Relationship Between Postharvest Management of Grain Sorghum and Phymatotrichum Root Rot in the Subsequent Cotton Crop

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ABSTRACT

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Research was conducted at four central Texas sites over a 3-yr period to determine the effects of postharvest sorghum treatments on incidence of Phymatotrichum root rot in the subsequent cotton crop. After sorghum harvest, stalks were disked (conventional treatment), sprayed with glyphosate at 420 g acid equivalent per hectare (glyphosate treatment), or allowed to regrow until killed by frost (ratoon treatment). In all cases, the incidence of cotton root rot the following year was higher with the ratoon treatment than with the glyphosate treatment. In three of four studies, the ratoon treatment also resulted in significantly more root rot than the conventional treatment. Results of an in vitro glyphosate toxicity study revealed that glyphosate restricts linear growth of *Phymatotrichum omnivorum* at concentrations $\geq 10\ \mu g/ml$. It is improbable that toxic levels of the herbicide accumulated in roots of treated sorghum in the field. Disease increase in ratoon plots was possibly due to an increase in inoculum density resulting from the prolonged availability of sorghum roots as a substitute for saprophytic growth.

Cotton (*Gossypium hirsutum* L.) and grain sorghum (*Sorghum bicolor* (L.) Moench), often grown in yearly rotation, are two of the main crops produced in the Blackland regions of central and south Texas. Phymatotrichum root rot of cotton, caused by *Phymatotrichum omnivorum* (Shear) Dug., is endemic to these regions and is responsible for reducing yields annually in infested fields. The rotation of sorghum with cotton is popular because sorghum tolerates Phymatotrichum root rot (2,11) and helps reduce disease incidence in the following cotton crop (6,10). Although grain sorghum is tolerant to Phymatotrichum root rot, it can still support sclerotia production by the fungus (7,9).

In recent years, economics have encouraged alternative farming practices that increase production without increasing costs. Ratoon cropping grain sorghum, i.e., allowing the plant to regrow for a second grain harvest, is one means of achieving this, and the long growing season in central and south Texas makes ratoon cropping possible (3). However, because grain sorghum can support sclerotia production by *P. omnivorum*, a ratoon crop could conceivably affect disease severity in the following cotton crop. Therefore, this study was conducted to determine the effects of ratoon cropping grain sorghum on Phymatotrichum root rot development in cotton.

MATERIALS AND METHODS

Plots were established at one site in Hill County, Texas, in 1982, at two sites in Hill County in 1983, and at one site in Bell County in 1984. With the exception of the 1984 site, where cotton had been grown in monoculture for over 10 yr, each site had a history of severe Phymatotrichum root rot and cotton-sorghum rotations. Immediately after harvest, sorghum stalks in eight-row, 30-m plots were plowed with a tandem disk (conventional control), sprayed with the isopropylamine salt of [*N*-(phosphonomethyl)glycine (360 g glyphosate acid/L)] at the rate of 420 g acid equivalent (a.e.)/ha, and plowed 3 wk later (glyphosate treatment) or allowed to ratoon (ratoon treatment). Plants in the ratoon plots grew until killed by frost in October or November and were then disked. Treatments were replicated four times and arranged in a randomized complete block design.

Root rot measurements. The year following plot establishment, cotton (cv. GP3774) was planted at each site. Disease incidence was evaluated five times in 1983 and six times in 1984 and 1985. Counts of diseased plants were taken in 15-m lengths of the four center rows of each eight-row plot. Only permanently wilted plants were counted. At each date, all diseased plants were pulled and roots were checked for strands of *P. omnivorum*. Data were analyzed by ANOVA, and means were separated using Fisher's LSD at $P = 0.05$ confidence level. Results are discussed by year of cotton crop, not by plot establishment.

Glyphosate toxicity. A study was conducted in vitro to establish levels of glyphosate toxic to *P. omnivorum*. Potato-dextrose agar was amended with glyphosate at rates of 0, 0.1, 0.5, 1.0, 5.0, 10.0, and 25.0 μg a.e./ml. There were five replicate plates of each glyphosate

Table 1. Cumulative incidence of cotton plants killed by *Phymatotrichum omnivorum* during the 1983, 1984, and 1985 growing seasons with respect to type of cultural practice after previous grain sorghum crop

	Percent diseased plants on sampling date[a]					
Treatment	**1**	**2**	**3**	**4**	**5**	**6**
Site I, Hill County, 1983						
Conventional	···	2.2	7.7	20.0	27.8	43.2
Ratoon	···	1.8	11.0	31.0	39.4	63.6
Glyphosate	···	1.0	5.6	20.4	22.0	38.8
LSD 0.05	···	NS	3.1	4.6	4.5	4.0
Site II, Hill County, 1984						
Conventional	1.3	2.1	3.7	4.4	5.0	11.7
Ratoon	1.4	2.1	4.0	5.5	6.5	19.0
Glyphosate	0.0	0.1	0.2	0.2	0.3	0.3
LSD 0.05	NS	NS	2.6	2.8	3.0	4.7
Site III, Hill County, 1984						
Conventional	0.4	2.5	5.2	11.0	14.8	24.1
Ratoon	2.2	4.3	9.7	15.9	20.7	39.3
Glyphosate	0.5	1.2	4.0	5.9	8.9	13.4
LSD 0.05	0.5	2.0	2.4	2.2	2.4	3.8
Site IV, Bell County, 1985						
Conventional	3.0	6.0	36.0	56.0	71.0	88.0
Ratoon	6.0	12.0	43.0	60.0	76.0	93.0
Glyphosate	4.0	8.0	38.0	56.0	73.0	89.0
LSD 0.05	NS	NS	NS	NS	NS	NS

[a] Site I: 2 = 6 July, 3 = 13 July, 4 = 20 July, 5 = 27 July, 6 = 18 August. Sites II and III: 1 = 25 June, 2 = 3 July, 3 = 10 July, 4 = 19 July, 5 = 31 July, 6 = 23 August. Site IV: 1 = 25 June, 2 = 3 July, 3 = 10 July, 4 = July 19, 5 = 31 July, 6 = 23 August.

