# Effects of Chemicals, Applied Before and After Planting, on Nematodes and Southern Stem Rot of Peanuts

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**ABSTRACT**

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Phenamiphos applied before planting and ethoprop and phenamiphos (alone or combined with pentachloronitrobenzene [PCNB]) applied after planting significantly increased yields of peanuts. No treatment applied after planting increased yields in plots that had been treated before planting with dibromochloropropane or phenamiphos, indicating that treatment only before planting is adequate to obtain maximum yields. Ethoprop applied only before planting, however, did not increase yields; but when ethoprop was applied before planting and when phenamiphos, PCNB, or PCNB plus ethoprop or phenamiphos was applied after planting, the yield was significantly greater than the yield from plots treated with preplant ethoprop. Yields were negatively correlated ($P = 0.01$) with root-knot indices ($r = -0.47$), soil populations of *Meloidogyne arenaria* larvae ($r = -0.20$), and *Macroposthonia ortatus* ($r = -0.25$) and southern stem rot ($r = -0.47$). When applied after planting, phenamiphos alone or with PCNB was equal to ethoprop in increasing yields and, when applied before planting, was superior to ethoprop.

Root knot (caused by *Meloidogyne arenaria* (Neal) Chitwood) and southern stem rot (caused by *Sclerotium rolfsii* Sacc.) are two important diseases of peanut (*Arachis hypogaea*) in Georgia. Recommendations for the control of both involve the use of a nematicide (19). A nematicide is usually applied before or at planting for nematode control, whereas a nematicide plus the fungicide pentachloronitrobenzene (PCNB) is usually applied in a 12-in. band over the row 40–60 days after planting for control of southern stem rot. Application of nematicides after planting is usually not recommended.

In Oklahoma, however, yields of Spanish peanuts were greater from nematode-infested plots that were treated with nematicides at pegging time than from plots that were treated at planting or not treated (6,14,17). More recently, in Florida (4), yields of Runner peanuts from plots that were infested with *M. arenaria* and treated with nematicides at planting and at pegging time were greater than yields from plots treated only at planting. Conversely, workers in Alabama (12) indicated that ethylene dibromide, alone or combined with chloropicrin, applied at planting of Runner peanuts was as effective as applications at planting and midbloom.

PCNB alone is effective for control of *S. rolfsii* (3,5,15). Sturgeon and Russell (16), however, reported that PCNB plus a nematicide increased peanut yields more than the additive increase from PCNB and the nematicide alone. They suggested the possibility of a synergistic effect with the chemical combination or suppression of a disease interaction between soilborne fungi and lesion nematodes. Rodriguez-Kabana et al (9,11) reported that PCNB, fensulfothion, and ethoprop reduced the incidence of *S. rolfsii* loci in peanuts. The effects of fensulfothion and ethoprop applied at early blooming, however, were not as long-lasting as those of PCNB. Boswell (2) found that the use of PCNB significantly increased the number of lesion nematodes (*Pratylenchus brachyurus* (Godfrey) Filipjev & Schuurmans Stekhoven) in the shells of Spanish peanuts. Thompson (18) found that PCNB applied after planting had no effect on numbers of lesion nematodes in shells of Florunner peanuts in Georgia. PCNB applied alone resulted in increased yields in 1 of 3 yr, and PCNB plus fensulfothion increased yields each of 3 yr. Field disease counts indicated that PCNB alone or with fensulfothion significantly reduced southern stem rot.

Adams et al (1) found that PCNB in vitro was toxic to several genera of nematodes. In greenhouse and field experiments, however, PCNB caused an increase or decrease in numbers of nematodes in the soil depending on the species and the PCNB concentration. The nematodes most likely to increase in numbers when PCNB was applied were *Pratylenchus scribneri* Steiner, *P. brachyurus, Helicotylenchus dihystera* (Cobb) Sher, and *Hoplolaimus galeatus* (Cobb) Thorne. The numbers of *M. incognita* (Kofoid & White) Chitwood, dorylaimoid, saprophagous, and mononchoid nematodes usually decreased.

