cv. Sugar Loaf appeared to be most resistant. Previous work has shown cv. Smooth Cayenne to be more affected by nematodes than cv. Red Spanish (2,6).

Nematode-damaged pineapple plants respond slowly, if at all, to nematicidal treatments. The initial vigour and subsequent development of pineapple plants depend on the roots produced early in the life of the plants (5). At Cave Valley, plants which developed an abundant and healthy root system early, were vigourous, produced high yields and such plants of cv. Smooth Cayenne produced many suckers thereby establishing the potential for good ratooning. It seems that pineapple plants recover slowly and in some cases not at all from severe damage to or loss of early roots, and further, these plants do not appear to have the capacity to replace roots that are damaged or lost. This could explain the insignificant response shown by nematode-damaged pineapple plants to nematicidal treatments. Any condition detrimental to the development of good early root systems by pineapple plants results in corresponding poor plant growth (5). Damage by parasitic nematodes can clearly establish such detrimental conditions.

The results of this trial show that applications of nematicides to nematode-damaged pineapple plants are of little economic benefit even if the treatments are made as early as four months after planting. Continued protection of early roots appears to be vital. It is clear that the best method of nematode control in heavily infested fields is by soil fumigation before planting, then treating at intervals after planting with a nematicide the plants can tolerate; the before-planting treatment is crucial. Any other method results in early nematode damage, loss of plant vigour and low production.

RESUMEN

Piñas de cvs Red Spanish, Smooth Cayenne y Sugar Loaf plantadas en un suelo infestado con nematodos y fumigado previamente a la siembra y que recibieron tratamientos con nematicidas en la postsiembra produjeron mejores sistemas radicales manifestaron menos síntomas de carencia nutritiva y rindieron significativamente más que plantas cuyo primer tratamiento se efectuó, 4, 8, o 12 meses después de la siembra en suelo infestado seguido por otros tratamientos cade 4 meses. Se notó poca diferencia entre plantas tratadas solamente en la postsiembra y las del testigo. Plantas de Smooth Cayenne en suelos con tratamiento de pre- y postsiembra produjeron aumentos importantes en número de retoños y esquejes en comparación con las de otros

suelos. Para todas las variedades los beneficios obtenidos con el tratamiento de presiembra continuó notándose en la cosecha derivada de los retoños. Los resultados indican que la piña mejora poco con tratamientos nematicidas una vez dañada por nematodos.

Claves: Combate, Ananas comosus, Pratylenchus, Helicotylenchus, DD, DBCP, Phenamiphos, Nemacur.

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NEMATICIDAL ACTIVITY OF SODIUM AZIDE [ACTIVIDAD NEMATICIDA DE LA AZIDA DE SODIO]. W.D. Kelley and R. Rodriguez-Kabana. Department of Botany and Microbiology, Auburn University, Auburn, Alabama 36830, USA.

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ABSTRACT

Sodium azide (134.5 kg/ha) was compared to methyl bromide (650 kg/ha) for nematicidal activity in field plots over a 2-year period. Plots treated with methyl bromide generally were free of nematodes throughout the study period. Initially, some decrease in nematode numbers was evident in plots treated with NaN3 but none was evident after 24 weeks. Generally, plant parasitic species of nematodes were more affected by NaN3 than were species of predatory or saprophogous nematodes. Data indicate that NaN3 is not an effective nematicide under field conditions.

Key Words: Smite 8-G, nurseries, biocides, Pinus elliottii, slash pine.

INTRODUCTION

Because of their broad-spectrum biocidal properties and lack of toxic residues, sodium and potassium azide have been proposed for use as soil fumigants. Although azides have been shown to have nematicidal activity (1, 2), their long-term effect on nematode populations in field plots has not been reported. The purpose of this investigation was to compare the nematicidal activity of sodium azide (NaN3) with that