COMPARISON OF IN-FURROW APPLICATIONS AND BANDED TREATMENTS FOR CONTROL OF *MELOIDOGYNE ARENARIA* IN PEANUTS AND SOYBEANS.

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ABSTRACT

Rodríguez-Kábana, R., P.S. King, and M.H. Pope. 1981. Comparison of in-furrow applications and banded treatments for control of *Meloidogyne arenaria* in peanuts and soybeans. Nematropica 11: 53-67.

Aldicarb, oxamyl, phenamiphos and carbofuran were applied at planting time in field experiments with Ransom soybeans and Florunner peanuts to study the effect of the method of application on their efficacy against *Meloidogyne arenaria* (Neal) Chitwood. Each nematicide was applied at rates of one and two pounds a.i./acre in the soybean tests and at one, two, and three pounds a.i./acre in the peanut experiments. Each nematicide rate in the soybean experiments was applied in-furrow, and in five and 14-inch bands followed by light incorporation; in the peanut experiments an additional seven-inch band application was included. Results indicated that banded applications were superior to in-furrow applications both for control of the nematode and in consequent yield response. Band widths of five or seven inches were adequate for optimal efficacy of the nematicides; no particular advantage was derived from the use of the 14-inch band when compared with the narrower bands of application.

Additional Key Words: root-knot nematodes, Arachis hypogaea, Glycine max, nematode control

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RESUMEN

Rodríguez-Kábana, R., P.S. King, and M.H. Pope. 1981. Comparación de tratamientos en la sementera y en franjas para el combate de *Meloidogyne arenaria* en maní y soya. Nematropica 11: 53-67.

Se aplicaron aldicarb, oxamil, fenamifos y carbofurán durante la siembra en experimentos de campo con soya Ransom y maní Florunner para determinar el efecto del método de aplicación sobre sus eficacias contra *Meloido-*

gyne arenaria (Neal) Chitwood. En los experimentos con soya cada nematicida se usó en dosis de una y dos libras i.a. por acre y en los de maní en dosis de una, dos y tres libras i.a./acre. Cada dosis en los experimentos con soya se aplicó en la sementera (in-furrow), así como en franjas de cinco y 14 pulgadas con incorporación ligera en el suelo. Los experimentos con maní fueron idénticos pero con una franja adicional de siete pulgadas. Los resultados señalaron que en general los tratamientos en franjas fueron superiores a los en sementera tanto para el combate del nematodo como en los aumentos en rendimientos consecuentes. Aparentemente franjas de cinco o siete pulgadas son adecuadas para la aplicación de los nematicidas obteniéndose óptimas eficacias con las mismas, siendo la franja de 14 pulgadas innecessria.

Palabras claves adicionales: nematodos noduladores, Arachys hypogaea, Glycine max, combate de nematodos.

INTRODUCTION

Control of plant parasitic nematodes on peanuts in the Southeastern United States is dependent on the use of nematicides (8). In soybeans the use of nematicides in conjunction with nematode-resistant cultivars of soybeans is viewed today as the most profitable approach to the control of the parasites (4,6,7). Until recently the nematicide of choice for the area was the fumigant DBCP. However, because DBCP posed unacceptable risks for human health (1) it is no longer available for use by farmers. Other fumigant nematicides such as ethylene dibromide (EDB) have replaced DBCP in peanuts and soybeans (4,10,11,13). In addition, the use of nonfumigant systemic nematicides in granular formulations has increased because of ease of application and because of the additional insecticidal properties of some of these materials. Increased use of systemic nematicides has raised questions regarding the correct methods for their application in peanuts and soybeans. Success or failure of these materials is often dependent on the degree of incorporation into the soil following application (12). Also, there are indications that systemic nematicides do not have to be applied over a wide area for effectiveness against root knot nematodes (9) in peanuts. However, no comparative information is available on the effect of the width of the nematicide treatment area on peanuts and soybeans on the effectiveness of systemic nematicides. To gain information on the subject we conducted field experiments comparing in-furrow applications and band applications of representative nematicides for control of *Meloidogyne arenaria* (Neal) Chitwood on the crops.

