Control of *Rotylenchulus reniformis* in pineapple with fosthiozate*

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Control of *Rotylenchulus reniformis* in pineapple with fosthiozate.

ABSTRACT
Fosthiozate, a nonfumigant nematicide under development, was evaluated for efficacy against *Rotylenchulus reniformis* in pineapple. It was applied through the drip irrigation system at different doses before and after planting. Fosthiozate was compared to 1,3-dichloropropene (1,3-D) for preplant nematode control and to fenamiphos for postplant control. Pineapple plant crop and first ratoon yields were lower when no nematicides were applied. The greatest pineapple yields were achieved with preplant application of 1,3-D followed by regular postplant applications of fenamiphos or fosthiozate. Application of an emulsifiable formulation of fosthiozate before planting was not as effective as fumigation with 1,3-D.

Utilisation du fosthiozate pour lutter contre *Rotylenchulus reniformis* en plantations d'ananas.

RÉSUMÉ
Le fosthiozate, nématicide non fumigant en cours de développement, a été testé dans le cadre de la lutte contre *Rotylenchulus reniformis* en plantation d'ananas. Le produit a été appliqué en goutte-à-goutte à différentes doses, soit avant, soit après plantation. Son efficacité a été comparée à celle du 1,3-dichloropropène (1,3-D) pour un contrôle des nématodes avant plantation et à celle du fénamiphos pour la lutte après plantation. En premier et deuxième cycle, les parcelles sans traitement nématicide ont donné les moins bonnes récoltes. Les meilleurs rendements ont été obtenus avec application de 1,3-D avant plantation, suivie d'apports réguliers de fénamiphos ou de fosthiozate en cours de culture. L'application d'une formulation émulsifiable de fosthiozate avant plantation n'a pas eu autant d'effet qu'une fumigation avec du 1,3-D.

Utilización del fostiozato para luchar contra *Rotylenchulus reniformis* en plantaciones de piña.

RESUMEN
El fostiozato, producto químico no fumigante en curso de desarrollo, fue sometido a prueba en el marco de la lucha contra *Rotylenchulus reniformis* en plantación de piña. El producto fue aplicado en gota a gota a diferentes dosis, sea antes, sea después de la plantación. Su eficacia fue comparada a la del 1,3 dicloropropeno (1,3-D) para un control de los nemátodos antes de su plantación y a la del fenamifos para la lucha después de la plantación. En primer y segundo ciclo, las parcelas sin tratamiento con producto químico dieron las peores cosechas. Los mejores rendimientos se obtuvieron con la aplicación de 1,3-D antes de la plantación, seguida de aportaciones puntuales de fenamifos o de fostiozato durante el cultivo. La aplicación de una formulación emulsifiable de fostiozato antes de la plantación no tuvo tanto efecto como una fumigación con 1,3-D.

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KEYWORDS
Ananas comosus, nematode control, *Rotylenchulus reniformis*, agricultural chemical products.

MOTS CLÉS
Ananas comosus, lutte antinématode, *Rotylenchulus reniformis*, produit agrochimique.

PALABRAS CLAVES
Ananas comosus, control de nemátodos, *Rotylenchulus reniformis*, productos químicos agrícolas.

introduction

Several genera of nematodes are important pathogens of pineapple, *Ananas comosus* (L) Merr, in the tropics and subtropics where the plant is grown commercially (CASWELL et al, 1990). In Hawaii, control of *Rotylenchulus reniformis*, the reniform nematode, and *Meloidogyne javanica*, the rootknot nematode, is necessary for economic pineapple production (ROHRBACH and APT, 1986). Without nematode control, plant crop yield can be significantly reduced and the ratoon crop devastated. Nematode damage results in the production of smaller fruit or the complete loss of fruit production. Current recommendations for nematode control are to fallow between cropping cycles, fumigate with nematicides before planting, and employ regular postplant nematicide treatments. Preplant fumigation is currently accomplished by the use of 1,3-dichloropropene (1,3-D) or methyl bromide.

Agrochemicals approved for postplant nematode control in pineapple in Hawaii include fenamiphos, ethoprophos, and oxamyl. Each pesticide is subject to environmental and regulatory challenges which may limit its continued use. Fenamiphos is the most commonly used product in Hawaii but has experienced accelerated microbial degradation in some soils (OU et al, 1993). The potential exists for loss of efficacy; consequently, alternatives to the standard commercial practices and compounds must be investigated. Fosthiozate is an organophosphate nematicide with efficacy equal to or better than fenamiphos (JOHNSON, 1994; PULLEN and FORTNUM, 1994; RICH et al, 1994). The objective of this experiment was to evaluate the efficacy of fosthiozate as a pre- and postplant treatment for control of *R reniformis* in pineapple.

methods

An experiment was established in a Dole Packaged Foods Company pineapple field infested with *R reniformis* on the island of Oahu (Hawaii). The field was prepared for planting with plantation equipment. A black plastic mulch (25 μm thick) 81 cm wide and a 2.5 cm-diameter drip irrigation tube were installed every 1.1 m, demarcating the planting beds. Thirty-six plots, 15.25 m long by four beds wide, were established in the field. The irrigation lines from each plot were interconnected to a shared valve and joined as a unit to the main irrigation line. The experimental design was a randomized complete block with nine treatments and four replications (table I).