There are indications from the above reports that treatments for southern stem rot may also control nematodes and treatments for nematodes may control southern stem rot. *M. arenaria* and *S. rolfsii* often are present in the same field and together may have devastating effects. No reports indicate the degree of control of these two pests when they occur together, and control measures for each pest are applied separately or in combination. Also, there are no reports of the use of phenamiphos plus PCNB to control southern stem rot. In this paper we report the effects of nematicides and PCNB applied before planting, after planting, and in combinations thereof on *M. arenaria, Macroposthonia ornatus* (Raski) de Grisse & Loof, and *S. rolfsii* in Florunner peanuts. A preliminary report has been published (8).

## MATERIALS AND METHODS

This study was conducted during 1977 and 1978 at Tifton, GA, on a loamy sand infested with *M. arenaria, M. ornatus,* and *S. rolfsii.* The experimental design was a split plot replicated four times. Whole plots were treated before planting in 1977 and at planting in 1978 with dibromochloropropane (DBCP), ethoprop, and phenamiphos, and after planting, subplots were treated with ethoprop, phenamiphos, PCNB, ethoprop plus PCNB, and phenamiphos plus PCNB. Subplots were 7.6 m long with two rows of Florunner peanuts spaced 0.9 m apart.

Each year the soil was turned 25 cm deep with a moldboard plow. The rows were marked and the herbicide benefin (1.3 kg a.i./ha) was applied. Preplant nematicides were applied 27 April 1977 and 25 April 1978. DBCP (10.1 kg a.i./ha) was injected 20 cm deep by using two chisels per row spaced 30 cm apart. Ethoprop (3.4 kg a.i./ha) and phenamiphos (2.8 kg a.i./ha) were applied in a 46-cm band and incorporated 10–15 cm deep with a power-driven rototiller. About 100 kg of viable Florunner peanut seeds per hectare were planted on 16 May

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This paper reports the results of research only. Mention of a pesticide does not constitute a recommendation by the USDA and does not imply registration under FIFRA.

1977 and 25 April 1978. The herbicides alachlor (3.7 kg a.i./ha) and naptalam (3.4 kg a.i./ha) plus dinoseb (1.9 kg a.i./ha) were applied after planting on 23 May 1977 and 2 May 1978. On 27 June 1977 and 19 June 1978, nematicide and fungicide treatments (in kg a.i./ha: ethoprop 3.4; phenamiphos 2.8; PCNB 11.2; ethoprop plus PCNB, 3.4 and 11.2; and phenamiphos plus PCNB, 2.8 and 11.2) were applied after planting, in a 46-cm band over the row before light cultivation.

Fertilizer and lime were applied as recommended on the basis of soil tests for peanut production in Georgia. Gypsum (calcium sulfate) was applied 700 kg/ha each year during the early bloom stage. Chlorothalonil and sulfur were used for foliar disease control and methomyl and monocrotophos were used to control insects.

The numbers of nematodes in the soil were determined on 20 July and 10 August 1977 and on 25 July and 14 September 1978. Soil was collected from both rows of each plot, and the nematodes were extracted by the centrifuge-sugar-flotation method (7). The plants were harvested on 29 September 1977 and 13 September 1978. Roots and pods of 10 plnats from each plot were rated for severity of galling immediately after digging. Root knot ratings were based on a 1–5 scale. The number of *S. rolfsii* infection loci (southern stem rot) per 30.5 m of row was recorded within 12 hr after harvesting by using the method of Rodriguez-Kabana et al (10). Peanut yields and percent sound mature kernels also were determined. Data were subjected to analysis of variance and Duncan's multiple range test procedures (13).