MATERIALS AND METHODS

Description of Experiments. Two tests with Ransom soybeans were conducted in 1980 at the Gulf Coast Substation near Fairhope, Alabama. The tests were contiguous in an essentially level field with a silt loam soil that had been under soybean monoculture for the previous five years. The soil was heavily infested with root-knot nematode (*M. arenaria)* and had a pH of 6.2 and an organic matter content of less than 1%. Plots in the experiments were two row (36 inches each) wide and 20 feet long. Each test was arranged in a randomized complete block design with eight replications (plots) per treatment. One test was designed to study the effects of aldicarb (Temik® 15G) and phenamiphos (Nemacur® 15G) on yield and larval populations when applied at planting time at one and two pounds active ingredient (a.i.) per acre. Effect of the mode of application of the chemicals on their efficacy was studied by applying each rate in-furrow and in a 5-inch or 14-inch band over the seed. The nematicides in the banded treatments were incorporated lightly to a 1.5 -2 inches depth, just prior to delivery of the seed. A treatment with EDB-90 (Soilbrom® 90) injected at two gal/acre and applied at planting time (10) was included to serve as positive control.

The second soybean test was of identical design to the one described above but had the purpose of determining the efficacies of carbofuran (Furadan® 10G) and oxamyl (Vydate® 10G).

Four peanut experiments were established in 1980 at the Auburn University Wiregrass Substation near Headland, Alabama, using the cultivar Florunner in a field that had been planted to peanuts in each of the previous five years. The field was essentially level with a sandy loam soil heavily infested with *M. arenaria* (ca. 80-100 larvae/100 cm^3 soil), a pH of 6.2 and organic matter content of less than 1%. Plot size and experimental design for these experiments were similar to the soybean tests except that plot length was 30 feet. The experiments were designed to study the effects of width of the treated area on the efficacy of the nematicides against *M. arenaria* and their effects on peanut yields. Each test contained one nematicide applied at rates of 1, 2, and 3 lbs a.i./acre and included for each rate an in-furrow application and planting time band applications at widths of 5, 7, and 14 inches. Banding applications were performed as described for the soybean tests.

Cultural practices, control of weeds, insects, and foliar diseases in all tests were as recommended (2). Yields were obtained at maturity of the crops by harvesting the entire plot area.

Nematode analyses. Soil samples in all tests were taken from each plot two (soybeans) to three (peanuts) weeks before harvest to coincide with the periods of maximal population development for *M. arenaria* (3). Each sample consisted of 15-20 one-inch diameter soil cores collected from the root zone to a depth of 6-8 inches along the center of both plot rows. The cores from each plot were composited and a 100 cm^3 subsample was used to extract nematodes with a modified Baerman method. The number of *M. arenaria* larvae from each sample was determined by direct counting with a dissecting microscope.

Statistical analyses. All data were subjected to statistical analyses following standard procedures for analysis of variance and when applicable the data were analyzed factorially (14) to determine the effects of methods of application and nematicide rates on the variables studied. Differences between means were evaluated for significance according to a modified Duncan's multiple range test (14). Unless otherwise stated all differences referred to in the text were significantly different at the 5% or lower level of probability.

RESULTS

Soybean Experiments. Data from the soybean experiments are presented in Tables 1 and 2. Nemacur and Temik failed to reduce larval populations of *M. arenaria* when compared with populations in control plots (Table 1). However, factorial analysis of the effects of the method of application on the efficacy of the nematicides against *M. arenaria* revealed a significant interaction between methods of application and nematicide rates indicating that no general trend could be established and that the effect was dependent on nematicide rate. Thus, while Nemacur at the one pound rate was not affected by the method of application, larval populations in plots with the in-furrow treatment at the two pound rate were higher than in plots where the dosage was applied by banding. Larval populations in plots that received one pound of Temik in banded applications were higher than when the nematicide was applied in-furrow; however, the reverse was true of the two pound rate. Soilbrom 90 was the only treatment that resulted in significant reductions in larval populations. All nematicide treatments resulted in increased yields. For this variable the interaction between rates and method of application was not significant so that some generalizations could be made. The two pound rate of each nematicide resulted in higher yields than the one pound rate. Further, in-furrow applications resulted in lower yields than banded applications and highest yields corresponded to the five-inch band treatments.

Vydate was more effective than Furadan in reducing larval populations of *M. arenaria* (Table 2). Thus, while both rates of Vydate significantly reduced larval populations to levels below those found in control plots, this was not true for Furadan 10G. The interaction between rates and methods of application for larval numbers was not significant, and results for Vydate 10G indicated that the banded treatments reduced numbers of larvae below those in the in-furrow treatment; however, differences in larval numbers between the banded treatments were not significant.

