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COMPARISON OF SIMULATED INSECT DEFOLIATION TO PREMATURE HARVEST-AID APPLICATION ON COTTON YIELD COMPONENTS

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Abstract

Field experiments were conducted at two Louisiana locations to evaluate the effect of simulated late-season insect defoliation and premature harvest-aid application on cotton lint yield and physical fiber properties. Defoliation timings were based on heat unit (HU) accumulation beyond the last effective boll population that contributes to yield (NAWF5). Lint yield, averaged across experiments, was 82% of the standard control (chemical defoliation at 80% open) when simulated insect defoliation occurred at the NAWF5 + 450 HU stage of development. Chemical defoliation at NAWF5 + 450 HU, + 550 HU, and + 650 HU development stages reduced lint yield 38, 37, and 15%, respectively, below that of the standard control. Simulated insect defoliation did not impact fiber properties, but chemical defoliation of plots ≤ NAWF5 + 550 HU significantly lowered fiber micronaire at one location in both years. Chemical defoliation did not influence fiber strength, length, elongation, or uniformity. These results suggest timing of insecticide termination strategies for late-season bottom defoliating insects occur done by NAWF5 + 550 HU, while chemical defoliation should not be initiated until plant development exceeds NAWF5 + 750 HU.

Introduction

Management of late-season defoliating insects in mid-south and southeastern cotton, *Gossypium hirsutum* L., producing states has changed dramatically with the introduction of Bollgard® cotton, the use of selective insecticides, and boll weevil, *Anthonomous grandis grandis (*Boheman), eradication programs. These technologies have dramatically reduced the number of broad spectrum insecticide applications per season.

Soybean looper, *Pseudoplusia includins* (Walker), and cabbage looper, *Trichoplusia ni* (Hübner), are generally considered secondary lepidopteran pests of cotton, however late-season infestation and defoliation prior to physiological maturity of the last harvestable boll population may negatively impact yield. Soybean and cabbage looper may develop into economically devastating levels late in cotton plant development. Soybean looper populations in Georgia are significantly higher in cotton - soybean [*Glycine max* (L.)] agroecosystems when compared to a soybean monoculture (Beach and Todd 1986). In Mississippi, populations of soybean looper and cabbage looper adults are highest from early – mid August, and generally decline in September (Jost and Pitre 2002). In Louisiana, soybean looper is found in cotton and soybean ecosystems and is characterized by dense larval populations in late August or September (Burleigh 1972). Weir and Boethel (1995) determined soybean looper to be the most serious defoliating pest of cotton and soybean in Louisiana.

Several studies have indicated that a first position white flower located five main stem nodes below the terminal (NAWF5) is the last boll likely to develop to maturity on the plant. Flowers set above this position contribute little to overall yield (Benson et al. 1999; Bourland et al. 1992; Jenkins et al. 1990). Those flowers that become harvestable bolls after a field average of four nodes above white flower contribute less than 2% to overall yield (Bernhardt et al. 1986; Bernhardt and Phillips 1986). Termination of late-season insect management strategies using the NAWF + accumulated heat unit (HU) method is not well-defined and may vary with insect pest species, variety, and the environment (Torrey et al. 1997). Managing for early crop maturity, which can help to avoid losses caused by late season insect injury, is important (Isely 1957). Multi-state evaluations of insecticide termination rules supported by the cotton modeling program COTMAN generally show that insecticide applications beyond NAWF5 + 350 HU are not economically feasible (Bryant et al. 1999; Cochran et al. 1998).

A range of boll maturities confer tolerance to cotton insect pests. Bagwell and Tugwell (1992) reported boll weevil damage to cotton bolls decreased dramatically at 350 HU after anthesis. Bollworm, *Helicoverpa* zea (Boddie), has been shown to significantly reduce yield of non-transgenic and transgenic cotton until bolls have accumulated >426 HU and >299 HU, respectively (Gore et al. 2000). Beet armyworm, *Spodoptera exigua* (Hübner), can penetrate the endocarp of bolls, for transgenic and nontransgenic cotton, until bolls accumulate >390 HU and >360 HU, respectively (Adamczyk et al. 1998). In the same study, fall armyworm, *Spodoptera frugiperda* (J.E. Smith), successfully penetrated >60% of nontransgenic bolls that had accumulated 852 HU, but <10% of transgenic bolls that had accumulated 864 HU (Adamczyk et al. 1998). Cotton bolls are generally safe significant yield losses due to tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois), (Russell 1999); brown stink bug, *Euschistus servus* (Say), (Willrich et al. 2004; Fromme 2000); and southern green stink bug, *Nezara viridula* (L.), (Greene et al. 2001) injury at 327 HU, 550 HU, and 559 HU beyond anthesis, respectively.