1,3-D (383 kg ai/ha) was injected directly through the plastic mulch on the planting mark with a hand-held fumigun (NA MacLean Co, San Francisco, CA, USA) to a depth of 30.5 cm, 1 month prior to planting with crowns of a Smooth Cayenne clone (58 700 plants/ha). Fosthiozate,

Table I
Pineapple yield in plots infested with *Rotylenchulus reniformis* and treated with the nematicide fosthiozate (Fos) at 67 or 134 kg ai/ha preplant and 17 or 34 kg ai/ha postplant, 1,3-dichloropropene (1,3-D) at 336 kg ai/ha preplant, or fenamiphos (Fen) at 17 kg ai/ha postplant.

	Plant crop				First ratoon crop			
Treatment	*Fruit weight (kg)*	*t/ha*	*Percent packable fruit*	*Marketable t/ha*	*Fruit weight (kg)*	*t/ha*	*Percent package fruit*	*Marketable t/ha*
Fos (6.7)/Fos (1.7)	1.49 e	119.4 cd	83 ab	99.7 de	1.07 d	92.2 e	41 d	38.2 c
Fos (6.7)/Fos (3.4)	1.52 de	121.6 c	83 ab	100.8 de	1.15 c	107.5 cde	48 bcd	54.6 bc
Fos (13.4)/Fos (1.7)	1.51 de	120.4 c	84 ab	100.9 de	1.14 c	104.5 de	53 abc	56.2 bc
Fos (13.4)/Fos (3.4)	1.56 cd	124.5 bc	86 ab	107.1 cd	1.22 b	119.7 bcd	59 ab	70.0 ab
1.3-D/Fos (1.7)	1.63 b	130.5 ab	88 ab	114.2 abc	1.28 ab	130.7 abc	61 a	80.4 ab
1.3-D/Fos (3.4)	1.69 a	135.3 a	87 ab	117.3 ab	1.29 a	134.0 ab	64 a	87.4 a
1.3-D/Fen	1.70 a	136.4 a	90 a	122.3 a	1.33 a	144.2 a	64 a	94.7 a
1.3-D	1.57 c	126.0 bc	87 ab	109.0 bcd	1.23 b	121.0 abcd	58 ab	70.6 ab
Untreated	1.40 f	112.4 d	81 b	91.1 e	1.08 d	93.4 e	44 cd	42.9 c

a, b, c, d, e, f : Values in a column followed by the same letter are not different according to the Waller-Duncan *k*-ratio *t*-test (*k* = 100).

(6.7 or 13.4 kg ai/ha) was mixed in 19 l of water and applied through the drip irrigation line 1 week after the pineapples were planted for the preplant treatment. After injecting the fosthiozate solution, the equivalent of 51 400 l/ha water was applied to the plots to move the chemical into the root zone.

Postplant nematicide applications of fenamiphos (1.7 kg ai/ha) and fosthiozate (1.7 and 3.4 kg ai/ha) commenced 3 months after planting and were repeated at 6, 9, 12, 15, 19, 23, and 25 months after planting.

The pineapple plants were fertilized, irrigated, and induced to flower 12 and 24 months after planting according to the standard plantation practice.

Plant growth was measured to evaluate treatment effects. Plant weight was estimated at 6 months after planting. The weight of ten randomly collected D-leaves (the youngest, fully mature leaf) was recorded at 9 months after planting. Pineapple harvest data were collected at shell color 4 for both the plant crop and first ratoon crop. The first 100 fruit in the two center beds of each plot were harvested. The fruit were individually weighed and graded (PY et al, 1987). Fruit yield is expressed in t/ha, percent packable fruit (fruit between 1.2 and 2.9 kg), and as marketable t/ha [(percent packable) x (t/ha)].