Applications of Vydate 10G and Furadan 10G increased yields significantly (Table 2). Highest yields were obtained with Vydate treatments, and among these the two pound rate resulted in higher yields than the one pound rate. Yield differences betwen the two rates of Furadan 10G were not significant. The interaction between rates and methods of application for the yield

Table 1. Effect of the method of application on the efficacy of two systemic nematicides against *Meloidogyne arenaria* in a 1980 field experiment with Ransom soybeans near Fairhope, Alabama

Method of Application	Pounds of Active Ingredient Per Acre							
	One Pound				Two Pounds			
	Nemacur 15G		Temik 15G		Nemacur 15G		Temik 15G	
	Larvae[y]	Yield (lbs/A)	Larvae	Yield (lbs/A)	Larvae	Yield (lbs/A)	Larvae	Yield (lbs/A)
In-furrow	175 A	1096 C	140 C	1252 D	220 A	1387 C	222 A	1463B
5" band	151 A	1281 B	324 A	1419 B	151 B	1565 A	108 BC	1670 A
14" band	159 A	1274 B	252 B	1310 C	148 B	1456 B	146 B	1615 A
Control	147 A	835 D	147 C	834 E	147 B	835 D	147 B	835 C
Soilbrom® 90 (2 gal/A)	75 B	1561 A	75 D	1561 A	75 C	1561 A	75 C	1561 B

[x]Figures for variables are the averages of 8 replications; those within the same column followed by a common letter were not significantly different (P = 0.05).

[y]Per 100 cm^3 soil.

Table 2. Effect of the method of application on the efficacy of Vydate 10G (oxamyl) and Furadan 10G (carbofuran) against *Meloidogyne arenaria* in a 1980 field experiment with Ransom soybeans near Fairhope, Alabama.

	Pounds of Active Ingredient Per Acre							
	One Pound				Two Pounds			
Method of	Vydate 10G		Furadan 10G		Vydate 10G		Furadan 10G	
Application	Larvae[y]	Yield (lbs/A)	Larvae	Yield (lbs/A)	Larvae	Yield (lbs/A)	Larvae	Yield (lbs/A)
In-furrow	235 A	1656 B	194 A	1347 B	212 A	1749 B	256 A	1306 BC
5" band	160 B	1871 A	231 A	1261 B	145 BC	2026 A	257 A	1245 C
14" band	131 B	1774 A	202 A	1322 B	173 B	1916 A	152 B	1432 B
Control	228 A	1162 C	228 A	1162 C	228 A	1162 C	228 A	1162 D
Soilbrom® 90 (2 gal/A)	110 B	1779 A	110 B	1779 A	110 C	1779 B	110 B	1779 A

[x]Figures for variables are the averages of 8 replications; those within the same column followed by a common letter were not significantly different ($P = 0.05$).

[y]Per 100 cm^3 soil.

Table 3. Effect of the method of application on the efficacy of Nemacur 15G (Phenamiphos) against *Meloidogyne arenaria* in a 1980 field experiment with Florunner peanuts at Headland, Alabama

	Pounds of Active Ingredient Per Acre					
	One Pound		Two Pounds		Three Pounds	
Method of Application	Larvae[y]	Yield (lbs/A)	Larvae	Yield (lbs/A)	Larvae	Yield (lbs/A)
In-furrow	51 A	3018 B	32 B	3160 B	40 B	3044 B
5" band	39 B	3231 A	19 C	3574 A	30 B	3456 A
7" band	23 B	3279 A	56 A	3153 B	6 C	3255 BC
14" band	38 B	2979 B	8 CD	3436 A	1 C	3320 AC
Control	65 A	2485 C	65 A	2485 C	65 A	2485 D
Soilbrom© 90 (2 gal/A)	1 C	3248 A	1D	3248 B	1 C	3248 BC

[x]Figures for variables are the averages of 8 replications; those within the same column followed by a common letter were not significantly different ($P = 0.05$).
[y]Per 100 cm^3 soil.

data was highly significant (P = 0.01) and is interpreted as a reflection of the differences in response obtained with the two nematicides. Thus, while differences in yields between methods of applications were not generally significant, yields obtained with the Vydate banded treatments were signficantly higher than those obtained with the in-furrow treatment; differences in yield between the banded treatments with Vydate 10G were not significant.

Peanut experiments. Nemacur 15G significantly reduced larval populations of *M. arenaria* at all rates tested (Table 3). Differences between rates, when considered independent from the method of application, revealed that the size of the larval population was inversely related to nematicide rate. The interaction between rates and methods of application was significant for larval numbers so that no generalized pattern of response could be derived by comparing differences between methods of application within rates. Thus, at the one pound rate larval numbers in all banded treatments were lower than in the in-furrow treatment; however, at the three pound rate this was true only for the two widest bands and for the two pound rate of the 5-inch and the 14-inch band treatments. The 14-inch band treatment resulted in consistently lower numbers of larvae than the in-furrow treatment, and with one exception (2 lbs rate) this was also true for the 7-inch band treatment. All rates of Nemacur 15G resulted in significantly higher yields than the untreated control. However, the only significant yield difference between rates were those between the one pound rate and the other two rates. The interaction between rates and methods of application for yields was not significant and a pattern of response to methods of application could be established; highest yields were obtained with the 5-inch band treatments and lowest with the in-furrow treatments. Differences in yield between the 7-inch and 14-inch band treatments were not signficant.

