Effects of Chlorpyrifos on Pod Damage, Disease Incidence, and Yield in Two Peanut Fungicide Programs[1]

J. W. Chapin[2*] and J. S. Thomas[2]

ABSTRACT

The benefits of chlorpyrifos (Lorsban 15G) soil insecticide treatment in standard (chlorothalonil) and developmental (tebuconazole) peanut fungicide programs were compared in five field tests over a 3-yr period. Chlorpyrifos treatment reduced incidence of southern stem rot (*Sclerotium rolfsii*) and insect pod injury, while increasing yield in the standard fungicide program. In contrast, chlorpyrifos treatment did not measurably affect stem rot incidence or yield in the tebuconazole program, and insect pod injury was reduced in only one of three years. Tebuconazole reduced Rhizoctonia limb rot (*R. solani* AG-4) and stem rot incidence, and decreased pod injury relative to the standard chlorothalonil program. Tebuconazole increased yield 804 kg/ha (716 lb/ac) over the standard fungicide. Chlorpyrifos increased yield 503 kg/ha (448 lb/ac) for a net return of $315/ha ($128/ac) in the standard fungicide program. However, in the developmental program, chlorpyrifos increased yield only 79 kg/ha (70 lb/ac) for a net return of -$2/ha (-$1/ac). Labeling of ergosterol biosynthesis inhibitor (EBI) fungicides such as tebuconazole would significantly affect peanut insect management in some production areas by reducing the economic incentive for preventative treatments of organophosphate insecticides.

Key Words: *Arachis hypogaea, Sclerotium rolfsii, Rhizoctonia solani, Elasmopalpus lignosellus, Diabrotica undecimpunctata,* Elateridae, ergosterol biosynthesis inhibitor, IPM, tebuconazole.

The organophosphate insecticide chlorpyrifos is widely recommended for management of soil insects on peanut, *Arachis hypogaea* L., in the United States. Use of chlorpyrifos has been shown to reduce pod injury and increase peanut yield when applied for control of lesser cornstalk borer, *Elasmopalpus lignosellus* (Zeller) (10, 18, 19) and southern corn rootworm, *Diabrotica undecimpunctata howardi* (Barber) (5). Mack et al. (19) found that chlorpyrifos provided superior residual control of lesser cornstalk borer and increased peanut yield more than other soil insecticides. In addition, chlorpyrifos can reduce the risk of aflatoxin contamination by suppressing lesser cornstalk borer (4).

Chlorpyrifos and other organophosphate insecticides also have significant fungicidal activity against southern stem rot, a major yield-limiting soil disease caused by *Sclerotium rolfsii* Sacc. (12, 16, 17, 22). The combination of insecticidal activity against a spectrum of soil pests, suppression of a major economic disease, and consistent yield response to treatment, has made prophylactic application of chlorpyrifos a standard grower practice in some production areas (11, 13).

The development of ergosterol biosynthesis inhibitor (EBI) fungicides may alter peanut production practices significantly. EBI products such as diniconazole, cyproconazole, and tebuconazole are more effective against stem rot and increase yield more than currently labeled fungicides (1, 8, 14, 15). These fungicides also suppress Rhizoctonia limb rot, *Rhizoctonia solani* Kuhn AG-4, when substituted for chlorothalonil as leaf spot [(*Cercospora arachidicola* Hori and *Cercosporidium personatum* (Berk. and Curt.) Deighton)] fungicides (1, 2, 6, 8, 9).

Registration of EBI fungicides will affect peanut insect management strategies if the consistent fungicidal yield benefit of chlorpyrifos application is significantly reduced or eliminated. Soil insecticides may need to be justified solely on the economic benefit of insecticidal activity. Use of EBI fungicides also may allow more accurate estimation of the actual economic impact of soil insects. Previous studies of insecticidal efficacy against peanut soil insects have not measured disease suppression and, to date, chlorpyrifos benefits have not been evaluated in an EBI fungicide program. This study compares insect pod injury, disease incidence, and peanut yield response to chlorpyrifos, in standard (chlorothalonil) and EBI (tebuconazole) fungicide programs.

