THE TIMING OF BRONZE WILT APPEARANCE AFFECTS FRUIT RETENTION

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Abstract

Bronze wilt (BW) is a disorder of cotton characterized by bronze discoloration and wilting of leaves. Symptoms may progress to shedding of fruit, but the extent of fruit loss relative to the time of BW appearance has not been documented. Because BW is also associated with damage to the secondary root system, soil nutrient availability may affect the appearance of symptoms. Our objectives were to quantify differences in fruit retention and other responses relative to BW appearance, and to determine if soil fertility and tillage affected BW appearance. The study was superimposed on plots used for soil fertility research at Ames Plantation and Jackson TN. Treatments at Ames included N and K rates as well as tillage. Treatments at Jackson included N, P, and K fertilizer rates. Plots of Paymaster PM 1218 BG/RR were monitored weekly for the progression of symptoms to include reddening of upper canopy and fruit shedding, and plants reaching this stage of symptoms were flagged each week. A few BW plants appeared each week between early and late bloom, but incidence remained very low at both locations. Prior to harvest, pairs of flagged and adjacent normal plants were mapped for height, fruiting-branch number, and first-position boll retention. Neither fertility nor tillage treatments affected BW incidence or severity. Plants in which BW symptoms appeared early were shorter in height, had fewer fruiting branches and lower fruit retention than adjacent normal plants. These responses were affected the most when symptoms appeared at early bloom, and less when symptoms appeared later. The extent of fruit loss ranged from 90% in plants developing symptoms at early bloom, to ~20 to 30% at late bloom. While total incidence of BW was insufficient to affect yields of overall populations, yield of individual plants were likely reduced by fruit loss.

Introduction

Bronze wilt (BW) is the common name for a disorder of cotton generally characterized by a bronze discoloration and wilting of the upper foliage. Symptoms may progress to square and boll shedding (Bell, 2000a; Phipps, 2000), but there is no published data relating foliar symptoms to fruit shedding and consequent yield reduction. Substantial yield losses have been attributed to BW (Bell, 2000a; Brown, 2000), although the contribution of square and boll abscission to yield loss has not been reported. Based on information from the Delta and Pine Land Co., Urbanek (2000) suggested that "tremendous differences" in boll set compared to healthy plants are needed to confirm BW. He said that when BW symptoms are noticeable and wilting begins, plants have already lost all large squares, most small squares, and all small bolls. This implies that substantial fruit loss occurs early in the development of BW symptoms. However, Phipps (2000) pointed out that relatively late appearance of symptoms affected yields much less than earlier symptoms. Data are lacking on the extent of fruit loss relative to the time of BW appearance.

Because BW is associated with damage to the secondary root system (Bell, 2000a), soil nutrient availability may affect the appearance or timing of symptoms. Working in growth chambers, Bell (2000a) found that BW-induced boll abscission was greatest when P and K were only marginally available in the fertilizer. Biomass comparisons indicated that BW severity was directly proportional to N and inversely proportional to P fertilizer (Bell, 2000b). In field situations, BW symptoms have resembled and sometimes been confused with K deficiency (Brown, 2000). In California cotton, where late-season K deficiencies were induced by Verticillium wilt infection, high rates of K fertilization reduced foliar disease symptoms (Mikkelson et al., 1988). Data are lacking, however, on the possible fertility effects on BW in the field.

Objectives of this study were to determine if N, P, or K fertility altered the incidence or severity of BW symptoms in field-grown cotton; and to quantify differences in fruit retention and other growth responses relative to the time of BW appearance.

Materials and Methods

A study to monitor the incidence and severity of bronze wilt was superimposed on plots used for K fertility research at Ames Plantation and Jackson TN. Soils were a Loring-Henry silt loam complex at Ames and a Memphis-Loring silt loam complex at Jackson. Both sites had long histories of no-tillage cotton, with established K fertility regimes on individual plots.

The Ames experiment was a randomized complete block, split-plot design, with tillage and fertilizer as the main- and sub-plot treatments, respectively. Fertilizer treatments ranged from 0 to 240 lb/ac K_2O broadcast as KCl, and 80 or 160 lb/ac N broadcast as NH_4NO_3 before planting. The 160 N treatments were applied only to 60 and 120 K treatment levels, but all K levels were tested with 80 lb/ac N. Tillage treatments consisted of conventional- and no-till, with discing and harrowing of conventional tillage plots between fertilizer application and planting.

