Disease and Yield Responses to Fungicides Among Peanut Cultivars Differing in Reaction to Sclerotinia Blight[1]

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ABSTRACT

Peanut cultivars with different disease reactions to Sclerotinia blight received a variable number of applications of iprodione at 1.12 kg/ha or fluazinam at 0.56 kg/ha to determine the most efficient management program. Significant ($P \leq 0.05$) cultivar × treatment interactions occurred for each fungicide. In two trials with iprodione, two applications reduced disease incidence for the susceptible cultivar Okrun from 62 to 27% as compared to the control, and increased yield from 2034 to 2581 kg/ha. Three applications did not improve disease control or increase yield as compared to two applications. Iprodione did not affect disease incidence or yields of the moderately resistant cultivar Spanco (9%, 2475 kg/ha) or the resistant cultivar Tamspan 90 (3%, 2903 kg/ha). In three other trials, fluazinam reduced disease incidence in one or more trials and increased yields across trials for all cultivars. Two applications provided the best disease control for Okrun as disease incidence was reduced from 77 to 22%. However, the increase in yield for one (1034 kg/ha) and two (1415 kg/ha) applications did not differ. Reductions in disease incidence with fluazinam varied for Spanco and Tamspan 90, and the yield increase was less than for Okrun. Two applications for Spanco reduced disease incidence from 17 to 7% and increased yield from 2900 to 3484 kg/ha. One application to Tamspan 90 reduced disease incidence from 10 to 5% and increased yield from 3348 to 3891 kg/ha. Tamspan 90 had the highest yield in all trials regardless of fungicide treatment.

Key Words: *Arachis hypogaea*, fungicides, groundnut, *Sclerotinia minor*, resistance.

Sclerotinia blight, caused by *Sclerotinia minor* Jagger (11), was first reported as a disease of peanut (*Arachis hypogaea* L.) in the United States in Virginia during 1971 (15). The disease was identified in Oklahoma in 1972 (21) where it has since become widespread and is now the most destructive soilborne disease of peanut in the state. Sclerotinia blight has been particularly severe in areas where runner cultivars are grown under irrigation.

Management of Sclerotinia blight has been only moderately effective. Sanitation practices are directed at limiting the spread of the fungus by preventing its introduction into new fields, and fungicides are used to minimize losses in problem fields (7). Fungicide strategies have included high rates of pentachloronitrobenzene, dicloran, and iprodione (2,3,13). These fungicides have provided only partial control and iprodione is the only fungicide currently registered for control of Sclerotinia blight. The experimental fungicide fluazinam has provided excellent disease control when sufficient rates are used (8,9,17,18).

An approach to lowering inputs for the management of Sclerotinia blight is the use of resistant cultivars. Germplasm screening in Virginia led to the release of the partially resistant, virginia-type cultivar VA 81B (4,5). Oklahoma produces mainly runner- and spanish-type cultivars and some of the latter are partially resistant

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(1,10). Over an 8-yr period, the spanish cultivar Spanco averaged 66% less disease than the runner cultivar Okrun (10). Tamspan 90 is a recently released spanish cultivar that is resistant to Sclerotinia blight (19). Over two trials, Tamspan 90 averaged 77% less disease and 1337 kg/ha higher yield than the susceptible cultivar Okrun (12).

The use of resistant cultivars for infested fields in Oklahoma has increased in recent years. To develop efficient management recommendations for Sclerotinia blight, information is needed on the response to fungicides among cultivars that differ in disease reaction. The objective of this study was to quantify the disease and yield responses of commonly grown cultivars to treatment with different levels of the fungicides iprodione, and fluazinam.

Materials and Methods

Three cultivars with different reactions to Sclerotinia blight were compared in five trials during 1992 and 1993 in irrigated fields with a history of the disease. The cultivars were Okrun, a susceptible runner type, Spanco, a moderately resistant spanish type, and Tamspan 90, a resistant spanish type. These were selected to represent the different resistance levels of cultivars commonly grown in Oklahoma.

