Effect of Application Techniques on Performance of Propiconazole for Peanut Disease Control

T. B. Brenneman[1]*, H. R. Sumner[2], L. R. Chandler[2],
J. M. Hammond[3], and A. K. Culbreath[1]

ABSTRACT

Propiconazole (Tilt®) was applied to Florunner peanut by injection into irrigation water (chemigation) or as a foliar spray. At rates of 0.12-0.25 kg/ha of propiconazole control of both Rhizoctonia limb rot (*Rhizoctonia solani* AG-4) and stem rot (*Sclerotium rolfsii*) was inconsistent. Chemigation resulted in the lowest incidence of stem rot, but the incidence of stem rot was only 26% less than the control. Yields from plots receiving chemigation were greater than expected based on disease ratings, indicating that some effects of the fungicide were not being evaluated. Where foliar sprays of chlorothalonil were applied for late leaf spot (*Cercosporidium personatum*), supplemental applications of propiconazole via chemigation improved leaf spot control. However, substituting chemigated propiconazole for foliar sprays of chlorothalonil consistently resulted in more severe leaf spot and, in one year, decreased yields. Propiconazole is most effective against leaf spot when applied as a foliar spray, whereas chemigation applications provide optimum efficacy against soilborne pathogens of peanut.

Key Words: Propiconazole, chemigation, stem rot, chemical control, limb rot, early leaf spot, late leaf spot.

Peanut (*Arachis hypogaea* L.) growers in the southeastern U.S. rely on fungicides to manage a variety of damaging diseases. Foliar diseases such as early and late leaf spot [(*Cercospora arachidicola* Hori and *Cercosporidium personatum* (Berk. & Curt.) Deighton, respectively)] can cause devastating losses and multiple applications of a protectant fungicide such as chlorothalonil (tetrachloroisophthalonitrile) are required for effective control. Soilborne diseases, primarily limb rot (*Rhizoctonia solani* Kühn AG-4) and stem rot (*Sclerotium rolfsii* Sacc.), are also major problems, and until recently chemical control alternatives were limited. Options for the control of limb rot and stem rot of peanut were greatly expanded in 1994 with the registration of propiconazole (1-((2-(2,4-dichlorophenyl)-4-propyl-1,3-dioxolan-2-yl)methyl)-1H-1,2,4-triazole) and tebuconazole (α-(2-(4-chlorophenyl)-ethyl)-α-(1,1-dimethylethyl)-1H-1,2,4-triazole-1-ethanol). These are both sterol demethylation inhibitors (DMI's), a class of chemicals with activity against a wide range of fungal pathogens (15). They are both also triazoles, a class of DMI that has shown promise for the control of peanut diseases (1,2,7,11,17).

Propiconazole was one of the earliest DMI's evaluated in the Southeastern U.S. and currently is also labeled for control of several diseases on crops such as cereals, pecans, and corn. It has been shown to inhibit C-14 demethylation in *C. arachidicola*, *C. personatum*, and *S. rolfsii* (13,20) and is registered for control of *R. solani* in rice. Growth of *C. arachidicola* and *C. personatum* are quite sensitive to propiconazole (13), while *S. rolfsii* is less sensitive *in vitro* on solid medium (16). However, Waterfield and Sisler (20) found *S. rolfsii* to be more sensitive to this fungicide in liquid culture than on solid medium.

Waterfield and Sisler (20) also speculated that propiconazole may be more effective against stem rot than indicated by *in vitro* data alone due to supplemental inhibition by the plants resistance system. Partial control of stem rot was noted in field experiments in 1979 (6) but the degree of control observed in subsequent studies has been erratic (11,20 and T. B. Brenneman, unpubl. data). Prior to its registration for leaf spot control in 1994, the fungicide had been used in both Oklahoma and Texas under either a Section 18 Emergency Exemption or a crisis exemption for control of stem rot (1988-1990). The emulsifiable concentrate formulation of propiconazole lends itself to chemigation applications which are commonly utilized in the southwest. Applications in larger volumes of water may be more appropriate for soilborne diseases such as stem rot since propiconazole is rapidly absorbed by plant foliage (12) and

[1]Dept. of Plant Pathology, Univ. of Georgia, Tifton, GA 31794.
[2]IBPMRL-USDA/ARS, Coastal Plain Exp. Stn., Tifton, GA 31793.
[3]Ciba Corporation, P. O. Box 2369, Auburn, AL 36830.
*Corresponding author.

is not downwardly translocated. Other triazoles have provided excellent control of both soilborne and foliar peanut pathogens when applied via chemigation (1,2,9).

