Effects of Application Method and Rate on Control of Sclerotinia Blight of Peanut with Iprodione and Fluazinam[1]

J. P. Damicone*, and K. E. Jackson[2]

ABSTRACT

Two trials with iprodione and three trials with fluazinam were conducted to assess the effects of application method and rate on the control of Sclerotinia blight of peanut with fungicide. In order to concentrate the fungicides near the crown area where the disease causes the most damage, applications were made through a canopy opener with a single nozzle centered over the row to achieve a 30.5-cm-wide band (canopy opener), and through a single nozzle centered over the row to achieve a 46-cm-wide band (band). Broadcast applications were compared to these methods at rates of 0, 0.28, 0.56, and 1.12 kg/ha on the susceptible cultivar Okrun. Sclerotinia blight was severe, with > 70% disease incidence and < 2000 kg/ha yield for the untreated controls in each trial. Linear reductions in area under the disease progress curve (AUDPC), but not final disease incidence, with iprodione rate were significant (P < 0.05) for all methods of application. However, the rate of decrease did not differ among application methods. Linear increases in yield with rate of iprodione were greater for canopy opener compared to the band or broadcast applications. Only a 50% reduction in AUDPC and a maximum yield of < 2700 kg/ha was achieved with iprodione using the best method. At the maximum rate of 1.12 kg/ha, fluazinam provided > 75% disease control and > 4000 kg/ha yield for all application methods. Differences in disease control and yield among application methods only occurred at the 0.28 and 0.56 kg/ha rates of fluazinam. Reductions in AUDPC with fluazinam rate were quadratic for all application methods, but AUDPC values were less for the canopy opener and band methods at 0.28 and 0.56 kg/ha compared to the broadcast methods. The yield response to rate for broadcast applications of fluazinam was linear. However, predicted yield responses to fluazinam rate were quadratic for the band and canopy opener methods and approached the maximum response at 0.84 kg/ha. Targeting fungicide applications using the band and/or canopy opener methods was beneficial for fluazinam at reduced rates. Disease control with iprodione was not adequate regardless of application method.

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

Sclerotinia blight, caused by *Sclerotinia minor* Jagger (10), was first reported on peanut (*Arachis hypogaea* L.) in the U.S. in Virginia during 1971 (11). The disease was identified in Oklahoma in 1972 (18) where it has since become widespread and is now the most destructive disease of peanut. Yield reductions of over 50% can occur following severe outbreaks (5). The disease is

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[2]Prof./Ext. Spec. and Assist. Ext. Spec., Dept. of Entomology and Plant Pathology, Oklahoma State Univ., Stillwater, OK 74078-3033.
*Corresponding author (email: jpd3898@okstate.edu).

particularly severe where runner cultivars are grown under irrigation. A survey of peanut growers in Oklahoma during 1997 and 1998 revealed that 45% of the acreage is currently infested with *S. minor* (unpubl. data).

Management of Sclerotinia blight has been only moderately effective despite the widespread adoption of integrated management strategies by growers in Oklahoma. Sanitation practices are directed at limiting the spread of the fungus by preventing its introduction into new fields (8). Tamspan 90, a spanish cultivar with partial resistance (1, 5), has been widely planted in infested fields. From 1993 to 1997, acres planted to spanish cultivars increased to 70% of the total acreage. However, controlling web blotch (*Phoma arachidicola* Marasas *et al.*) on Tamspan 90 has been problematic. In addition, growers have become interested in increasing the profitability of peanut production in light of the federal legislation enacted in 1997 that reduced peanut support price levels by 10%. Runner peanuts have greater yield potential and unit value than spanish types. As a result, acreage has shifted to predominantly (70%) runners in 1999 and 2000. Runner cultivars are more susceptible to Sclerotinia blight, necessitating improved methods of control.

