EFFECT OF LATE-SEASON FRUIT REMOVAL ON COTTON YIELD AND QUALITY: IMPLICATIONS IN INSECTICIDE TERMINATION

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Abstract

The crop monitoring program COTMAN uses the concept of 350 heat units after anthesis of the last effective flower population at NAWF=5 for termination of insecticide applications. It has been reported that terminating insecticides at 350 heat units after NAWF=5 results in a higher yield than when terminating at either before or after 350 heat units, although the evidence for this is lacking. It is hypothesized that insect damage to upper canopy (above NAWF=5) squares results in improved partitioning of carbon to lower developing bolls. Three field studies and a ^{14}C labeling study were conducted to evaluate this hypothesis. Treatments consisted of a control with no fruit removal, and a simulated fruit damage (hand removal) of all upper canopy squares at approximately 250, 350 and 450 heat units after NAWF=5. This was related to differential movement of ^{14}C, particularly in the 350 heat unit treatment, from upper canopy leaves with squares removed to bolls developing below the area of square removal. The differential movement of ^{14}C supports the field study and our hypothesis that available carbohydrates from the upper canopy source leaves were translocated to alternative sinks such as bolls developing in the upper part of the canopy. The data supports the COTMAN concept of insecticide termination at 350 heat units after NAWF.

Introduction

Cotton is a perennial with an indeterminate growth habit and will continue to produce fruit as long as the season persists. However, these late-formed bolls are often small in size, lower in fiber quality, costly to protect, and provide a food source for late-season insects. In most crop monitoring programs, such as COTMAN (Cochran et al., 1998) a major aim is to identify the last effective boll population and project a date for insecticide termination. It has been shown that bollworm and boll weevil damage to cotton bolls decreases dramatically at about 350 heat unit accumulation after anthesis (Bagwell, 1995). 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, associated with increased 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 anthesis of the last effective flower population at NAWF=5 (Cochran et al., 1998).

It has been reported that terminating insecticides at 350 heat units after physiological cutout, NAWF=5, (Oosterhuis et al., 1996) results in a higher yield than when terminating either before or after 350 heat units, although the evidence for this is lacking. 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 study was to investigate the effect of different times of upper-canopy square removal after physiological cutout (NAWF=5) on subsequent boll weights at or below NAWF=5. The movement of carbohydrates from upper-canopy leaves with squares removed to developing bolls lower in the plant was followed using a ^{14}carbon labeling technique.

Materials and Methods

A field experiment was conducted in Fayetteville, Arkansas in 1996, and at Rohwer in southeast Arkansas and Clarkedale in northeast Arkansas in 1998. Cotton (*Gossypium hirsutum* L.) cv. Deltapine 20 was hand-planted in early May each year. Rows were spaced 0.9 m apart in a north-south direction and plots were 4 rows wide and 5 m long with 10 plants per meter. All plots received fertilizer and pesticide applications following the cotton production recommendations for Arkansas. The field studies were furrow irrigated as needed. The experiments were arranged in a randomized block design with four treatments and three replications.

Treatments consisted of a control with no fruit removal, and a simulated upper canopy fruit damage (hand removal) of all upper canopy squares or young bolls at approximately 250, 350 and 450 heat units after NAWF=5. Taggings of 50 white flowers per plot were made at the first fruiting position of the main-stem node at NAWF=5. At final harvest, the tagged bolls were harvested and the boll immediately below NAWF=5. Regrowth and final yield were also recorded.

A growth chamber experiment was conducted in Fayetteville in 1998 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 a septum in the plastic bag and the resulting $^{14}CO_2$ fixed by the leaf. After 15 minutes the leaf was removed, dried, combusted, and the ^{14}C fixation determined in a liquid scintillation counter.

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Results and Discussion

The Field Studies

In Fayetteville in 1996, square removal significantly increased the lint weight of the boll at NAWF=5, but not the total boll weight (Fig. 1). In 1998 at Rohwer, boll weight in the NAWF=5 plus 350 heat units square removal treatment was significantly (P=0.05) higher than the control (Fig. 2A). Furthermore, there was a trend for the 350 HU treatment to have a higher boll weight than the 250 or 450 HU treatments, both of which were higher than the control (Fig. 2A). The pattern for boll weight for Clarkedale in 1998 was similar with the NAWF=5 plus 350 HU treatment having the highest yields, although the other trends were not clear (Fig. 2B). In 1996 in Fayetteville, the weight of the boll immediately below the tagged node at NAWF=5 also showed a trend for a weight increase associated with upper canopy square removal, particularly at NAWF=5 plus 350 heat units (Kim, 1998). The pattern between heat unit treatments at the node immediately below NAWF=5 was unclear.

