RELATIONSHIP BETWEEN LEVELS OF CAVITATION AND YIELD PERFORMANCE

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Abstract

Reports of cavitation, also known as Phomopsis boll dangle, Phomopsis boll rot, xylem cavitation, vascular cavitation, cotton blossom rot, or atypical boll shed, have increased in the Mid-South and Southeastern regions of the U.S. Cotton Belt since the mid-1990s. Cavitation describes a condition in which small bolls rapidly desiccate, become necrotic prior to the initiation and/or completion of the abscission process, and have an accompanying characteristic elongated scar that extends basipetally from the peduncle. The result is that these small bolls become adhered to the sympodium. The cause of cavitation is not known, although two hypotheses (physiological and pathological) have been reported. Levels of cavitation, expressed as the number of cavitated sites per plant at fruiting positions 1 and 2, were recorded, along with the number of bolls per plant at fruiting positions 1 and 2, and lint yield, when available, in 1999 and 2000 for 125 varieties planted in grower fields, university official variety trials, and Delta and Pine Land Company on-farm trials in Alabama, Florida, Georgia, Mississippi, North Carolina, and South Carolina. Overall, cavitation levels were higher in 2000 than in 1999. No association between cavitation level and lint yield or relative boll load was detected. While 25 varieties had cavitation levels significantly higher than zero, the lint yields of these varieties were not different from the lint yields of varieties for which cavitation levels were not statistically different from zero. These data suggest that, while cavitation warrants continued observation and monitoring, lint yields are not impacted by its occurrence, which supports data reported previously.

Introduction

Although the occurrence of cavitation, which is also known as Phomopsis boll dangle, Phomopsis boll rot, xylem cavitation, vascular cavitation, cotton blossom rot, or atypical boll shed (Padgett, 2000; McCarty, 1999), has been observed in the Western cotton-growing region of the U.S. for several years (Hake et al., 1996), reports of its occurrence in the Mid-South and Southeastern cotton-growing regions of the U.S. began in the mid-1990s (McCarty, 1999).

Cavitation is the result of a young boll (usually 1 to 3 days post-anthesis) undergoing desiccation and necrosis before the process of abscission can be initiated and/or completed. Since the lack of abscission prevents the degradation of the vascular tissue at the juncture of the peduncle and sympodium, the fruiting structure adheres to the sympodium without shedding. With further weathering, cavitated bolls have been observed to fall from the plant after the peduncle has deteriorated. Scars from cavitated sites can be distinguished from non-cavitated sites by the characteristic "tear-drop" shaped or basipetally-elongated scars extending from the site of attachment. Non-cavitated or "normal" scars from squares or bolls that have undergone the process of abscission are more circular in shape (McCarty, 1999; Delta and Pine Land, 2000; Hake et al., 1996).

The cause of cavitation is not known, though two theories have been reported. The physiological theory suggests that cavitation is the result of the breakage or collapse of the water column in the xylem tissue or other vascular tissue immediately following anthesis, causing rapid desiccation and necrosis of the fruiting structure prior to the process of abscission (McCarty, 1999). The disease theory suggests that cavitation is caused by *Phomopsis* (Padgett, 2000) or other unidentified pathogens (Stewart, 1999), although the mechanism of infection or subsequent damage has not been determined.

Padgett (2000) examined varietal response to this phenomenon in Louisiana in the university official variety trials (OVTs) at three locations from 1997 to 1999. Results indicated that cavitation levels were highest for medium-maturing varieties, although most varieties were affected. Sure-Grow 501 was most affected, and PSC355, Sure-Grow 248, ACSI EXP0805, HCR9310, DP90RR, DP90B, DP5415, DP5690RR, and DP675 were also heavily affected. Padgett also compared two affected grower fields of DP90RR and NuCOTN33B. Plant pairs (affected vs. unaffected) were compared for cavitation, boll development, and seedcotton yield. Affected plants had more harvestable bolls than unaffected plants. DP90RR had cavitation ranging from 2.24 to 4.64 sites per plant, while NuCOTN33B had 2.08 to 2.62 affected sites per plant. Most of the affected bolls were found at the first fruiting position (69% for NuCOTN33B and 56% for DP90RR). Seedcotton yields were higher for affected plants, suggesting that cavitation did not have a significant impact on yield, but may have delayed maturity.