## RESULTS

Among preplant treatments, peanut yields were significantly greater for plots that received phenamiphos than for plots that received ethoprop or no treatment (Table 1). All treatments after planting, except PCNB, increased yields significantly in plots that did not receive a preplant treatment. Yields from plots that received no preplant treatment but were treated after planting with phenamiphos plus PCNB were greater than yields from plots that received only ethoprop, phenamiphos, PCNB, or no treatment. Also, yields from plots that received no preplant treatment but received ethoprop plus PCNB after planting were greater than yields from plots that received only PCNB or no treatment. None of the treatments applied after planting to plots treated with DBCP or phenamiphos before planting increased yields over the preplant treatments. Conversely, all treatments after planting, except ethoprop, that were applied to plots treated with preplant ethoprop increased yields significantly. When phenamiphos was applied before planting, yields were significantly greater in plots that received ethoprop plus PCNB after planting than in plots that received phenamiphos, PCNB, and phenamiphos plus PCNB after planting. All treatments applied after planting significantly increased average yields, but ethoprop plus PCNB and phenamiphos plus PCNB were superior to each chemical applied alone.

Root-knot severity was reduced by DBCP and phenamiphos in plots that received only preplant treatments (Table 2). All treatments after planting, except PCNB and ethoprop plus PCNB, significantly reduced root knot in plots that did not receive a preplant treatment. Root-knot severity was reduced in plots that received DBCP before planting and phenamiphos or phenamiphos plus PCNB after planting compared with plots that received only DBCP before planting. Root-knot severity was reduced in plots treated with ethoprop before planting and phenamiphos, PCNB, or phenamiphos plus PCNB after planting compared with plots that received only ethoprop before planting. Root knot was less severe in plots that received ethoprop before and phenamiphos after planting than in plots that received ethoprop before planting and ethoprop or ethoprop plus PCNB after planting. No treatment applied after planting reduced root-knot severity in plots treated with preplant phenamiphos. DBCP and phenamiphos applied before planting significantly reduced average root-knot severity. Also, average root-knot severity was reduced significantly by all treatments applied after planting except PCNB. Reductions were greatest with phenamiphos and phenamiphos plus PCNB.

No treatment applied before or after planting alone significantly reduced the number of *M. arenaria* larvae in the soil (Table 2). In plots that were treated only after planting, however, the numbers of larvae were greater in plots treated with PCNB than in those treated with phenamiphos, ethoprop plus PCNB, or phenamiphos plus PCNB. No treatment applied after planting to plots treated with preplant DBCP or phenamiphos reduced *M. arenaria* larvae. Phenamiphos applied after planting to plots treated with preplant ethoprop, however, reduced the number of *M. arenaria* larvae. Average numbers of *M. arenaria* larvae were reduced significantly by only phenamiphos applied after planting.

The numbers of *M. orantus* in the soil were reduced by DBCP and phenamiphos in plots that received only preplant treatments (Table 2). All treatments after planting except PCNB reduced the numbers of *M. ornatus* in plots with no preplant treatment. The numbers of *M. ornatus* in plots that received ethoprop before planting and phenamiphos and phenamiphos plus PCNB after planting were reduced compared with plots that received only preplant ethoprop. Treatments after planting did not reduce *M. ornatus* in plots treated with DBCP or phenamiphos before planting. Average numbers of *M. ornatus* were reduced significantly by DBCP and phenamiphos applied before planting and also by phenamiphos and phenamiphos plus PCNB after planting.

No preplant treatment alone and no treatment applied after planting to plots treated with preplant DBCP significantly reduced the number of southern stem rot loci (Table 2). Conversely, the numbers of southern stem rot loci were significantly reduced by all treatments applied after planting to plots with no preplant treatment and were reduced by all treatments except phenamiphos applied after planting to plots treated with preplant ethoprop. Plots treated before planting with ethoprop and after planting with ethoprop and phenamiphos plus PCNB had fewer southern stem rot loci than did plots treated with ethoprop before planting and phenamiphos after planting. The number of southern stem rot loci was lower in plots treated with

