EFFECT OF INSECTICIDE TERMINATION AT 250, 350, AND 450 HEAT UNITS ON CARBON PARTITIONING FROM UPPER-CANOPY LEAVES TO THE DEVELOPING BOLL LOAD

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RESEARCH PROBLEM

COTMAN, a crop monitoring program for cotton, uses the concept of 350 heat units after anthesis of the last effective flower population at NAWF=5 for termination of insecticide applications. Research and field observations have indicated that terminating insecticides at 350 heat units after physiological cutout (NAWF=5) results in a higher yield than when terminating earlier or later, although evidence is lacking. Furthermore, it is hypothesized that insect damage to upper-canopy (above NAWF=5) squares results in improved partitioning of carbon to lower developing bolls (Kim and Oosterhuis, 1998). The objective of this 3-year study was to investigate the effect of different times of upper-canopy square removal after NAWF=5 on subsequent first-position boll weights at the NAWF=5 main-stem node and seedcotton yields. The movement of carbohydrates from upper-canopy leaves with squares removed to developing bolls lower in the plant was followed using a ^{14}C labeling technique.

BACKGROUND INFORMATION

Since cotton (*Gossypium hirsutum* L.) is a perennial with an indeterminate growth habit, it will continue to produce fruit as long as the season persists. However, these late-season bolls are often small, low in fiber quality, costly to protect with increasing insect pressure, and provide a food source for insects. In most crop-monitoring programs such as COTMAN (Danforth and O'Leary, 1998), a major aim is to identify the last effective boll population and project a date for insecticide termination (Oosterhuis *et al.*, 1996). Bagwell (1995) showed that bollworm [*Helicoverpa zea* (Boddie)] and boll weevil (*Anthonomus grandis* Boehman) damage to cotton bolls decreases dramatically at about 350 heat units after anthesis. This finding was supported by Kim (1998), who showed increased resistance of the boll wall to penetration at NAWF=5 plus about 350 heat units, which was associated with lignification and tannin concentration of the boll wall endocarp. This phenomenon is made use of in COTMAN for decisions about late-season termination of insecticide applications at 350 heat units after NAWF=5.

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RESEARCH DESCRIPTION

Five field studies and a ^{14}C labeling growth chamber study were conducted to test the hypothesis that removing upper-canopy square above NAWF=5 will increase cotton yields from improved carbon partitioning to lower developing bolls. Field experiments were conducted in Fayetteville in 1996 and at Rohwer in Southeast Arkansas, and Clarkedale in Northeast Arkansas in 1998 and 1999. Cotton cultivar Deltapine 20 was hand-planted in early May 1996, and cultivar Suregrow 125 was mechanically planted in early May for the 1998 and 1999 seasons. Rows were spaced 0.9 m apart and plots were 4 rows wide and 15 m long with a plant density of 10 plants per meter. The field studies were furrow-irrigated as needed, and all plots received fertilizer and pesticide applications following cotton production recommendations for Arkansas (Bonner, 1994). The field experiments were arranged in a randomized complete-block design, with four treatments and three replications in 1996 and four replications in 1998 and 1999. Treatments consisted of a control with no fruit removal and a simulated upper-canopy fruit damage (hand removal) of all upper-canopy squares above NAWF=5 at approximately 250, 350, and 450 heat units after the NAWF=5 stage. Taggings of 20-30 flowers per plot were made at the first fruiting position of the main-stem node at NAWF=5, and treatments were initiated as the appropriate heat units were accumulated. At harvest, 10 mature tagged bolls were hand-harvested to determine first position boll weight of NAWF=5 bolls, and seedcotton yields were determined from mechanical harvest.

In 1998, a growth chamber experiment was conducted in Fayetteville to study the effect of square removal on ^{14}C movement from upper-canopy leaves with squares removed to developing bolls lower in the plant. The ^{14}C technique involved enclosing the selected upper-canopy main-stem leaf in a plastic bag containing a septum and small vial of lactic acid. The source of ^{14}C ($NaH^{14}CO_3$) was injected into the lactic acid via the septum in the plastic bag resulting in fixed $^{14}CO_2$ by the leaf. After 15 min, the leaf and bolls were removed, dried, combusted and the ^{14}C fixation determined in a liquid scintillation counter.

RESULTS

Field Studies

Results from Fayetteville in 1996 indicated that removing upper-canopy squares at (NAWF=5+350 H.U.) resulted in the highest numerical first-position boll weights at NAWF=5. These boll weights were not significantly different from the control, where no fruit above NAWF=5 was removed, but were greater ($P \leq 0.05$) than the weights of bolls where squares were removed at 250 or 450 heat units after NAWF=5 (Table 1). Results from the 1998 and 1999 field studies indicated no treatment differences with respect to increasing first-position boll weight at the NAWF=5 main-stem node; however, boll weight was numerically higher for the (NAWF=5+350 H.U.) treatment at both locations and years with the exception of Clarkedale in 1999 (Table 1). Overall, first-position boll weight at NAWF=5 was generally increased when upper-canopy fruit was removed at NAWF=5+350 H.U. These results support the COTMAN concept of

insecticide termination at 350 heat units after NAWF=5.