Fungicide programs for Sclerotinia blight have included pentachloronitrobenzene, dicloran, and iprodione (2, 3, 9). These fungicides have provided only partial control with iprodione the only fungicide currently registered for use on peanuts. At $125/ha/application, iprodione is expensive. A program of three applications has generally provided less than 50% disease control and yield increases of 560 to 840 kg/ha for susceptible runner cultivars such as Okrun (5, 9). Use of iprodione has not proven economical on spanish cultivars (5, 9). The experimental fungicide fluazinam has provided good to excellent disease control depending on the rate applied (5, 9, 14, 15). Two applications of at least 0.56 kg/ha have generally provided better than 70% disease control and yield increases of 600 to 1400 kg/ha for Tamspan 90 and Okrun, respectively (5, 9). Use of fluazinam on peanuts was approved for the first time under emergency exemption in Oklahoma and other states in 2000, but the fungicide also is expensive ($98 to $147/ha/application). Due to the high cost of fungicide programs for Sclerotinia blight and the limitations of the current price support system for peanuts, methods are needed to increase the efficiency of fungicide programs for Sclerotinia blight. Fungicide placement in a narrow band has been used in peanut production to enhance control of southern stem rot (*Sclerotium rolfsii* Sacc.) with flutolanil (4). At reduced rates, the method provided similar disease control as wider band widths at a normal rate, while disease control was increased with narrow banding at normal rates. Enhanced disease control with narrow bands has been associated with increased concentration of fungicide near the plant crown where infection by *S. rolfsii* begins (7). A canopy opening device has been described which may permit even better fungicide penetration to the soil-stem interface where initial infection by *S. minor* occurs (17). The objective of this research was to evaluate the interacting effects of application rate and method on control of Sclerotinia blight with iprodione and fluazinam.

Materials and Methods

Field trials evaluating the effects of fungicide rate and method of application were conducted at the Caddo Res. Sta. near Ft. Cobb, OK in a field of Meno fine sandy loam with a history of severe Sclerotinia blight. In separate trials, iprodione was evaluated in 1991 and 1992, and fluazinam was evaluated from 1993 to 1995. All trials were planted with Okrun which is a runner cultivar and susceptible to Sclerotinia blight. Planting dates ranged from 14 to 25 May. Plots were four 9.1-m-long rows spaced 0.9 m apart. The experimental design for each trial was a randomized complete block with four replications.

Three methods of application were evaluated using a CO_2-pressurized sprayer mounted on a wheelbarrow-like frame. The first method used a canopy opener (17) to place the fungicide around the plant crown. The canopy opener consisted of two 30.5-cm-long × 7.6-cm-wide steel strips attached along their widths at a 60° angle to form V-shaped wings. The unit was mounted with the point forward to a spray boom using a rod that permitted height adjustment. An 8004EVS flat-fan nozzle was attached at the center of the wings midway back from the leading point. One canopy opener was centered over each row and adjusted so that the upper 15 cm of the canopy was swept forward and a 30.5-cm-wide spray band was applied. The second method was a 46-cm-wide band application through a single 8008LP flat-fan nozzle centered over each row. The third method was a broadcast application through 8003VS flat-fan nozzles spaced 45.7 cm apart. The sprayer was calibrated to deliver 148 to 158 L/ha, 269 L/ha, and 221 L/ha on a broadcast basis for the canopy opener, band, and broadcast method, respectively.

