Research

Early-Season Fungicide Programs for Peanut Disease Management

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Abstract

The efficacy of early-season prothioconazole applications on stem rot (*Sclerotium rolfsii*) epidemics of peanut (*Arachis hypogaea*) planted on different dates was evaluated to better understand stem rot development and obtain more consistent disease control. The industry standard cultivar (Georgia-06G) was planted on four different dates at about 2-week intervals starting 25 April of both 2012 and 2013. Plots were either not treated or treated with prothioconazole (0.16 kg a.i./ha) at 21 or 35 days after planting (DAP) applied in a 30-cm band. All plots received chlorothalonil (2.09 kg a.i./ha) for leaf spot control. The mean final stem rot incidence in nontreated plots for planting dates 1 to 4 were 32, 15, 13, and 9% in 2012 and 25, 13, 24, and 6% in 2013, respectively. Final incidence of stem rot in plots treated with prothioconazole

followed a similar pattern, but disease incidence was reduced by an average of 36 and 46% in 2012 and 4 and 14% in 2013 for the 21 and 35 DAP applications, respectively. Pod yields in nontreated plots for planting dates 1 to 4 (chlorothalonil only) were 6,446, 6,578, 5,479, and 2,613 kg/ha in 2012 and 2,914, 6,456, 5,399, and 3,123 kg/ha in 2013, respectively. Prothioconazole-treated plots (at either 21 or 35 DAP) averaged 475 and 600 kg/ha higher yield than nontreated plots in 2012 and 2013, respectively, but the differences between these two timings were not significant ($P > 0.10$). Both 2012 and 2013 had relatively cooler spring temperatures and lower risk of early stem rot. The efficacy and yield increase from the early prothioconazole application may have been greater in a warmer spring.

Stem rot, caused by the soilborne fungus *Sclerotium rolfsii* Sacc., causes severe losses annually on peanut (*Arachis hypogaea* L.) in Georgia. The disease normally is initiated in the field during the midseason when the peanut foliage has covered the row middles and the weather conditions favor disease development. Chemical control plays an important role in stem rot management in Georgia, with estimated annual fungicide costs of \$25 million (Georgia Plant Disease Loss Estimate, <http://extension.uga.edu/publications>). Several classes of fungicides are used for stem rot management, including succinate dehydrogenase inhibitors, quinone outside inhibitors, and triazoles (Backman and Brenneman 1997). Fungicides are recommended to be initially applied at 60 days after planting (DAP) and reapplied to ensure protection through at least the next 60 days. However, in recent years such as 2010 and 2011, abnormally warm spring temperatures resulted in stem rot outbreaks around 30 days earlier in the season than typically observed.

Fungicides applied in-furrow at the time of planting can provide additional benefits on disease control. In-furrow application of azoxystrobin can improve plant stands and seedling health and can reduce the incidence of *Aspergillus* crown rot (*Aspergillus niger*), which is the major disease of peanut seedlings (Rideout et al. 2002). Prothioconazole, a triazole fungicide, is currently used in-furrow in Georgia to suppress early-season root infections of *Cylindrocladium parasiticum*, causing *Cylindrocladium* black rot (CBR) (Brenneman et al. 2011b). Later studies showed that early-season, postemergence application of prothioconazole in a high volume and banded directly to the plant had a similar effect on CBR and could also suppress early stem rot and leaf spot (Brenneman et al. 2011a, b; Culbreath et al. 2008). The details of the most favorable spray

timing of these early sprays still need to be refined, but these applications hold great potential as an effective solution for minimizing early-season development of stem rot.