Materials and Methods

Five tests were conducted from 1990 to 1992 on peanut cv. Florunner planted 15 to 19 May at the Edisto Research and Education Center, Barnwell County, SC. The experimental design for each test was a randomized complete block with six replicates. Each experimental unit was a plot 15.2 m x 7.7 m (8 rows x 0.96-m row spacing). Tests 1 and 2, in 1990 and 1991 respectively, were on a Varina loamy sand (clayey, kaolinitic, thermic, Plinthic Paleudult) following a 3-yr rotation in corn. Test 3 (1991) was conducted on a Dothan loamy sand (fine-loamy, siliceous, thermic, Plinthic Paleudult) with a 3-yr previous crop history of corn, peanut, corn (i.e. 1-yr rotation). Test 4 (1992) was on the same soil type as tests 1 and 2 following a corn, corn, millet rotation. Test 5 (1992) was on a Clarendon loamy sand (fine-loamy, siliceous, thermic, Plinthaquic Paleudult) with a 3-yr previous crop history of sorghum, cotton, sorghum.

The four treatments used in each test were: a standard fungicide program [chlorothalonil 1.26 kg a.i./ha (6X)], with and without soil insecticide (chlorpyrifos 2.24 kg a.i./ha), and a developmental EBI fungicide program [chlorothalonil 1.26 kg a.i./ha (2X) + tebuconazole 0.25 kg a.i./ha (4X)], with and without chlorpyrifos. We applied chlorpyrifos 15G with a 2-row electric Gandy applicator (Gandy Co., Owatonna, MN) using 13-cm banders centered on the row and kept as close as possible to the foliage. Chlorpyrifos treatments were applied at early pegging [R2 growth stage (3)] on 26 June (42 DAP), 1 July (45 DAP), and 1 July (43 DAP) in 1990, 1991, and 1992 respectively. Foliar fungicide applications were made at about 14-day intervals beginning on 22 June 1990, 20 June 1991, and 19 June 1992. In 1990, the first three fungicide applications were made with TeeJet (Spraying Systems Co., Wheaton, IL) 8003 flat fan nozzles (235 l/ha), and the final three applications with TeeJet TX6 hollow cone nozzles (68.6 l/ha). Applications in 1991 and 1992 were with TX6 nozzles at 68.3 to 85.5 l/ha, with the exception of the initial 1992 application (8003 flat fan applying 185 l/ha). All fungicides were applied with an 8-row three-point-hitch sprayer (2 nozzles per row), designed so that four rows on either side of the tractor center line could be sprayed independently. Thus, traffic lanes were established between rows 1 and 2, and rows 7 and 8 of adjacent plots to assure that no compaction or lateral vine damage occurred on the middle-four rows harvested for yield. There was no traffic on yield rows other than for chlorpyrifos and gypsum ($CaSO_4$) application prior to canopy closure. Plots not treated with chlorpyrifos were driven through to maintain uniform traffic.

Disease ratings were taken within 3 h of crop inversion in 1991 and 1992. In 1991, one 15-m row within each plot was scanned to estimate the number of 0.3-m increments within each row symptomatic for stem rot, Rhizoctonia limb rot, or Cylindrocladium black rot, *Cylindrocladium crotalariae* (Loos) Bell and Sobers. In 1992, two rows within each plot were rated for

[1]Technical Contribution No. 3383 of the South Carolina Agriculture Experiment Station, Clemson University, Clemson, SC.

[2]Department of Entomology, Clemson University, Edisto Research and Education Center, Blackville, SC 29817.

*Corresponding author.

incidence of these diseases. Limb rot ratings were based on counts of 0.3-m row increments with characteristic darkened lateral vines and the presence of zonate *Rhizoctonia* lesions. They were not estimates of disease intensity (i.e., percent of vine area covered with lesions) within the symptomatic area. Stem rot ratings were counts of 0.3-m row increments with symptomatic plant crowns, and *Cylindrocladium* ratings were based on counts of linear row with characteristic deterioration of the taproot. We compared leaf spot control of the standard and EBI programs 1 wk prior to crop inversion by randomly pulling five leaves from the upper and lower canopy of each plot in four replicates (40 leaves/treatment) and counting the number of lesions per leaf.

