Disease and Yield Response of a Stem-rot-resistant and -Susceptible Peanut Cultivar under Varying Fungicide Inputs

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Abstract

Peanut (*Arachis hypogaea* L.) producers rely on costly fungicide programs to manage stem rot, caused by *Sclerotium rolfsii*. Planting disease-resistant cultivars could increase profits by allowing for the deployment of less-expensive, lower-input fungicide programs. Field experiments were conducted to characterize stem rot and early and late leaf spot (caused by *Passalora arachidicola* and *Nothopassalora personata*, respectively), yield, and overall profitability of cultivars Georgia-06G (stem-rot-susceptible) and Georgia-12Y (stem-rot-resistant) as influenced by seven commercial fungicide programs. Stem rot incidence was consistently lower on Georgia-12Y for all fungicides when compared with Georgia-06G and was lowest for both cultivars in plots treated with prothioconazole plus a tank mixture of penthiopyrad and tebuconazole. Leaf spot severity was similar for both the resistant and susceptible cultivars, and the greatest reduction occurred in plots treated with

prothioconazole plus a tank mixture of penthiopyrad and tebuconazole. Fungicide programs gave similar yield and net return on Georgia-12Y; however, plots of Georgia-06G treated with prothioconazole plus a tank mixture of penthiopyrad and tebuconazole had the greatest yield and net return. Yields and economic return from the highest level of fungicide inputs on Georgia-06G were numerically less than those of Georgia-12Y treated with only chlorothalonil. These results show the value of fungicides in peanut disease management with susceptible cultivars, as well as the benefits of planting stem-rot-resistant cultivars in high-risk situations.

Keywords: chemical disease management, cultivar/resistance disease management, field crops, fungi, oilseeds and legumes, yield loss and economic impacts

Stem rot (also known as white mold), caused by the soilborne pathogen *Sclerotium rolfsii* Sacc., is one of the most damaging diseases of peanut (*Arachis hypogaea* L.) worldwide and causes severe yield losses in Georgia. Initial symptoms present as yellow and wilted lateral branches, main stems, or entire plants, typically occurring alongside sheaths of white mycelia and abundant white to dark-brown sclerotia found on both the soil surface and diseased plant tissues (Backman and Brenneman 1997). Infection of peanut plants by *S. rolfsii* is restricted to the plant parts in contact with the soil (e.g., lower stems, pegs, pods, and roots), and high soil moisture content, dense plantings, and frequent irrigation all favor infection and mycelial spread within and between plants (Coley-Smith and Cooke 1971; Punja 1985; Sconyers et al. 2005). With a conducive environment, the fungus will continue to colonize tissue throughout the season and rot pods, pegs, roots, and stems (Backman and Brenneman 1997). Stem rot is the most damaging soilborne disease in Georgia, where estimated crop losses from 2012 to 2016 averaged 4.6%; during those same years, the total combined cost of damage and control measures averaged \$47.3 million (Kemerait 2015a,b, 2016, 2017, 2019).

Several effective fungicides are available and labeled for use on peanut to manage stem rot and include members of the demethylation inhibitors, quinone outside inhibitors, and succinate dehydrogenase inhibitors (Fungicide Resistance Action Committee codes 3, 11, and 7, respectively) (University of Georgia Extension 2019).

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However, the high cost of these fungicides may prohibit their use in certain situations. Additionally, *S. rolfsii* may infect multiple parts of the plant, making stem rot management with fungicides difficult. Furthermore, delivering the fungicide to the belowground tissues has been particularly problematic, especially in fields where irrigation is not available to redistribute the fungicide from the aboveground foliage (Woodward et al. 2012). In Georgia, irrigation pivots are commonly used to supply overhead irrigation to peanut fields, which allows for the fungicide to be washed off of foliage and deposited at the soil line where *S. rolfsii* infections take place. Even when irrigation is available for fungicide redistribution, doing so may present additional disease management challenges because peanut producers may also be relying on these fungicides to control early and late leaf spot, caused by *Passalora arachidicola* (Hori) U. Braun (syn. *Cercospora arachidicola*) and *Nothopassalora personata* (Berk. & M. A. Curtis) U. Braun, C. Nakash., Videira & Crous (syn. *Cercosporidium personatum*). Both *P. arachidicola* and *N. personata* are endemic to Georgia and their associated losses have been estimated at an average of \$39.7 million in crop damage and control costs from 2012 to 2016 (Kemerait 2015a,b, 2016, 2017, 2019).