Nematode soil population densities were recorded on a trimonthly basis. A soil sample was collected from the area between the two center beds, sieved (0.5 cm mesh), and a 250 cm^3 subsample processed by elutriation (BYRD et al, 1976) and centrifugation (JENKINS, 1964) to extract nematodes for counting. Sucker counts were made in the ratoon crop at the time of flower induction, 6 months after plant crop harvest. Fruit yield and nematode counts were subjected to an analysis of variance to test for differences among treatments. Treatment differences are shown by a Waller-Duncan *k*-ratio *t*-test (STEELE and TORRIE, 1980).

results

Nematode soil population densities increased from low preplant levels (70-418 nematodes/250 cm^3 soil) to what is probably the average carrying capacity in the field, 4 200 *R reniformis*/250 cm^3 soil (range 3900-8900/250 cm^3), by the plant crop harvest (fig 1). Nematode population densities decreased after treatment with 1,3-D but not with preplant application of fosthiozate (fig 1). The nematode population density increase was similar among all treatments. Nematode soil population densities were not correlated to plant crop harvest.

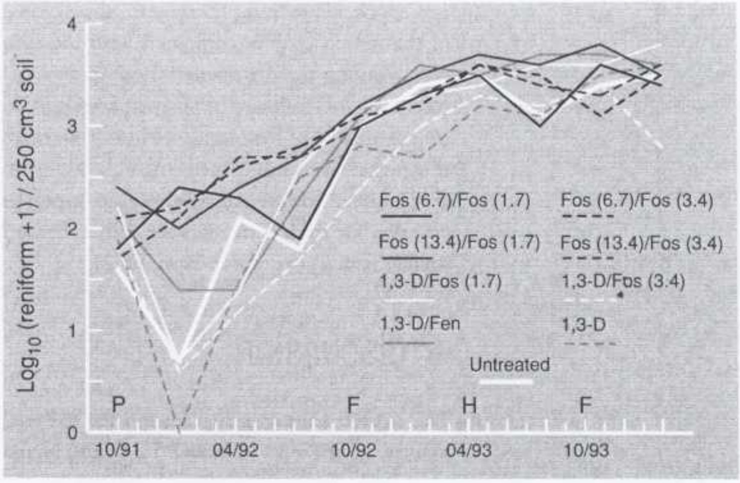

Figure 1
Soil populations of Rotylenchulus reniformis under different nematicide regimes: fosthiozate (Fos) preplant at 67 or 134 kg ai/ha and 17 or 34 kg ai/ha postplant; 1,3-dichloropropene (1,3-D) (383 kg ai/ha) preplant; and fenamiphos (Fen) at 17 kg ai/ha. Preplant treatments precede postplant nematicides in all legends. Planting (P), forcing (F), and harvesting (H) are shown on the axis for reference.

Pineapple plant growth was different among the treatments. At 6 months after planting, plants in plots treated with 1,3-D were larger than those in plots not receiving a 1,3-D treatment. Differences were more pronounced by 9 months after planting (fig 2). The largest D-leaves were found in plots treated with 1,3-D and postplant fosthiozate at 3.4 kg ai/ha. The smallest D-leaves were found in the plots receiving the pre- and postplant fosthiozate at 13.4 and 1.7 kg ai/ha, respectively.

Plant crop yield reflected slight differences among the treatments in average fruit weight, t/ha, percentage packable fruit, and marketable t/ha (table I). Average fruit weight was greatest in the 1,3-D- and fenamiphos-treated plots, followed closely by the 1,3-D and fosthiozate (3.4 kg ai/ha) treatments. The smallest fruit occurred in the untreated plots.

More differences occurred among treatments in the ratoon crop (table I). Marketable t/ha was reduced by over 50% in the untreated plots compared to the 1,3-D- and fenamiphos-treated plots. Average fruit weight was smaller and the percent packable fruit decreased in all treatments of the ratoon crop as compared with the plant crop. Among the treatments, those plots which received 1,3-D followed by postplant applications of fenamiphos or fosthiozate yielded better than those which were not treated with 1,3-D preplant applications. Fruit size distribution, an important criterion for fresh fruit markets, shifted towards smaller fruit in the ratoon crop (fig 3).

discussion

The desired fruit size distribution for the fresh market lies between 1.4 and 2.5 kg/fruit. Nematode feeding on the pineapple roots caused a reduction in plant size and consequently in fruit size. Nematicides play an important and necessary role in maintaining the desired fruit size distribution for the fresh fruit market. Inadequate nematode control resulted in less total fruit production and smaller fruit. The consequence was a substantially lower marketable yield when nematodes were not controlled, especially in the ratoon crop.