The planting season for peanut in Georgia starts in mid-April and continues into June. The Peanut Rx disease management program developed for use in the southeastern peanut states indicates that planting dates prior to 1 May have the highest risk of developing stem rot, followed by plantings from 1 to 10 May, with the lowest risk for later plantings after 10 May (Brenneman and Hadden 1996). April was the primary month for peanut planting until tomato spotted wilt became a major problem, and it was found that early planting dates often had more severe epidemics of that disease (Culbreath et al. 2003). Consequently, the majority of peanut acreage in Georgia is now planted in May. However, many growers would like to plant peanut earlier because of the favorable cultivation conditions for winter crops, and the trend is for more April plantings with the advent of Tomato spotted wilt virus-resistant cultivars that have greatly reduced losses from tomato spotted wilt.

Soil temperatures affect the development of both the plant and soilborne pathogens such as *S. rolfsii*, and average soil temperatures are generally lower for earlier planting dates. As the date of planting is moved later in the season, soil temperatures increase, as does the rate of plant growth and the relative risk for the development of stem rot. Thus, the timing for an early-season fungicide to prevent stem rot may well be different for peanuts planted in mid-April versus those planted later in May or June in much warmer soils. The objectives of this study were to evaluate the effects of postemergence, early-season prothioconazole applications mainly on peanut stem rot epidemics as well as *Aspergillus* crown rot and peanut leaf spots across a range of planting dates. Different application timings for prothioconazole were included to determine if they provided similar disease control benefits over a range of planting dates.

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Effect of Prothioconazole Application Timings and Peanut Planting Date on Stem Rot Incidence

Field trials were conducted at a commercial farm located near Chula, GA, in 2012 and 2013. The peanut cultivar Georgia-06G was planted (16 seeds per meter per row) on four different dates each year (25 April, 8 May, 21 May, and 4 June in 2012, and 25 April, 9 May, 24 May, and 11 June in 2013). All plots received the final five sprays (3 to 7) of a normal seven sprays chlorothalonil program (2.09 kg a.i./ha, Bravo Weather Stik, Syngenta Crop Protection, Greensboro, NC) (applied at approximately 2-week intervals), which aims to control leaf spot. A randomized complete block design with three or four replications of each treatment was used for each planting date, but the planting dates were not replicated. The plots consisted of three adjacent beds; each was 15.2 m long and 1.83 m wide with 0.91-m row spacing. The center bed was used for disease assessment and yield. Plots were either not treated or treated with prothioconazole (0.16 kg a.i./ha, Proline, Bayer CropScience, Nichino America, Wilmington, DE) at 21 or 35 DAP applied in a 30-cm band (by a tractor-mounted sprayer with a 4006E even flat fan tip, 187 liters/ha).

Disease Assessment

The progress of stem rot and *Aspergillus* crown rot was evaluated by calculating disease incidences at 25, 40, 55, 70, and 100 DAP by destructive sampling in the two outside beds of each plot (Bowen 1998). The center bed was used for yield data and not inverted until the plants reached physiological maturity. At each scheduled sampling, a total of 1.52 m of the sample row for each plot was dug with a shovel, and the individual plants were assessed for signs and symptoms of *S. rolfii* and *A. niger*. Bioassay of diseased tissues on potato dextrose agar (PDA) with antibiotic was used to verify the causal pathogen. The infected peanut roots, pods, or the tissues near the crown were surface sterilized by soaking in 10% bleach for 1 min and then rinsed with distilled water for 1 min. Infected tissues were cultured on PDA for 7 days, and isolated fungi were identified by visual examination. The incidence of stem rot and *Aspergillus* crown rot was calculated as the percentage of sampled plants with disease. Foliar diseases (both early and late leaf spot) were evaluated before harvest using the Florida 1 to 10 scale where 1 = no disease and 10 = dead plants (Chiteka et al. 1988).

The incidence of disease on the below-ground portions of the plants after inverting was evaluated using the following method. For each plot, the number of symptomatic segments (30.5-cm long) per row was counted. The disease incidence was calculated as a percentage according to the following formula: disease incidence = (number of symptomatic 30.5-cm row segments / number of 30.5-cm row segments in plot) × 100 (Rodriguez-Kabana et al. 1975).