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concentration. A 5-mm plug from a 7-day-old culture of *P. omnivorum* was used to inoculate each plate, and all plates were incubated at 30 C for 7 days. Fungal growth rates were measured daily.

RESULTS

Cotton following the ratoon grain sorghum treatment had significantly more disease at the end of the growing season than either the conventional or the glyphosate treatment in three of the four field experiments (Table 1). In 1983, cotton in the ratoon plots had significantly more disease at four of the five measurement dates. Differences were significant at all but the earliest date.

In 1984, the same trends were observed at both sites. Disease development at site II was minimal, reaching only 19% in the ratooned plots. Although differences between the ratoon and glyphosate treatments were significant at five of the six measurement dates, differences between ratoon and conventional control were significant at only the last date. However, at site III, where more disease developed, the ratoon plots had more disease than the glyphosate plots at all six dates and more than the conventional control at five of the six dates.

Killing the sorghum roots with glyphosate before disking reduced disease incidence in all tests. In 1983, plots treated with glyphosate had significantly less disease than conventional control plots at the last two dates. In 1984, glyphosate plots had less disease at four of the six dates at site II and at three of the six dates at site III. The differences in the glyphosate plots and the other two treatments became more pronounced as the season progressed.

Results of the 1985 test were strikingly different from those of all previous tests. Treating sorghum with glyphosate did not significantly reduce disease severity in cotton the following year even though the same trends were evident. Disease incidence was much higher in 1985 than in previous years, with over 85% plant death in all treatments.

The glyphosate toxicity study showed that glyphosate reduced the linear growth rate of *P. omnivorum* only at relatively high concentrations (Table 2). Glyphosate concentrations of 5 μg/ml or greater significantly reduced growth 2 days after the plates were inoculated. After 4 days, however, only the 10- and 25-μg/ml concentrations reduced growth.

DISCUSSION

Sorghum plants often survive the conventional postharvest treatment of shredding and disking and continue to grow until first frost. Because sorghum is a perennial, an undamaged root system will remain alive through the winter, even after tops have frozen. *P. omnivorum* can survive on sorghum roots and form sclerotia (7). It is therefore reasonable to assume that prolonged growth of the sorghum crop would benefit survival of this fungus. Saprophytic survival of soil microorganisms on root exudates is commonplace (1,4). *P. omnivorum* is a poor competitor as a saprophyte (5), however, and killing sorghum roots with glyphosate should reduce availability of nutrient to *P. omnivorum*. Although this study provided no direct evidence that the glyphosate treatment affected sclerotia production or the ability of *P. omnivorum* to survive on living sorghum roots, the treatment, compared with ratoon treatment, did significantly reduce disease in every test. We speculate that glyphosate treatment reduced disease by removing the food source, thereby reducing sclerotial inoculum density the following year, and not by any direct toxic effect on the organism. In the glyphosate toxicity study, only the highest rates of 10 and 25 μg a.e./ml reduced linear growth of *P. omnivorum*. It is unlikely that these concentrations accumulated in roots of field-grown sorghum when only 420 g a.e./ha was applied (A. Wiese, *personal communication*).

The results of the 1985 test were disappointing but not totally unexpected. Although sorghum can support sclerotia production by *P. omnivorum*, its ability to do so is much less than that of cotton (7). The 1985 site was the only one where cotton had been grown in monoculture before this test. All other sites had been in a cotton-sorghum rotation. Therefore, the inoculum density at the 1985 site was probably higher than that at the other sites. In addition, heavy rains in May and June provided optimum conditions for disease development. Soil moisture is the primary factor affecting Phymatotrichum root rot development (5,8,10), and it appears that optimum conditions for disease development may have overwhelmed treatment effects.

The results of this study suggest that early removal of the sorghum crop and elimination of the root system would be a beneficial cultural practice in areas where Phymatotrichum root rot is a problem. However, the benefits of reduced disease levels in the subsequent cotton crop would need to be evaluated against the added cost of the glyphosate treatment and the loss of the income provided by the ratoon crop.

Table 2. In vitro growth of *Phymatotrichum omnivorum* on potato-dextrose agar amended with various concentrations of glyphosate[a]

Glyphosate (μg a.e./ml)	Linear growth (cm) 2 Days	4 Days	7 Days
0.0	2.33	3.66	6.57
0.1	2.26	3.98	7.34
0.5	2.30	3.85	6.30
1.0	2.28	3.80	6.96
5.0	2.08	3.52	6.42
10.0	1.42	2.26	4.60
25.0	1.10	2.00	4.20
LSD 0.05	0.20	0.30	0.56

[a]There were five replicate plates of each concentration. A 5-mm plug from a 7-day-old culture of *P. omnivorum* was used to inoculate each plate, and all plates were incubated at 30 C for 7 days.

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