Establishing plantings of stem-rot-resistant cultivars would allow for fewer fungicide inputs or for the use of less expensive fungicide programs to manage both stem rot and leaf spots while retaining yield. This practice could also provide a greater economic return to producers. The most commonly cultivated runner-type peanut in the southeastern United States is currently Georgia-06G, which is a high-yielding cultivar with a large-sized seed and a medium maturity pattern (Branch 2007); however, it is susceptible to stem rot. Several runner-type cultivars with higher levels of stem rot resistance exist, beginning with Southern Runner (Brenneman et al. 1990), then followed by Georgia-07W (Branch and Brenneman 2009), York, Georgia-12Y, and Georgia-10T (Branch and Brenneman 2015). Of these cultivars, Georgia-12Y has the highest yield potential and is suited for sale in the same market as other runner-type peanut cultivars (Branch 2013). The response of Georgia-12Y to a range of fungicide inputs has never been explored but optimizing this cultivar for high stem rot pressure situations could allow peanut producers to spend less on fungicides while maintaining the same levels of disease

control. Thus, the objective of this study was to compare the cultivars Georgia-06G and Georgia-12Y for disease reactions and yield potential under seven different stem rot fungicide programs.

Materials and Methods

Experimental design and crop management. This study was initiated at the University of Georgia Blackshank Farm (31.50167, -83.54361) located in Tifton, GA during the 2013 growing season and was repeated in 2014 and 2015. The plot area was a Tifton loamy sand (slope 2 to 5%, pH 5.9 to 6.4) that had been in continuous peanut cultivation for at least 20 years and had a history of early and late leaf spot and stem rot disease pressure. Field plots were arranged in a split-plot design with peanut cultivar (Georgia-06G and Georgia-12Y) as the main plot and stem rot fungicide program as the subplots; there were four replications (blocks) of treatments. The land was deep turned to a depth of 20 to 25 cm, disk harrowed, and marked off in beds. Each plot consisted of a single two-row bed (7.6 by 1.8 m), separated by a 2.4-m fallow alleyway. Seven stem rot fungicide programs were assessed in this study and were based around cover applications of chlorothalonil (as Bravo Weather Stik; ADAMA Americas Inc., Aventura, FL, U.S.A.) applied at a rate of active ingredient at 1.26 kg/ha for leaf spot control. The tested fungicide programs were a nontreated control (nontreated for stem rot but included seven applications of chlorothalonil as noted above); prothioconazole (as Proline 480 SC; Bayer CropScience, Research Triangle Park, NC, U.S.A.) and chlorothalonil; chlorothalonil and a tank mixture of chlorothalonil + tebuconazole (as Orius 3.6F; ADAMA Americas Inc.); chlorothalonil and penthiopyrad (as Fontelis 1.67 SC; Corteva Agriscience, Indianapolis, IN, U.S.A.); prothioconazole, penthiopyrad, and chlorothalonil; chlorothalonil and a tank mixture of penthiopyrad + tebuconazole; and prothioconazole, a tank mixture of penthiopyrad + tebuconazole, and chlorothalonil. The details of fungicide programs (e.g., specific rates, timings of applications, and associated costs) are presented in Table 1. The midseason spray treatments were applied in water equivalent to 187 liters/ha at 276 kPa using a CO₂-pressurized broadcast boom sprayer with three Conejet TX-SS6 nozzles. Beyond disease management, the trial was irrigated as needed via solid set sprinklers and all production practices were based on the University of Georgia peanut recommendations (University of Georgia Extension 2019).

Disease and yield assessments. Natural epidemics of leaf spot and stem rot were monitored throughout the three growing seasons. Final leaf spot severity was assessed visually prior to digging (9 October 2013, 29 September 2014, and 8 October 2015) using the ordinal Florida 1-to-10 scale (Chiteka et al. 1988). This rating system initially describes the prevalence of early or late leaf spot lesions and their location in the peanut canopy, where 1 = no disease and 4 = some lesions, some on the upper canopy, and approximately 5% defoliation. The scale then shifts to describe percent defoliation and eventually death, where 5 = numerous lesions even on the upper canopy and approximately 20% defoliation, and 10 = plants completely defoliated or dead due to leaf spot (Chiteka et al. 1988). Pod maturity