The fungicide iprodione was applied to the three cultivars in two trials on commercial farms near Calvin, OK in 1992 and Gerty, OK in 1993. The site at Calvin was a Konawa fine sandy loam previously cropped to peanut and the site at Gerty was a Eufala fine sand previously cropped to corn. Planting dates were 17 June 1992 and 2 June 1993. Plots were four 7.6-m-long rows spaced 0.9 m apart. The experimental design was 3 × 3 factorial arranged in a randomized complete block design with four replications. The three cultivars received 0, 2, or 3 applications of iprodione at 1.12 kg/ha as Rovral 4F (Rhône-Poulenc Inc., Research Triangle Park, NC). The first application was made 60 d after planting (DAP) followed by the second and third applications at 21-d intervals. Iprodione was applied in a volume of 281 L/ha with a wheelbarrow sprayer equipped with one 8008lp flat-fan nozzle centered over each row at a height to provide complete coverage of the plants. All plots received chlorothalonil as Bravo 720 (ISK Biosciences, Marietta, GA) at 1.26 kg/ha for control of early leaf spot caused by *Cercospora arachidicola* Hori. Six and four applications of chlorothalonil were made in 1992 and 1993, respectively. Other crop and pest management practices were applied according to Oklahoma Extension Service recommendations (16).

The fungicide fluazinam was tested on the three cultivars at Calvin in 1992 and at the Caddo Research Station, Ft Cobb, OK in 1992 and 1993. The trial at Calvin was on the same site described previously. The site at Ft. Cobb was a Meno fine sandy loam continuously cropped to peanut. The planting dates were 17 June 1992 at Calvin and 15 May 1992 and 26 May 1993 at Ft. Cobb. Plots of each cultivar received zero, one, or two applications of fluazinam at 0.56 kg/ha as ASC 66825 4F (ISK Biosciences, Marietta, GA). The first application was made 60 DAP and the second 90 DAP. Application methods, plot dimensions, experimental designs, and crop and pest management practices were the same as described previously. Early leaf spot was controlled in each trial with six applications of chlorothalonil at 1.26 kg/ha.

Incidence of Sclerotinia blight was determined just prior to harvest by counting the number of 15-cm row segments with symptomatic plants in the two center rows of each plot. Counts were converted to the percentage of total row length affected. Plots were dug and inverted, dried in windrows for 2 d, and the pods were removed from the vines with a stationary thresher. Pods were dried to *ca.* 10% moisture and cleaned prior to weighing. Digging dates were 9 Nov. 1992 at Calvin for both trials, 15 Oct. 1992 at Ft. Cobb, 2 Nov. 1993 at Gerty, and 20 Oct. 1993 at Ft Cobb.

A separate analysis of variance (AOV) for disease incidence and yield data was performed by fungicide. The main effects of trial, cultivar, treatment (no. applications), and their interactions were tested in a factorial design. Mean separations were made using Fisher's least significant difference test (19) where indicated by significant effects ($P \leq 0.05$) in the AOV. The relationship between disease incidence and yield was assessed with simple correlation analysis (19). Only significant differences ($P \leq 0.05$) are described below unless otherwise indicated.

Results

Iprodione. In the two trials with iprodione, the mean incidence of Sclerotinia blight was 2.8% for Tamspan 90, 9% for Spanco, and 36.2% for Okrun. In the AOV for disease incidence, the effects of cultivar, treatment, and cultivar × treatment were significant ($P < 0.01$). Therefore, data were pooled across trials and means for fungicide treatment were separated by cultivar (Table 1). Disease incidences for Tamspan 90 and Spanco were not reduced by two or three applications of iprodione compared to the control. Two applications reduced disease incidence for Okrun by 56%. Three applications reduced disease incidence for Okrun by 70%, but this was not significantly different from two applications.

Mean yields in the two trials with iprodione were 2903 kg/ha for Tamspan 90, 2475 kg/ha for Spanco, and 2483 kg/ha for Okrun. Yields were negatively correlated with disease incidence for Okrun ($r = -0.58$, $P < 0.01$), but not for Tamspan 90 ($r = -0.37$, $P = 0.07$) or Spanco ($r = -0.25$, $P = 0.23$). In the AOV for yield, the effects of cultivar ($P < 0.01$), treatment ($P = 0.01$), and cultivar × treatment ($P = 0.05$) were significant. Therefore, data were pooled across trials and treatment means were separated by cultivar (Table 2). Yields of Tamspan 90 and Spanco were not increased by two or three applications of iprodione as compared to the control. Two and three applications increased yields of Okrun by 547 kg/ha and 801 kg/ha, respectively. However, yields were similar for two or three applications.

