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Evaluation of the Insecticide Chlorpyrifos for Activity Against Southern Stem Rot of Peanut

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ABSTRACT

Chlorpyrifos, a soil insecticide reported to have activity in controlling southern stem rot of peanuts, was evaluated in an area heavily infested with the southern stem rot pathogen *Sclerotium rolfsii* Sacc. over a three year period (1981-1983). Chlorpyrifos 4E at 0, 1.12 or 2.24 kg ai/ha was applied preplant incorporated broadcast followed by 0, 1.12 or 2.24 kg ai/ha chlorpyrifos 15G or 4E at pegging in a 40 cm band over the row. Combinations of chlorpyrifos and PCNB were also evaluated as a formulated granule and as concomitantly applied separate materials. Disease loci were enumerated during the season and at inverting and yields were determined for plots. Chlorpyrifos alone did not significantly decrease disease in any of the tests over the three year period at any rate or method of application tested. A PCNB + chlorpyrifos (11.2-2.24 kg ai/ha) combination granule and the two chemicals applied concomitantly were as effective as PCNB + fensulfothion (11.2-3.36 kg ai/ha) in reducing disease and increasing yield. Potential niches for the use of chlorpyrifos in reducing southern stem rot are discussed.

Key Words: White mold, *Sclerotium rolfsii.*

Southern stem rot of peanuts caused by *Sclerotium rolfsii* Sacc. is one of the most serious soil-borne diseases of peanut. The disease causes an estimated 10% loss of crop value or about $40 million loss each year in Georgia (10). Recommended control of the disease in Georgia includes a combination of cultural practices such as rotation with a grass crop, deep plowing to bury crop litter, avoidance of dirting of plants during cultivation and the use of PCNB in combination with fensulfothion or ethoprop applied at pegging time (8,9).

Several researchers have reported antifungal activity of nematicides and insecticides against soil-borne pathogens associated with peanut (1,2,3,5,6,8). Backman and Hammond (1) showed that the 4EC formulation of chlorpyrifos suppressed the growth of *Sclerotium rolfsii* in vitro and reduced southern stem rot of peanut in the field. They reported a synergism between the active and inert ingredients in the EC formulation in laboratory studies, and suggested that the granular formulation would show lower activity, because of the absence of the emulsifier in the granular formulation. The use of a pesticide such as chlorpyrifos that has both insecticidal and fungicidal activity, would be important in peanut culture because of the reduced applications of pesticides required. Non target effects have been cited frequently (1,2,3,5,6,7) but few have been exploited for the benefit of commercially grown crops.

This study further evaluates the antifungal activity of chlorpyrifos under field conditions. Rates of chlorpyri-

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fos, methods of application, application timing and both emulsifiable concentrate and granule formulation were evaluated for control of southern stem rot of peanut. A combination of chlorpyrifos with PCNB applied in a single formulated product or concomitantly as separate products was also evaluated.

Materials and Methods

The field plot area was a Tifton loamy sand infested with *Sclerotium rolfsii*. In 1982 and 1983, when peanuts were 30 days old, infested soil containing sclerotia, from a diseased lupin field, was used to further infest the soil with *S. rolfsii*. Approximately 50 sclerotia in sand were distributed over each plot. Experimental design was a randomized complete block with four replications. Plots were two rows, 7.6 m long and 0.7 m apart. Chemical treatments were: chlorpyrifos 4E applied at 1.12 or 2.24 kg ai/ha preplant incorporated or at pegging; chlorpyrifos 15G at 1.12 or 2.24 kg ai/ha at pegging; PCNB 10G applied at 11.2 kg ai/ha as a single application or split into two equal applications at pegging and three weeks later; PCNB + chlorpyrifos 10-2G at 11.2 + 2.24 kg ai/ha as a single application or split into two; and PCNB-fensulfothion 10-3G applied at 11.2 + 3.36 kg ai/ha at pegging. Chlorpyrifos formulations were supplied by Dow Chemical USA, Midland, Mich., and PCNB and combination materials were supplied by Olin Corp., Little Rock, Ark. Preplant incorporated (PPI) treatments were applied with a tractor mounted sprayer-rototiller before planting and incorporated up to 15 cm deep. Peanut, *Arachis hypogaea* L., cultivar Florunner was seeded at the rate of 112 kg/ha on May 5, 1981, May 7, 1982, and May 12, 1983. At pegging treatments were applied over the row in a 40 cm band. Granules were preweighed and applied with salt shaker-like containers, and emulsifiable concentrates were applied with a knapsack sprayer in 466 L of spray/ha. Recommended fertilization, cultural practices, and insect and foliar disease control were followed. Water was applied by overhead irrigation as required when water stress was visually apparent. Numbers of disease loci were counted twice during the season and at inverting. A disease locus consisted of a 30 cm section of row or less, infected with *S. rolfsii* as described by Rodriguez-Kabana *et al.* (4). In 1982 and 1983 plots were given a severity rating of 0.1-1.0, where 0.1 = visable damage and 1.0 = all nuts decayed or missing from crown of inverted peanuts. A disease index was calculated as follows:

DI = No. disease loci at digging x severity rating

Plots were inverted 140, 132 and 145 days after planting in 1981, 1982 and 1983, respectively. After plots were harvested, peanuts were dried and weighed and yields determined. Data were analyzed by analysis of variance, Duncan's multiple range test and regression.

Results

Peanuts treated with combinations of PCNB and chlorpyrifos or fensulfothion tended to have the best control of disease and the highest yields (Tables 1,2,3,4). In 1981 (Table 1) yields were relatively low, but disease pressure was moderate. Although significant differences among treatments did not occur in disease at 87 days post planting, plots treated with chlorpyrifos 15G alone had less disease than chlorpyrifos 4E + PCNB at 120 days post planting. However, at 140 days post plant (at inverting) no differences for numbers of disease loci among treatments were detected. Plots treated with chlorpyrifos (4E or 15G) + PCNB had higher yields than the control or chlorpyrifos 4E or 15G alone at 2.24 kg ai/ha.

In 1982, peanuts treated with PCNB + chlorpyrifos as a single or split application had less disease than the control 112 days post planting and at inverting; and smaller disease indices than the control plots (Table 2). Peanuts in all treatments had less disease 131 and 132 days post plant (before and after inverting) and had smaller disease indices than the control (Table 2). Only PCNB + chlorpyrifos as a split application increased yield. Disease loci counts taken 112 and 131 days post plant were correlated negatively (P=0.01) with yield at r = -0.43 and -0.41, respectively. Disease loci counted 132 days post plant (at inverting) and disease indices were not significantly correlated with yield.

In 1982 in a chlorpyrifos formulation rate and method of application experiment (Table 3), none of the treatments decreased disease or increased yield over the control. There was no particular trend in increased disease control with either of the chlorpyrifos formulations. Disease loci counted 112 and 132 days post plant and disease index were negatively correlated (P = 0.01) with yield at -0.45, -0.51 and -0.39, respectively.

In 1983, no treatment reduced numbers of disease loci over the control (Table 4). However, plots treated with chlorpyrifos 4E at 2.24 kg ai/ha applied before planting plus chlorpyrifos 15G 1.12 kg ai/ha applied at pegging and PCNB + chlorpyrifos 10-2G at 11.2 + 2.24 kg ai/ha applied at pegging increased yield. Disease loci counts taken 120 and 145 days post planting were negatively correlated (P = 0.01) with yield at -0.40, and -0.35, respectively. In all tests disease loci were higher when counted at digging then just before digging. This was because of increased visibility on inverted peanuts.

Pods evaluated in 1983, indicated a general low level of insect damage. Other tests were not evaluated for insect damage, but obvious insect damage was not observed. No nematode damage occurred in any year.

Table 1. Evaluation of chlorpyrifos alone and with PCNB for control of *Sclerotium rolfsii*, 1981.

Treatment and formulation[1]	Rate (kg ai/ha)	Disease loci (No/30.5 m row) Days post plant 87	120	140[2]	Yield[3] (kg/ha)
Chlorpyrifos 15G + PCNB 10G	2.24 + 11.2	3.0 a	7.0 ab	16.2 a	3802 a
Chlorpyrifos 4E + PCNB 10G	2.24 + 11.2	6.0 a	11.6 a	19.6 a	3628 ab
Chlorpyrifos 4E	1.12	1.9 a	4.0 ab	16.6 a	3254 bc
PCNB + fensulfothion 10-3G	11.2 - 3.36	5.6 a	6.0 ab	23.0 a	3222 bc
Chlorpyrifos 15G	2.24	3.6 a	3.0 b	19.6 a	3135 c
Chlorpyrifos 4E	2.24	1.0 a	5.6 ab	23.6 a	3011 c
Control	--	3.0 a	9.0 ab	25.0 a	2868 c

[1]All materials were applied at pegging in a 40 cm band on June 26, 1981.

[2]Disease loci were counted 87, 120 and 140 days post plant. The last evaluation was made after inverting.

[3]Means in columns followed by common letters are not significantly different according to Duncan's multiple range test, P = 0.05.