The peanuts were inverted on 12 September, 26 September, 10 October, and 25 October for planting dates 1 to 4 of 2012. The peanuts were inverted on 16 September, 2 October, 14 October, and 28 October for planting dates 1 to 4 of 2013. After drying for about 14 days (when soil on pods dried), all plots were picked with a commercial combine. Before weighing the yield, peanuts were dried to about 10% moisture at room temperature.

Statistical Analysis

The significant treatment effects on disease incidence and yield were subject to analysis of variance by using Proc GLM (SAS version 9.3, Cary, NC) ($P < 0.05$). The Fisher's protected LSD ($\alpha = 0.05$) was then calculated for mean separations among treatments.

Effect of Fungicide Applications on Incidence of Stem Rot and Aspergillus Crown Rot Disease

Overall, stem rot epidemics were moderate, but the disease was not found until late in the season in both years of the study. The first stem rot signs and symptoms were found on 11 August, 14 August, 26 July, and 14 August for planting dates 1 to 4 of 2012, respectively (Table 1). Final stem rot incidence was 32, 15, 13, and 9% in nontreated plots for planting dates 1 to 4 of 2012, respectively (Table 2). The first stem rot of 2013 was found on 3 June, 18 June, 19 June, and 5 July for planting dates 1 to 4, respectively (Table 1). Final stem rot incidence for the nontreated plots was 25, 13, 24, and 6% for planting dates 1 to 4, respectively (Table 2). The disease tended to appear earlier on the later planting date peanuts for both years, and disease onset was earlier in 2013 than in 2012. The first peanut stem rot was found on 26 July and 3 June in 2012 and 2013, respectively.

The prothioconazole-treated plots (21 or 35 DAP) often had numerically lower stem rot incidence than nontreated plots, but the differences were significant only in trials planted on 9 May 2013 and destructively rated on 100 DAP. There were no differences between the 21 and 35 DAP sprays of prothioconazole (Table 1).

Aspergillus crown rot incidence was low (<10%) and mostly without significant differences among treatments for all four planting dates in both years (data not shown). The 21 DAP prothioconazole treated plots did have lower incidence than the 35 DAP treated and nontreated plots in all five assessments for the third planting date (24 May) in 2013.

TABLE 1
Effect of prothioconazole application timings and peanut planting date on percent underground stem rot incidence over time^z

Year	Planting date	Treatment	Days after planting				
			25	40	55	70	100
2012	25 April	Nontreated	0	0	0	0	25 a
		Prothioconazole 21 DAP	NA	0	0	0	10 a
		Prothioconazole 35 DAP	NA	0	0	0	13 a
	8 May	Nontreated	0	0	0 a	0 a	5 a
		Prothioconazole 21 DAP	0	0	0 a	0 a	5 a
		Prothioconazole 35 DAP	0	0	1 a	1 a	1 a
	21 May	Nontreated	0	0	0	2 a	12 a
		Prothioconazole 21 DAP	0	0	0	0 a	0 a
		Prothioconazole 35 DAP	0	0	0	2 a	11 a
	4 June	Nontreated	0	1 a	1 a	3 a	10 a
		Prothioconazole 21 DAP	0	0 a	0 a	0 a	7 a
		Prothioconazole 35 DAP	0	0 a	0 a	0 a	0 a
2013	25 April	Nontreated	0	0 a	4 a	13 a	38 a
		Prothioconazole 21 DAP	0	0 a	0 a	1 a	1 a
		Prothioconazole 35 DAP	0	4 a	5 a	8 a	18 a
	9 May	Nontreated	0	6 a	14 a	25 a	46 a
		Prothioconazole 21 DAP	0	0 a	6 a	11 a	32 ab
		Prothioconazole 35 DAP	0	3 a	5 a	5 a	6 b
	24 May	Nontreated	0 b	4 a	5 a	1 a	29 a
		Prothioconazole 21 DAP	4 a	4 a	9 a	12 a	21 a
		Prothioconazole 35 DAP	0 b	1 a	1 a	3 a	21 a
	11 June	Nontreated	0 a	0 a	0 a	0 a	8 a
		Prothioconazole 21 DAP	0 a	0 a	0 a	0 a	0 a
		Prothioconazole 35 DAP	5 a	5 a	5 a	5 a	5 a

