Irrigation Rate and Fungicide Effects on Peanut Kernel Damage, Yield, and Net Return

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ABSTRACT

Field studies from 2002 through 2004 examined effects of irrigation rate and fungicide on peanut kernel damage, yield and net return in Gaines County, TX. Irrigation rates, the main plots of a split-plot design, were applied with a center pivot system planted in concentric circles, and represented a base irrigation rate (B)(*ca.* 75% of evapotranspiration), B + 33%, and B − 33%. Azoxystrobin or metalaxyl were applied to the subplots at 60 and 90 days after planting and there was a no-fungicide control. Irrigation rate had no effect on percent damaged kernels from harvested pods. Plots with B + 33% irrigation rate had higher pod yields ($P < 0.05$) than B or B − 33% irrigation rates in 2002 and 2003, but had similar yields to the B rate in 2004, a relatively wet growing season. Irrigation rate did not result in an overall difference in net return in any year. Plots treated with azoxystrobin had higher peanut grades and lower percent damaged kernels in all 3 yr than no-fungicide and metalaxyl treated plots. Azoxystrobin treated plots had higher yield and net return than metalaxyl treated and no-fungicide treated plots in 2 of 3 yr. *Rhizoctonia* spp. was the primary fungal pathogen isolated from peanut pods. Use of azoxystrobin resulted in an average net return of $170/ha. Azoxystrobin effects on yield were additive to water status across the entire spectrum of irrigation rates during the combined three years. Peanut producers from this region who want to maximize yield by increasing irrigation rate should use azoxystrobin if there is any history of *Rhizoctonia* pod rot.

Key Words: *Arachis hypogea*, azoxystrobin, irrigation, *Rhizoctonia*.

Pod rot caused by *Pythium* spp. and *Rhizoctonia* spp. affects peanut yield and quality. In Oklahoma, 43% of 37 peanut fields sampled had pod rot, with the disease incidence in the range of 5 to 37% (Filonow *et al.*, 1988). Pod rot was found to cause considerable losses in Israel (Frank, 1968). In North Carolina, pod rot was estimated at 6 to 7% in 1995 and 1996 (Hollowell, *et al.*, 1998). In both North Carolina (Hollowell *et al.*, 1998) and the High Plains of Texas (Wheeler *et al.*, 2006), *Rhizoctonia* spp. and *Pythium* spp. were the most common pathogens isolated from peanuts with pod rot symptoms.

Peanut producers with pod rot problems caused by either *Pythium* spp. alone, or by a combination of *Pythium* spp. and *Rhizoctonia*, can spend > $250/ha/season in fungicide costs in an effort to minimize losses. Producers rely heavily on fungicides as the primary means of reducing pod rot caused by fungi and oomycetes and other fungal disease problems. Very few cultivars are recognized to have pod rot tolerance or resistance (Baughman and Dotray, 2007). Calcium has been found to reduce pod rot incidence in soils where calcium is deficient (Csinos and Gaines, 1986).

Irrigation can affect diseases caused by fungi and oomycetes. In Israel, pod rot developed in well-aerated sandy soils, which were irrigated frequently (Frank and Ashri, 1985). Under aerated conditions, both wet and dry conditions favor the growth of *R. solani* (Rotem and Palti, 1969). Infection and disease development of soil rot of tomato caused by *R. solani* was favored when soil moisture was at 60% of the water holding capacity of soil (mixture of sand and peat) when compared to 20, 40, and 100% levels (Gonzalez and Owen, 1963). Damage caused by *Pythium* spp. on peanut pods increased with frequent short irrigations compared with heavier irrigations for longer time periods (Frank, 1967). Incidence of pod rot induced by *Sclerotinia minor* and *P. myriotylum* was higher in sprinkler irrigated plots than in plots that were not irrigated (Porter *et al.*, 1987).

In the semiarid Southern High Plains of Texas, rainfall during the pod forming period may be limited, so most producers use overhead center pivot irrigation to provide water for good crop growth and suitably moist conditions for pegging and pod development. Depending on weather conditions, peanuts grown in West Texas require about 50 to 70 cm of water during the growing season for optimum peanut yields. Application of 2.5 to 4 cm of water weekly, split into two applications is recommended during peak blooming period (from early July to late August) (Baughman and Dotray,

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2007). However, deficit irrigation due to limited irrigation capacities is common in this region, as pumping capacities of irrigation wells are often insufficient to meet peak water demand for peanuts. Hence, higher irrigation rates are generally associated with higher yields in peanuts for this region. However, there is a poor understanding of the tradeoff between higher irrigation rates and pod rot. The objectives of this study were to investigate the impact of irrigation rates and fungicides on kernel damage, yield and net returns on peanut production in the Southern High Plains of Texas, in a field with a history of Pythium and Rhizoctonia pod rot.