Discussion

Generally, all the materials tested performed poorly, or were very variable in performance. This is basically a function of the disease organism which is active over several months of the peanut growing season. No fungicides control the disease, however, some reduce damage (2,8,9).

Work by Backman and Hammond (1) suggested that the emulsifiable concentrate formulation of chlorpyrifos would be a better fungicide than the granule formulation for control of southern stem rot of peanuts. This

Table 2. Evaluation of PCNB alone and in combination with chlorpyrifos for control of *Sclerotium rolfsii*, 1982.

Treatment and Formulation	Rate (kg ai/ha)	Method of application[1]	Disease Loci (No/30.5 m row)[2] Days post planting 112	131	132	Disease index[3]	Yield[4] (kg/ha)
PCNB + chlorpyrifos 10-2G	5.6 - 1.12 + 5.6 - 1.12	Peg + 3 wks	7.0 b	6.6 c	14.5 c	6.7 d	6130 a
PCNB + chlorpyrifos 10-2G	11.2 - 2.24	Peg	4.6 b	6.0 c	13.5 c	7.3 d	6074 ab
PCNB + fensulfothion 10-3G	11.2 - 3.36	Peg	9.6 ab	9.0 bc	17.5 bc	9.7 cd	5954 ab
PCNB 10G	11.2	Peg	10.0 ab	11.6 bc	25.0 b	16.3 b	5843 ab
PCNB 10G	5.6 + 5.6	Peg + 3 wks	9.6 ab	7.6 bc	17.5 bc	12.3 bc	5840 ab
Control	--	--	15.0 a	17.0 a	33.0 a	21.5 a	5216 b

[1]Materials were applied at pegging (Peg), June 30, and 3 weeks later (+ 3 wks) on July 21, 1982.

[2]Disease loci counts were made 112, 131 (1 day before inverting) and 132 days post plant, after peanuts were inverted.

[3]Disease index is disease loci counted post inverting multiplied by a subjective severity rating.

[4]Means in columns followed by common letters are not significantly different according to Duncan's multiple range test, $P = 0.05$.

Table 3. Effect of chlorpyrifos formulations and PCNB alone and in combinations on control of *Sclerotium rolfsii* in peanut, 1982.

Treatment and Formulation	Rate (kg ai/ha)	Method of application[1]	Disease loci (No/30.5 m row)[2] Days post planting[3] 112	131	132	Disease index[4]	Yield (kg/ha)
Chlorpyrifos 4E + chlorpyrifos 15G	2.24 + 2.24	PPI + Peg	8.0 b	8.0 ab	19.0 a	14.2 a	6094 a
PCNB + fensulfothion 10-3G	11.2 - 3.36	Peg	13.6 ab	9.0 ab	20.5 a	11.8 a	6011 ab
Chlorpyrifos 15G + PCNB 10G	1.12 + 11.2	Peg	13.6 ab	10.0 ab	20.0 a	11.2 a	5926 abc
Chlorpyrifos 4E	1.12	PPI	13.6 ab	10.6 ab	26.5 a	17.8 a	5799 abc
Chlorpyrifos 4E + chlorpyrifos 15G	1.12 + 2.24	PPI + Peg	13.6 ab	7.6 b	17.0 a	11.7 a	5723 abc
PCNB 10G	11.2	Peg	8.6 b	8.0 ab	17.5 a	11.0 a	5720 abc
Chlorpyrifos 15G + PCNB 10G	2.24 + 11.2	Peg	14.6 ab	8.0 ab	23.0 a	15.1 a	5688 abc
Control	--	--	12.0 ab	10.6 ab	25.5 a	17.0 a	5612 abc
Chlorpyrifos 4E	2.24	PPI	16.6 a	12.0 ab	27.0 a	14.6 a	5610 abc
Chlorpyrifos 4E	2.24	Peg	13.0 ab	8.0 ab	27.5 a	17.9 a	5557 bc
Chlorpyrifos 15G	2.24	Peg	11.0 ab	8.6 ab	30.0 a	18.9 a	5548 bc
Chlorpyrifos 15G	1.12	Peg	13.0 ab	13.0 a	24.5 a	14.6 a	5506 c
Chlorpyrifos 4E + PCNB 10G	2.24 + 11.2	Peg	12.0 ab	9.6 ab	18.0 a	9.9 a	5480 c
Chlorpyrifos 4E	1.12	Peg	13.0 ab	11.0 ab	26.5 a	17.3 a	5479 c

[1]Chemicals were applied at pegging (Peg) on June 30; PPI is preplant incorporated just before planting on May 7, 1982.

