EFFICACY OF PLANTING TIME INJECTIONS TO SOIL OF LIQUID FORMULATIONS OF THREE SYSTEMIC NEMATICIDES AGAINST ROOT-KNOT NEMATODES IN PEANUTS [EFICACIA DE INYECCIONES AL SUELO EN LA SIEMBRA DE PREPARACIONES LIQUIDAS DE TRES NEMATICIDAS SISTEMICOS CONTRA NEMATODOS NODULADORES DEL MANI]

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ABSTRACT

Diluted liquid formulations of the systemic nematicides carbofuran (Furadan® 4F), oxamyl (Vydate® 2L), and phenamiphos (Nemacur® 3SC) were chisel injected at planting time for control of *Meloidogyne arenaria* on peanuts *(Arachis hypogaea)* during the 1978 and 1979 season in South Alabama. Applications of oxamyl improved the general growth of peanuts and increased yields to levels comparable to those obtained with the fumigant EDB (Soilbrom® 90 EC). Phenamiphos was as effective as oxamyl in the 1979 experiment but not in 1978. Significant reductions in larvae of *M. arenaria* in soil at the end of the season were obtained only with oxamyl and only in 1979. Application of carbofuran did not reduce larval numbers in soil and failed to improve the general appearance of plots. Injections of carbofuran significantly increased yields only when applied at rates higher than 2.2 kg ai/ha. Results indicate that injection of liquid formulations of systemic nematicides is a practical and economical method for nematode control in peanuts.
Key Words: methods of application, formulations, nematode control, phosphorothioates, carbamates, root-knot nematodes.

INTRODUCTION

Systemic nematicides have been available for use on peanuts *(Arachis hypogaea)* for several years. However, acceptance of use of these materials by farmers has not been satisfactory. The fumigant nematicide DBCP has been the traditional chemical used to combat nematodes on peanuts (2,6). Recently, DBCP use was cancelled on peanuts in the USA because of its effect on human health (1). Although the fumigant EDB has been recommended as an alternative for DBCP (9), the systemic nematicides are receiving greater attention for use on peanuts. Performance of systemic nematicides in peanuts has been erratic (4,8), perhaps because knowledge is lacking on correct procedures for their use on peanuts. In a recent study, for example, we reported that thorough incorporation of systemic nematicides into soil was not necessary and under certain conditions was detrimental for optimal effectiveness of the chemicals against nematodes (8). Use of systemic nematicides on peanuts has been predominantly with granular application while the use of liquid formulations has not been explored as extensively. In this paper we present data on the use of liquid formulations of three systemic nematicides for control of *Meloidogyne arenaria* on peanuts.

MATERIALS AND METHODS

Experiments were conducted in 1978 and 1979 at the Wiregrass Substation at Headland, Alabama. The experimental field was irrigated and had been under continuous peanut culture for 3 years. The soil was a sandy loam with a pH of 6.2, 1% organic matter, and moderately (ca. 15-20 larvae/50 cm^3 soil) to heavily (20 larvae/50 cm^3 soil) infested with *M. arenaria* depending on the location. Other plant parasitic nematodes were present in insignificant numbers.

Each plot in the experiments consisted of two 91 cm rows 10 m long. Each treatment was replicated 8 times in a randomized complete block design. The peanut cultivar "Florunner" was used. Control of peanut leafspot *(Cercospora arachidicola)*, weeds, and insects was obtained following recommended practices for South Alabama (2).

In 1978, the efficacies of oxamyl (Vydate® 2L) and phenamiphos (Nemacur® 3SC) were compared with that of the soil fumigant EDB (Soilbrom® 90 EC) (9). The fumigant was applied at planting at the rate of 18.7 l/ha to a depth of 20 cm using a gravity flow applicator with 2 chisels per row set 20 cm apart one on either side of the seed furrow. Nemacur and Vydate were diluted in water to have emulsions that contained 60 g ai/l (0.5 lb ai/gal). The emulsions were injected into the soil using 3 chisels per row as described previously. The center chisel delivered the nematicide directly below the seed furrow to a depth of 10 cm; the other 2 chisels were spaced 7.6 cm on either side of the center chisel and were set to inject the chemical to a depth of 13 cm. Nemacur and Vydate were each applied at the rate of 2.2, 3.3, and 4.5 kg ai/ha.

