# Comparison of Soil Insecticides Alone and In Combination With PCNB for Suppression of Southern Stem Rot of Peanut[1]

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**ABSTRACT**

The soil insecticides, chlorpyrifos 15G (2.2 kg a.i./ha), ethoprop 15G (3.3 kg a.i./ha), and fonofos (2.2 kg a.i./ha) were compared with pentachloronitrobenzene (PCNB) 10G (11.2 kg a.i./ha) and PCNB (11.2 kg a.i./ha) + insecticide combinations for suppression of southern stem rot caused by *Sclerotium rolfsii* on peanut in a series of field trials in 1985, 1986, and 1987 in southeastern Alabama. Stem rot loci counts were reduced each year by chlorpyrifos and two of three years of ethoprop, and fonofos compared to the non-treated control. Disease suppression with chlorpyrifos and ethoprop was similar all three years and two of three years with fonofos to that with the fungicide PCNB. Significant differences (P = 0.05) in yield were noted only in 1986 between each of the soil insecticides and the non-treated control. PCNB and PCNB + insecticide combinations with the exception of PCNB + ethoprop in 1985 significantly increased yields over the non-treated control each year. PCNB + insecticide combinations generally provided better disease suppression and/or yield response than each insecticide but not PCNB applied alone. When data were pooled for all 3 years, all treatments significantly reduced disease incidence and significantly increased yield except fonofos and ethoprop.

Key Words: *Arachis hypogaea*, *Sclerotium rolfsii*, groundnut, white mold, Lorsban, Mocap, Dyfonate, Terraclor, pentachloronitrobenzine, quintozene.

The fungicide pentachloronitrobenzene (quintozene) applied alone or in combination with an insecticide remains a recommended treatment for southern stem rot (*Sclerotium rolfsii* Sacc.) on peanut in Alabama (8). In field trials, PCNB alone (9,15) or in combination with ethoprop (7), fensulfothion (7,15), and chlorpyrifos (4,9) often reduced southern stem rot incidence and increased yields, however, high pesticide costs have greatly reduced the acreage treated with this fungicide in Alabama.

Several organophosphate insecticides commonly used for soil insect control on peanut have antifungal activity against *S. rolfsii* (1,6,7,8,12,13). Fensulfothion (13) inhibited *S. rolfsii* growth on culture media, but applied to peanut in the field at-bloom (R2-R3 stage according to Boote (2)) the insecticide did not provide season-long disease suppression. Ethoprop reduced growth of *S. rolfsii* on culture media. Suppression of southern stem rot through harvest and increased yield in several field trials compared to non-treated control was noted when ethoprop was applied at-peg (R5-R6 stage according to Boote (2)) (7, 10, 12). Technical and formulated chlorpyrifos, as well as a chlorpyrifos hydrolysis product, reduced *S. rolfsii* radial growth and sclerotia formation in vitro (6). Significant reductions in disease loci counts and higher yields were obtained in field trials with the granular formulation of chlorpyrifos (9). However, Csinos (4) and Shew *et al.* (14) found that chlorpyrifos had little impact on disease suppression or yield response. Stem rot suppression in the field with fonofos, but not subsequent yield response, has been demonstrated (5).

[1]Journal article no. 18-881609P of the Alabama Agricultural Experiment Station. This study was funded in part by the Alabama Peanut Producers Association.

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Granular chlorpyrifos has been widely used by Alabama peanut growers since a supplemental label for stem rot suppression was obtained. Reasons often cited for chlorpyrifos popularity are low per hectare product costs and southern stem rot suppression, as well as good activity against lesser cornstalk borer *(Elasmopalpus lignosellus* Zeller) (3). Labels of granular ethoprop and fonophos have also now been amended to include southern stem rot suppression on peanut as well. This report describes the results of on-farm trials to evaluate southern stem rot suppression on peanut with granular formulations of the soil insecticides now cleared for suppression of this disease and compare their activity with that of PCNB and respective PCNB + insecticide combinations.