[2]Means in columns followed by the same letters are not significantly different according to Duncan's multiple range test, $P = 0.05$.

[3]Disease loci were counted 112 and 131 days post planting and when they were inverted 132 days post planting.

[4]Disease index is disease loci counted post inverting multiplied by a subjective severity rating.

Table 4. Evaluation of chlorpyrifos and PCNB for control of *Sclerotium rolfsii* and effect on yield, 1983.

Treatment and Formulation	Rate (kg ai/ha)	Method of application[1]	Disease loci (No/30.5 m row) Days post planting[2] 118	145	145	Disease index[3]	Yield[4] (kg/ha)
Chlorpyrifos 4E + chlorpyrifos 15G	2.24 + 1.12	PPI + Peg	8.6 ab	7.6 b	11.6 a	9.2 a	5098 a
PCNB + chlorpyrifos 10-2G	11.2 - 2.24	Peg	7.6 ab	7.6 b	10.0 a	7.4 a	5076 a
PCNB 10G	11.2	Peg	9.6 ab	6.6 b	12.6 a	8.4 a	5029 ab
Chlorpyrifos 15G	1.12	Peg	9.0 ab	7.6 b	19.0 a	12.8 a	4878 ab
Chlorpyrifos 4E + chlorpyrifos 15G	1.12 + 1.12	PPI + Peg	4.0 b	7.0 b	12.0 a	8.8 a	4785 ab
Chlorpyrifos 15G	2.24	Peg	5.6 ab	7.0 b	16.6 a	12.2 a	4751 ab
Chlorpyrifos 4E	1.12	PPI	16.0 a	15.0 a	18.6 a	13.0 a	4471 ab
Chlorpyrifos 4E + chlorpyrifos 15G	2.24 + 2.24	PPI + Peg	12.6 ab	9.0 ab	11.6 a	9.4 a	4465 ab
Chlorpyrifos 4E + chlorpyrifos 15G	1.12 + 1.12	PPI + Peg	5.6 ab	7.0 b	15.0 a	10.6 a	4360 ab
Chlorpyrifos 4E	2.24	PPI	11.6 ab	13.6 ab	16.6 a	12.6 a	4143 ab
Control	--	--	17.0 a	13.6 ab	18.6 a	14.6 a	4029 b

[1]PPI is preplant incorporated on May 12 and peg is at pegging application on July 6, 1983.

[2]Disease loci were counted 118 and 145 days post seeding and again after inverting 145 days post seeding.

[3]Disease index is disease loci counted post inverting multiplied by a subjective severity rating.

[4]Means followed by same letter are not significantly different according to Duncan's multiple range test, $P = 0.05$.

conclusion was based on laboratory data which indicated a synergistic effect between chlorpyrifos and the emulsifier. These field trials do not support this contention. Numbers of disease loci and yield were similar for both formulations in all three years of evaluation across several rates and application methods (Tables 1,3,4). Although there were trends in disease reduction and increases in yield with chlorpyrifos, the insecticide did not significantly reduce southern stem rot of peanut. Yield was increased in one of three years tested at a total rate of 3.36 kg ai/ha; however, a total rate of 4.48 kg ai/ha did not (Table 4).

The combination of PCNB and chlorpyrifos applied as a formulated granule or applied concomitantly as separate materials was as effective as PCNB + fensulfothion in reducing disease and increasing yield. PCNB alone was effective in reducing disease only in 1982 in one test (Table 2), but not in two other tests (Table 3,4). Yield was not increased by PCNB alone in any test.

Rodriguez-Kabana *et al.* (5,6) have demonstrated antifungal activity of both ethoprop and fensulfothion at relatively high rates of 8.97 and 8.9 kg ai/ha, respectively. The activity of chlorpyrifos was not as consistent as they were for ethoprop and fensulfothion (5,6). However, considerably lower rates of chlorpyrifos (1.12-4.48 kg ai/ha) were used (Tables 2,3,4). The widespread use of insecticides in Georgia on peanuts (11) underscores the importance of understanding their non-target effects in peanut fields. Our studies did not indicate that chlorpyrifos alone should be used as a specific treatment for control of Southern stem rot of peanut. However, because chlorpyrifos is recommended for control of several soil insects (11) and application timing for both insect control and southern stem rot control coincide, under light infestations of *Sclerotium rolfsii* chlorpyrifos may be effective in reducing southern stem rot of peanuts. No chemical treatments are available which control southern stem rot of peanut. However, chemical combinations for reduction of the disease are recommended in Georgia including a combination of chlorpyrifos and PCNB (8,9,10).

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