Insect pod injury was measured within 24 h of crop inversion by randomly removing from the plants, two 25-pod samples per plot. Each pod was examined for external (hull) feeding injury and internal (kernel) damage. If feeding penetrated the hull such that kernel discoloration occurred, it was considered internal injury. Pods with either external or internal injury were summed to form the external injury category. Soil insects were monitored approximately every 14 d from mid-July to 1 September by uprooting two plant clumps from nonyield rows of check plots, examining the vines and pods for insect damage, and examining the soil for insect larvae. In 1992, a 930 cm^2 stainless steel sampling frame was centered on the row and forced into the soil to a depth of 10 cm. All soil was removed and larvae retained on a wire mesh (1.6 mm) sieve were counted.

Canopy-feeding lepidoptera were sampled weekly from mid-July to early September by sampling nonyield rows with a 1-m beat cloth. When significant infestations occurred, two samples per plot were taken from each treatment to compare pest population density. In 1991 and 1992, methomyl (0.25 kg a.i./ha) was applied to the foliage on 24 July and 7 August respectively, to control corn earworm, *Helicoverpa zea* (Boddie), and fall armyworm, *Spodoptera frugiperda* (J. E. Smith). The middle four rows of each plot were harvested with a commercial combine modified with a bagger attachment. Recommended production practices were followed for all tests, including use of 0.84 kg a.i./ha aldicarb 15G in-furrow for thrips control.

Yield, disease incidence, pod injury, and insect population density data were subjected to ANOVA and Duncan's multiple range test (20). We used a two-by-two factorial model to evaluate fungicide X insecticide, test X fungicide, and test X insecticide interactions across all tests. Analysis of disease incidence data was done on whole number counts of symptomatic row length rather than percentage data, thus the $\sqrt{x+0.5}$ transformation was used to satisfy the assumptions of ANOVA (21). The same transformation was used on counts of pod injury and larval population density. The significance level for all statistical tests was $\alpha = 0.05$.

Results

Over all tests, chlorpyrifos treatment increased yield by 503 kg/ha in the standard fungicide program (Table 1). There was no test X insecticide interaction ($F = 1.45$; df = 4, 148; $P = 0.220$), indicating a consistent yield response to chlorpyrifos. The greatest chlorpyrifos yield response under the standard fungicide program (1063 kg/ha) occurred in a drought year (test 1). In contrast to the standard fungicide program, there was no measurable yield response to chlorpyrifos in the EBI fungicide program. This is consistent with a significant insecticide X fungicide interaction effect ($F = 6.05$; df = 1, 148; $P = 0.015$). Tebuconazole increased yield in all tests (589-1063 kg/ha) relative to the standard fungicide program. The mean yield increase from tebuconazole over all tests was 804 kg/ha. Test X fungicide interaction was not significant ($F = 2.24$; df = 4, 148; $P = 0.068$).

Chlorpyrifos reduced stem rot symptoms in the standard fungicide program for three of the four fields evaluated (Table 2). Test X insecticide interaction was not significant ($F = 0.79$; df = 3, 53; $P > 0.50$) indicating a consistent response to chlorpyrifos across tests. Insecticide X fungicide interaction was significant for stem rot ($F = 12.81$; df = 1, 53; $P < 0.01$), and in contrast to the standard fungicide program, chlorpyrifos did not reduce stem rot symptoms in the EBI fungicide program. Tebuconazole reduced stem rot symptoms relative to both the standard fungicide program and chlorpyrifos treatment. Test X fungicide interaction was not significant ($F = 1.25$; df = 3, 53; $P > 0.30$).

Chlorpyrifos treatment had no effect on Rhizoctonia limb rot symptoms in either the standard or EBI funigicide program (Table 2). Tebuconazole reduced limb rot symptoms in 1991 tests, but not in 1992, when limb rot incidence was lower. Test X fungicide interaction was significant ($F = 2.88$; df = 3, 53; $P = 0.044$) and therefore, limb rot ratings were not pooled in Table 2.