Iprodione (Rovral 4F, Rhône-Poulenc Inc., Research Triangle Park, NC) and fluazinam (Omega 4F, ISK Biosciences, Mentor, OH) were applied at rates of 0.28, 0.56, and 1.12 kg/ha for each application method except that the 0.28 kg/ha rate of iprodione applied broadcast was not included. These rates represented 0.25×, 0.5×, and 1× of the recommended rate (×) of iprodione, respectively. The first application of iprodione was made when symptoms of the disease and/or signs of the pathogen first appeared followed by a second and third application on 21-d intervals. The first application of fluazinam was made at 60 d after planting (DAP) and was followed by a second at 90 DAP. Chlorothalonil (Bravo 720, ISK Biosciences, Marietta, GA) at 1.26 kg/ha was used to control early leaf spot caused by *Cercospora arachidicola* S. Hori. From 1991 to 1994, four to six applications of chlorothalonil were made. In 1995, chlorothalonil was applied before and after three sprays of tebuconazole (Folicur 3.6F, Bayer Corp., Kansas City, MO) at 0.23 kg/ha. Other crop and pest management practices were followed according to Oklahoma Ext. Serv. recommendations (13).

Incidence of Sclerotinia blight was assessed on *ca.* 30-d intervals beginning in August of each year by counting the number of 15-cm row segments with symptomatic plants along the two center rows of each plot. Counts were converted to the percentage of total row length affected. Final disease incidence was assessed just before harvest. 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 ranged from 15 to 20 Oct.

Analysis of variance (AOV) for disease incidence, area under the disease progress curve (AUDPC) (12), and yield was performed separately for each fungicide. The AOV evaluated the main effects of trial, rate, method of application, and their interactions. The untreated control was dropped from the AOV to maintain the structure of the experimental effects. Where effects of rate were significant, regression analysis was performed to evaluate its linear effects using the control as rate = 0 for each model. Standard errors were calculated for comparing mean values and regression parameter estimates (16). Only significant differences ($P \leq 0.05$) are described below unless otherwise indicated.

Results

Iprodione. The only significant disease that occurred in plots during 1991 and 1992 was Sclerotinia blight. Disease incidence in the untreated controls reached 70 and 90% by harvest in 1991 and 1992, respectively. In the analysis of variance, the effects of application method and rate were significant ($P \leq 0.05$) for AUDPC and yield, but not final disease incidence. Interactions among trial, method of application, and rate were not significant.

For each application method, the linear regression of final disease incidence against rate was not significant (Table 1). By the end of the season, iprodione did not provide adequate disease control regardless of the application method (Fig. 1A). Final disease incidence ranged from 60 to 80% and did not differ among application methods for any given rate.

Linear reductions in AUDPC with iprodione rate were significant for each application method (Table 1). However, coefficients of determination (R^2) were low, and considerable variation was evident. The slopes of the regression equations were not precisely estimated and did not differ among application methods. Iprodione provided a modest reduction in AUDPC with increasing

Table 1. Regression analysis by method of application for the effects of iprodione rate (x) on control of Sclerotinia blight of Okrun peanuts.[a]

Method	Intercept a	±se[b]	P>F	Linear b	±se	P>F	R^2
			Y = final disease incidence (%)[c]				
Canopy opener	78.8	6.1	< 0.01	-15.7	9.6	NS[d]	0.08
Band	76.7	5.4	< 0.01	-2.4	8.4	NS	0.00
Broadcast	77.7	8.1	< 0.01	-8.3	11.1	NS	0.02
			Y = AUDPC (% d)[e]				
Canopy opener	3706.0	280.1	< 0.01	-1968.7	436.6	< 0.01	0.40
Band	3941.9	251.4	< 0.01	-1656.3	391.9	< 0.01	0.37
Broadcast	4002.5	351.5	< 0.01	-1188.9	486.2	< 0.05	0.21
			Y = Yield (kg/ha)				
Canopy opener	1785.1	108.4	< 0.01	850.2	169.0	< 0.01	0.46
Band	1644.4	103.2	< 0.01	670.3	160.8	< 0.01	0.37
Broadcast	1671.2	134.7	< 0.01	446.5	186.4	< 0.05	0.21

[a]For canopy opener and band methods, observed values were from two trials, four application rates, and four blocks (n = 32). For the broadcast method, observed values were from two trials, three application rates, and four blocks (n = 24).

[b]Standard error of the estimated regression parameter.