## Material and Methods

Field plots were established at three different locations per year for three years, each with a history of southern stem rot. In all fields, a winter cover crop of rye (*Secale cereale* L.) was turned under in the spring with a moldboard plow. All fields were planted to corn (*Zea mays* L.) or grain sorghum (*Sorghum bicolor* L.) the year before peanuts were planted. Peanut cv. Florunner was planted 91-cm rows in late April to early May. The soil type at all sites was either an Orangeburg fine sandy loam (fine-loamy, siliceous, thermic Typic Palendults) or Dothan sandy loam (fine-loamy, siliceous, thermic Plinthic Palendults). Tillage, fertility, weed, insect, and leafspot control recommendations of the Alabama Cooperative Extension Service were followed at all locations (8). A split-plot design with locations as whole plots and treatments as sub-plots was used. At each location, plots two rows wide by 19.8-24.4 m in length were randomized in four complete blocks.

PNCB (Uniroyal Chemical, Raleigh, N.C.) at 11.2 kg a.i./ha, chlorpyrifos (Dow Chemical, Midland, Mich.) at 2.24 kg a.i./.ha, ethoprop (Rhone-Poulenc Inc., Monmouth Junction, N.J.) at 3.36 kg a.i./ha, fonofos (Stauffer Chemical, Westport Conn.) at 2.24 kg a.i./ha and combinations of PCNB at 11.2 kg a.i./ha plus chlorpyrifos, ethoprop, or fonofos at 2.24, 3.36, or 2.24 kg a.i./ha, respectively, were evaluated on peanut for southern stem rot suppression and effect on yield. Chemicals were applied separately in all combination treatments using a two-row Gandy granular applicator mounted on an all-terrain vehicle between 80 and 90 days after planting (growth stage R5-R6(2)) on a 25-cm band centered over the row. All insecticide treatments were included at all test sites each year except 1985.

Disease loci counts (1 locus was defined as $\leq$ 30 cm of consecutive stem rot damaged plants in a row) were made after the peanuts were inverted about 140 days after planting, according to Rodriguez-Kabana *et al.* (11). Due to differences in plot length, all counts were adjusted to 30 m row. Plots were harvested five to seven days later and yields were adjusted to 10% moisture. Significance of treatment effects across all locations for each year was tested by analysis of variance and least significance difference (LSD) test.

## Results

Southern stem rot incidence was significantly reduced by all fungicide, insecticide, and fungicide + insecticide combination treatments in 1985 (Table 1). Disease loci counts in the ethoprop-treated plots differed significantly from those of the fonofos but not chlorpyrifos-treated plots. PCNB alone provided a similar level of disease suppression as the three insecticides. Fewer disease loci were noted in the PCNB + fonofos-treated plots than those treated with fonofos. PCNB combinations with chlorpyrifos and ethoprop did not reduce disease incidence compared to either insecticide or PCNB alone. Disease loci counts were similar across all PCNB + insecticide combinations. Significant reductions in stem rot incidence observed with all treatments did not always result in higher yields. None of the insecticides alone yielded significantly better than the non-treated control and yield in the fonofos-treated plots actually was significantly less. Yields in the chlorpyrifos and PCNB-treated plots were not significantly different but the fungicide yielded significantly higher than the non-treated control. PCNB combinations with ethoprop and fonofos outyielded each respective insecticide alone though PCNB + chlorpyrifos yields were similar to chlorpyrifos. Ranking of treatments means across all test sites was the same for yield ($P<0.22$) but significantly different for disease loci ($P<0.02$).

In 1986, all treated plots had significantly fewer stem rot loci than the non-treated control (Table 1). Loci counts in the chlorpyrifos, ethoprop, and fonofos-treated plots were not significantly different. PCNB did not provide better disease suppression than any of the insecticides. The only PCNB + insecticide combination that reduced disease incidence compared with the corresponding insecticide only treatment was PCNB + fonofos. All treatments significantly increased yield over the non-treated control. A similar yield response was obtained with all three insecticides. PCNB-treated plots yielded significantly higher than plots treated with ethoprop or fonofos but not with chlorpyrifos. The PCNB + insecticide-treated plots outyielded those treated with one of the three insecticides but not those treated with PCNB alone. Non-significant location x treatment interactions for disease loci ($P<0.65$) and yield ($P<0.13$) indicated that treatments behaved similarly across all locations.

In 1987, all treatments except fonofos and ethoprop resulted in significantly fewer stem rot loci than on untreated plots (Table 1). Little difference in disease suppression was observed among the insecticide treatments. PCNB was as effective in reducing disease loci as ethoprop and chlorpyrifos but was significantly better than fonofos. All PCNB + insecticide combinations suppressed stem rot better than each corresponding insecticide only treatment. Fewest disease loci were recorded in the PCNB + chlorpyrifos and PCNB + ethoprop-treated plots. None of the insecticides alone resulted in significantly greater yields than, the non-treated control. PCNB plots outyielded those treated with ethoprop and fonofos but not chlorpyrifos. The PCNB-insecticide combinations significantly outyielded each respective insecticide alone. Treatment mean rankings for disease loci ($P<0.75$) and yield ($P<0.07$) was similar across all test sites.