The purpose of this study was to evaluate the efficacy of propiconazole for control of limb rot and stem rot of peanut when applied by chemigation or foliar sprays. Additionally, replacing scheduled foliar treatments of chlorothalonil with chemigated propiconazole treatments for foliar disease control was investigated. Such information is essential to formulating the most cost-effective use strategy for propiconazole on peanut.

Materials and Methods

Center Pivot Experiment. The study was initiated in 1989 in a field of Pelham loamy sand (thermic Arenic Paleaquult) at the Bowen research farm, Tifton, GA, in one quadrant (0.15 ha) of a single-tower, center-pivot irrigation system. The test was repeated in 1990 in an adjacent quadrant of the same pivot. Both quadrants were previously cropped to tobacco and corn. The field was moldboard-plowed, disked, and bedded. The peanut cultivar Florunner was planted in rows spaced 0.91 m apart at 112 kg/ha of seed in 1989 and 101 kg/ha of seed in 1990. The planting dates were 22 May 1989 and 11 May 1990. Standard management practices of the Georgia Coop. Ext. Serv. were followed (14). Plots were single beds (6.1 x 1.8 m) with two rows per bed. Two border rows separated plots within blocks and 2.1-m fallow alleys were used between blocks. A randomized complete block design with four blocks was utilized.

Foliar sprays of fungicides were scheduled on a 14-d interval beginning 35 d after planting (DAP) with a maximum of seven applications. Specific treatments were: (a) seven applications of chlorothalonil; (b) seven applications of chlorothalonil plus propiconazole at application three; (c) chlorothalonil at application times 1, 2 and 4 through 7 plus propiconazole at application three; (d) seven applications of chlorothalonil plus propiconazole at applications three and five; and (e) chlorothalonil at applications 1, 2, 4, 6, and 7 plus propiconazole at applications three and five. Chlorothalonil was applied as Bravo 720 (1.26 kg ai/ha) with a CO_2-pressurized backpack sprayer equipped with three D2-25 nozzles per row to deliver 187 L/ha of spray at 296 kPa. Propiconazole was applied as Tilt 3.6 EC (0.25 kg ai/ha) injected into the irrigation water. Prior to injection, the fungicide was diluted (10.9:1, water:fungicide) and each application was made in 25.4 kL/ha of irrigation water. During chemigations, plots not treated were covered with elevated fiberglass shelters. To minimize the effect of additional water, the entire field received 129 kL/ha of water the evening before each application. Peanuts were inverted 13 Oct. 1989 and 9 Oct. 1990. Plots were harvested with a commercial combine on 25 Oct. 1989 and 17 Oct. 1990. Pods were dried to 10% moisture (w/w).

Center Pivot Simulator Experiment. This study was conducted in 1989-1991 at the Gibbs research farm, Tifton, GA in a field of Tifton loamy sand (fine-loamy, siliceous, thermic Plinthic Kandiudults, pH 5.8) with a history of continuous peanut production. The field was prepared as described above and Florunner peanut was planted at 101 kg seed/ha in rows spaced 0.91 m apart on 16 May 1989, 11 May 1990, and 17 May 1991. Plots were 4.6 m wide by 9.1 m long and blocks were separated by 7.6-m fallow alleys. A randomized complete block design was used all 3 yr with three blocks in 1989 and 1990 and four blocks in 1991.

All plots were sprayed by tractor-mounted sprayer every 14 d with chlorothalonil (1.26 kg/ha) for leaf spot control. Treatments for soilborne pathogens included a nontreated control, pentachloronitrobenzene (PCNB) applied as Terraclor® 10G at 5.6 kg ai/ha, propiconazole in 64.5 kL/ha of irrigation water, propiconazole in 25.4 kL/ha of irrigation water, propiconazole sprayed in 561 L/ha of water, and propiconazole sprayed in 187 L/ha of water. Propiconazole was applied at the rate of 0.12 kg ai/ha (Tilt® 3.6 EC) 60, 74, and 88 DAP.