Analysis of results obtained for Temik 15G (Table 4) indicated that, when rates were considered independently from the method of application, the nematicide reduced larval populations at all rates tested. Further, the reductions in larval populations were inversely proportional to nematicide rate. The interaction between rates and methods of application for larval populations was significant indicating that the effect of the methods of application on nematicide efficacy was rate dependent. Thus, while at the one pound rate lower numbers of larvae were found in response to the banded treatments than with the in- furrow applicatons, this pattern was not true at the two pound rate; at the three pound level only the 5-inch and the 7-inch band treatments had lower numbers of larvae than the in-furrow treatment. In contrast, the corresponding interaction between rates and methods for yield was not significant. Yield response was positively related to Temik rates and band treatments resulted in significantly higher yields than the in-furrow treatments; yield differences between band treatments were generally not significant.

Table 4. Effect of the method of application on the efficacy of Temik 15G (aldicarb) against *Meloidogyne arenaria* in a 1980 field experiment with Florunner peanuts at Headland, Alabama

	Pounds of Active Ingredient Per Acre					
	One Pound		Two Pounds		Three Pounds	
Method of Application	Larvae[y]	Yield (lbs/A)	Larvae	Yield (lbs/A)	Larvae	Yield (lbs/A)
In-furrow	102 A	2335 C	42 B	2664 BC	41 B	3027 B
5" band	66 B	2819 B	72 A	3417 A	10 C	3189 B
7" band	44 BC	2957 B	33 BD	3352 A	14 C	3221 AB
14" band	25 C	2993 B	21 BD	2863 B	30 BC	3497 A
Control	96 A	2449 C	96 A	2449 C	96 A	2449 C
Soilbrom© 90 (2 gal/A)	15 D	3359 A	15 D	3359 A	15 C	3359 A

[x]Figures for variables are the averages of 8 replications; those within the same column followed by a common letter were not significantly different ($P = 0.05$).
[y]Per 100 cm^3 soil.

Table 5. Effect of the method of application on the efficacy of Vydate 10G (oxamyl) against *Meloidogyne arenaria* in a 1980 field experiment with Florunner peanuts at Headland, Alabama

	Pounds of Active Ingredient Per Acre					
	One Pound		Two Pounds		Three Pounds	
Method of Application	Larvae[y]	Yield (lbs/A)	Larvae	Yield (lbs/A)	Larvae	Yield (lbs/A)
In-furrow	113 B	2747 C	76 B	3049 B	89 B	3124 A
5" band	38 CD	3008 BC	25 C	3323 A	42 C	3359 A
7" band	67 C	3146 AB	36 C	3262 AB	35 C	3160 A
14" band	106 B	3344 A	28 C	3231 AB	16 C	3323 A
Control	182 A	2451 D	182 A	2451 C	182 A	2451 B
Soilbrom© 90 (2 gal/A)	5 D	3284 A	5 C	3284 A	5 C	3284 A

[x]Figures for variables are the averages of 8 replications; those within the same column followed by a common letter were not significantly different (P = 0.05).

[y]Per 100 cm^3 soil.

Table 6. Effect od the method of application on the efficacy of Furadan 10G (carbofuran) against *Meloidogyne arenaria* in a 1980 field experiment with Florunner peanuts near Headland, Alabama

Method of Application	Pounds of Active Ingredient Per Acre: One Pound		Two Pounds		Three Pounds	
	Larvae[y]	Yield (lbs/A)	Larvae	Yield (lbs/A)	Larvae	Yield (lbs/A)
In-furrow	54 A	2323 C	106 A	3020 B	37 A	2400 CD
5" band	61 A	2819 B	56 B	2701 BC	27 A	3052 B
7" band	61 A	3194 AB	104 A	2899 BC	34 A	3001 B
14" band	75 A	2364 C	65 B	2689 C	57 A	2693 C
Control	60 A	2294 C	60 B	2294 D	60 A	2294 D
Soilbrom© 90 (2 gal/A)	4 B	3463 A	4 C	3463 A	4 B	3463 A

[x]Figures for variables are the averages of 8 replications; those within the same column followed by a common letter were not significantly different ($P = 0.05$).