Materials and Methods

Field studies were conducted in Gaines County, TX (Longitude = −102.745, Latitude = 32.903, altitude = 1039 m). The soil type was Brownfield loamy sand (loamy, mixed, superactive, thermic Arenic Aridic Paleustalfs) of 81% sand, 4% silt, and 15% clay, OM 0.1%, and pH 7.8. Tests were conducted in the two innermost spans of the center pivot irrigation system with rows planted in circles. This area was kept in continuous peanuts from 2000 to 2004. Ethalfluralin (Sonalan; 1.75 L/ha) was used as a preplant herbicide. Post-emergence herbicides (including Benzothiazol/Diphenylether, Storm; Bentazon, Basagran) were used on peanuts as needed. No insecticides were applied to peanuts. The center pivot system nozzle package was modified to apply three irrigation rates consisting of a base (B) rate, B + 33% rate, and B − 33% rate. The base rate was designed to meet approximately 75% of the crop needs based on estimated crop evapotranspiration (ETc) (Jensen *et al.*, 1990), and subject to the limits of pumping capacity for that center pivot system. In most years, the pumping capacity was insufficient during the months of July and August when crop water demand is highest. In 2002, the irrigation amounts applied were 47, 71, and 95 cm for low, medium, and high rates of irrigation, and in-season rainfall totaled 9 cm. In 2003, the irrigation amounts applied were 36, 53, and 71 cm for low, medium, and high rates of irrigation, and in-season rainfall totaled 24 cm. In 2004, the irrigation amounts applied were 37 and 46 cm for medium and high rates of irrigation, and in-season rainfall totaled 44 cm. Daily reference evapotranspiration (ETo) and peanut evapotranspiration (ETc) were calculated from a weather station located near Lamesa, TX (http://txhighplainset.tamu.edu). This weather station website is no longer available as of September 2010.

In all 3 yrs of the study, cv. FlavorRunner 458 was planted on 91 cm row spacing. *Bradyrhizobium* inoculant was applied. Planting dates were 25 April 2002, 30 April 2003, and 26 April 2004.

During June each year, the center pivot irrigation system nozzle package (Senninger LDN low drift spray nozzles, Senninger Irrigation, Clermont, FL, www.senninger.com) was modified to apply the three irrigation rates. Spray nozzles were operated at 41 kPa pressure by using pressure regulators. Nitrogen fertilizer at 67.2 kg N/ha/season was supplied by three applications of 22.4 kg N/ha during the growing season. The first application went out preplant using 30-24-0-0; the second application went out in late June using 28-0-0-5; and the third application went out in late July using 28-0-0-5.

Irrigation rate treatments were arranged in a randomized complete block design with three replications. Irrigation treatments were 14 rows wide in the first span (replication 1), and seven rows wide in the second span (replications 2 and 3) under the center pivot irrigation system. Each irrigation treatment was applied to the same circular rows of the entire circle. Fungicide plots were two-rows wide by 4.6 m long and were replicated in each irrigation plot [i.e. nine replications for each fungicide treatment (three irrigation rates × three replications) within the test area]. Fungicide treatments consisted of a non fungicide check, azoxystrobin (Abound FL) at 0.45 kg ai/ha applied at 60 and 90 days after planting, and metalaxyl (Ridomil Gold EC) applied at 0.24 kg ai/ha applied at 90 days after planting in 2002, and applied at 60 and 90 days in 2003 and 2004. Fungicides were applied with a CO_2-pressurized back pack sprayer at 110 kPa. The fungicide applications were applied using a hand-held boom with teejet® nozzles (8002VS) spaced at one nozzle per row and the rate of 85 L water/ha. In all years, water (2805 L/ha) was applied through a sprinkler device (developed by T. Wheeler and D. Porter, Fig. 1) to the plots within 1 hr after the fungicide was applied to mimic chemigation.