There were no differences in Cylindrocladium black rot ratings for any of the treatments in any test ($P > 0.05$). Cylindrocladium ratings in test 5 were confounded by the presence of tomato spotted wilt virus, which also causes taproot deterioration. However, the plot area symptomatic from the combined effect of these two diseases was relatively low (< 2%). There were no measurable differences in leaf spot infection between the standard and EBI fungicide programs, other than test 5 (1992), where the EBI treatment had more leafspot lesions (primarily late leaf spot) in the upper canopy than the chlorothalonil standard ($F = 13.4$; df = 1, 35; $P < 0.01$).

Chlorpyrifos treatment reduced external and internal insect pod damage in all five tests of the standard fungicide

Table 1. Effect of chlorpyrifos on peanut yield in standard and EBI fungicide programs.

		Yield (kg/ha[d])					
		1990	1991		1992		Pooled[e]
Fungicide program	Soil insecticide	Test 1	Test 2	Test 3	Test 4	Test 5	
Standard[a]	None	1622 b	4896 b	4841 b	4339 b	4665 b	4073 c
Standard	Chlorpyrifos[c]	2575 a	5084 b	5288 b	4616 b	5318 a	4576 b
EBI[b]	None	2211 a	5534 a	5904 a	5116 a	5618 a	4877 a
EBI	Chlorpyrifos	2547 a	5544 a	6175 a	5043 a	5473 a	4956 a

[a]Standard = chlorothalonil 1.26 kg/ha (6X).
[b]EBI (ergosterol biosynthesis inhibitor) = chlorothalonil 1.26 kg/ha (2X) + tebuconazole 0.25 kg/ha (4X).
[c]2.24 kg/ha.
[d]Means within a column followed by the same letter are not significantly different DMRT ($P \leq 0.05$).
[e]Yield data pooled based on nonsignificant ($P > 0.05$) test X insecticide and test X fungicide interactions.

Table 2. Effect of chlorpyrifos on peanut disease incidence in standard and EBI fungicide programs.

		Disease Rating [d,e]								
		1991				1992				Pooled[f]
Fungicide program	Soil insecticide	Test 2		Test 3		Test 4		Test 5		
		SSR	RLR	SSR	RLR	SSR	RLR	SSR	RLR	SSR
Standard[a]	None	16.4 a	40.4 ab	13.6 a	32.2 a	9.8 a	12.0 a	11.5 a	11.8 a	12.9 a
Standard	Chlorpyrifos[c]	5.6 b	55.2 a	7.0 ab	54.0 a	2.5 bc	15.1 a	2.3 b	13.0 a	4.5 b
EBI[b]	None	0.0 d	9.6 c	3.0 b	13.4 b	1.1 c	7.3 a	0.5 b	6.5 a	1.2 c
EBI	Chlorpyrifos	1.6 cd	21.0 bc	2.0 b	17.4 b	0.0 c	7.5 a	0.0 b	4.0 a	1.0 c

[a]Standard = chlorothalonil 1.26 kg/ha (6X).
[b]EBI (ergosterol biosynthesis inhibitor) = chlorothalonil 1.26 kg/ha (2X) + tebuconazole 0.25 kg/ha (4X).
[c]2.24 kg/ha.
[d]RLR = Rhizoctonia limb rot; SSR = southern stem rot. Stem rot and limb rot ratings estimate percent of linear row with visible symptoms. They do not estimate disease intensity (i.e. percent vine infection for *Rhizoctonia*) within the infected area.
[e]Means within a column followed by the same letter are not significantly different DMRT ($P \leq 0.05$).
[f]Southern stem rot data pooled based on nonsignificant ($P > 0.05$) test X insecticide and test X fungicide interactions.