^z Prothioconazole was applied at 0.16 kg a.i./ha. Means within columns within each planting date in 2012 or 2013 followed by the same letter are not significantly different according to Fisher's protected LSD ($P < 0.05$). DAP = days after planting, and NA = not available.

Effect of Fungicide Applications on Incidence of Leaf Spot

Leaf spot intensity was 3.7, 7.3, and 8.7 on the Florida scale in nontreated plots for planting dates 1, 3, and 4 (second planting: missing value caused by human mistake), respectively, in 2012. Prothioconazole suppressed leaf spot at harvest only for the earliest planting date of 25 April ($P < 0.05$), and no differences in leaf spot intensity among treatments were found for the later three planting dates ($P > 0.05$). Prothioconazole applied at 35 DAP resulted in statistically less disease than the 21 DAP application for the 25 April planting date in 2012 ($P < 0.05$). Leaf spot intensity was 5.9, 7.1, 7.8, and 7.7 in nontreated plots for planting dates 1 to 4, respectively, in 2013. No significant reduction of leaf spot was found for any treatments in 2013 (Table 3).

Effect of Fungicide Applications on Pod Yield

Pod yields in 2012 were generally high, and the nontreated plots (i.e., those receiving no in-furrow fungicide, but five foliar sprays of chlorothalonil only) yielded 6,446, 6,578, 5,479, and 2,613 kg/ha for planting dates 1 to 4, respectively. Yield on the fourth planting date was lower owing to a bad stand issue perhaps caused by having compacted soil at planting. Most treated plots had numerically higher pod yields than the nontreated plots, but differences were not significant. In 2013, pod yields from the nontreated plots (five sprays of chlorothalonil only) were 2,914, 6,456, 5,399, and 3,123 kg/ha for planting dates 1 to 4, respectively. Peanuts planted on 8 or 9 May tended to produce higher yields in both years of the study. The later application of prothioconazole resulted in significantly higher yields than the nontreated for the first planting dates in 2013, whereas only the earlier application increased yield for the last planting date (Table 4). There were no differences among treatments in yield for the second or third planting dates in 2013.

Implications for Fungicide Application for Control of Peanut Stem Rot

This study demonstrated in 2013 that the banded applications of prothioconazole could provide season-long reductions in stem rot (Tsai and Brenneman 2013). There were no differences observed between application dates (21 versus 35 DAP) in terms of stem rot control owing to the high level of variability often associated with

nonuniform distribution of soilborne pathogens such as *S. rolfisii*. However, there were differences in pod yield in 2013, with the later spray timing resulting in higher yields in the early-planted plots and the earlier timing resulting in higher yields in the late plantings. This pattern could possibly be explained by the fact that favorable conditions for disease development would occur later in the season for the early-planted peanuts, and the reverse would be true for the late plantings. However, the overall timing of the first stem rot found in the plots in 2012 was similar across planting dates (in late July or August) and was actually late compared with 2010 and 2011. The 2013 epidemic started earlier (early June to early July), and the date of initiation of stem rot disease symptoms paralleled the planting date. Normally, the warmer temperatures and higher humidity within the developing plant canopy become more favorable for disease initiation as the season progresses.

Implications for Management of Stem Rot in Peanut

We were not able to replicate the planting date plots in this study, so it was not possible to statistically analyze the apparent differences observed. However, the pattern of decreasing stem rot incidence and increasing leaf spot intensity from early to late plantings is consistent with previous studies (Brenneman et al. 2011a; Shokes et al. 1982).