To determine the causal agents of diseased pods in 2003 and 2004 (but not in 2002), five plants were removed from each plot at 60 days after planting (before the first fungicide application). Pods with rot or discoloration symptoms (four pods/plot were used if sufficient diseased pods were available) were washed under running tap water for 2 min and then dried in a flow of sterile air under a laminar flow hood for 3–4 hr. Lesions were then placed on water agar (1.5%) and a *Pythium* selective media (Mircetich, 1971). Fungal and oomycete growth from these plates was transferred to potato dextrose agar and identified to genus.

Fig. 1. Device used to apply water over the top of fungicide treated plots, to simulate chemigation. The device was constructed by T. Wheeler and D. Porter.

Peanuts were inverted using a two-row digger on 18 October 2002, 6 October 2003, and 11 October 2004. After plants had dried for ≥1 wk, pods were harvested using a small plot thresher and weighed. A 250-g sample from each plot was graded. The sample was shelled and all damaged kernels were weighed to obtain percent damaged kernels (DK). Shelled peanuts were sieved (0.64 × 1.9 cm openings) to obtain sound mature kernels (SMK), sound splits (SS), foreign material, and other kernels (OK = other kernels that were small or defective, minus SS). Grade was the combined percentage of SMK and SS.

Runner peanut values were calculated by ($5.34 × percent Grade) + ($1.54 × percent OK)/1000 kg peanuts (prices were based on the 2009 peanut loan schedule, obtained from Golden Peanut Company, Brownfield, TX), minus deductions and fungicide application costs. Deductions for damaged kernels cost $3.74/1000 kg peanuts for samples with 1.5 to 2.49% damage, and for higher amounts of damage, the peanuts were valued at 35% of their calculated value for grade and other kernels (based on a peanut loan schedule for the 2009 crop, obtained from Golden Peanut Company). Deductions were also acquired for %SS that were > 4.49%. For each additional percentage of SS, the value was reduced by $0.88/1000 kg peanuts based on a peanut loan schedule for the 2009 crop. Azoxystrobin cost $146.75/ha for two broadcast applications, and metalaxyl cost $120.47/ha for two broadcast applications. Peanut pod yield/ha was calculated based on the plot weights, and an overall value (grade × price - deductions)/ha was calculated. Net return ($/ha) was calculated from the overall value (yield × price), minus pumping and fungicide costs. Pumping costs for the irrigation treatments were calculated based on a depth to the groundwater table of 39.4 m, typical for the vicinity of the field studied. The operating pressure for the pivot was approximately 138 kpa and the pivot was nozzled at 2120 L/min. The electricity cost was estimated at $0.073/kWh, and the pumping plant efficiency was assumed to be 46.2%, an average based upon surveys of pumping plants in the area (Fipps and Neal, 1995). The pumping cost given these assumptions would be $0.0261/m^3 ($2.68/acre-inch).

Isolations were made as described previously using pods with lesions collected immediately after inverting plots. Pods were stored in paper sacks until isolations were conducted. Eight pods/plot were used in the isolation procedures at harvest if sufficient number of diseased pods were available.

Data were analyzed using PROC MIXED (SAS version 9.1, Cary, NC) on DK, grade, yield (kg/ha), and the net return/ha. The analysis was based on a split plot design with irrigation rate (IrrRate) as the main plot and fungicide treatment (TRT) as the subplot. The model statement included IrrRate, TRT, and their interaction. The initial analysis was conducted on all three data sets combined. The random statement had year, year nested within replication [REP(year)], year × IrrRate, REP × IrrRate (year), year × TRT, and year × IrrRate × TRT. However, the results were inconsistent among years, particularly in regards to the random factor REP × IrrRate(year) which had a significant effect, so each year was analyzed separately. In these analyses, the model statement was the same as for the overall analysis, but the random statement contained REP, and REP × IrrRate. In 2004, there were no B − 33% irrigation rate that was treated with fungicides so only the B and B + 33% irrigation rates were included in that analysis. Factors were considered significant if $P \leq 0.05$.