Fluazinam. In the three trials with fluazinam, the mean disease incidence was 5.6% for Tamspan 90, 13.4% for Spanco, and 47.7% for Okrun. In the AOV for disease incidence, the effects of trial ($P < 0.01$), cultivar ($P < 0.01$), treatment ($P < 0.01$), cultivar × treatment ($P < 0.01$), and trial × cultivar × treatment ($P < 0.05$) were significant. Treatment means were thus separated by trial and cultivar (Table 3). At Calvin, fluazinam had no effect on disease incidence for Tamspan 90. At Ft. Cobb where disease incidence was higher, one and two appli-

Table 1. Effect of the fungicide iprodione on incidence of Sclerotinia blight for resistant (Tamspan 90), moderately resistant (Spanco), and susceptible (Okrun) peanut cultivars.

Treatment and rate/ha (no. applications)	Incidence[a] Tamspan 90 1992[b]	Tamspan 90 1993	Tamspan 90 Mean	Spanco 1992	Spanco 1993	Spanco Mean	Okrun 1992	Okrun 1993	Okrun Mean
	%			%			%		
Control	2.5	3.1	2.8	9.7	11.9	10.8	62.2	62.8	62.5
Iprodione 1.12 kg (2)	4.1	2.2	3.1	6.6	7.2	6.9	22.2	33.1	27.6
Iprodione 1.12 kg (3)	3.1	1.6	2.3	4.7	14.1	9.4	21.9	15.0	18.4
LSD ($P \leq 0.05$)			ns[c]			ns			18.2

[a]Disease incidence before harvest was determined by counting the number of 15-cm row segments with infected plants and converting to the percentage of total row length infected.
[b]The 1992 trial was at Calvin and the 1993 trial was at Gerty.
[c]ns = not significant.

Table 2. Effect of the fungicide iprodione on yield of peanut cultivars resistant (Tamspan 90), moderately resistant (Spanco), and susceptible (Okrun) to Sclerotinia blight.

Treatment and rate/ha (no. applications)	Yield Tamspan 90 1992[a]	Tamspan 90 1993	Tamspan 90 Mean	Spanco 1992	Spanco 1993	Spanco Mean	Okrun 1992	Okrun 1993	Okrun Mean
	kg/ha			kg/ha			kg/ha		
Control	3255	2543	2899	2390	2339	2365	1704	2365	2034
Iprodione 1.12 kg (2)	2848	2517	2683	2441	2645	2543	2390	2772	2581
Iprodione 1.12 kg (3)	3229	3026	3128	2568	2467	2517	2645	3026	2835
LSD ($P \leq 0.05$)			ns[b]			ns			473

[a]The 1992 trial was at Calvin and the 1993 trial was at Gerty.
[b]ns = not significant.

Table 3. Effect of the fungicide fluazinam on incidence of Sclerotinia blight in resistant (Tamspan 90), moderately resistant (Spanco), and susceptible (Okrun) peanut cultivars.

Treatment and rate/ha (no. applications)	Incidence[a] Tamspan 90 1992A[b]	Tamspan 90 1992B	Tamspan 90 1993	Tamspan 90 Mean	Spanco 1992A	Spanco 1992B	Spanco 1993	Spanco Mean	Okrun 1992A	Okrun 1992B	Okrun 1993	Okrun Mean
	%				%				%			
Control	3.4	15.0	10.6	9.7	11.6	16.2	24.7	17.5	64.7	87.2	79.4	77.1
Fluazinam 0.56 kg (1)	3.1	5.3	5.9	4.8	8.7	9.1	28.1	15.3	15.3	40.9	75.6	43.9
Fluazinam 0.56 kg (2)	2.8	2.5	2.2	2.5	2.8	5.6	13.4	7.3	11.9	17.5	36.6	22.0
LSD ($P \leq 0.05$)	ns[c]	4.1	6.8		6.2	2.9	ns		26.0	21.3	30.3	

[a]Disease incidence before harvest was determined by counting the number of 15-cm row segments with infected plants and converting to the percentage of total row length infected.
[b]The 1992A trial was at Calvin, and the 1992B and 1993 trials were at Ft. Cobb.
[c]ns = not significant.

cations reduced incidence as compared to the control for Tamspan 90 in 1992 by a minimum of 65%, while two applications were required to reduce incidence in 1993.