was estimated using the hull-scrape method (Williams and Drexler 1981). The plants were inverted, and stem rot incidence was determined on 10 October 2013, 29 September 2014, and 12 October 2015 by counting the number of disease foci (one or more consecutive diseased plants in a 30-cm section, or less, of row) within a plot. Percent stem rot incidence was then assessed as [(number of 30-cm sections affected)/(number of 30-cm total sections in the plot)] × 100 (Rodriguez-Kabana et al. 1975). Inverted plants were left to dry for 5 to 8 days before harvest, at which point the kernels were placed in a commercial drying trailer to reach an approximate moisture content of 10% (wt/wt). Pod weight was determined after separation of soil and foreign material.

Pod quality assessment and economic analysis. A 500-g subsample of pods was shelled using commercial shelling equipment for grading. The kernels were classified and graded according to Federal-State Inspection Service method (USDA-AMS 1997). Crop quality was assessed as percent total sound mature, immature, or damaged kernels. The estimated crop value was based on \$441/metric ton and adjusted for grade values. The actual cost of fungicides to a farmer can be quite variable; these were determined by taking an average cost found by surveying several commercial dealers during the 2015 growing season. The return on fungicide costs was calculated for each plot as the gross return based on yield and grade minus the cost of the fungicide program. All other input costs, including application of the fungicides, were the same for all treatments and, therefore, were not considered in the economic analysis.

Data analysis. Generalized linear mixed-model analyses were conducted on stem rot incidence, pod yield (kilograms per hectare), and net return (dollars per hectare) using the GLIMMIX procedure in SAS (version 9.4; SAS Institute, Cary, NC, U.S.A.). For each of the three response variables, the fixed effects in the model were peanut cultivar, stem rot fungicide programs, and the two-way interaction of those terms; random effects were year, block within year, and block by cultivar within year. When an interaction was present, an analysis of simple effects was performed using the SLICE and SLICEBY statements. Unlike the stem rot, yield, and net return datasets, final leaf spot severity assessments were made using an ordinal scale. Thus, a nonparametric analysis was conducted on ranked data using PROC MIXED to evaluate the relative effects of the fungicide programs on final leaf spot severity (Shah and Madden 2004). The trials were analyzed across years and 95% confidence intervals were constructed using the LD_CI macro for SAS (Brunner et al. 2002; Shah and Madden 2004). The relative effects range from 0.0 to 1.0 and two fungicide programs were considered significantly different ($P \leq 0.05$) if their relative treatment effects each lie outside confidence intervals of the other. This nonparametric analysis has been used to describe treatment effects in previous studies where peanut leaf spot severity was assessed with the Florida 1-to-10 scale (Culbreath et al. 2018; Jordan et al. 2017, 2019). Finally, yield loss caused by stem rot was evaluated by regressing yield in kilograms per hectare on stem rot incidence estimates for each cultivar in each year of the study.

Table 1. Details of fungicide programs, rate, timing of applications, and associated costs of programs

Program ^w	Active ingredient	Rate ^x	Schedule ^y	Cost (\$) ^z
BWS	Chlorothalonil	1.26	1–7	103.74
Proline, BWS	Prothioconazole, chlorothalonil	0.20, 1.26	30 DAP, 3–7	130.91
BWS, BWS + Orius 3.6F	Chlorothalonil, chlorothalonil + tebuconazole	1.26, 1.26 + 0.23	1, 2, 6, 7, 3–5	123.50
BWS, Fontelis	Chlorothalonil, penthiopyrad	1.26, 0.22	1, 2, 6, 7, 3–5	242.06
Proline, Fontelis, BWS	Prothioconazole, penthiopyrad, chlorothalonil	0.20, 0.22, 1.26	30 DAP, 3–5, 6, 7	271.70
BWS, Fontelis + Orius 3.6F	Chlorothalonil, penthiopyrad + tebuconazole	1.26, 0.22 + 0.23	1, 2, 6, 7, 3–5	261.82
Proline, Fontelis + Orius 3.6F, BWS	Prothioconazole, penthiopyrad + tebuconazole, chlorothalonil	0.20, 0.22 + 0.23, 1.26	30 DAP, 3–5, 6, 7	288.99

^w BWS = Bravo Weather Stik.

^x Fungicide application rate in kilograms of active ingredient per hectare.