In order to look at the relative importance of water and fungicide application to yield, regression analysis was performed with these factors. Fungicide application was coded as 1 if azoxystrobin was used and 0 if metalaxyl or no-fungicide was used. The linear and quadratic function of water (cm of irrigation plus rainfall during the growing season) was also used as a factor. Initially the linear, quadratic, and interaction terms were examined across all three years, using PROC RSREG (SAS) to identify the significant terms. Then regression analysis was used to develop the final equation with those terms that were significant with PROC RSREG. Factors were included that were significant at $P \leq 0.05$.

The isolation frequency of pathogens (*Rhizoctonia* spp. and *Pythium* spp.) at 60 days after planting, as affected by IrrRate and presence of

Pythium spp. or *Rhizoctonia* spp. was determined using PROC MIXED (SAS). The data for the analysis consisted of each pod separately, and positive for either *Pythium* spp., *Rhizoctonia* spp., or neither. In none of the samples were both organisms isolated from the same lesion. The model statement included IrrRate and fungal type (i.e. the incidence of *Pythium* spp. isolation and of *Rhizoctonia* spp. isolation), and their interaction with the chi-square option used to determine significance at P=0.05. The Satterthwaite method was used to calculate degrees of freedom and the PDIFF option was used to determine differences between treatments at P=0.05. At harvest, a similar analysis was conducted, except fungicide treatment (TRT) was also included in the model statement as a main effect, and with 2-way and 3-way interactions. The random states for both analyses were similar to that done for yield, and initially included year as a factor. However, as was found with the previous analyses, the REP × IrrRate (year) was significant, so each year was analyzed separately.

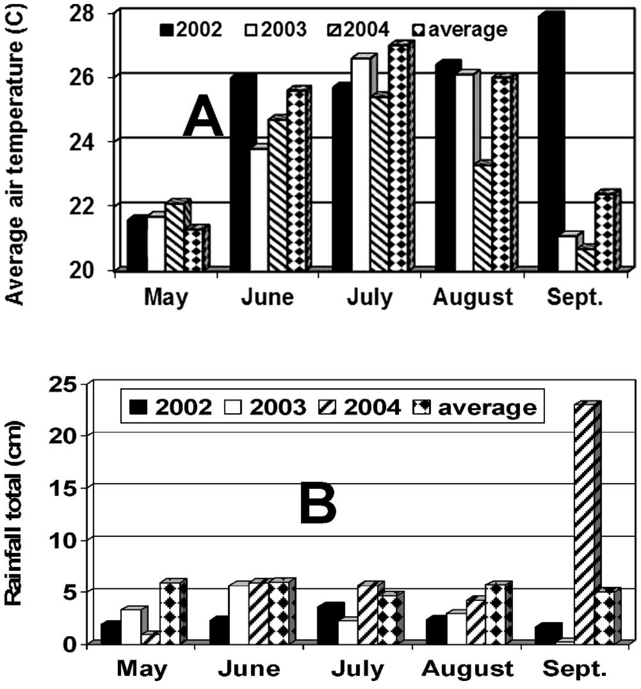

Fig. 2. Average air temperature (A) and rainfall (B) for 2002–2004 collected with a weather station at the test site. The long term average for air temperature and rainfall are also included in the Figure ▦ (obtained from the National Climate Data Center, NOAA).

Results and Discussion

Mean air temperature in 2002 was ca. 26 °C during June, July, and August, and then became unseasonably warm in September with mean ca. 28 °C (Fig. 2A). Warm temperatures were coupled with low levels of rainfall (Fig. 2B) during all months of the growing season. In 2003, air temperature was highest during July and August, as is typical in this region and very cool during September (Fig. 2A). Rainfall was low during July through August 2003, when plant water demands were highest. In 2004, air temperature was unusually cool during August and rainfall was unusually high during September (Fig. 2A,B).

In 2002 and 2004, there was no effect of irrigation on DK. In 2003 there was an interaction between irrigation rate and fungicide treatment, with respect to DK. At the B − 33% irrigation rate there were more ($P < 0.01$) DK associated with the metalaxyl (1.4% DK) and no-fungicide (1.5% DK) treated plots than the azoxystrobin (0.1% DK) treated plots. At the B irrigation rate, there were no effect of fungicide treatments on DK (average of 0.3% DK), and at the B + 33% irrigation rate, there were more ($P < 0.01$) DK associated with the metalaxyl (2.0% DK) treated plots than the azoxystrobin (0.3% DK) or no-fungicide (0.7% DK) treated plots.