Levels of cavitation have also been shown to have no association with the Roundup Ready® or Bollgard® genes, or with applications of Roundup Ultra® herbicide (Carey et al., 2000)

Therefore, our objectives were to quantify the levels of cavitation for each variety, and to determine if cavitation is associated with yield performance and/or relative boll load.

Methods

In response to grower inquiries in 1999, personnel from Delta and Pine Land Company and Monsanto Company collected detailed plant maps from over 500 locations throughout Alabama, Florida, Georgia, and Mississippi. We collected data from over 22,000 plants from grower fields, Delta and Pine Land Agronomic Service Trials (DPL ASTs), university official variety trials (OVTs), and consultant trials. Data collection began in late-August and continued to late-October, which generally coincided with cutout to nearly 100% open boll.

In 2000, Delta and Pine Land Company Technical Service Agronomists in the Eastern Region (east of the Mississippi River) collected cavitation level data from DPL ASTs while collecting final plant maps at cutout to early open boll. Cavitation was observed in these DPL ASTs in Alabama, Florida, Georgia, Mississippi, North Carolina, and South Carolina in 2000.

For both years, data are reported only from locations in which cavitation was observed for at least one variety. Cavitation levels were collected from fruiting positions 1 and 2 (FP1 and 2) only from all nodes, and are expressed as the number of cavitated sites per plant at FP1 and 2. Similarly, the total number of harvested bolls per plant at FP1 and 2 was collected from the same plants. When available, lint yield is reported from machine-picked samples. For DPL ASTs, seedcotton samples were ginned on a 20-saw commercial-scale gin with seedcotton and lint cleaners. For OVTs, seedcotton samples were ginned on laboratory-scale gins, and lint yields are those reported in the official publications from the universities involved.

For statistical analyses, least square means were generated and comparisons made by t tests (SAS, 1990).

Results and Discussion

When averaged over varieties and locations, levels of cavitation were significantly higher in 2000 compared to 1999; lint yields also significantly

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differed between the two years (Table 1). Cavitation levels ranged from 0 to 5.6 sites per plant in 1999 and 0 to 7.8 sites per plant in 2000.

The number of cavitated sites per plant was not associated with lint yield (Fig. 1) or with the number of bolls per plant (Fig. 2).

Of the 125 individual varieties within the dataset, 25 had cavitation levels that were significantly higher than 0, based on t test (Table 2). The range of the number of cavitated sites per plant for those varieties was 0.24 to 2.73. Table 2 also shows the corresponding least square means for lint yield by variety. The lint yield data in Table 2 further support the lack of association between cavitation level and lint yield shown in Fig. 1.

The least square mean for all varieties with cavitation levels significantly greater than 0 was significantly higher than for the cavitation level of all varieties for which cavitation levels were not significantly greater than 0 (based on t tests). Furthermore, while cavitation levels significantly differed between the two groups of varieties, lint yield did not (bottom of Table 2).

Summary

The number of cavitated sites per plant was recorded for 125 varieties over a period of two years from the cotton-growing states east of the Mississippi River. Overall, cavitation levels were higher in 2000 than in 1999. No association between levels of cavitation and lint yield or relative boll load was detected. Twenty-five varieties had cavitation levels significantly higher than 0, but lint yield was not significantly lower for these varieties compared to the lint yield of varieties with cavitation levels not statistically different from 0.

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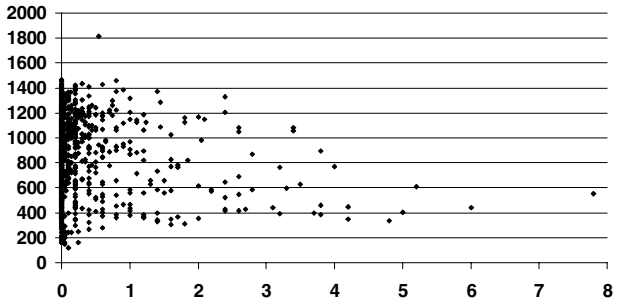

Figure 1. Relationship between lint yield and the number of cavitated sites (fruiting positions 1 and 2) per plant over years (1999 and 2000) and varieties (125 individual varieties). R^2=0.02, n=983.