Chemigated treatments were applied with an irrigation simulator equipped with E53 WhirlJet® nozzles designed to apply volumes of water typical of chemigation with a center-pivot system. This motorized, self-contained apparatus has been described previously (19). Foliar-ground sprays were applied with a CO_2-pressurized backpack sprayer. Three D2-25 nozzles per row at 296 kPa delivered 187 L/ha and one 8015 nozzle per row at 359 kPa delivered 561 L/ha of water. The PCNB treatment was applied 60 DAP with a bicycle wheel-driven pushcart using a single drop tube centered over the row. Peanuts were inverted 21 Sept. 1989, 27 Sept. 1990, and 27 Sept. 1991. Plots were harvested with a commercial combine on 10 Oct. 1989, 4 Oct. 1990, and 4 Oct. 1991. Pods were dried to 10% moisture (w/w).

Disease Rating and Statistical Analysis. Leaf spot ratings were taken for both experiments using the Florida scale (1-10), which accounts for both lesion incidence and defoliation (5). Severity of Rhizoctonia limb rot was rated immediately after digging by visually estimating the percentage of symptomatic vines and leaves at each of six randomly selected areas per plot. Incidence of stem rot was also evaluated after digging by counting the number of 30-cm row segments with symptomatic plants per plot. Data were analyzed by analysis of variance, and Fisher's protected least significant difference (18) values were calculated for treatment comparisons.

Results

Center Pivot Experiment. Due to significant ($P < 0.05$) year by treatment interactions for all parameters evaluated, each year of this experiment was analyzed individually. Stem rot was not observed in 1989 and was present only at low levels in 1990. Plots treated with chlorothalonil alone had an incidence of 4.4% and there were no significant treatment effects. Limb rot was more severe, especially in 1989 (Table 1). Propiconazole did not reduce limb rot severity, and where two applications were substituted for chlorothalonil disease levels were higher. Dry, hot conditions in 1990 resulted in lower limb rot severities in all plots and propiconazole had no significant effect on disease.

Late leaf spot, the primary foliar disease in the test, was also more severe in 1989 than 1990. Leaf spot was most severe in plots where propiconazole was substituted for chlorothalonil (Fig. 1). Chemigated propiconazole applied in addition to chlorothalonil provided superior control to that achieved with chlorothalonil alone. Pod yields in 1989 followed the same pattern. The highest yielding plots received two applications of propiconazole via chemigation in addition to seven foliar sprays of chlorothalonil (Table 1). Replacing two chlorothalonil sprays with chemigated propiconazole reduced yields by 753 kg/ha as compared to using chlorothalonil full season. Due to the extremely hot

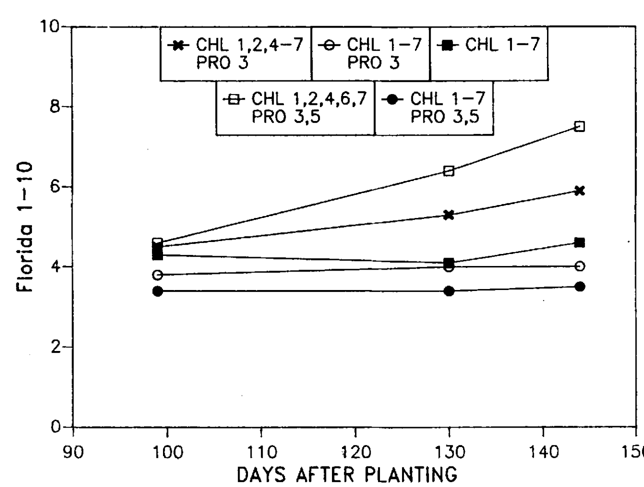

Fig. 1. Effect of propiconazole applied via chemigation either substituted for, or in addition to, foliar sprays of chlorothalonil for control of late leaf spot, 1989. Chl = chlorothalonil (1.26 kg/ha) and Pro = propiconazole (0.12 kg/ha). Numbers refer to the spray number from 1-7 in a seven-spray, 14-d schedule. Leaf spot was rated with the Florida 1-10 sale (5).

Table 1. Effects of propiconazole applied via chemigation either in addition to, or in place of, conventionally applied chlorothalonil on peanut diseases and yield.