Irrigation rate did not significantly ($P \leq 0.05$) impact peanut grade except in 2004, where kernels from plots with the B irrigation rate had a higher grade (79) than did kernels from plots in the B + 33% irrigation rate (76). Irrigation rate did affect ($P < 0.04$) yield in 2 of 3 yr (Table 1). Plots from the B + 33% irrigation rate had higher yields in 2002 and 2003 than plots from the B and B − 33% irrigation rates (Table 1). Plots from B − 33% irrigation rate had lower yields than plots from the B irrigation rate in 2002 (Table 1). Irrigation rate did not affect the net return of the crop/ha in any year ($P > 0.37$ in all years). Net return factored in pumping costs for the irrigation as well as value of the peanuts and fungicide costs.

Table 1. Effect of irrigation rate[1] on yield in 2002, 2003, and 2004 at a field in Gaines County, TX.

	Yield (kg/ha)		
Irrigation rate	2002	2003	2004
Base − 33%	3438 c[2]	3064 b	—
Base	4329 b	3102 b	4054 a
Base + 33%	5641 a	4150 a	4008 a

[1] Base stands for base irrigation rate. The lowest irrigation rate had 33% less water applied than the base rate and the high rate had 33% more water applied than the base rate. The base rate had 71, 53, and 37 cm of irrigation water applied in 2002, 2003, and 2004, respectively. In-season rainfall added 9, 24, and 44 cm in 2002, 2003, and 2004, respectively.

[2] Means within a column followed by the same letter are not significantly different at P = 0.05.

Table 2. Effect of fungicides (F[1]) on percent damaged kernels (DK), yield, and net return[2] of the peanut crop in 2002 (02), 2003 (03), and 2004 (04) at a field in Gaines County, TX.

	DK			Grade			Yield (kg/ha)			Net return ($/ha)		
F	02	03	04	02	03	04	02	03	04	02	03	04
N	3.4 a[3]	0.8 b	2.6 a	76 b	68 b	76 b	4013 b	3194 b	3727 b	906 b	1036	1025 b
A	0.2 b	0.2 c	0.3 b	79 a	73 a	80 a	5247 a	3585 a	4528 a	1848 a	1118	1651 a
M	2.7 a	1.3 a	2.2 a	77 b	69 b	77 b	4147 b	3536 a	3837 b	955 b	979	1105 b

[1] Fungicides include none (N), azoxystrobin (A) at 0.45 kg ai/ha and metalaxyl (M) at 0.24 kg ai/ha, each applied at 60 and 90 days after planting.

[2] Net return was calculated at a base rate of \$5.34/1000 kg of (% sound mature kernels + % sound splits) + \$1.54/1000 kg of %other kernels, minus deductions for damaged kernels (> 2.49%), foreign material (> 5%), sound splits (> 5%), fungicide applications, and pumping costs.

[3] Means within a column followed by the same letter are not significantly different at P = 0.05.

Plots treated with the fungicide azoxystrobin had fewer DK than plots with no-fungicide or plots treated with metalaxyl in all 3 years (Table 2). Metalaxyl treated plots had similar DK (2002, 2004) or more DK (2003) than the no-fungicide plots in all years. Peanut grades were higher for plots treated with azoxystrobin than for no-fungicide plots or plots treated with metalaxyl in all 3 years (Table 2). Yields were higher in the plots treated with azoxystrobin than no-fungicide plots in all 3 yr. Metalaxyl treated plots had higher yield than the no-fungicide treated plots in 1 of 3 yr (2003). Net return/ha was significantly ($P < 0.05$) higher for plots treated with azoxystrobin than plots receiving no-fungicide or metalaxyl treated plots in 2 of 3 yr (Table 2).

Yield was predicted with a quadratic function for water (irrigation plus rainfall in cm during the season) and linear function for fungicide (1 = azoxystrobin, 0 = metalaxyl or no-fungicide treatment) ($P < 0.01$). The interaction term between water and fungicide was not significant ($P = 0.88$). The model fitted by regression analysis was:

$$\mathrm{Yield(kg/ha)} = 7473.3 + 760.9(\mathrm{fungicide}) - 144.5(\mathrm{water}) + 1.2\left(\mathrm{water}^2\right),\ R^2 = 0.50\ \text{(Fig. 3)}.$$