TABLE 3
Effect of prothioconazole application timings and peanut planting date on final leaf spot severity^z

Year	Treatment	Planting date			
		1	2	3	4
2012	Date	25 April	8 May	21 May	4 June
	Nontreated	3.7 a	NA	7.3 a	8.7 a
	Prothioconazole 21 DAP	3.6 b	NA	7.8 a	8.6 a
	Prothioconazole 35 DAP	3.3 c	NA	6.7 a	8.6 a
2013	Date	25 April	9 May	24 May	11 June
	Nontreated	5.9 a	7.1 a	7.8 a	7.7 a
	Prothioconazole 21 DAP	5.6 a	6.7 a	7.7 a	7.7 a
	Prothioconazole 35 DAP	5.4 a	6.7 a	7.8 a	7.6 a

^z Leaf spot severity was rated using the Florida 1 to 10 scale. Prothioconazole was applied at 0.16 kg a.i./ha. Means within columns followed by the same letter are not significantly different according to Fisher's protected LSD ($P < 0.05$). DAP = days after planting, and NA = not available.

TABLE 2
Effect of prothioconazole application timings and peanut planting date on final stem rot incidence^z

Year	Treatment	Planting date			
		1	2	3	4
2012	Date	25 April	8 May	21 May	4 June
	Nontreated	32 a	15 a	13 a	9 a
	Prothioconazole 21 DAP	14 b	13 a	12 a	3 b
	Prothioconazole 35 DAP	13 b	13 a	7 a	3 b
2013	Date	25 April	9 May	24 May	11 June
	Nontreated	25 a	13 a	24 a	6 a
	Prothioconazole 21 DAP	24 a	12 a	27 a	5 a
	Prothioconazole 35 DAP	19 a	9 a	24 a	6 a

^z Disease incidence was calculated by the following formula: (number of symptomatic 30.5-cm row segments/number of 30.5-cm row segments in plot) $\times 100$. Prothioconazole was applied at 0.16 kg a.i./ha. Means within columns followed by the same letter are not significantly different according to Fisher's protected LSD ($P < 0.05$). DAP = days after planting.

TABLE 4
Effect of prothioconazole application timings and peanut planting date on pod yield (kg/ha)^z

Year	Treatment	Planting date			
		1	2	3	4
2012	Date	25 April	8 May	21 May	4 June
	Nontreated	6,446 a	6,578 a	5,479 a	2,613 a
	Prothioconazole 21 DAP	7,281 a	6,451 a	5,666 a	3,970 a
	Prothioconazole 35 DAP	6,691 a	6,611 a	6,026 a	3,323 a
2013	Date	25 April	9 May	24 May	11 June
	Nontreated	2,914 b	6,456 a	5,399 a	3,123 b
	Prothioconazole 21 DAP	3,740 ab	6,426 a	5,692 a	4,049 a
	Prothioconazole 35 DAP	5,212 a	6,349 a	5,343 a	3,783 ab

^z Prothioconazole was applied at 0.16 kg a.i./ha. Means within columns followed by the same letter are not significantly different according to Fisher's protected LSD ($P < 0.05$). DAP = days after planting.

Frequent rainfall in 2012 and 2013 contributed to the relatively high levels of leaf spot intensity that may have contributed to the lower yields, especially late in the year (correlation coefficient between leaf spot and yield: -0.51 , $P < 0.0001$).

These results illustrate the differences that can occur between seasons in terms of disease development owing to varying environmental conditions, even in the same field. Overall, there was little difference between the application timings of 21 and 35 DAP. This may not be the case in years with earlier epidemics. However, the later sprays would be preferred because they will provide protection further into the season and may result in fewer additional applications of fungicides. The one exception may be for late-planted peanuts, particularly in a year with very favorable conditions for disease during the early growing season. The early-season prothioconazole spray does not always make a difference in disease control and yield, but it provides a good foundation for later season spray programs and prevents the initiation of diseases prior to other scheduled fungicides.

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