Differences in disease suppression and yield response among the treatments can be more clearly demonstrated by pooling 3 years of data. All soil insecticides reduced disease loci counts compared to the non-treated control though fonofos proved significantly less effective suppressing stem rot than chlorpyrifos and ethoprop (Table 2). Disease loci counts in the chlorpyrifos and ethoprop-treated plots were similar to those treated with PCNB. All the PCNB + insecticide combinations provided significantly better disease suppression than any of the insecticides alone. No differences in disease suppression were noted among the PCNB + in-

Table 1. Comparison of the soil insecticides chlorpyrifos, ethoprop, or fonofos with PCNB and respective PCNB + insecticide combinations for suppression of southern stem rot caused by *S. rolfsii* and effect on peanut yield in southeastern Alabama in 1985, 1986, and 1987.

| | | 1985 | | 1986 | | 1987 | |
|---|---|---|---|---|---|---|---|
| Treatment | Rate[y] (kg a.i./ha) | Disease Loci[z] (no./30m row) | Yield kg/ha | Disease Loci[z] (no./30m row) | Yield kg/ha | Disease Loci[z] (no./30m row) | Yield kg/ha |
| PCNB | 11.2 | 5.8 | 4805 | 9.1 | 3872 | 4.4 | 4864 |
| chlorpyrifos | 2.2 | 6.5 | 4373 | 8.3 | 3530 | 5.2 | 4578 |
| PCNB + chlorpyrifos | 11.2 + 2.2 | 3.4 | 4714 | 5.7 | 4271 | 2.5 | 5072 |
| ethoprop | 3.3 | 4.0 | 3715 | 10.0 | 3259 | 6.0 | 4409 |
| PCNB + ethoprop | 11.2 + 3.3 | 3.0 | 4189 | 10.0 | 3977 | 2.5 | 5163 |
| fonofos | 2.2 | 8.1 | 3557 | 11.0 | 3294 | 7.0 | 4412 |
| PCNB + fonofos | 11.2 + 2.2 | 1.8 | 5405 | 6.2 | 4100 | 3.5 | 4934 |
| Non-treated Control | --- | 12.1 | 4135 | 15.3 | 2625 | 7.6 | 4387 |
| LSD (P=0.05) | | 3.7 | 407 | 3.7 | 395 | 1.8 | 355 |

[y]Applied at growth stage R5-R6.

[z]Disease loci counts were determined from consecutive stem rot damaged plants in $\leq$ 30 cm of row.

secticide treatments. Of the insecticides evaluated, the best yield response was obtained with chlorpyrifos. Chlorpyrifos significantly out-yielded the non-treated control as well as the fonofos and ethoprop. PCNB and the PCNB + insecticide combination treatments significantly outyielded all the insecticides. Yields in the PCNB and PCNB + insecticide combination treatments except PCNB + fonofos were similar.

## Discussion

Southern stem rot suppression during this three year study, as measured by disease loci counts on peanuts, was clearly demonstrated for chlorpyrifos, ethoprop, and fonofos. Compared to the non-treated control, significant reductions in disease loci counts were obtained each year with chlorpyrifos and two of three years with ethoprop and fonofos. Generally, the level of stem rot suppression with these three insecticides each year was similar. Only in 1985 were significant differences in disease suppression noted between ethoprop and fonofos. Across the three-year test period, chlorpyrifos provided better stem rot suppression than fonofos but not ethoprop (Table 2). Reductions in stem rot incidence with chlorpyrifos and ethoprop concurred with those obtained in previous studies (1,9,10,12). Other studies have failed to show any significant reduction in disease incidence with either insecticide (4,7,14). Experimental design is the best explanation for the different results obtained with chlorpyrifos and ethoprop in field trials. Specifically, replication numbers which influence

Table 2. Effect of the soil insecticides chlorpyrifos, ethoprop, and fonofos alone, PCNB, and PCNB + insecticides combinations on southern stem rot incidence and peanut yield in southeastern Alabama from 1985 to 1987.