Disease control with fluazinam also was variable with the cultivar Spanco. At Calvin, one application did not affect disease incidence, while two applications reduced incidence by 76%. Both fluazinam treatments were effective at Ft. Cobb in 1992. However, two applications provided a greater reduction in disease incidence (64%) as compared to one (44%). None of the fluazinam treatments reduced disease incidence for Spanco at Ft. Cobb in 1993.

For the cultivar Okrun, two applications were effective at each location, providing reductions in disease incidence ranging from 54 to 80%. Disease control with one application was variable across trials for Okrun. One application provided a similar level of disease control as two applications at Calvin in 1992. One application was intermediate at Ft. Cobb in 1992, and one application was not effective at Ft. Cobb in 1993.

Mean yields in the fluazinam trials were 3729 kg/ha for Tamspan 90, 3199 kg/ha for Spanco, and 2969 kg/ha for Okrun. Yields of Tamspan 90 ($r = -0.60$), Spanco ($r = -0.58$), and Okrun ($r = -0.70$) were negatively correlated with disease incidence ($P < 0.01$). The effects of trial, cultivar, treatment, and cultivar × treatment were significant ($P < 0.01$). Therefore, data were pooled across trials and treatment means were separated by cultivar (Table 4). For Tamspan 90, one and two applications were similar, increasing yield compared to the control by 543 and 602 kg/ha, respectively. For Spanco, one application did not affect yield, while two applications increased yield by 584 kg/ha. For Okrun, one application increased yield by 1034 kg/ha and two applications did not result in further yield increase.

Discussion

The significant cultivar × treatment interactions in these trials indicate that cultivars differing in reaction to Sclerotinia blight require specific fungicide programs for efficient disease control. Iprodione did not increase yields or enhance disease control for the resistant cultivar Tamspan 90 or the moderately resistant cultivar Spanco. For the susceptible cultivar Okrun, iprodione reduced disease incidence and increased yield similar to levels reported previously (3,17,18). However, the three applications permitted on the iprodione label may not be cost efficient because the additional application did not improve disease control or yield for Okrun compared to two applications. These results are similar to those of Phipps (14) who reported that treatment of the resistant virginia-type cultivars VA 81B and AD 1 with iprodione did not increase yields, while a significant yield response with iprodione was observed for the susceptible cultivar Florigiant.

Yields of all cultivars in this study increased with fluazinam treatment. However, the yield responses differed among cultivars depending on the number of applications. The yield response to fluazinam was greater for Okrun than for Spanco and Tamspan 90. While two applications provided better disease control than one for Okrun in two of three trials, yield was not significantly improved by the second application. The yield response of Okrun in this study was similar to reports with the same application rates for susceptible virginia-type cultivars (17,18). The minimum number of applications to achieve a significant yield response was two for Spanco and one for Tamspan 90. However, the yield increase for Tamspan 90 was greater than expected given the low disease incidence in the control which averaged less than 10% over the three trials. Fluazinam is reported to be active against *Sclerotium rolfsii* Sacc., the cause of southern blight, and *Rhizoctonia solani* Kühn which causes limb and pod rots (18). Incidence of southern blight was low (< 1%) at Ft. Cobb in 1993. None of these diseases were evident at the other locations where fluazinam was tested. It is possible that in the evaluations for Sclerotinia blight, some infections may have been missed. Sclerotinia blight causes more localized infections in Tamspan 90 as compared to the spreading infection centers in runner-type cultivars. Peg infections that would result in pod loss during harvest are difficult to evaluate in the above-ground ratings that were taken before harvest.