Yield results in 1998 and 1999 indicated no significant differences between treatments at either location. In 1998, all square removal treatments resulted in numerically higher yields than the control (Table 2). However, in 1999 the control treatment yielded the highest, with the NAWF=5 + 350 H.U. treatment representing the lowest yields (Table 2). Favorable late-season growing conditions may explain why the control treatment resulted in the highest yields. These favorable conditions allowed the upper-canopy squares not removed by the control to mature and contribute to yield. For the most part, it appears that removing late-season cotton fruit may aid in increasing boll weight and yield; however, at times yield was reduced, necessitating additional field evaluations to ensure the adequacy of fruit removal.

^{14}C Study

At 351 heat units after NAWF=5, there was a greater amount of ^{14}C translocated to the upper developing boll from the ^{14}C-labeled main-stem leaf than in the 240 or 467 heat unit treatments (Table 3). These results support those of the field study in 1996 and 1998, and the hypothesis that available carbohydrates from upper-canopy source leaves were translocated to alternative sinks such as bolls developing below the area of square removal. Boll weight at the NAWF=5 main-stem node was again highest in the 310 heat unit treatment (Table 3).

PRACTICAL APPLICATION

Results from the 1996 and 1998 seasons indicated that the weight of lower developing bolls could be enhanced from the removal of upper-canopy squares at 350 heat units after the NAWF=5 stage. Yield results from Clarkedale in 1998 also supported the hypothesis that removing late-season squares could enhance cotton yields. Improvements in boll weight and seedcotton yield are related to translocation of carbohydrates from upper-canopy leaves with squares removed to alternative sinks such as the boll developing below the area of square removal. The 1996 and 1998 data supports the COTMAN concept of insecticide termination at 350 heat units after NAWF=5, however the 1999 data suggests that removing this fruit did not enhance lower boll weights or cotton yield.

LITERATURE CITED

Bagwell, R.D. 1995. Monitoring the cotton plant for insecticide effects and late-season insecticide termination. Ph.D. Dissertation, University of Arkansas, Fayetteville, Arkansas.

Bonner, C.M. 1994. Cotton Production Recommendations. University of Arkansas Cooperative Extension Service. AG310-03-92.

Danforth, D.M. and P. O'Leary (eds.). 1998. COTMAN expert system. Version 5.0. p. 198. University of Arkansas Agricultural Experiment Station, Fayetteville. Published by Cotton Incorporated, Raleigh, North Carolina.

Kim, M.J. 1998. Changes in the cotton fruit wall in relation to COTMAN insecticide termination rules. M.S. Thesis, University of Arkansas, Fayetteville, Arkansas.

Kim, M.J. and D.M. Oosterhuis 1998. Effect of upper-canopy square removal before and after NAWF=5 plus 350 heat units on carbon partitioning from upper-canopy leaves to bolls lower in the canopy. *In*: D.M. Oosterhuis (ed.). Proc. 1998 Cotton Research Meeting and Summaries of Research in Progress. University of Arkansas Agricultural Experiment Station Special Report 188:174-176.

Oosterhuis, D.M., F.M. Bourland, N.P. Tugwell, and M.J. Cochran. 1996. Terminology and concepts related to COTMAN crop monitoring system. University of Arkansas Agricultural Experiment Station Special Report 174.

Table 1. Mean boll weight of first position bolls at NAWF=5 for the control treatment and the square removal treatments at approximately 250, 350, and 450 heat units past NAWF=5.

Treatment	Average Boll Weight		
	1996	1998	1999
	g		
Control	4.39 ab[z]	3.52 a[y]/3.75 a[x]	3.83 a[y]/5.29 a[x]
NAWF=5+250 H.U.	3.95bc[w]	3.82 a/3.62 a	4.06 a/5.07 a
NAWF=5+350 H.U.	5.25 a	4.03 a/4.34 a	4.06 a/4.99 a
NAWF=5+450 H.U.	2.99 c	3.76 a/3.98 a	3.84 a/5.41 a

[z] Represent boll weights from the Fayetteville location.
[y] Represent boll weights from the Rohwer location.
[x] Represent boll weights from the Clarkedale location.
[w] Treatment means within a column followed by the same letter are not significantly different at $P \leq 0.05$.

Table 2. Means for total seedcotton yield, after square removal above NAWF=5, for the 250, 350, and 450 heat unit and control treatments. Clarkedale, Arkansas 1998 and 1999.

Treatment	Seedcotton Yields	
	1998	1999
	kg/ha	
Control	2485 a[z]	3112 a
NAWF=5+250 H.U.[y]	2880 a	3072 a
NAWF=5+350 H.U.	2656 a	2912 a
NAWF=5+450 H.U.	2844 a	3000 a

[z] Treatment means within a column followed by the same letter are not significantly different at $P \leq 0.05$.
[y] Represent approximate heat unit values at which squares were removed.

Table 3. Effect of upper-canopy square removal on boll weight and translocation of ^{14}C from the labeled upper-canopy main-stem leaf to the boll at the first fruiting position at NAWF=5. Growth Chamber 1998, Fayetteville, Arkansas.

Treatment	Boll Dry Weight	14C Translocated[z]
	g	%
240 Heat Units[y]	3.3	1.8
351 Heat Units	3.8	75.4
467 Heat Units	2.8	44.4
LSD (0.05)	0.9	63.2

[z] Calculated from leaf percent of leaf 14C that moved to the boll.
[y] Squares removed by hand at 240 heat units after NAWF=5.