Several studies have reported the effect of removal of various plant parts on cotton yield and fiber quality. Jones et al (1996) found that cotton could compensate from early season square removal by shifting fruit production to upper fruiting branches on the main stem and at distal sites on all fruiting branches. Moreover, delayed photosynthetic decline has been associated with floral bud removal (Wells 2001; Holman and Oosterhuis 1999). These studies indicated that cotton has the ability to either delay photosynthetic decline in relation to cutout, or alter the source-sink relationship in response to the removal of fruiting structures. However, little data exists regarding plant response to late-season foliage removal. Foliage feeding can indirectly affect yield by reducing leaf area that produces photosynthate to mature bolls (Mascarenhas et al. 1999). Cotton plants can withstand ≤ 57% simulated defoliation before first square without a significant reduction in lint yield (Kerby et al. 1988). However, Russell et al. (1993) suggested that severe defoliation (>20%) during boll maturation could significantly impact yield by reducing the production of photosynthate necessary for maximum boll development. Torrey et al. (1997) reported significant yield loss associated with removal of all foliage from the bottom 66% of the cotton canopy when plant development was at NAWF ≤ 5 + 350 HU. The objective of this study was to determine the effects of simulated late-season defoliation on cotton lint yield and physical fiber quality compared to premature harvest aid application, and to establish guidelines for managing late-season bottom defoliating insects of cotton.

Materials and Methods

Site Location and Management Practices

Experiments were conducted at the Dean Lee Research Station in Alexandria, LA and the Macon Ridge Research Station near Winnsboro, LA during the 2003 and 2004 growing seasons. Varieties planted at Macon Ridge were “DP DeltaPearl” and “ST 5599 BR”; and at Dean Lee were “DP 451 BR” and “ST 4892 BR” in 2003 and 2004, respectively. Cultural practices and integrated pest management strategies recommended by Louisiana Cooperative Extension Service were used to optimize plant development and yield. The only experimental area to receive supplemental irrigation was at Macon Ridge in 2004. The experimental design was a randomized complete block with a factorial treatment arrangement and four replications at each location. The first factor was defoliation method and consisted of simulated insect (manual) or chemical. The second factor was defoliation timing. Nodes above white flower (NAWF) and daily heat unit (HU) accumulations were used to characterize the late-season reproductive stages of plant development. Daily HU accumulation was calculated as: HU = ([maximum daily temperature + minimum daily temperature]/2) – 60, using a base of 60°F (15.5°C) (Landivar and Benedict 1996). Defoliation timings consisted of NAWF5 + 450 HU, + 550 HU, + 650 HU, + 750 HU, and + 850HU. Plot size was three rows (centered on 38 or 40 inches) by 10 feet. All data were collected from the center row of each three row plot.

Simulated Insect and Chemical Defoliation Treatments

Simulated insect defoliation levels were based on previous research (Torrey et al. 1999) which established that ≥ 66% of leaf removal at NAWF5 + 350 HU significantly reduced seedcotton yield. Plant height was used to divide the plant into three equal vertical zones (bottom, middle, and top). The 66% defoliation level corresponded to removal of all leaves from the bottom and middle zones of each plant on all three rows of the plot.

Chemical defoliation treatments were applied with a CO_2 backpack sprayer calibrated to deliver a spray volume of 15 gpa at 32 psi and 3.2 mph through a one row boom equipped with ConeJet® nozzles. All three rows of each plot were treated with the tankmix combination of 0.05 lb ai/A thidiazuron (Dropp®) + 0.75 lb ai/A tribufos (DEF®) + 1.125 lb ai/A ethephon (Prep®). The standard chemical defoliation treatment at 80% open was also included.