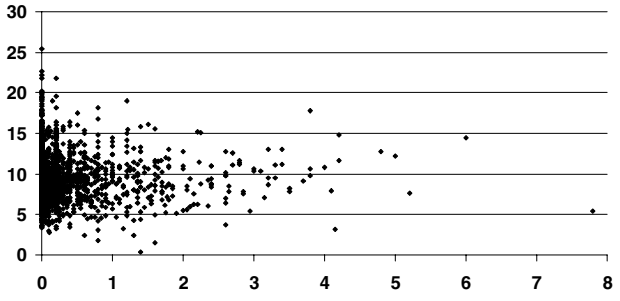

Figure 2. Relationship between the number of harvestable bolls per plant at fruiting positions 1 and 2, and the number of cavitated sites per plant at fruiting positions 1 and 2, over years (1999 and 2000) and varieties (125 individual varieties). R^2=0.004, n=1697.

Table 1. Least Square Means for number of cavitated sites per plant on fruiting positions 1 and 2, and lint yield for 1999 and 2000 over all varieties.

Year	Cavitation†			Lint Yield		
	n	# var.	LS mean #/plt @ FP 1&2	n	# var.	LS mean lbs./acre
1999	1208	104	0.33 b‡	515	87	955 a
2000	489	49	0.47 a	468	49	733 b

† n = number of observations; # var. = number of varieties; LS mean = least square mean; cavitation is expressed in numbers of cavitated sites per plant at fruiting positions 1 and 2.

‡ values followed by the same letter within a column do not differ significantly based on t tests.

Table 2. Least square means for number of cavitated sites per plant at fruiting positions 1 and 2, and lint yield for 25 varieties for which cavitation levels were significantly higher than zero (based on t test). Data represents means over years (1999 and 2000), and are in order of cavitation level (highest to lowest).

Variety	Cavitation†					Lint Yield			
	year	n	LS mean	Std. Err.	Pr>t	year	n	LS mean	Std. Err.
DPLX 99X02	00	6	2.73	0.26	***	00	6	824	123
DP565	00	6	2.20	0.26	***	00	6	707	123
DP5690R	99-00	42	1.30	0.10	***	99-00	18	717	71
ST KC311	99	3	1.08	0.36	**	n/a	n/a	n/a	n/a
NC35B	99-00	26	0.98	0.12	***	99-00	15	879	78
DP655BR	99-00	108	0.94	0.06	***	99-00	27	814	58
PSC355	99-00	11	0.91	0.19	***	99-00	10	863	91
DP90R	99-00	19	0.84	0.14	***	00	1	468	302
DPLX 99Q47B	00	15	0.81	0.16	***	00	12	1020	87
DP429R	99-00	3	0.80	0.36	*	00	2	356	214
DP90	99	24	0.78	0.13	***	99	7	966	114
DP90B	99	5	0.64	0.28	*	n/a	n/a	n/a	n/a
HCR9310	99	5	0.63	0.28	*	99	5	750	135
DP5415R	99-00	53	0.62	0.09	***	99-00	22	781	64
DP675	99-00	23	0.58	0.13	***	99-00	16	856	76
DP458BR	99-00	212	0.50	0.04	***	99-00	34	855	52
DP5690	99	10	0.44	0.20	*	99	5	820	135
Delta PEARL	99-00	14	0.39	0.17	*	99-00	12	888	87
SG821	99-00	18	0.39	0.15	**	99-00	13	821	84
DP409BR	99	12	0.39	0.18	*	99	6	970	123
FM989	99-00	31	0.35	0.11	**	99-00	14	811	81
NC33B	99-00	80	0.35	0.07	***	99-00	26	887	59
DP5415	99-00	22	0.34	0.13	*	99-00	8	737	107
ST474	99-00	36	0.28	0.10	**	99-00	20	733	68
ST 4892BR	99-00	38	0.24	0.10	*	99-00	35	944	51
All Sig. Var.‡	99-00	822	0.63a§	0.02	***	99-00	814	841 a	17
All NS Var.¶	99-00	875	0.12b	0.02	***	99-00	169	853 a	12

† year designation: 99 = 1999, 00 = 2000; n = number of observations; LS means = least square means; Std. Err. = standard error of the mean; Pr>t: * ≤0.05, ** ≤0.01, *** ≤0.001; cavitation values are expressed as number of cavitated sites per plant at fruiting positions 1 and 2; lint yield is expressed as lbs. lint per acre.

‡ All Sig. Var. = least square means of all varieties for which the t test indicated the number of cavitated sites per plant was significantly greater than zero. These values represent a compilation of the values of the 25 varieties that appear in the lines above this line.

¶ All NS Var. = least square means of all varieties for which the t test did not indicate the number of cavitated sites per plant was significantly greater than zero.

§ Values followed by the same letter within a column are not significantly different based on t tests.