| Treatment | Rate[y] kg a.i./ha | Disease Loci[z] (no./30m row) | Yield kg/ha |
|---|---|---|---|
| PCNB 10G | 11.2 | 6.4 | 4513 |
| chlorpyrifos 15G | 2.2 | 6.7 | 4160 |
| PCNB 10G + chlorpyrifos 15G | 11.2 + 2.2 | 3.9 | 4687 |
| ethoprop | 3.3 | 6.7 | 3794 |
| PCNB 10G + ethoprop | 11.2 + 3.3 | 5.2 | 4443 |
| fonofos 10G | 2.2 | 8.7 | 3754 |
| PCNB 10G + fonofos | 11.2 + 2.2 | 3.8 | 4813 |
| Non-treated Control | --- | 11.7 | 3715 |
| LSD (P=0.05) | | 1.7 | 217 |

[y]Applied at growth stage R5-R6.

[z]Disease loci counts were determined from consecutive stem rot damaged plants in $\leq$ 30 cm of row.

analysis of variance test sensitivity to significance, were often higher where reductions in stem rot incidence with both insecticides were noted (1,9,10,12) than where they were not recorded (4,13). Results concur with those reported by Csinos and Andress (5) that fonofos reduces stem rot damage on peanut.

Stem rot suppression noted in the insecticide-treated plots each year often was not reflected in higher yields. Only in 1986 did chlorpyrifos, ethoprop, and fonofos significantly outyield the non-treated control. Higher yields in the insecticide-treated plots were likely due to disease suppression as no soil insect or nematode pests were observed in the plot areas. Yield response with chlorpyrifos, ethoprop, and fonofos each year was similar except 1985 when chlopyrifos significantly outyielded the other two insecticides. However, chlorpyrifos clearly outyielded both fonofos and ethoprop across the three-year test period. Significant yield increases have been previously reported for chlorpyrifos (9) and ethoprop (7,10). However, Minton and Bell (10) during one of those studies attributed higher yields in the ethoprop-treated plots more to nematode control than stem rot suppression. Inconsistant yield responses despite effective disease suppression with chlorpyrifos (9) and ethoprop (7) have been previously reported. Csinos (4) and Shew *et al.*(14) failed to obtain a significant yield increase with chlorpyrifos in field trials. Again, experimental design may largely account for obtaining a significant yield response with ethoprop and chlorpyrifos.

Each year, PCNB consistently outyielded both ethoprop and fonofos. However, yield in the chlorpyrifos and PCNB-treated plots each year was similar. Despite these similarities, the pooled results showed that yield response to PCNB was better than that with chlorpyrifos. Hagan *et al.* (9) has noted the similarities in yields of chlorpyrifos and PCNB-treated plots. As previously reported, Chlorpyrifos (9) and ethoprop (10) proved equally as effective as the fungicide PCNB in reducing stem rot damage on peanut. Results of this study confirm those reported by Csinos *et al.* (7) that yield response with PCNB is generally superior to that with ethoprop. Significant differences in disease loci counts between fonofos and PCNB were noted only one of three years.

As noted in previous studies (4,7,8,9,10,15), the PCNB + insecticide combinations often provided superior disease suppression and yield response over the soil insecticides alone. The greatest improvement in stem rot suppression and yield over an insecticide-only treatment was noted between the fonofos and PCNB + fonofos-treated plots. The combinations of PCNB with chlorpyrifos and ethoprop resulted in reduced disease incidence one year in three and better yields at least two years in three above those in the respective insecticide-only plots. Additive yield increases often noted in other studies (4,5,9,15) with PCNB + insecticide or nematicide combinations over PCNB alone generally were not observed.

In summary, the soil insecticides chlorpyrifos, ethoprop, and fonofos consistently reduced southern stem rot on peanut. Yield response, particularly to ethoprop and fonofos, was erratic. Though differences in disease suppression among the insecticides were limited, chlorpyrifos clearly outyielded both ethoprop and fonofos. Based on yield response, PCNB was a more effective treatment for southern stem rot on peanut, particularly under heavy disease pressure than any of the soil insecticides. Of the three soil insecticides, only chlorpyrifos remains a possible alternative to PCNB primarily on dryland peanuts where there is a risk of mid-season damage from soil insects coupled with light to moderate pressure from southern stem rot. Applications of costly PCNB or PCNB + insecticide combinations are suggested only in disease-prone irrigated fields with a high yield potential.

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Accepted June 28, 1988