**Table 1.** Effects on peanut yields of nematicides applied before planting and nematicides and a fungicide applied after planting (2-yr average)

| Preplant treatment | Treatment (kg/ha) after planting[a] Control | Ethoprop | Phenamiphos | PCNB[b] | Ethoprop + PCNB | Phenamiphos + PCNB | Average |
|---|---|---|---|---|---|---|---|
| Control | 4,143 b D | 4,756 a BC | 4,891 a BC | 4,446 a CD | 5,184 a AB | 5,484 a A | 4,817 a |
| DBCP[c] | 4,703 ab A | 4,837 a A | 4,871 a A | 4,966 a A | 5,187 a A | 5,246 a A | 4,968 a |
| Ethoprop | 4,238 b B | 4,708 a AB | 4,866 a A | 4,904 a A | 4,842 a A | 5,271 a A | 4,805 a |
| Phenamiphos | 5,078 a AB | 5,209 a AB | 4,647 a B | 5,032 a B | 5,609 a A | 4,844 a B | 5,070 a |
| Average | 4,541 C | 4,878 B | 4,819 B | 4,837 B | 5,206 A | 5,211 A | |

[a] Data in columns followed by the same lowercase letter or data in rows followed by the same capital letter are not significantly different ($P = 0.05$) according to Duncan's multiple range test.
[b] PCNB = pentachloronitrobenzene.
[c] DBCP = dibromochloropropane.

**Table 2.** Effects of nematicides applied before planting and nematicides and a fungicide applied after planting on nematodes and incidence of southern stem rot of peanuts (2-yr average)

| Preplant treatment | Treatment (kg/ha) after planting[a] Control | Ethoprop | Phenamiphos | PCNB[b] | Ethoprop + PCNB | Phenamiphos + PCNB | Average |
|---|---|---|---|---|---|---|---|
| | | | Root-knot index[c] | | | | |
| Control | 3.1 a A | 2.5 ab B | 2.3 a BC | 3.1 a A | 2.6 a AB | 1.9 a C | 2.6 a |
| DBCP[d] | 2.4 b A | 2.1 bc ABC | 1.7 a C | 2.4 b A | 2.3 ab AB | 1.8 a BC | 2.1 b |
| Ethoprop | 3.3 a A | 3.0 a AB | 1.9 a D | 2.7 ab BC | 2.8 a ABC | 2.3 a CD | 2.7 a |
| Phenamiphos | 1.8 b A | 1.6 c A | 1.7 a A | 1.7 c A | 1.7 b A | 1.7 a A | 1.7 c |
| Average | 2.6 A | 2.3 B | 1.9 C | 2.5 AB | 2.3 B | 1.9 C | |
| | | | *Meloidogyne arenaria* larvae (no./150 $cm^3$ of soil) | | | | |
| Control | 178 a AB | 120 a AB | 26 a B | 293 a A | 88 ab B | 19 b B | 121 a |
| DBCP | 124 a A | 68 a A | 24 a A | 211 a A | 30 b A | 52 ab A | 85 a |
| Ethoprop | 343 a A | 253 a AB | 106 a B | 232 a AB | 274 a AB | 269 a AB | 246 a |
| Phenamiphos | 129 a A | 79 a A | 91 a A | 133 a A | 63 ab A | 67 ab A | 94 a |
| Average | 194 AB | 130 ABC | 62 C | 217 A | 114 BC | 102 BC | |
| | | | *Macroposthonia ornatus* nematodes (no./150 $cm^3$ of soil) | | | | |
| Control | 183 a B | 48 b C | 77 a C | 265 a A | 94 b C | 43 a C | 118 a |
| DBCP | 9 b A | 4 b A | 5 a A | 33 c A | 9 c A | 7 a A | 11 b |
| Ethoprop | 190 a A | 184 a A | 88 a B | 186 b A | 190 a A | 66 a B | 151 a |
| Phenamiphos | 15 b A | 16 b A | 9 a A | 31 c A | 8 c A | 11 a A | 15 b |
| Average | 93 AB | 63 BCD | 45 CD | 128 A | 75 BC | 32 D | |
| | | | Southern stem rot infection (no. of loci/30.5 m of row) | | | | |
| Control | 27.5 A | 16.8 B | 18.5 B | 18.3 B | 10.5 B | 9.5 B | 16.8 |
| DBCP | 18.8 A | 16.0 A | 23.0 A | 14.5 A | 16.0 A | 15.3 A | 17.3 |
| Ethoprop | 22.8 A | 8.8 C | 20.0 AB | 13.0 BC | 14.0 BC | 8.3 C | 14.5 |
| Phenamiphos | 17.3 AB | 12.5 BC | 22.5 A | 21.0 AB | 6.3 C | 15.3 AB | 15.8 |
| Average | 21.6 A | 13.5 BC | 21.0 A | 16.7 B | 11.7 C | 12.1 C | |