In 1979, the same formulations were evaluated along with carbofuran (Furadan® 4F). The nematicides were applied using 2 chisels set 10 cm apart, one on either side of the seed furrow and delivering the chemicals to a depth of 10 cm. Each nematicide was applied at the rate of 1.1, 2.2, 3.3, and 4.5 kg/ha.

A relative visual rating of plants in each plot was made in mid-August using a subjective scale of 1 (poor appearance, restricted growth, and chlorotic leaves) to 5 (best appearance and excellent growth).

Soil samples for nematode analysis were collected just prior to harvest to coincide with the period of maximum population development (3). Each sample consisted of soil cores 2.5 cm in diam obtained from the root zone to a depth of 15-20 cm along the center of each plot to provide a total of 15-18 cores per plot. The cores from each plot were composited and a 50 cm^3 subsample was used to extract nematodes following the molasses flotation sieving technique (10,11). Peanut yield was determined at maturity from each plot. Data were analyzed by analysis of variance, and differences between means were evaluated for significance with the least significant difference test (12). Unless otherwise specified all differences mentioned in the text were significant to the 5% or lower level of probability.

RESULTS

In 1978 the experiment was located in an area with a moderate infestation of *M. arenaria*. This was reflected in the relatively low number of larvae extracted (Table 1). None of the nematicides significantly reduced the number of larvae below those found in the control. However, Soilbrom reduced the nematode to very low levels. A significant ($P = 0.05$) improvement in the growth response of plants was observed in plots treated with Vydate, Soilbrom, and the highest dosage of Nemacur. Peanut yields were increased significantly by Soilbrom, and by all the Vydate treatments. Yield differences between the Vydate treatments or between Vydate, Soilbrom, or the 3.3 kg/ha Nemacur treatment were not significant.

Results from the 1979 experiment are presented in Table 2. Furadan failed to

Table 1. Effect of two systemic nematicides injected at planting on the root-knot nematode, *Meloidogyne arenaria*, in a field with Florunner peanuts during the 1978 season at Headland, Alabama.

Treatment	Rate (kg ai/ ha)	*M. arenaria* (larvae/50 cm^3 soil)	Growth response rating [y]	Yield (kg/ha)
Control		14	3.2	3379
Nemacur 3 SC (phenamiphos)	2.2	16	3.0	3607
Nemacur 3 SC	3.3	25	3.5	3954
Nemacur 3 SC	4.5	18	3.7	3756
Vydate 2L (oxamyl)	2.2	11	3.6	4087
Vydate 2L	3.3	9	3.8	4339
Vydate 2L	4.5	6	3.6	4198
Soilbrom 90 EC (EDB)	(18.7 l/ha)	1	3.6	4285
LSD (P = 0.05):		15	0.4	443
LSD (P = 0.01):		21	0.6	478

[y] Growth response rating of plants in plots based on a scale where 1 = poorest and 5 = excellent.

significantly reduce the number of larvae of *M. arenaria* in soil or to improve the growth response. Only the 2 highest rates of this nematicide resulted in significant (P = 0.05) increases in yields. The only Nemacur treatment that resulted in significant reductions in the number of larvae was the 4.5 kg/ha rate. Soilbrom and all the Vydate treatments, with the exception of the 3.3 kg/ha rate significantly (P = 0.05) reduced the numbers of the larvae. All Nemacur, Vydate, and Soilbrom applications significantly (P = 0.01) increased the value of the growth response rating and peanut yields.

DISCUSSION

Systemic nematicides have been applied traditionally to peanuts in granular form either as a 10% or a 15% formulation. The use of granules increases bulk and hence the cost of transportation. Liquid formulations such as those used in the present study permit conveyance to the farmer of large amounts of active ingredients in a more concentrated form reducing some of this cost. In addition, for some systemic nematicides (phenamiphos and oxamyl) liquid formulations are considerably more stable than granular formulations so that the active ingredients can be stored from season to season without a significant loss of active ingredient. The difficulty in utilizing liquid formulations has been the lack of a suitable method of application. When sprayed either in-furrow or in narrow bands with the planting equipment the spray wets the soil

Table 2. Effect of three systemic nematicides injected at planting on the root-knot nematode, *Meloidogyne arenaria*, in a field with Florunner peanuts during the 1979 season at Headland, Alabama.