^y Application schedule in a standard 7-spray program at 14-day intervals. Initial applications were made between 30 and 40 days after planting (DAP), unless otherwise noted.

^z Fungicide program costs in dollars per hectare were estimated by surveying several dealers in the Georgia peanut production area.

Results

Stem rot incidence differed significantly by cultivar ($P < 0.0001$) and fungicide program ($P < 0.0001$); however, the two-way interaction of the main effects was significant ($P = 0.0039$) (Table 2). Fungicide program significantly reduced stem rot incidence for both cultivars but a greater reduction was observed for Georgia-06G (Table 3) and is likely the cause of the significant two-way interaction. For Georgia-06G, stem rot incidence was greatest in the chlorothalonil-only and prothioconazole plots. Several programs significantly reduced incidence compared with the chlorothalonil-only control, and included the tebuconazole, penthiopyrad, prothioconazole plus penthiopyrad, penthiopyrad and tebuconazole, and the prothioconazole plus a penthiopyrad and tebuconazole tank mixture. The effect of fungicide program on Georgia-12Y was significant but considerably less than for plots planted to Georgia-06G. Prothioconazole plus penthiopyrad, the tank mixture of penthiopyrad and tebuconazole, and prothioconazole plus the tank mixture of penthiopyrad and tebuconazole significantly reduced stem rot incidence compared with both the nontreated and the other fungicide programs.

Yield differences were significant due to cultivar ($P = 0.0083$) and fungicide program ($P < 0.0001$), and the two-way interaction of the main effects was significant ($P = 0.0346$) (Table 2). Fungicide program did not significantly influence the yield of Georgia-12Y but did affect the yield of Georgia-06G (Table 3). Compared with the chlorothalonil-only control, prothioconazole plus chlorothalonil did not significantly improve yield but all other fungicide programs did and no other significant differences were observed among the other fungicide programs. The effects of cultivar and fungicide program on net returns were not significant; however, the two-way interaction was (Table 2). When sliced by cultivar, fungicide program significantly increased net returns for plots planted to Georgia-06G but not for plots of Georgia-12Y. Similar to yield, prothioconazole

plus chlorothalonil did not significantly improve net return compared with the chlorothalonil-control but all other fungicide programs did, and did not differ significantly from one another (Table 3).

Leaf spot data were analyzed separately for each of the 3 years because the epidemics were considerably different among those years. Based on relative treatment effects, leaf spot ratings for each of the fungicide programs were lower for Georgia-12Y than Georgia-06G in 2013 and 2015 but were similar for both cultivars in 2014. Disease ratings using the Florida 1-to-10 scale in 2014 were considerably lower for all treatments when compared with 2013 and 2015, possibly due to differing environmental conditions. In 2013 and 2015, total rainfall from 1 May to 31 October was 717 and 631 mm, respectively, compared with 399 mm in 2014 (Supplementary Table S1). The environment in 2014 was not as conducive for leaf spot development, which is reflected in the reduced median leaf spot severity (Table 4). Fungicide programs differed and followed similar trends on both cultivars. The chlorothalonil-only plots were essentially the nontreated control plots for stem rot but received the chlorothalonil applications to protect against leaf spot. This treatment had the greatest leaf spot severity throughout the study (Table 4). Prothioconazole plus chlorothalonil did not significantly reduce leaf spot compared with the chlorothalonil-only plots for either cultivar in any of the 3 years. In 2013, the tebuconazole tank mixture, penthiopyrad, prothioconazole plus penthiopyrad, penthiopyrad plus tebuconazole, and the prothioconazole plus penthiopyrad and tebuconazole programs significantly reduced leaf spot for both cultivars (Table 4). In 2014, the tebuconazole tank mixture, penthiopyrad and tebuconazole tank mixture, and the prothioconazole plus penthiopyrad and tebuconazole tank mixture significantly reduced leaf spot severity compared with the chlorothalonil-only treatment. Likewise, for Georgia-12Y, the tank mixture of chlorothalonil and tebuconazole, prothioconazole plus penthiopyrad and chlorothalonil, a tank mixture of penthiopyrad and tebuconazole, and prothioconazole plus a tank mixture of penthiopyrad and tebuconazole significantly reduced leaf spot severity compared with the chlorothalonil-only control (Table 4). In 2015, the penthiopyrad and tebuconazole tank mixture, chlorothalonil and tebuconazole tank mixture, penthiopyrad, and the prothioconazole plus a tank mixture of penthiopyrad and tebuconazole programs significantly reduced leaf spot severity compared with chlorothalonil-only on Georgia-06G. For Georgia-12Y, leaf spot severity reductions were observed for the chlorothalonil and tebuconazole, penthiopyrad, prothioconazole plus penthiopyrad and chlorothalonil, penthiopyrad and tebuconazole, and the prothioconazole plus penthiopyrad and tebuconazole tank mixture programs when compared with the chlorothalonil-only control plots (Table 4).