program (Table 3). Significant test X insecticide interaction for external pod damage ($F = 11.44$; $df = 4, 295$; $P < 0.01$) reflects the fact that prevention of pod damage by chlorpyrifos treatment was not as effective in test 1 relative to the other four tests. Insecticide X fungicide interaction was significant for external and internal damage ($F = 6.18$; $df = 1, 295$; $P = 0.013$) and ($F = 5.29$; $df = 1, 295$; $P = 0.022$) respectively. Unlike the standard fungicide program, chlorpyrifos treatment reduced external and internal pod damage in the EBI fungicide program only in 1991 (tests 2 and 3). Conversely, tebuconazole treatment reduced external and internal pod damage ratings in 1990 and 1992, but not 1991. Rainfall from planting until 1 September was considerably lower in 1990 than 1991 or 1992 (31, 48, and 43 cm, respectively). Rainfall distribution was also less uniform in 1990, when only 4.5 cm occurred from 26 July to 22 August. Due to this drought stress, 1990 pod injury was caused primarily by lesser cornstalk borer. We found lesser cornstalk borer larvae and characteristic sand-covered, silken tubes attached to damaged pods and vines in our plots. In 1991, pod injury was primarily due to southern corn rootworm, based on the presence of rootworm pupae in August soil samples. Pod damage in 1992 was primarily due to wireworms (Elateridae), since wireworm larvae were consistently found in low numbers (0.5 to 1.5/row m) in soil sieve samples. No rootworm larvae or pupae were found in 1992.

Chlorpyrifos treatment increased canopy-feeding corn earworm populations ($F = 3.22$; $df = 3, 25$; $P = 0.04$) in the standard fungicide program of test 4, but had no effect in the other tests. Tebuconazole had no measurable effect on canopy-feeding Lepidoptera.

Table 3. Effect of chlorpyrifos on peanut pod damage in standard and EBI fungicide programs.

		% Pod Damage[d,e]									
		1990		1991				1992			
		Test 1		Test 2		Test 3		Test 4		Test 5	
Fungicide program	Soil insecticide	Ext[f]	Int[f]	Ext	Int	Ext	Int	Ext	Int	Ext	Int
Standard[a]	None	26.6 a	10.9 a	11.0 a	3.5 a	17.1 a	3.6 a	5.0 a	2.0 a	5.0 a	1.7 a
Standard	Chlorpyrifos[c]	9.4 b	3.1 b	1.0 b	0.0 b	2.8 b	0.4 b	0.6 b	0.0 b	0.3 b	0.0 b
EBI[b]	None	13.1 b	5.0 b	11.5 a	4.0 a	14.9 a	2.2 ab	0.0 b	0.0 b	1.3 b	0.0 b
EBI	Chlorpyrifos	15.3 b	3.4 b	0.5 b	0.0 b	1.0 b	0.4 b	0.0 b	0.0 b	0.0 b	0.0 b

[a]Standard = chlorothalonil 1.26 kg/ha (6X).
[b]EBI (ergosterol biosynthesis inhibitor) = chlorothalonil 1.26 kg/ha (2X) + tebuconazole 0.25 kg/ha (4X).
[c]2.24 kg/ha.
[d]Means within a column followed by the same letter are not significantly different DMRT ($P \leq 0.05$).
[e]1990 pod damage primarily due to lesser cornstalk borer; 1991 primarily southern corn rootworm; 1992 primarily wireworm.
[f]Ext = external hull feeding (includes internal); Int = internal (kernel) damage only.

Discussion

The efficacy of tebuconazole in reducing southern stem rot and Rhizoctonia limb rot infection, and increasing peanut yield relative to a standard fungicide program, agrees with results of previously cited studies (2, 8, 9, 14). Likewise, the ability of chlorpyrifos to suppress stem rot symptoms (12, 16, 17) and reduce insect pod damage (5, 10, 18, 19) has been previously documented in standard fungicide programs. Tebuconazole has been shown to be equivalent to chlorothalonil (1.26 kg/ha) for control of late leaf spot, even at a lower rate (0.19 kg/ha) than was used in our study (7). We have no explanation for the higher late leaf spot lesion count in the upper canopy of tebuconazole plots in test 5. There was no apparent difference in defoliation at harvest and the tebuconazole-treated yield was 953 kg/ha higher.