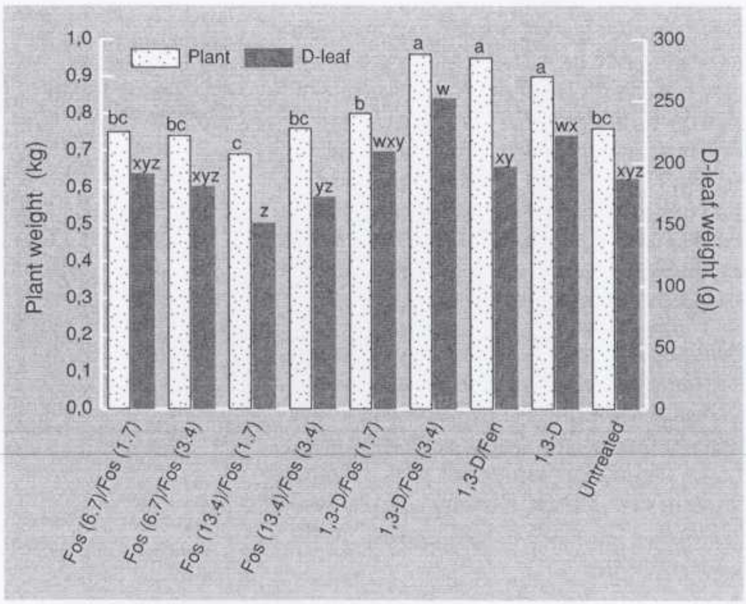

Figure 2
Pineapple growth at 6 (plant weight) and 9 months (D-leaf weight) after planting in plots treated with fosthiozate (Fos) at 67 or 134 kg ai/ha and 17 or 34 kg ai/ha postplant; 1,3-dichloropropene (1,3-D) (383 kg ai/ha) preplant, and fenamiphos (Fen) at 17 kg ai/ha postplant. Letters above bars represent statistical differences (k = 100).

Population densities of *R reniformis* in the soil were not an accurate indicator of the efficacy of the chemical treatments. In fact, high nematode

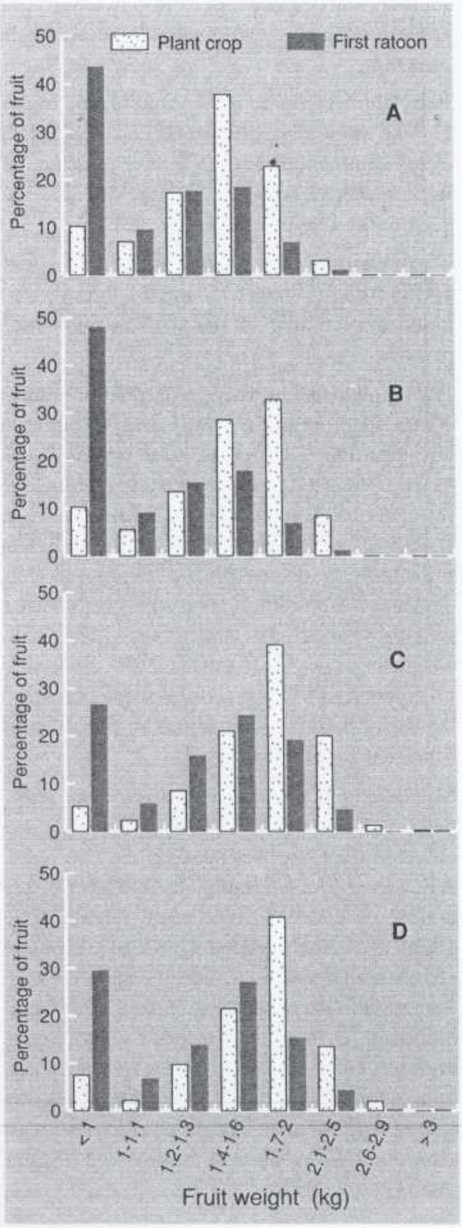

Figure 3
Pineapple fruit size distribution in the plant and ratoon crops from plots receiving (A) no nematode control, (B) fosthiozate (Fos) preplant at 67 kg ai/ha and 17 kg ai/ha postplant, (C) 1,3-dichloropropene (1,3-D) (383 kg ai/ha) preplant and fenamiphos (Fen) at 17 kg ai/ha postplant, or (D) 1,3-D (383 kg ai/ha) preplant and Fos at 17 kg ai/ha postplant.

numbers probably reflected a vigorous pineapple root system which was able to support large numbers of nematodes. This often occurs in annual crops where nematicides protect early root growth providing a large food base for a nematode population late in the season (SCHMITT et al, 1983). Future research may show that nematodes per gram of root is a better indicator of treatment efficacy than the standard evaluation of vermiform soil populations.

Fosthiozate controlled and limited damage of *R reniformis* to pineapple when used as a postplant treatment following preplant treatment with 1,3-D. Its efficacy was similar to fenamiphos. The results of this experiment reiterate the need for effective preplant nematode control. The preplant applications of fosthiozate were insufficient to protect the pineapple plants from nematode damage. The preplant irrigation application of fosthiozate probably was not sufficient to distribute the pesticide uniformly in the soil. Nonfumigant nematicides, such as fenamiphos and fosthiozate, are typically less effective when compared to fumigant nematicides such as 1,3-D. Consequently, poor distribution of the fosthiozate in the soil could reduce efficacy.

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