A significant negative linear relationship was observed between pod yield and stem rot incidence in plots planted to Georgia-06G in all 3 years (Table 5; Fig. 1). The yield potentials for these plots (as the y-intercept) were 5,972.3, 4,257.6, and 5,800.1 kg/ha in 2013, 2014, and 2015, respectively, with model slopes of -57.9 ,

Table 2. Significant levels (P values) from generalized linear mixed-model analyses of the effect of cultivar and stem rot fungicide program on stem rot incidence, peanut pod yield, and return on investment over three years

Effects	Stem rot incidence ^x	Yield (kg/ha) ^y	Net return (\$/ha) ^z
Cultivar	<0.0001	0.0083	0.1463
Fungicide	<0.0001	<0.0001	0.1931
Cultivar × fungicide	0.0039	0.0346	0.0447

^x Percentage of 30-cm row sections showing stem rot symptoms or signs of *Sclerotium rolfsii* infection.

^y Estimated weights of peanut pods per hectare after drying to 10% moisture (wt/wt).

^z Gross income above the fungicide cost was calculated by subtracting the cost of each fungicide program from the gross return for that treatment.

Table 3. Interactive effects of stem rot fungicide programs and peanut cultivar on stem rot incidence, yield, and return on investment^u

Fungicide ^v	Stem rot incidence ^v		Yield (kg/ha) ^w		Net return (\$/ha) ^x	
	Ga-06G	Ga-12Y	Ga-06G	Ga-12Y	Ga-06G	Ga-12Y
CHL	24.3 a	8.0 a	3,840 c	4,977	1,398 c	1,740
PRO, CHL	20.1 ab	8.2 a	4,186 bc	5,004	1,450 bc	1,771
CHL, CHL + TEB	19.0 b	6.7 ab	4,564 ab	5,053	1,681 a	1,769
CHL, PEN	13.5 c	4.7 ab	4,820 a	5,183	1,668 a	1,704
PRO, PEN, CHL	9.0 d	3.5 b	4,879 a	5,103	1,666 a	1,620
CHL, PEN + TEB	10.0 cd	2.5 b	4,868 a	5,076	1,644 ab	1,629
PRO, PEN + TEB, CHL	7.6 d	3.0 b	4,959 a	5,399	1,688 a	1,803
$P > F^z$	<0.0001	0.0449	<0.0001	0.5390	0.0167	0.4469

^u Cultivars Georgia-06G (Ga-06G) and Georgia-12Y (Ga-12Y). Means within column followed by the same letter are not significantly different at $P \leq 0.05$.

^v Percentage of 30-cm row sections showing stem rot symptoms or signs of *Sclerotium rolfsii* infection.

^w Estimated weights of peanut pods per hectare after drying to 10% moisture (wt/wt).

^x Gross income above the fungicide cost was calculated by subtracting the fungicide cost from the gross income per hectare.

^y Abbreviations: CHL = chlorothalonil, PRO = prothioconazole, TEB = tebuconazole, and PEN = penthiopyrad.

^z P values generated using the SLICE and SLICEBY statements in PROC GLIMMIX to identify the effects of fungicide on cultivar.

–36.1, and –61.9, indicating the kilograms per hectare lost with each percent increase in stem rot incidence (Table 5). The R^2 values in 2013 and 2015 were 0.46 and 0.48, respectively, indicating that stem rot incidence at digging explained just less than 50% of the variation in observed yield; however, the R^2 value of 0.20 in 2014 indicates that stem rot incidence did not predict yield well in that year. For plots planted to Georgia-12Y, the models were not significant in 2013 or 2014 but were in 2015, when yield potential was estimated at 6,083.6 kg/ha, with a slope of –106.1 (Table 5). Nevertheless, in each of the 3 years, stem rot incidence on Georgia-12Y explained less than 24% of the variation in observed yield.