Assuming a crop value of \$0.75/kg and treatment costs (material and application) of \$61.75/ha, chlorpyrifos net returns would have ranged from \$79/ha (\$32/ac) to \$653/ha (\$264/ac) in the standard fungicide program. The average net return of chlorpyrifos for all tests was \$315/ha (\$128/ac) in the standard fungicide program. In contrast, for the EBI fungicide program, chlorpyrifos net returns ranged from - \$170/ha (-\$69/ac) to \$190/ha (\$77/ac). The average net return for chlorpyrifos was - \$2/ha (- \$1/ac) in the EBI fungicide program. Chlorpyrifos applications were profitable only in tests 1 and 3 of the EBI program. Test 1 was a drought year with high levels of pod injury caused primarily by LCB, and test 3 was a 1-yr rotation field. These calculations of chlorpyrifos economic benefit do not include value from grade improvement, which may be substantial with severe LCB infestation (4, 10). The economic value of reducing the risk of aflatoxin detection is also not considered in this comparison.

Our data indicate that the primary benefit of chlorpyrifos was from disease control, with the exception of 1990, when lesser cornstalk borer caused a high level of pod damage. The consistent profitability of chlorpyrifos treatment even in years of low soil insect infestation, such as 1992, is a strong grower incentive for preventative use under current fungicide programs. The labeling of EBI fungicides would decrease this incentive and probably necessitate changes in insecticide recommendations for some states. Organophosphate soil insecticides will remain profitable for suppression of LCB and severe infestations of other soil insects, but it is interesting that the yield response from chlorpyrifos treatment was reduced in the EBI program even in a drought year with a heavy lesser cornstalk borer infestation. Under certain field conditions, organophosphate insecticides may profitably supplement the fungicidal benefit of EBI fungicides, as has been reported for currently available soil fungicides (16, 17). However, in our study, chlorpyrifos fungicidal benefits were essentially eliminated by the use of tebuconazole. Our data also indicate that correlations of insect pod damage and yield loss in soil insecticide tests must be interpreted cautiously, given that the disease control benefit of organophosphate insecticides consistently confounds measurement of insecticidal benefit. EBI fungicides could be experimentally useful in more precisely measuring the relationship between soil insect injury and yield loss.

Although only chlorpyrifos data are presented, fonophos 15 G (2.24 kg/ha) was compared to chlorpyrifos in the standard fungicide program of test 3 (1991), and the standard and developmental fungicide programs of test 4 (1992). In both tests, fonophos was equivalent to chlorpyrifos in stem rot suppression, pod injury reduction, and yield response.

The reduction of pod damage ratings by tebuconazole in 1990 and 1992 could result from sampling bias. Suppression of fungal diseases on the pods could make insect pod scarification less obvious, and some pod deterioration from disease may be misidentified as insect injury. Tebuconazole treatment would also tend to reduce percent pod injury from a given insect population by increasing the total number of pods retained on the plant at harvest. Regardless of any effect on pod damage ratings, tebuconazole use would alter soil insect management decisions under South Carolina conditions. The superior efficacy of tebuconazole against southern stem rot and Rhizoctonia limb rot eliminates the consistent yield response from organophosphate insecticide treatment. Profitable use of soil insecticides is therefore not as simple in EBI fungicide programs, and will require a better understanding of the biology and economic significance of the soil insect complex.