[c]Percentage of row length with symptomatic plants.

[d]NS = parameter estimate not significant at $P \leq 0.05$.

[e]Area under the disease progress curve.

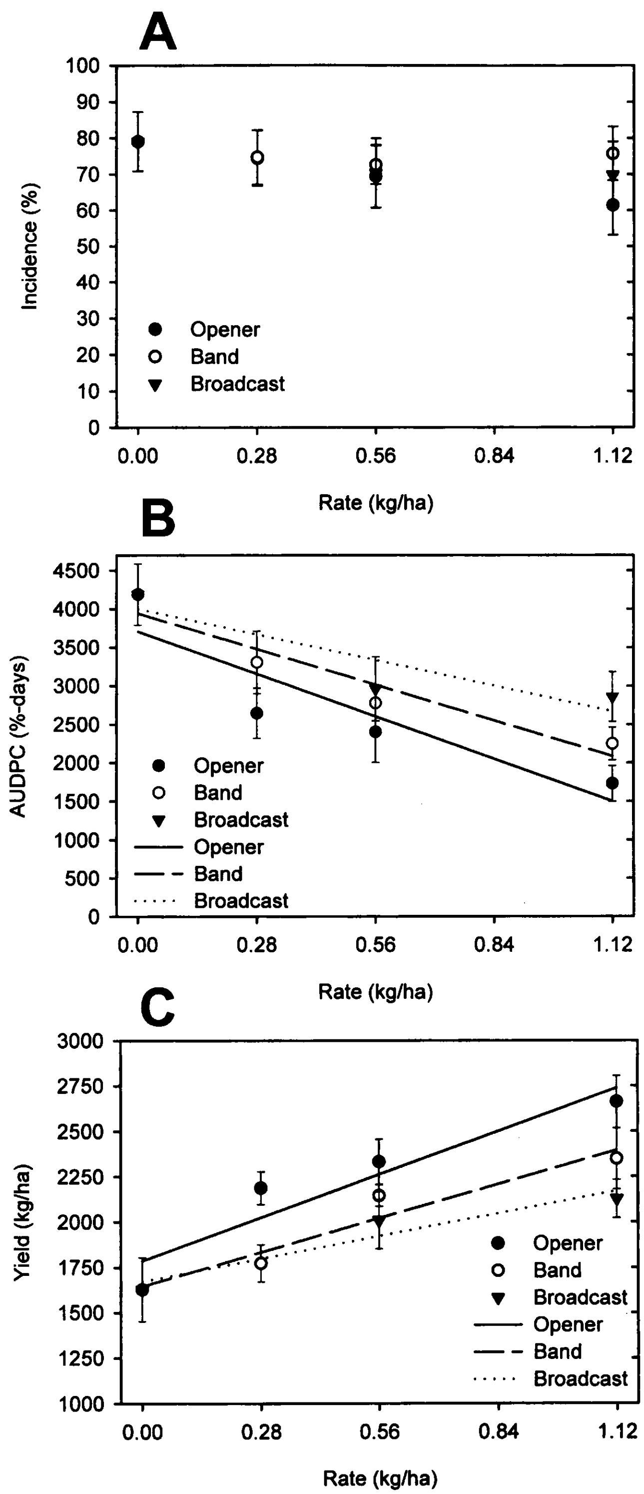

Fig. 1. Effect of application method and rate of iprodione on control of Sclerotinia blight of peanut. A = Final disease incidence, B = Area under the disease progress curve, C = Yield. Data points represent mean values over two trials and four blocks per rate and method of application (n = 8). Error bars represent standard errors of the mean.

rate of application (Fig. 1B). For each kg iprodione per ha, reductions in AUDPC ranged from 47% for the canopy opener to only 28% for the broadcast application. Within each application rate, differences among methods of application were only evident at the full rate where the canopy opener provided the greatest reduction in AUDPC. AUDPC for the band application also was lower than the broadcast application at the 1.12 kg/ha rate.