It was surprising that yield of the susceptible cultivar Okrun receiving two applications of fluazinam was not better than that receiving one application. Most previous studies with fluazinam included evaluations of two applications at rates from 0.28 to 1.12 kg/ha (8,9,17,18). In previous trials with susceptible runner cultivars in Oklahoma, two applications of 1.12 kg/ha has been superior to lower rates when disease incidence is high (9). While Smith *et al.* (17) reported no difference in yield between two applications of 0.28 and 0.56 kg/ha in Virginia, yield increases were observed in Oklahoma with increasing rates from 0.28 to 1.12 kg/ha (9).

In the two trials with iprodione, comparisons were made between management strategies for Sclerotinia blight that are currently available to growers in Okla-

Table 4. Effect of the fungicide fluazinam on yield of peanut cultivars resistant (Tamspan 90), moderately resistant (Spanco), and susceptible (Okrun) to Sclerotinia blight.

Treatment and rate/ha	Yield											
	Tamspan 90				Spanco				Okrun			
(no. applications)	1992A[a]	1992B	1993	Mean	1992A	1992B	1993	Mean	1992A	1992B	1993	Mean
	kg/ha				kg/ha				kg/ha			
Control	3280	3120	3662	3348	2419	2848	3433	2900	1552	2441	2467	2153
Fluazinam 0.56 kg (1)	3509	3891	4272	3891	2950	3255	3433	3212	3306	3001	3255	3187
Fluazinam 0.56 kg (2)	3458	4199	4272	3950	2721	3535	4196	3484	3255	3255	4196	3568
LSD ($P \leq 0.05$)				324				317				448

[a]The 1992A trial was at Calvin, and the 1992B and 1993 trials were at Ft. Cobb.

homa. Use of the resistant cultivar Tamspan 90 without iprodione treatment was the most cost efficient management strategy. Grade samples bulked across blocks of each treatment were used with the ASCS Loan Schedules for each year to estimate the value ($/ha) of each treatment. Treatment costs, calculated as the 1993 price for iprodione per application ($92.62/ha) times the number of applications, were subtracted from the value/ha to estimate partial returns for each treatment. For Okrun, two applications increased returns/ha from $1462 in the control to $1633. Three applications returned $1665, which was similar to two applications. The highest return/ha for Spanco was $1635 for the control, which was similar to the returns for Okrun treated with iprodione. The highest return/ha was $2099 for the untreated Tamspan 90. Treatment of Tamspan 90 or Spanco with iprodione reduced returns per acre below those of the respective controls. In 1995, the price for iprodione increased to about $121/ha. Returns/ha with the current price are thus even lower for Spanco and Tamspan 90 treated with iprodione, and the profitability of Tamspan 90 has increased as compared to Okrun treated with iprodione.

Bulked grade samples also were taken as described above to estimate treatment values for fluazinam. Fluazinam increased the value/ha for all cultivars. For Okrun, values/ha were $1539 for the control, $2280 for one application, and $2550 for two applications. Treatment values/ha for Spanco were $2030 for the control, $2314 for one application, and $2431 for two applications. Treatment values/ha were highest for Tamspan 90 at each level of fungicide application. Values/ha for Tamspan 90 were $2406 for the control, $2677 for one application, and $2830 for two applications. It was not possible to determine partial returns for the fluazinam treatments because the cost of fluazinam, should it be registered for use on peanut, was not known.

Nearly all of the fields in Oklahoma having a history of Sclerotinia blight problems are now cropped to Tamspan 90 without receiving iprodione. This cultivar has reduced production costs and the tonnage of fungicide applied to peanut, and increased productivity in infested fields. It should be possible to further increase productivity with a modest level of treatment with fluazinam, should this fungicide be registered in the future. However, problems with marketing spanish peanuts exist and a runner cultivar with resistance to Sclerotinia blight is needed. Breeding efforts in Texas and Oklahoma continue in an effort to select for resistance in runner types (6). Results of this study indicate that any new cultivar must be evaluated to determine the optimum level, if any, of fungicide treatment to achieve efficient disease control.

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