Azoxystrobin application resulted in an average yield increase of 761 kg/ha based on this model. The average value of peanuts in azoxystrobin plots was \$416.85/1000 kg peanuts. The cost of the broadcast treatment was \$146.75/ha. The net return of the treatment after subtracting fungicide costs was \$170/ha. The net return of irrigation to the crop is more complicated to calculate due to the quadratic function and because some of the water was rainfall. To compare the relative importance between fungicide and irrigation, azoxystrobin added 761 kg/ha at a cost of \$146.74/ha. To get a similar increase in yield, it would be necessary to go from 56 cm water (the lowest amount in the study) to 86 cm water (Fig. 3). The cost of pumping 30 cm of water/ha is \$76.75/ha, given the stated assumed conditions for that site (depth to groundwater, irrigation system pressure, given efficiency, etc.). Other locations would note different costs of pumping, and these values can vary substantially. So, the cost of increasing yield due to water at this site was 52% of the cost of increasing yield a similar increment due to fungicide application. However, with fungicide application, there is a limit to the response, while for water there was no limit to the increase that occurred over the range of the study. However, as the water amount approaches the maximum that the crop required, there would be an expectation of diminished returns. The maximum water applied during the growing season was > 100 cm, which greatly exceeds the published maximum peanut ETc (Bandyopadhyag *et al.*, 2005; Kheira, 2009). The fact that yield was still increasing in response to

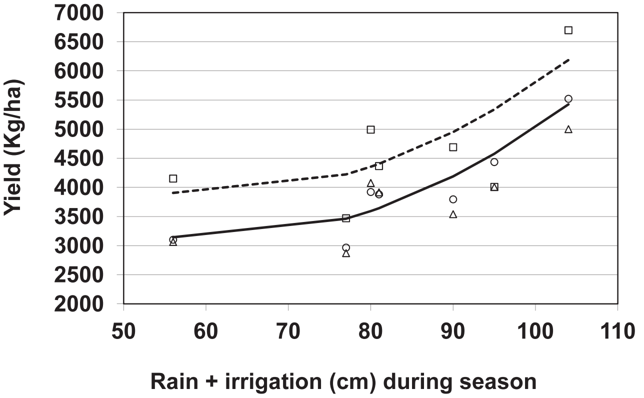

Fig. 3. Effect of water (rainfall plus irrigation) and azoxystrobin on peanut yield from 2002–2004. Water was in cm, and if azoxystrobin was applied then X=1, otherwise, X=0. Model predicted was: Yield (kg/ha) = 7473.3 + 760.9(X) − 144.5(Water) + 1.2(Water^2), R^2 = 0.50, $P < 0.01$ for all estimated parameter in the model. Average yield for a given water level for plots treated with axoxystrobin (□), metalaxyl (○), and no-fungicide (△). The line predicting yield in the absence of azoxystrobin (———) and the line predicting yield in the presence of azoxystrobin (– – –).

Table 3. Effect of irrigation rate on frequency of isolation of *Pythium* spp. and *Rhizoctonia* spp. from discolored and rotted pods at 60 days after planting.

	Isolation frequency (%)			
	2003		2004	
Irrigation Rate[1]	Pyth[2]	Rhiz[2]	Pyth	Rhiz
Base−33%	0.0 by	3.1 az	—	—
Base	3.1 az	3.1 az	0.5 ay	3.1 az
Base+33%	0.4 by	6.7 az	0.0 ay	4.4 az

[1] Base stands for base irrigation rate. The lowest irrigation rate had 33% less water applied than the base rate and the high rate had 33% more water applied than the base rate. The base rate had 71, 53, and 37 cm of irrigation water applied in 2002, 2003, and 2004, respectively. In-season rainfall added 9, 24, and 44 cm in 2002, 2003, and 2004, respectively.

[2] Pyth=*Pythium* spp. and Rhiz=*Rhizoctonia* spp.

[3] Means within a column followed by the same letter (a) are not significantly different at P = 0.05. Means within a row for a year, followed by the same letter (z) are not significantly different at P=0.05.

water in our study at this amount suggests that there may be greater losses to evapotranspiration and deep percolation than found in published studies, and peanut evapotranspiration models may not be a good fit for this region.