Sclerotinia blight had a significant impact on yield as correlation coefficients (r) among plot yields vs final disease incidence and AUDPC were -0.56 ($P < 0.01$) and -0.83 ($P < 0.01$), respectively. Linear increases in yield with iprodione rate were significant for all three application methods (Table 1). While considerable variation was indicated by the low coefficients of determination, the rate of increase in yield with iprodione rate was greater for the canopy opener compared to band and broadcast application methods. However, maximum yields for iprodione only reached *ca.* 2600 kg/ha for the highest application rate (Fig. 1C). Within each application rate, yields for the canopy opener method were greater than the broadcast method. The band application did not improve yield compared to the broadcast for any of the application rates. Yield for the canopy opener was superior to band application only at 0.28 kg/ha.

Fluazinam. Incidence of Sclerotinia blight was severe in all trials, ranging from 83 to 98% by harvest for the untreated controls. The effects of application method and rate were significant ($P \leq 0.01$) for final disease incidence, AUDPC, and yield. In addition, the interaction of application method and rate was significant for AUDPC ($P \leq 0.01$) and yield ($P \leq 0.05$), but not for final disease incidence. In 1993 and 1995, Sclerotinia blight was the only disease that reached levels warranting assessment. In 1994, incidence of Verticillium wilt (*Verticillium dahliae* Kleb) ranged from 4 to 27%. However, the effects of application method and rate on levels of Verticillium wilt were not significant ($P > 0.05$).

Linear reductions in final disease incidence with increasing rate of application were significant for both the band and broadcast methods (Table 2). The rate of disease reduction did not differ between the band and broadcast methods. The reduction in disease incidence with rate for the canopy opener method was quadratic. Disease incidence was lower for the canopy opener compared to the band and broadcast method at 0.28 kg/ha, and compared to the broadcast method at 0.56 kg/ha (Fig. 2A). Disease incidence did not differ among application methods at the high rate of 1.12 kg/ha where disease control was greater than 80%.

The reductions in AUDPC with increasing rate of application were quadratic for all application methods (Table 2). The band and canopy opener methods provided greater reductions in AUDPC at 0.28 and 0.56 kg/ha compared to the broadcast method (Fig. 2B). At 1.12 kg/ha there were no differences among application methods and reduction in AUDPC was 90% or greater.

Sclerotinia blight had a large influence on yield as r values for disease incidence and AUDPC vs plot yields were -0.80 ($P < 0.01$) and -0.76 ($P < 0.01$), respectively. Incidence of Verticillium wilt was not correlated with yield. The yield response to increasing fluazinam rate was linear for the broadcast method, but was quadratic for the canopy opener and band applications (Table 2). Yields of