Treatment[a]	Rate	Applications[b]	Leaf spot[c]		Limb rot[d]		Yield	
			1989	1990	1989	1990	1989	1990
	kg/ha						-------- kg/ha -------	
Chlorothalonil	1.26	1-7	4.6	2.3	17.5	10.0	3863	2183
Chlorothalonil + propiconazole	1.26 0.25	1-7 3	4.0	2.3	17.1	6.7	4137	2458
Chlorothalonil + propiconazole	1.26 0.25	1,2 & 4-7 3	5.9	2.7	21.5	8.1	3527	2359
Chlorothalonil + propiconazole	1.26 0.25	1-7 3 & 5	3.5	2.1	16.5	8.1	4370	2025
Chlorothalonil + propiconazole	1.26 0.25	1,2,4,6, & 7 3 & 5	7.5	3.2	26.9	8.8	3110	2462
LSD[e]			0.6	0.5	5.2	3.4	684	672

[a]Chlorothalonil was applied as Bravo 720 and propiconazole was applied as Tilt 3.6 EC.

[b]Refers to the application number in a standard seven spray, 14-d leaf spot spray schedule.

[c]Rated at harvest using the Florida 1-10 scale (5).

[d]Rating is an estimate done immediately after digging from six locations per plot of the percentage of vines and leaves colonized by *R. solani*.

[e]Means were separated within columns by Fisher's protected LSD (P = 0.05).

and dry weather in 1990, pod yields for all treatments were low 1990 and there were no significant treatment differences.

Center Pivot Simulator Experiment. Since the year by treatment interactions were not significant for any parameters evaluated, all data analysis was for the combined means of the 3 yr of this study. Although all plots were sprayed every 14 d with chlorothalonil and evaluating leaf spot control was not an objective of this test, late leaf spot was severe enough in 1989 and 1991 to warrant rating. All plots receiving propiconazole had less leaf spot than those receiving just chlorothalonil or chlorothalonil plus PCNB (Table 2). The best control was achieved when propiconazole was applied as a foliar spray in the smallest volume of water (187 L/ha). No leaf spot was observed in 1990.

Rhizoctonia limb rot severity in nontreated plots was nearly 50% in 1989 and 1991 and only 22% in 1990. The PCNB treatment was applied in a narrow band and therefore did not reduce limb rot severity. All propiconazole treatments except the applications in 561 L/ha of water significantly lowered limb rot. However, the least amount of Rhizoctonia limb rot with any propiconazole treatment was only 20.4% less than the control (Table 2).

Stem rot was also severe, especially in 1991 when 67% of the row length in nontreated plots had plants infected with *S. rolfsii*. While some of the PCNB and propiconazole treatments had numerically less stem rot, the only treatment that significantly reduced disease was propiconazole applied in the highest volume of water (Table 3).

Grades (% sound mature kernels and sound splits) of harvested peanuts averaged 71.3, 66.6 and 70.8% in 1989, 1990, and 1991, respectively. Analysis of the 3-yr mean indicated that there were no significant differences in grade due to the fungicide treatments. Peanut yields were consistent for all 3 yr of the study. Plots receiving only chlorothalonil yielded 3171 kg/ha (Table 3). Only the propiconazole treatments applied via chemigation in either volume of water increased yield compared to the chlorothalonil control.

Discussion

Propiconazole demonstrated some activity against several peanut diseases of significance in the southeastern U.S. The efficacy of this fungicide appears to be influenced by the manner in which it is applied and the volume of water used. Applications via chemigation where the fungicide was washed down through the canopy were the most effective against stem rot and produced the highest yields in fields with severe soilborne disease pressure. This was likely due to improved placement of the fungicide since triazoles are known to be absorbed by foliage (12). Studies with chlorothalonil have clearly shown much higher deposition levels on the upper versus lower peanut canopy with foliar sprays whereas chemigated treatments leave residues that are lower but more uniform throughout the canopy (4). Chemigated chlorothalonil has also been shown to provide less control of late leaf spot than conventionally applied chlorothalonil (3).

Propiconazole is known to be more active on early (*C. arachidicola*) than on late (*C. personatum*) leaf spot. Late leaf spot was the primary foliar disease in all of these studies, and results indicate that propiconazole applied via chemigation did not control this disease. Chemigation applications could provide an additional degree of control, but conventional foliar applications of chlorothalonil on a full-season schedule would still be needed. Growers using propiconazole for management of leaf spot should utilize conventional ground spray equipment. These foliar sprays should be used early season to midseason to take advantage of propiconazole's activity on early leaf spot, and also avoid exacerbating late season rust epidemics (17). An alternative

Table 2. Effects of application method and water volume on efficacy of propiconazole for control of leaf spot and Rhizoctonia limb rot of peanut.[a]