Table 4. Median rating values and relative treatment effects of seven stem rot fungicide programs on final leaf spot Florida scale ratings collected from Georgia-06G and Georgia-12Y in 2013 to 2015^v

Year, fungicide ^w	Georgia-06G			Georgia-12Y		
	Med ^x	RE ^y	95% CI ^z	Med ^x	RE ^y	95% CI ^z
2013						
CHL	5.0	0.92	0.88–0.94	4.8	0.76	0.52–0.89
PRO, CHL	4.9	0.85	0.71–0.92	4.6	0.69	0.57–0.79
CHL, CHL + TEB	4.5	0.56	0.30–0.79	4.3	0.34	0.18–0.55
CHL, PEN	4.5	0.61	0.46–0.74	4.1	0.27	0.17–0.41
PRO, PEN, CHL	4.3	0.39	0.23–0.58	4.3	0.45	0.28–0.63
CHL, PEN + TEB	4.3	0.42	0.18–0.73	4.2	0.30	0.13–0.57
PRO, PEN + TEB, CHL	4.1	0.24	0.12–0.43	4.1	0.21	0.10–0.39
2014						
CHL	2.5	0.72	0.52–0.85	2.5	0.70	0.40–0.88
PRO, CHL	3.4	0.88	0.76–0.93	3.1	0.84	0.63–0.93
CHL, CHL + TEB	1.3	0.51	0.29–0.72	1.1	0.17	0.11–0.26
CHL, PEN	1.6	0.59	0.56–0.62	1.3	0.49	0.36–0.62
PRO, PEN, CHL	1.5	0.54	0.25–0.80	1.2	0.35	0.20–0.54
CHL, PEN + TEB	1.4	0.42	0.23–0.65	1.1	0.20	0.15–0.26
PRO, PEN + TEB, CHL	1.6	0.44	0.16–0.78	1.1	0.17	0.10–0.29
2015						
CHL	5.5	0.90	0.73–0.95	4.8	0.72	0.54–0.84
PRO, CHL	5.4	0.86	0.77–0.91	4.6	0.58	0.29–0.81
CHL, CHL + TEB	4.7	0.71	0.62–0.78	3.8	0.48	0.34–0.62
CHL, PEN	3.0	0.55	0.35–0.74	3.0	0.39	0.24–0.56
PRO, PEN, CHL	3.3	0.53	0.42–0.65	2.5	0.26	0.16–0.42
CHL, PEN + TEB	2.8	0.38	0.21–0.58	2.2	0.17	0.12–0.26
PRO, PEN + TEB, CHL	2.4	0.32	0.14–0.61	2.1	0.16	0.09–0.29

^v Final leaf spot severity was assessed visually with the ordinal Florida 1-to-10 scale prior to digging.

^w Abbreviations: CHL = chlorothalonil, PRO = prothioconazole, TEB = tebuconazole, and PEN = penthiopyrad.

^x Median leaf spot severity.

^y Estimated relative treatment effects ($0 < RE < 1.0$) and 95% confidence intervals (CI) were calculated using a nonparametric ranks-based analysis and the LD_CI SAS macro (Brunner et al. 2002; Shah and Madden 2004).

^z Lower and upper confidence limits for each respective relative effect. Two fungicide programs are considered different ($P \leq 0.05$) if their relative treatment effects each lie outside the CI of the other.

Table 5. Linear regression analysis of the relationship between stem rot incidence and pod yield^z

Cultivar	Year	Intercept	Slope	R^2	P value
Georgia-06G	2013	5,972.3	–57.9	0.456	0.0002
	2014	4,257.6	–36.1	0.195	0.0187
	2015	5,800.1	–61.9	0.480	<0.0001
Georgia-12Y	2013	6,095.2	–24.0	0.108	0.0871
	2014	3,740.6	4.2	0.001	0.8822
	2015	6,083.6	–106.1	0.233	0.0093

^z Incidence = percentage of 30-cm row sections showing stem rot symptoms or signs of *Sclerotium rolfsii* infection and yield = estimated weights of peanut pods per hectare after drying to 10% moisture (wt/wt).