[y]Per 100 cm^3 soil.

Applications of Vydate 10G reduced larval populations of *M. arenaria* at all rates tested (Table 5). Lowest numbers of the larvae were found in plots that received either two or three pounds of the nematicide; differences in larval numbers between the two rates were not significant. The interaction between rates and methods of application for larval populations was not significant. In general, band treatments of Vydate 10G resulted in lower numbers of larvae than in-furrow treatments, but *M. arenaria* populations in plots with band treatments were statistically equivalent.

Applications of Furadan 10G failed to reduce larval populations below levels found in control plots (Table 6). When the effect of rates on larval populations was considered independently of the method of application, lowest larval numbers were observed in response to the three pound rate and highest in plots treated with two pounds of the nematicide. Differences in larval numbers were not affected by the method of application and the interaction between rates and methods of application was not significant for the larval data. Yield differences in response to Furadan 10G rates were not significant, however, the opposite was true for methods of application and for the interaction between rates and application methods. Highest yields with the one and two pound rates were obtained with the 5-and 7-inch band treatments. Yield differences at the two-pound rate were not significant for comparisons between the in-furrow, 5- and 7-inch band treatments; the 14-inch band treatment, although resulting in lower yields than the in-furrow treatment, did not differ from yields obtained with the other two band treatments. The 5- and 7-inch band treatments were the only ones that resulted in higher yields than the control at all rates tested. The Soilbrom 90 treatment resulted, with only one exception (one pound of Furadan 10G in a 7-inch band), in higher yields than any of the Furadan 10G treatments.

DISCUSSION

Interpretation of these results can be based primarily on two properties of the nematicides used in the study: their systemic nature, and their solubility in water. In previous greenhouse work (15) we have shown that systemic nematicides can be impregnated in seed to obtain substantial nematode control with soybeans, squash, and other seeds. Also, in work with peanut field experiments we have shown that thorough incorporation of systemic nematicides into soil is not essential and may even be detrimental for maximal efficacy against *M. arenaria* (12). We have also found that some materials such as oxamyl and phenamiphos can be injected into soil in very narrow bands around peanut seeds to obtain control of *M. arenaria* (9). These findings suggest that systemic nematicides such as those used in the present study are most effective when applied to soil in a manner that enhances their quick absorption by developing root systems. In this connection, the diffusion of the nematicide through soil from the place of application into the zone where roots develop is critical. Diffusion through the soil from the point of application, is of course dependent on the solubility of the nematicides in water. The four nematicides chosen for the study have considerable solubility in water ranging from as low as 450 ppm(25° C) for phenamiphos to as high as 28% (w/w) for oxamyl (5). Our results indicate that this range of solubility is adequate to assure good diffusion through soil and subsequent absorption by roots of soybeans and peanuts. Differences in efficacy and yield response to the methods of application are then interpreted as the result of the pattern of diffusion established after delivery of the materials into the soil. An accurate interpretation of diffusion patterns of the nematicides in relation to their observed behavior in the study cannot be given because of a lack of data on diffusion. However, our results do indicate that, in general, single point or very narrow band (in-furrow) type applications are not the most efficacious way of applying the nematicides tested. Instead, our results suggest that broader band applications result in diffusion patterns in soil that are most likely to optimize efficacy of these materials against *M. arenaria* and consequent yield response. Broad diffusion patterns can be expected to carry the nematicides through the soil profile as a "moving front" resulting in greater kill of larvae through direct toxicity and increase the probability of greater absorption of the materials by the developing root system. Our results, however, also suggest that the optimal band width is fairly well defined, since for both crops no benefit was derived from the use of the widest bands of the study when compared to the five and seven inch band applications. This fact is fortunate and of practical significance since it agrees well with the type of banding equipment most commonly available on commercial planters.

The relative yield inferiority of in-furrow applications as compared to banded treatments could be the result of phytotoxicity, especially for the two-and three-pound rates. However, since no conspicuous signs of phytotoxicity were observed with any of the nematicides used, we regard this possibility as unlikely.

We consider this study as preliminary, and clearly more research on patterns of diffusion and root absorption by crops is needed to provide an accurate interpretation of the observed results.

CONCLUSIONS

Planting time banded applications of aldicarb, carbofuran, oxamyl, and phenamiphos are generally superior to in-furrow applications both for control of *M. arenaria* and for yield response of peanuts and soybeans. Band widths of five or seven inches are sufficiently adequate to obtain optimal efficacy of the nematicides, and wider bands are not necessary.

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