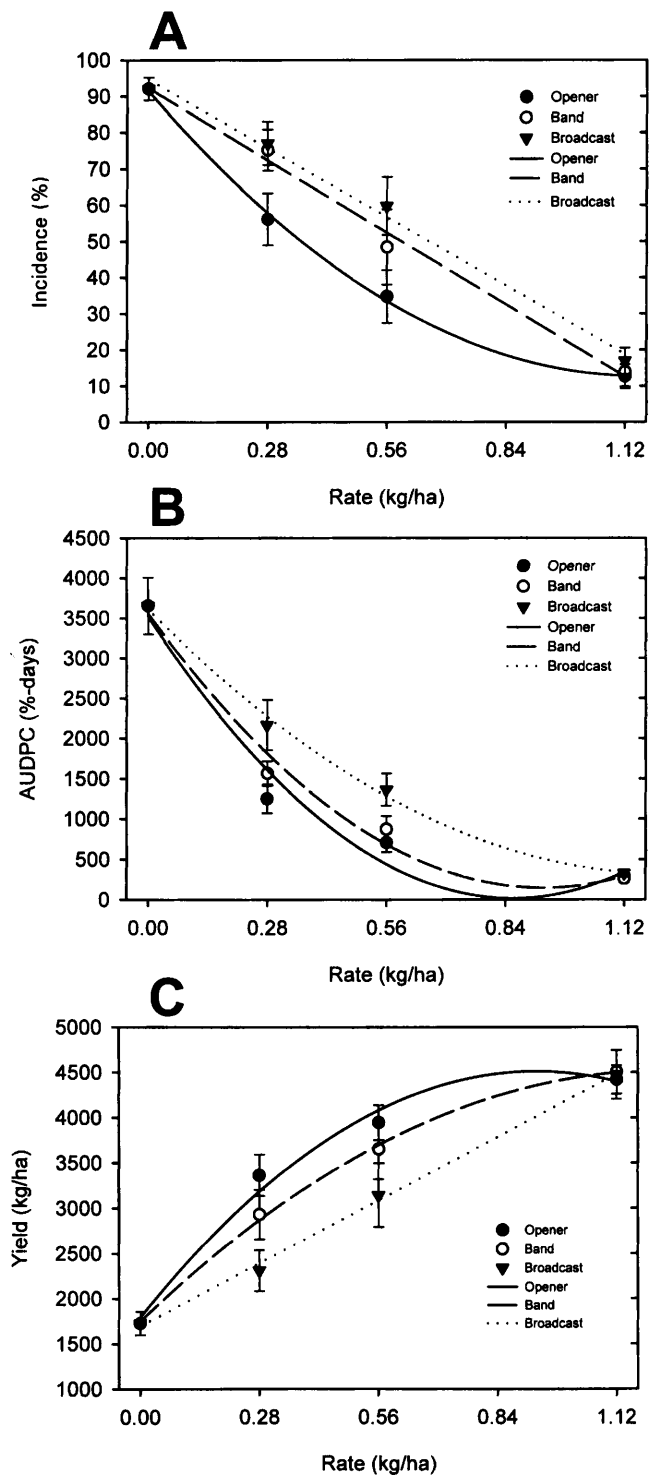

Fig. 2. Effect of application method and rate of fluazinam on control of Sclerotinia blight of peanut. A = Final disease incidence, B = Area under the disease progress curve, C = Yield. Data points represent mean values over three trials and four blocks per rate an method of application (n = 12). Error bars represent standard errors of the mean.

Table 2. Regression analysis by method of application for the effects of fluazinam rate (X) on control of Sclerotinia blight on Okrun peanuts.[a]

	Intercept			Linear			Quadratic			
Method	*a*	± se[b]	P > F	*b*	± se	P > F	*c*	± se	P > F	R^2
				Y = final disease incidence (%)[c]						
Canopy opener	91.5	4.6	< 0.01	-136.9	24.1	< 0.01	59.6	20.0	< 0.01	0.71
Band	92.2	4.9	< 0.01	-71.1	7.6	< 0.01			NS[d]	0.65
Broadcast	94.6	4.2	< 0.01	-67.7	6.6	< 0.01			NS	0.70
				Y = AUDPC (% d)[e]						
Canopy opener	3520.1	208.9	< 0.01	-8167.8	947.3	< 0.01	4758.9	784.4	< 0.01	0.75
Band	3561.2	204.9	< 0.01	-7352.1	929.4	< 0.01	3956.7	769.6	< 0.01	0.76
Broadcast	3613.9	245.1	< 0.01	-5405.9	1111.1	< 0.01	2217.3	920.1	< 0.05	0.67
				Y = Yield (kg/ha)						
Canopy opener	1795.3	173.7	< 0.01	5843.9	787.7	< 0.01	-3143.2	652.3	< 0.01	0.73
Band	1750.8	241.6	< 0.01	4506.8	1095.1	< 0.01	-1834.4	906.9	< 0.05	0.59
Broadcast	1695.3	194.9	< 0.01	2488.7	303.7	< 0.01			NS	0.59