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Literature Cited

1. Backman, P. A. and M. A. Crawford. 1985. Effects of triazole fungicides on soilborne diseases of peanuts. Proc. Am. Peanut Res. Ed. Soc. 17: 42 (Abstr.).
2. Barnes, J. S., A. S. Csinos, and W. D. Branch. 1990. Sensitivity of *Rhizoctonia solani* isolates to fungicides and evaluation of peanut cultivars to Rhizoctonia limb rot. Peanut Sci. 17: 62-65.
3. Boote, K. J. 1982. Growth stages of peanut (*Arachis hypogaea* L.). Peanut Sci. 9: 35-40.
4. Bowen, K. L. and T. P. Mack. 1993. Relationship of damage from lesser corntalk borer to *Aspergillus flavus* contamination in peanuts. J. Entomol. Sci. 28: 29-42.
5. Brandenburg, R. L. and D. A. Herbert, Jr. 1991. Effect of timing on prophylactic treatments for southern corn rootworm (Coleoptera: Chrysomelidae) in peanut. J. Econ. Entomol. 84: 1894-1898.
6. Brenneman, T. B., A. S. Csinos, and R. H. Littrell. 1987. Activity of diniconazole on foliar and soilborne peanut pathogens in vivo and in vitro. Proc. Am. Peanut Res. Ed. Soc. 19: 23 (Abstr.).
7. Brenneman, T. B. and A. P. Murphy. 1991. Activity of tebuconazole on *Cercosporidium personatum*, a foliar pathogen of peanut. Plant Dis. 75: 699-703.
8. Brenneman, T. B. and A. P. Murphy. 1991. Activity of tebuconazole on *Sclerotium rolfsii* and *Rhizoctonia solani*, two soilborne pathogens of peanut. Plant. Dis. 75: 744-747.
9. Brenneman, T. B. and D. R. Sumner. 1989. Effects of chemigated and conventionally sprayed tebuconazole and tractor traffic on peanut diseases and pod yields. Plant Dis. 73: 843-846.
10. Chapin, J. W. 1984. Control of lesser cornstalk borer with granular chlorpyrifos. Proc. Amer. Peanut Res. Ed. Assoc. 16: 35 (Abstr.).
11. Chapin, J. W. and M. J. Sullivan. 1989. Optimal timing of soil insecticide applications to peanuts. Proc. Amer. Peanut Res. Ed. Soc. 21: 59 (Abstr.).
12. Csinos, A. S. 1984. Evaluation of the insecticide chlorpyrifos for activity against southern stem rot of peanut. Peanut Sci. 11: 98-102.
13. Gilreath, M. E., J. E. Funderburk, D. W. Gorbet, D. J. Zimet, R. E.

Lynch, and D. C. Herzog. 1989. Economic benefits of selected granular insecticides for control of lesser cornstalk borer in nonirrigated peanut. Peanut Sci. 16: 82-87.
14. Hagan, A. K., J. R. Weeks, and K. Bowen. 1991. Effects of application timing and method on control of southern stem rot of peanut with foliar-applied fungicides. Peanut Sci. 18: 47-50.
15. Hagan, A. K., J. R. Weeks, and K. Bowen. 1991. Effect of placement and rate of PCNB and PCNB + ethoprop on the control of southern stem rot of peanut. Peanut Sci. 18: 94-97.
16. Hagan, A. K., J. R. Weeks, and J. A. McGuire. 1988. Comparison of soil insecticides alone and in combination with PCNB for suppression of southern stem rot of peanut. Peanut Sci. 15: 35-38.
17. Hagan, A. K., J. R. Weeks, and R. B. Reed. 1986. Southern stem rot suppression on peanut with the insecticide chlorpyrifos. Peanut Sci. 13: 36-37.
18. Mack, T. P., J. E. Funderburk, R. E. Lynch, E. G. Braxton, and C. B. Backman. 1989. Efficacy of chlorpyrifos in soil to lesser cornstalk borer (Lepidoptera: Pyralidae). J. Econ. Entomol. 82: 1224-1229.
19. Mack, T. P., J. E. Funderburk, and M. G. Miller. 1991. Efficacy of selected granular insecticides in soil in 'Florunner' peanut fields to larvae of lesser cornstalk borer (Lepidoptera: Pyralidae). J. Econ. Entomol. 84: 1899-1904.
20. SAS Institute. 1985. GLM Procedure, pp. 183-260. In SAS/STAT guide for personal computers, version 6 edition. SAS Inst., Cary, NC.
21. Steel, R. G. D. and J. H. Torrie. 1960. Principles and procedures of statistics, 1st ed. McGraw-Hill, New York.
22. Thompson, S. S. 1978. Control of southern stem rot of peanuts with PCNB plus fensulfothion. Peanut Sci. 5: 49-52.

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