The Jackson experiment was a RCB design, with N, P, and K fertilizer treatments broadcast pre-plant. No tillage was used for all plots at Jackson. Potassium treatments ranged from 0 to 180 lb/ac K_2O as KCl. Nitrogen treatments were 80 or 160 lb/ac N as NH_4NO_3, and phosphorus treatments were 30 and 90 lb/ac P_2O_5 as TSP. The N and P treatments were not applied to all K levels, but all K levels were tested with 80 lb/ac N and 30 lb/ac P_2O_5.

The same commercial seed lot of Paymaster PM 1218 BG/RR was planted in 40" rows on 8 May 2000 at Ames and in 38" rows on 11 May 2000 at Jackson. Plant stands were counted after emergence, and standard cultural practices were followed. Plots were monitored weekly for the progression of bronze wilt (BW) symptoms, which first appeared at early bloom. Plants reaching the second stage of symptom progression as described in Table 1 (i.e., reddening of upper canopy stem or leaf tissue, and shedding of fruit, plus some evidence of first-stage symptoms) were observed. Such plants were flagged each week until symptoms could no longer be distinguished from senescence. Plants reaching just the first stage of symptom progression were not counted due to the transience of those symptoms. As new plants showed BW symptoms over a 4-week period, four sets of plants were flagged from 60 to 85 days after planting (DAP) at each location. Plant counts were statistically analyzed using a square-root transformation to normalize the data.

At 108-110 DAP, pairs of flagged and adjacent unflagged plants were mapped for height, fruiting-branch number, and first-position boll retention at both locations. Possible interactions between treatments and BW injury were detected by treating flagged and unflagged mapping plants as sub-treatments in the analyses of variance. Where interactions were not found, paired t-tests were performed to detect differences between the BW and adjacent normal plants for each date of BW appearance.

Results and Discussion

Bronze wilt symptoms first appeared at both locations shortly after first flower (60 DAP), with additional plants showing symptoms in each

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subsequent week until last bloom (~85 DAP)(Table 1). Plants with BW appeared randomly distributed within plots. Under the prevailing hot weather conditions, most plants that reached the first stage of symptom expression rapidly progressed to the second stage and were thus tagged. A few plants with first-stage symptoms may have reverted to an asymptomatic state. Stage 3 symptoms were not observed in this study.

Table 2 shows analyses of variance of second-stage BW incidence at Ames and Jackson by time of observation. The mean BW plant counts indicate that a few BW plants developed second-stage symptoms each week of flowering, but that the rate of incidence remained very low at both locations. The total incidence of BW represented about 1.4% of the plant population at Ames and just 0.5% of the population at Jackson. Neither fertility nor tillage treatments affected BW incidence at Ames, and fertility did not affect BW incidence at Jackson. Stands averaged 3.2 plants/ft row at Ames and 3.0 plants/ft row at Jackson, and they did not differ by fertility or tillage treatment (data not shown).

Statistical analyses of plant mapping data indicated no significant interactions between treatments and bronze wilt injury at either location (data not shown). Therefore, plant mapping data on pairs of BW and adjacent normal plants were compiled across treatments by date of BW appearance at each location.

Table 3 shows BW influence on plant growth and development at Ames Plantation, using t-tests to compare BW and adjacent normal plants. Plants in which BW symptoms appeared by 60 DAP were shorter in height, had fewer fruiting branches and lower fruit retention than adjacent normal plants. Plant height was reduced the most (-16%) for plants in which symptoms appeared by 60 DAP, with less reduction in cases where symptoms appeared later. Height reduction was not significant where symptoms appeared later than 67 DAP. Fruiting branch number was reduced by 12% when symptoms appeared by 60 DAP, but differences were not significant thereafter. Fruit retention was significantly lower in BW plants than adjacent normal plants in all observations, but the timing of BW appearance altered the extent of fruit loss. When BW symptoms appeared by 60 DAP, fruit retention was reduced from 53% to 5% -- equivalent to a 90% fruit loss. Later BW appearance reduced fruit retention to lesser extent, but appearance of symptoms as late as last bloom (85 DAP) reduced retention from 52% to 35%.

Table 3 also shows that BW had similar effects on plant growth and development at Jackson as observed at Ames. The earlier that BW symptoms appeared, the more severe the responses were. Plant height and fruiting branch numbers were reduced about 25% when BW symptoms appeared by 60 DAP, with lesser reductions at 67 DAP. Effects were not significant thereafter. Fruit retention was reduced from 54% to 5% in plants in which symptoms appeared by 60 DAP, but losses were less in plants with later appearance of symptoms.