Determination of Yield Components

Cotton plants were monitored biweekly until they reached the NAWF5 reproductive stage of development. At NAWF5, plastic “snap-on-tags” (A.M. Leonard, Inc., Piqua, OH) were placed on the fourth mainstem internode below the terminal. This marker was used to bisect the main stem and identify bolls set below NAWF5 and bolls above that point. Seedcotton yield was determined by harvesting the center row of each plot two weeks after a defoliation treatment was applied. All plots were harvested a second time two weeks after application of the standard chemical defoliation treatment. Each plot was harvested in sections (above or below the NAWF5 tag) to determine the contribution of each section to total yield. Seedcotton subsamples (≈ 200 grams) from each plot were ginned with a ten saw laboratory gin to determine lint: seed ratio and lint weight. Fiber properties were measured using the high volume instrumentation (HVI) method at the LSU AgCenter Fiber Laboratory, Department of Agronomy, Baton Rouge, LA (Sasser 1981).

Statistical Analysis

Seedcotton yields and fiber properties were analyzed using ANOVA (PROC MIXED, SAS Institute 1998) and Dunnett's *t*-tests comparing means of all treatments to the chemically defoliated standard (SAS Institute 1998).

Results

There was no year by location interaction for treatment effects on lint yield; therefore data are combined across locations. The contribution of seedcotton harvested above the NAWF5 tag to total yield was negligible (≤ 7.3%); therefore yield data are combined across sections. The simulated insect defoliation level of 66% leaf removal (all leaves from the bottom ⅔ of the plant) significantly reduced lint yield 18% at the NAWF5 + 450 HU timing compared to the chemically defoliated standard (Table 1). Chemical defoliation at the NAWF5 + 450 HU, + 550 HU, and + 650 HU developmental stages reduced yields by 38%, 36%, and 15%, respectively, compared to that of the standard chemical defoliation treatment. Fiber properties (elongation, fiber strength, micronaire, staple length, and uniformity) were not significantly affected by simulated insect defoliation treatments. Chemical defoliation before NAWF5 + 650 HU at Dean Lee in both years significantly reduced micronaire when compared to the chemically defoliated standard, but did not affect other fiber properties (Table 2). Snipes and Baskin (1994) also demonstrated that micronaire can be decreased with premature chemical defoliation. Based on these data, insect management of late-season bottom defoliators such as cabbage looper and soybean looper can be terminated at NAWF5 + 550 HU, which corresponds to 10% open bolls and seven nodes above cracked boll (NACB) (Figure 1). In addition, chemical defoliation can be initiated at 40% open bolls and 5.6 NACB (NAWF5 + 750 HU) without significant yield losses. However, maximum lint yield occurred by chemically defoliating at NAWF5 + 1050 HU, or 80.2% open bolls and 2.6 NACB.

Discussion

Although crop development rules for terminating late-season insect pest management is accepted in several southeastern cotton producing states, Louisiana insecticide termination decisions may not consistently follow the NAWF5 + 350 HU rule. Studies at the Macon Ridge research station in 1994 showed significantly higher seedcotton yields in plots that had termination intervals ≥ NAWF5 + 400 HU. Although no statistical differences occurred, seedcotton yields generally increased when termination treatments were delayed to NAWF5 + 350 to 400 HU in studies conducted from 1993 to 1995 (Torrey et al. 1997). Torrey et al. (1998) reported significantly lower yields in plots receiving ≥ 66% simulated insect defoliation (removal of all lower leaves from ≥ bottom ⅔ of each plant) at NAWF5 + 350 HU. These findings were similar to those reported by Burris et al. (1997) and are consistent with the findings in our studies.

Results from chemical defoliation treatments confirm current defoliation timing recommendations of 65 to 90% open bolls (Brecke et al. 2001) and NACB ≤ 4 (Kerby et al. 1992). Defoliation timing based on HU accumulation after cutout (NAWF5) is a published method based on cotton management with the COTMAN decision aid tool (Tugwell et al. 1998). COTMAN recommends defoliation timing of NAWF5 + 850 HU; however, Benson et al. (2000) reported one situation where timing according to this method resulted in defoliation one week prior to the grower standard and significantly reduced yield. Timing defoliation using the COTMAN system may not be suited for locations outside Arkansas where longer growing seasons and different cultural practices may require more heat unit accumulation before harvest-aid application in order to maximize yield.