Rhizoctonia spp. and *Pythium* spp. were isolated from diseased pods, but more *Rhizoctonia* spp. was found than *Pythium* spp., both at midseason and harvest in 2003 and 2004 (Tables 3 and 4). Irrigation rate did not have a consistent effect on isolation frequency of either *Rhizoctonia* spp. or *Pythium* spp. (Tables 3 and 4). However, when azoxystrobin was applied, then isolation frequency of *Rhizoctonia* spp. was low. The isolation frequency and the performance of azoxystrobin compared with metalaxyl and the no-fungicide treatments suggest that the primary pod rot pathogen in the field was caused by *Rhizoctonia*. Metalaxyl, which only protects against the oomycetes (Hoy and Schneider, 1988; Stone *et al.*, 1987), did not perform as well as azoxystrobin, which protects against many fungi and oomycetes, including some activity against *Pythium* spp (Besler *et al.*, 2003; Grichar *et al.*, 2000). In this field, *Pythium* spp. was probably not as important a component in the pod rot complex as was *Rhizoctonia*.

Producers in this region associate higher irrigation capacity with higher yield. This relationship was also consistent with our results. However, the increase in yield did not result in higher net return. Soilborne diseases caused by fungi and oomycetes are often more severe under wet conditions (Cook and Papendick, 1972; Duniway, 1979). Damaged kernels, which can be caused by *Pythium* spp. and *Rhizoctonia* spp. were generally not associated with irrigation rate in these studies. Yield, however, was affected by irrigation rate in 2 of 3 yr and in 2004 where irrigation rate was not significant, the irrigation treatment totals only differed by 9-cm applied over the entire season.

DK was strongly affected by fungicide treatment. Azoxystrobin greatly reduced the amount of DK and improved yields in all 3 yr of the test. Metalaxyl was ineffective on DK in all 3 yr.

Losses due to pod rotting organisms can reduce harvestable yield by destroying pegs, and pods may detach before they can be harvested. Therefore, DK does not include all peg and pod disease. Yield and net return (including penalties for DK) may be a better measure, since it would represent the loss in pods from peg rot before pod formation or peg rot that detached pots. Since azoxystrobin did positively impact percent damaged kernels every

Table 4. Effect of irrigation rate and fungicide treatment on frequency of isolation of *Pythium* spp. and *Rhizoctonia* spp. from discolored and rotted pods at harvest during 2003 and 2004.

		Frequency of isolation (%)					
		Rhizoctonia spp.			*Pythium* spp.		
Year	Irrigation rate[1]	None[2]	Azox[2]	Metal[2]	None	Azox	Metal
2003	B−33%	18.8 ay*[3]	0.0 ax	28.1 az*	0.0 az	0.0 az	0.0 az
2003	Base	0.0 bz	0.0 az	3.1bz	0.0 az	0.0 az	0.0 az
2003	Base+33%	18.8 az*	3.1 ay	6.3 by	0.0 az	0.0 az	0.0 az
2004	Base	28.1 az*	0.0 ax	9.4 by*	0.0 az	0.0 az	0.0 az
2004	Base+33%	15.6 by*	3.1 ax	34.4 az*	0.0 az	3.1 az	0.0 az

[1] Base stands for base irrigation rate. The lowest irrigation rate had 33% less water applied than the base rate and the high rate had 33% more water applied than the base rate. The base rate had 71, 53, and 37 cm of irrigation water applied in 2002, 2003, and 2004, respectively. In-season rainfall added 9, 24, and 44 cm in 2002, 2003, and 2004, respectively.

[2] None is no fungicide treatment, Azox is azoxystrobin treated plots, and Metal is metalaxyl treated plots.

[3] Means within a column within the same year, followed by the same letter (a) are not significantly different at P = 0.05. Means within a row for a pathogen followed by the same letter (z) are not significantly different at P=0.05. Means for an irrigation rate/fungicide combination were compared between pathogens and * indicates that means are significantly different at P=0.05.

year, we conclude that irrigation rate had minimal impact on disease compared with application of azoxystrobin. Increasing amounts of irrigation led to higher yield in 2 of 3 yr without an increase in DK. If a producer from this region, or a region with a similarly high evapotranspiration rate coupled with low rainfall, chooses to maximize yield with irrigation, there is no evidence that it will lead to more kernel damage caused primarily by *Rhizoctonia* spp. However, use of a fungicide like azoxystrobin to protect pods is recommended, particularly if there is any history of pod rot.

Acknowledgments

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