Treatment	Rate (kg ai/ ha)	*M. arenaria* (^{3}) (larvae/50 cm soil)	Growth response rating [y]	Yield (kg/ha)
Control		44	3.4	1824
Furadan 4F (carbofuran)	1.1	40	3.4	1849
Furadan 4F	2.2	43	3.4	1824
Furadan 4F	3.3	63	2.8	2243
Furadan 4F	4.5	30	3.1	2293
Nemacur 3 SC (phenamiphos)	1.1	48	3.8	2736
Nemacur 3 SC	2.2	47	4.1	2663
Nemacur 3 SC	3.3	49	4.0	2983
Nemacur 3 SC	4.5	21	3.9	2934
Vydate 2L (oxamyl)	1.1	21	4.0	3106
Vydate 2L	2.2	23	4.3	3230
Vydate 2L	3.3	29	4.1	3106
Vydate 2L	4.5	23	4.1	3649
Soilbrom 90 EC (EDB)	(18.7 l/ha)	23	4.1	3378
LSD (P = 0.05):		20	0.3	369
LSD (P = 0.01):		36	0.4	517

[y] Growth response rating of plants in plots based on a scale where 1 = poorest and 5 = excellent.

quite often resulting in muddying and plugging of the planter (7). Injecting the nematicides is free of this inconvenience and opens the possibility of practical usage of liquid formulations of systemic nematicides by farmers.

Injection of oxamyl and phenamiphos at high rates is amenable for control of *M. arenaria* on peanuts. Previous investigations (8,5) indicate that maximal effectiveness of systemic nematicides is obtained when the chemicals are applied to the soil in narrow concentrated bands around the seed with minimal incorporation into the soil. The liquid formulations were applied with a gravity flow applicator used normally for

delivery of soil fumigants. Injection of systemic nematicides into the soil could also be performed with the use of a positive pressure system, which would eliminate in part the clogging of chisels by soil and debris that occasionally occurs when using a gravity flow applicator.

We used 3 chisels in 1978 and 2 chisels in 1979 to deliver the concentrated nematicides below the seed. It is conceivable that only one chisel would be sufficient to attain the same level of efficacy. We believe that these materials should be available in concentrated form for absorption by the developing root system and not be dispersed in the soil subject to leaching or decomposition before the roots can reach them and absorb them in significant concentrations.

RESUMEN

La efectividad de preparaciones líquidas de los nematicidas sistémicos carbofurán (Furadan 4L), fenamifos (Nemacur 3SC) y oxamil (Vydate 2L) para el combate de *Meloidogyne arenaria* en maní *(Arachis hypogaea)* fueron estudiadas en 1978 y 1979 en un campo en el sur de Alabama. Las preparaciones fueron diluidas en agua para obtener emulsiones con 60 gm de ingrediente activo (ia) por litro (0.5 lbs ia/galon) y luego se inyectaron en el suelo en concentraciones de 1.1-4.5 kg ia/ha. La inyección se efectuó utilizando 3 (1978) o 2 (1979) inyectores por cada surco y a 7.6-10 cm bajo la sementera y por cada lado de la misma (1978) o bién sólo lateralmente (1979). Los tratamientos con oxamil mejoraron la apariencia general de las plantas y aumentaron los rendimientos a niveles comparables a los obtenidos con el fumigante BDE (Soilbrom 90 EC). Fenamifos fue tan efectivo como oxamil en el experimento de 1979 pero no asi en el de 1978. Sólo se obtuvieron disminuciones significativas en el número de larvas de *M. arenaria* en el suelo al final de la estación con oxamil y sólo en 1979. La inyección de carbofurán en el suelo no redujo el número de larvas y no mejoró la apariencia general de las plantas. La aplicación de carbofurán al suelo sólo resultó en un aumento en rendimiento con dosis superiores a 2.2 kg ia/ha. Los resultados obtenidos señalan que la inyección al suelo de preparaciones líquidas de nematicidas sistémicos es un método práctico y económico para combatir nematodos en maní.

Claves: métodos de control, preparaciones nematicidas, combate de nematodos, fosforotioatos, carbamatos, nematodos noduladores.

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