There is a need for insect specific insecticide termination rules. Although bolls may be safe to most piercing and sucking insects at 350 HU beyond cutout, limited information is available on the effect of premature insect defoliation. Additional research should be conducted to evaluate the late-season injury potential for other sporadic pests of cotton, and to better define late season management strategies for individual cotton pests.

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Table 1. Effect of insect-simulated and chemical defoliation on lint yield, averaged across locations and years.

	Lint Yield (lbs/A) [a]	
Defoliation Timing	Insect-simulated Defoliation	Chemical Defoliation
NAWF5 + 450 HU	782.7*[b]	588.7**
NAWF5 + 550 HU	828.0	607.4**
NAWF5 + 650 HU	827.1	812.9*
NAWF5 + 750 HU	870.3	877.8
NAWF5 + 850 HU	945.0	878.8
Standard (NAWF5 + 1050 HU)	956.2	

[a]Lint yield averaged across both locations and years.
[b]Lint yield significantly differs from chemically defoliated standard, Dunnett's t-test, P=0.05* and P=0.01**.

Table 2. Effect of chemical defoliation on micronaire by location and averaged across years.

Chemical Defoliation	Micronaire[a]	
Timing	Dean Lee[b]	Macon Ridge
NAWF5 + 450 HU	3.9*	4.2
NAWF5 + 550 HU	4.1*	4.0
NAWF5 + 650 HU	4.3	4.2
NAWF5 + 750 HU	4.7	4.1
NAWF5 + 850 HU	4.7	4.2
Standard (NAWF5 + 1050 HU)	4.7	4.6

[a]Micronaire averaged across years.
[b]Within location, micronaire significantly differs from chemically defoliated standard, Dunnett's t-test, P=0.05*.

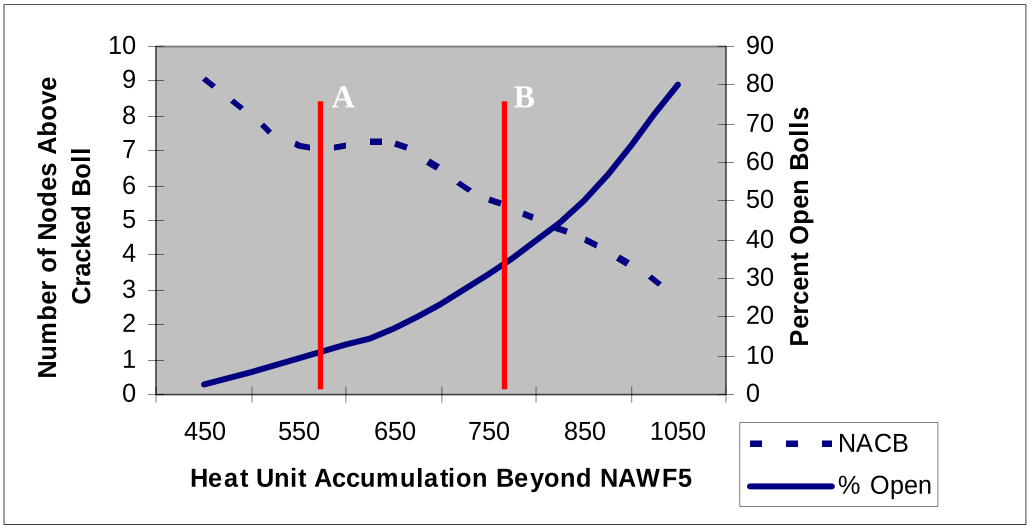

Figure 1. Insecticide termination and chemical defoliation timing based on nodes above cracked boll (NACB) and percent open.

[A] Defoliating insect management may be terminated without negatively impacting lint yield; 7 NACB, 10% open bolls.

[B] Chemical defoliation may be initiated without significant yield reductions; 5.6 NACB, 40% open bolls.