[a]Observed values were from three trials, four application rates, and four blocks (n = 48).
[b]Standard error of the estimated regression parameter.
[c]Percentage of row length with symptomatic plants.
[d]NS = not significant at $P \leq 0.05$.
[e]Area under the disease progress curve.

the band and canopy opener methods at 0.28 kg/ha were similar, but at least 500 kg/ha greater than the broadcast method (Fig. 2C). At 0.56 kg/ha, yield for the canopy opener was ca. 500 kg/ha greater than the broadcast method, but was similar to the band method. Yields did not differ among application methods at 1.12 kg/ha where yields were over 2000 kg/ha greater than the untreated control.

Discussion

The method and rate of application were important factors in the control of Sclerotinia blight for both iprodione and fluazinam. However, application rate generally had a larger impact on disease control and yield than did application method. Except for iprodione, which had no effect on final disease incidence, linear or curvilinear reductions in disease incidence and AUDPC and corresponding increases in yield were evident for both fungicides. However, superior disease control and yield were achieved with fluazinam compared to iprodione. The superior activity of fluazinam compared to iprodione for control of Sclerotinia blight observed in this study has previously been documented (5, 9, 14, 15). The benefits of concentrating fungicide placement in a band over the row with a canopy opener or a single nozzle differed depending on the fungicide. For iprodione, improvements in disease control were primarily observed at the highest application rate. For fluazinam, disease control was improved at the low and mid application rates.

The yield response to a fungicide program will ultimately determine the acceptance of a given fungicide and method of application by growers. At the full rate of iprodione, the canopy opener provided a 500 kg/ha yield increase compared to the broadcast method. However, relatively low yields (< 2700 kg/ha) were achieved with iprodione for even the best application method. Many growers in Oklahoma have been able to exceed this level of yield in infested fields by growing the resistant variety Tamspan 90 without a fungicide program for Sclerotinia blight (5, 9). Given the linear increases in yield with iprodione rate for all application methods, it was not possible to achieve a maximum yield response with a reduced rate for any method of application. The 1.12-kg/ha rate of fluazinam was sufficient to provide maximum disease control and yield regardless of the application method. For fluazinam, yield responses to rate of application were curvilinear for the band and canopy opener application methods. Predicted yield increases leveled off at 0.84 kg/ha which was near that observed for 1.12 kg/ha. While the 0.84 kg/ha application rate was not tested in this study, it may be possible to maximize the efficiency of disease control by using a banded application at this rate.

Applications of 0.56 to 0.84 kg/ha were permitted by emergency exemption in 2000 for the use of fluazinam to control Sclerotinia blight of peanut in North Carolina, Oklahoma, Texas, and Virginia in 2000. Since these rates are less that the 1.12 kg/ha which provided maximum disease control in this study, use of banded applications are likely to be important in Oklahoma should use of this fungicide be permitted in the future. At the current cost of $98 to $147/ha/application, programs to increase the efficiency of fluazinam will be critical. While canopy openers were fabricated by some growers in Oklahoma who attempted to improve the performance of iprodione, their use has been discontinued. Aside from the poor performance of iprodione, most growers could only treat a limited number of rows per pass and the resulting damage from tractor tires was thought to be excessive. Banded applications through a single nozzle centered over the row will likely be better accepted because nozzle spacing would be the only modification required.

Susceptible runner cultivars such as Okrun and Florunner are no longer being grown in infested fields in Oklahoma. In addition to Tamspan 90, progress has been made in improving the levels of resistance to Sclerotinia blight in runner cultivars adapted to southwestern production areas (6). Currently, most of the infested acreage is planted with Tamrun 98 (moderately resistant) and Tamrun 96 (moderately susceptible). It is possible that reduced rates along with targeted fungicide placement will be sufficient to maximize production of the newer cultivars in fields infested with the disease.

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