Discussion

In this study, we characterized stem rot, leaf spot, yield, and overall profitability of Georgia-06G and Georgia-12Y as influenced by seven fungicide programs. Additionally, we quantified the effects of stem rot incidence on yield and crop value for both cultivars. The results show the value of fungicides in peanut disease management and underscores the benefits of planting stem-rot-resistant cultivars in high-risk situations. Over this 3-year study, stem rot incidence on both cultivars was lowest in the plots treated with the prothioconazole plus a tank mixture of penthiopyrad and tebuconazole plus chlorothalonil program and overall incidence was consistently lower on Georgia-12Y for all fungicide programs when compared with Georgia-06G. Leaf spot severity was reduced by fungicide program in plots of both cultivars, and similar trends were observed in all 3 years. The greatest leaf spot severity was observed in the chlorothalonil-only plots or the prothioconazole plus chlorothalonil programs, and the greatest reduction in leaf spot severity was observed in plots receiving the prothioconazole plus a tank mixture of penthiopyrad and tebuconazole plus chlorothalonil program. However, the individual fungicide programs were similar in how they influenced leaf spot severity and the overall relative effects fluctuated slightly depending on the year. Yield and net return in plots planted to Georgia-12Y did not differ significantly by fungicide program but plots planted to Georgia-06G did differ significantly. Plots treated with the prothioconazole plus a tank mixture of penthiopyrad and tebuconazole had both the greatest yield and greatest net return, though not significantly better than the chlorothalonil and tebuconazole tank mixture, and not numerically better than the chlorothalonil-only Georgia-12Y plots. Throughout this study, the most expensive fungicide program applied was prothioconazole plus a tank mixture of penthiopyrad and tebuconazole (approximately \$289/ha). For Georgia-06G the net return on this investment was not significantly greater than the less expensive chlorothalonil and tebuconazole tank mixture, at less than half the cost (approximately \$123.50/ha). The seven different fungicide programs established a range of stem rot levels and allowed for the quantification of the effects of stem rot on yield. In 2013 and 2015, yield potential for plots planted to Georgia-12Y was greater than that of Georgia-06G but not in 2014, where yield was reduced for both cultivars. This reduction in yield in 2014 is likely due to an unexpected outbreak of root knot nematode (*Meloidogyne arenaria*). Root knot nematode damage can greatly reduce peanut pod yields when found alone, and has been shown to compromise cultivar resistance to stem rot when both *M. arenaria* and *S. rolfsii* occur in the same field (Culbreath et al. 1992).

The peanut disease risk index, officially known as Peanut RX, allows producers in the southeastern United States to assess their risk of tomato spotted wilt (caused by *Tomato spotted wilt virus*), leaf spots, and stem rot based on production practices (Kemerait et al. 2004). One of the key factors influencing leaf spot or stem rot risk in peanut is the susceptibility of the selected cultivars to either of those diseases. As such, a guiding principle of Peanut RX is that a field with lower disease risk would require fewer fungicide inputs, and the results with Georgia-06G presented here illustrate that point. For this stem-rot-susceptible cultivar, the greater amount of fungicide

Fig. 1. Relationship between pod yield and percent stem rot incidence over 3 years for cultivars Georgia-06G and Georgia-12Y. Data points represent the observed values and lines are models of yield based on stem rot incidence. Dashed lines and open symbols represent Georgia-12Y; solid lines and symbols represent Georgia-06G.

inputs applied in this study corresponded with a sequential increase in pod yield; however, there was a broad overlap of programs when considering net return to the grower. The greater cost of premium fungicide programs likely offsets the higher net returns associated with better disease control. However, this was not the case with the stem-rot-resistant cultivar Georgia-12Y, where reduced-cost programs performed as well as the more expensive programs, a finding that corroborates previous reports of reduced-cost programs on stem-rot-resistant cultivars (Woodward et al. 2008).

The results presented here validate the inherent resistance of Georgia-12Y to stem rot and its high yield potential (Branch 2013). This information is particularly useful because the economic returns from peanut production are often marginal, and growers constantly seek more efficient production methods to increase profits when possible. The yield potential and disease resistance of Georgia-12Y, as documented here, demonstrates how planting fields to disease-resistant cultivars may help to achieve this goal. This was evident even in a field with a history of continuous peanut production and high levels of stem rot and leaf spot pressure. Planting disease-resistant cultivars such as Georgia-12Y will allow growers to utilize less-expensive fungicide programs to not only increase the potential profit from the crop but also reduce the inherent financial risks associated with greater input costs.

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