Treatment[b]	Appl. method (volume)	Leaf spot[c] '89	'90	'91	Avg	Rhizoctonia limb rot[d] '89	'90	'91	Avg
None		4.0	-	6.7	5.5	47	22	48	39.6
PCNB	15 cm band	4.3	-	6.9	5.8	37	21	48	36.5
Propiconazole	Chemigated (65.0 kL/ha)	3.0	-	6.1	4.7	27	24	41	31.5
Propiconazole	Chemigated (25.4 kL/ha)	4.3	-	5.4	4.9	39	17	39	32.2
Propiconazole	Ground spray (561 L/ha)	4.7	-	4.6	4.6	39	20	43	34.7
Propiconazole	Ground spray (187 L/ha)	3.3	-	4.3	3.9	34	20	39	31.7
LSD[e]					0.5				5.8

[a]All plots were sprayed with chlorothalonil (1.26 kg/ha) on a 14-d schedule.

[b]PCNB (5.6 kg ai/ha) was applied as Terraclor 10G at 60 DAP. Propiconazole (Tilt 3.6 EC, 0.12 kg ai/ha) was applied three times beginning 60 DAP on a 14-d schedule.

[c]Rated at harvest using the Florida 1-10 scale (5).

[d]Rating is an estimate done immediately after digging from six locations per plot of the percentage of symptomatic vines and leaves.

[e]Means were separated within columns by Fisher's protected LSD (P = 0.05).

program utilizing a tank mix of reduced rates of both propiconazole and chlorothalonil performed well and needs to be evaluated further (8).

Propiconazole is probably best suited to use in Virginia, North Carolina, or Oklahoma where early leaf spot is the primary foliar disease. However, the southeastern U.S. has experienced a shift toward more early leaf spot in 1993 and 1994 (T. B. Brenneman, pers. observation). If this trend continues, propiconazole would be more effective in that region. One option for control of late leaf spot is to use it on the moderately resistant cultivar Southern Runner (10). The southeast also suffers the greatest losses to stem rot and limb rot and has many hectares of irrigated peanuts that could be treated via chemigation. The recent registration of tebuconazole, which is more effective than propiconazole against stem rot (11), offers growers an excellent control

Table 3. Effects of propiconazole application method and water volume on control of stem rot and peanut yield.[a]

Treatment[b]	Appl. method (volume)	Stem rot[c] '89	'90	'91	Avg	Yield '89	'90	'91	Avg
						kg/ha			
None	-	24	36	67	44.4	3071	3507	2991	3171
PCNB	15 cm band	17	28	59	37.1	3732	4344	3201	3705
Propiconazole	Chemigated (65.0 kL/ha)	8	36	50	32.9	4021	4101	4273	4147
Propiconazole	Chemigated (25.4 kL/ha)	16	39	57	39.3	3605	3659	4124	3830
Propiconazole	Ground spray (561 L/ha)	26	42	64	45.7	3433	3722	3486	3543
Propiconazole	Ground spray (187 L/ha)	15	36	59	38.9	3632	3534	3819	3678
LSD[d]					8.2				577

[a]All plots were sprayed with chlorothalonil (1.26 kg/ha) on a 14-d schedule.

[b]PCNB (5.6 kg ai/ha) was applied as Terraclor 10G 60 DAP. Propiconazole (Tilt 3.6 EC, 0.12 kg ai/ha) was applied three times beginning 60 DAP on a 14-d schedule.

[c]*Sclerotium rolfsii.* Percentage of 30.5-cm sections of linear row per plot with at least on infected plant.

[d]Means were separated within columns by Fisher's protected LSD (P = 0.05).

option. However, tebuconazole can only be applied as a foliar spray by conventional equipment. Propiconazole can be applied through irrigation systems in Georgia according to a section 24(C) registration. Midseason chemigation applications of propiconazole provide an alternative for suppression of soilborne diseases, particularly when fields are too wet for conventional equipment or a grower doesn't want to damage the vines with tractor traffic.

The yield increases resulting from propiconazole use were sometimes greater than might have been expected based on disease control. This may have been due to the protection of pegs from *R. solani* and other pathogens that can cause pod loss. Such damage is not easily quantified. Although the cause remains unknown, propiconazole has caused similar yield increases previously (8). In summary, propiconazole is another management tool for several peanut diseases, and the option of chemigation increases its utility.

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