Although total incidence of BW was nearly three times higher at Ames than at Jackson, it was not high enough in either test to affect yields of the overall populations. Yields of individual plants at both locations -- especially those with early symptom expression -- were obviously reduced by severe fruit losses. Fruit shed on the order of 90% in a large proportion of the population would therefore result in substantial yield losses, particularly in short-season environments where plant compensation is limited. Results suggest that the timing of bronze wilt appearance can have a major effect on injury and yield loss, if a significant proportion of the population is affected. Future research will attempt to quantify the effects of BW-induced fruit loss on yield reduction.

In this study, neither fertility nor tillage treatments altered the incidence or severity of BW. The relatively low incidence of BW throughout Tennessee in 2000 leads us to speculate that necessary environmental conditions such as high soil temperature (Bell, 2000b) may have been insufficient. We speculate that agronomic variables such as fertilizer and tillage may come into play when these conditions are met.

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Table 1. Stages of bronze wilt symptom progression used in studies at Ames Plantation and Jackson TN in 2000.

Stage	Description
1	Bronze leaf tint, lower leaf angle (wilting), and higher leaf temperature in upper canopy than neighboring plants. †
2	Evidence of some Stage 1 symptoms, plus reddening of upper canopy (stem or leaf) and abnormal shedding of fruit. ‡
3	Evidence of some Stage 2 symptoms, plus necrosis of whole plants or stem tissue.

† Stage 1 symptoms may sometimes disappear or not progress.
‡ Leaf color may revert to green or reddish-green after fruit shed.

Table 2. Analysis of variance of bronze wilt incidence by observation date and cumulative totals at Ames Plantation and Jackson TN in 2000.

Loc.	Obs.	Mean BW Plant Count†	Source of Variance	df	F	Prob. P (F)
	DAP	no./60' row				
Ames	60	0.35	Tillage	1	0.77	>0.50
			Fertility	5	0.54	>0.50
			T x F	5	2.03	0.10
	67	0.88	Tillage	1	1.23	0.35
			Fertility	5	1.07	0.40
			T x F	5	0.44	>0.50
	74	0.60	Tillage	1	2.64	0.20
			Fertility	5	1.50	0.22
			T x F	5	2.05	0.10
	85	0.88	Tillage	1	0.10	>0.50
			Fertility	5	0.54	>0.50
			T x F	5	1.17	0.35
	total	2.71	Tillage	1	1.77	0.28
			Fertility	5	0.69	>0.50
			T x F	5	1.25	0.31
Jackson						
	60	0.17	Fertility	11	0.40	0.95
	67	0.27	Fertility	11	1.13	0.36
	74	0.25	Fertility	11	1.13	0.36
	81	0.25	Fertility	11	0.33	0.98
	total	0.93	Fertility	11	0.72	0.71

†Number of plants showing second-stage symptoms since previous observation.

Table 3. Influence of bronze wilt on end-of season plant map traits at Ames and Jackson TN, using paired T-tests to compare BW and adjacent normal plants.

Loc.	Plant Map Trait	Time of BW Appearance (DAP)	Plant Category Normal	BW	Prob. P (T)
	Plant				
Ames	Height		(in.)	(in.)	
		60	25.6	21.5	<0.01
		67	25.1	24.0	0.04
		74	25.3	25.1	0.74
		85	25.0	24.6	0.27
	Fruiting Branches		(no.)	(no.)	
		60	9.2	8.1	0.01
		67	8.8	8.8	0.93
		74	8.4	9.1	0.15
		85	8.5	8.6	0.69
	Boll Retention		(%)	(%)	
		60	53.1	5.4	<0.01
		67	53.2	10.1	<0.01
		74	54.7	19.0	<0.01
		85	52.2	35.2	<0.01
Jackson	Plant Height		(in.)	(in.)	
		60	31.3	23.6	<0.01
		67	31.5	26.5	<0.01
		74	31.8	30.0	0.10
		81	31.4	29.8	0.22
	Fruiting Branches		(no.)	(no.)	
		60	12.0	8.8	<0.01
		67	11.5	9.3	<0.01
		74	11.1	11.0	0.91
		81	11.1	11.0	0.93
	Boll Retention		(%)	(%)	
		60	54.1	5.3	<0.01
		67	52.8	31.1	<0.01
		74	54.5	42.3	0.09
		81	52.7	40.5	0.04