[a] For each nematode or disease, data in columns followed by the same lowercase letter or in rows followed by the same capital letter are not significantly different ($P = 0.05$) according to Duncan's multiple range test.
[b] PCNB = pentachloronitrobenzene.
[c] Ratings were based on a 1–5 scale: 1 = no galling, 2 = 1–25, 3 = 26–50, 4 = 51–75, and 5 = 76–100% of root system galled.
[d] DBCP = dibromochloropropane.

phenamiphos before planting and ethoprop plus PCNB after planting than in plots that received only preplant phenamiphos. Among preplant phenamiphos treatments, the number of loci was significantly lower in plots treated with ethoprop plus PCNB after planting than in plots treated with phenamiphos, PCNB, or phenamiphos plus PCNB after planting. Also, the number of southern stem rot loci was significantly lower in plots treated with phenamiphos before and ethoprop after planting than in plots treated with phenamiphos before and after planting. Average numbers of southern stem rot loci were significantly reduced by all treatments applied after planting except phenamiphos.

Peanut yields were negatively correlated ($P = 0.01$) with root-knot indices ($r = -0.47$), *M. arenaria* larvae in the soil ($r = -0.20$), *M. ornatus* in the soil ($r = -0.25$), and southern stem rot loci ($r = -0.47$).

## DISCUSSION

The results reported here show that ethoprop, phenamiphos, ethoprop plus PCNB, and phenamiphos plus PCNB applied after planting increased yield similarly to preplant applications of phenamiphos. *M. arenaria, M. ornatus*, and southern stem rot loci levels suggest that yield increases were associated with suppresson of both types of pests by these treatments, although southern stem rot loci were not reduced significantly by any preplant treatment. PCNB applied alone after planting to plots that did not receive preplant treatments reduced southern stem rot loci but had no effect on nematode populations or yields. This suggests that the nematodes had a greater effect on yield than did southern stem rot. Sturgeon (14) reported increased peanut yields with fensulfothion and ethoprop applied after planting to soil infested with lesion nematodes. Jackson (15) controlled southern stem rot on peanuts with liquid PCNB applied through the sprinkler irrigation system and with granular PCNB applied by ground equipment over the row. Thompson (18) controlled southern stem rot with PCNB or PCNB plus fensulfothion and *P. brachyurus* with PCNB plus fensulfothion applied after planting. Yields were increased 1 of 3 yr with only PCNB and all 3 yr with PCNB plus fensulfothion.

Yields from plots treated with preplant DBCP and phenamiphos were not increased by any treatment after planting. However, when applied after planting, phenamiphos alone or with PCNB reduced root-knot severity in plots that received preplant DBCP, and ethoprop plus PCNB reduced the number of southern stem rot loci in plots that received preplant phenamiphos. Conversely, yields were increased by phenamiphos, PCNB, and ethoprop or phenamiphos plus PCNB when applied to plots treated with preplant ethoprop. This suggests that the preplant application of effective nematicides was adequate for maximum yields. Hence, applications of nematicides and PCNB after planting were of little value after preplant application of effective nematicides. In Alabama (12), application of nematicides to *M. arenaria*-infested soil at planting was as effective as treatments that included nematicide applications at and after planting, whereas in Florida (4) an additional response was obtained by the application after planting. Also, Jackson and Sturgeon in Oklahoma (6) found that a nematicide applied at and after planting controlled *P. brachyurus* and increased yields more effectively than did an application at planting. These differences in results may be related to different nematodes, different levels of nematode infestations, the chemicals tested, methods of applications, and other factors.

Our data indicated that phenamiphos is equal to ethoprop applied alone or with PCNB after planting and is superior to preplant ethoprop applied to soil infested with nematodes and *S. rolfsii*.


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