The possible explanation is that when squares were removed, the immediate sink was removed. Therefore, the available carbohydrates from the upper canopy source leaves were translocated to alternative sinks such as bolls developing below the area of square removal. This was confirmed in the ^{14}C labeling study.

^{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 1). These results support those of the field study and our hypothesis that available carbohydrates from the upper canopy source leaves were translocated to alternative sinks such as bolls developing below the area of square removal. Boll weight at the node at NAWF=5 was again highest in the 310 HU treatment (Table 1).

Conclusions

Results indicate possible yield benefits of square removal (by insects) at about 350 heat units after physiological cutout (NAWF=5). This was related to differential movement of carbohydrates from upper canopy leaves with squares removed to developing bolls below the area of square removal. The data supports the COTMAN concept of insecticide termination at 350 heat units after NAWF=5.

References

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

Cochran, M.J., Tugwell, N.P., Bourland, F.M., Oosterhuis, D.M., and Danforth, D.M. 1998. COTMAN expert system. Version 5.0. University Arkansas, Agric. Exp. Sta., Fayetteville. Published Cotton Incorporated, Raleigh, NC. Pp 198.

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

Kim,M. and Oosterhuis, D.M. 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. Agric. Exp. Sta., Univ. of Arkansas. Special Report 188:174-176.

Oosterhuis, D.M., Bourland, F.M., Tugwell, N.P., and Cochran, M.J. 1996. Terminology and concepts related to COTMAN crop monitoring system. Agric. Exp. Sta., Univ. of Arkansas. Special Report. 174.

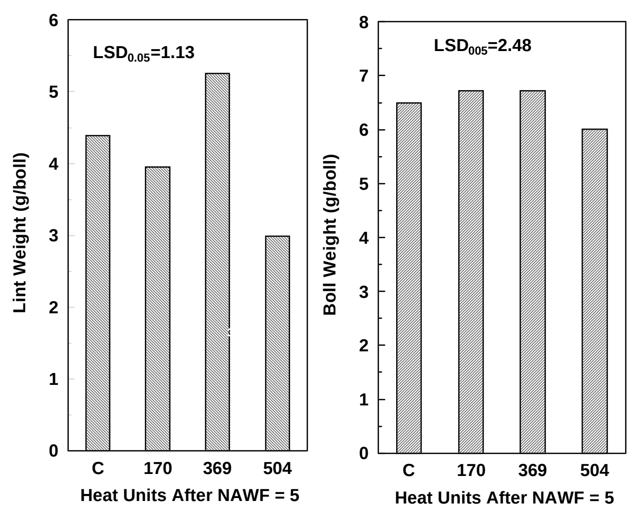

Figure 1. Means of boll lint weight and total boll weight (at NAWF=5) after square removal above NAWF=5 at 170 heat units, 369 heat units and 504 heat units post anthesis. Fayetteville, 1996. (From Kim, 1998).

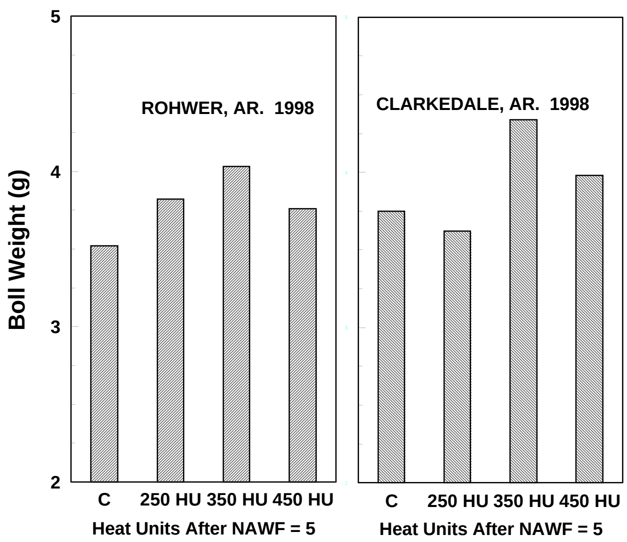

Figure 2. Means of boll dry matter (upper canopy at NAWF=5) after square removal above NAWF=5 at 250, 350 and 450 heat units after NAWF=5 compared to the control (C) which had no square removal. Rohwer and Clarkedale, 1998.

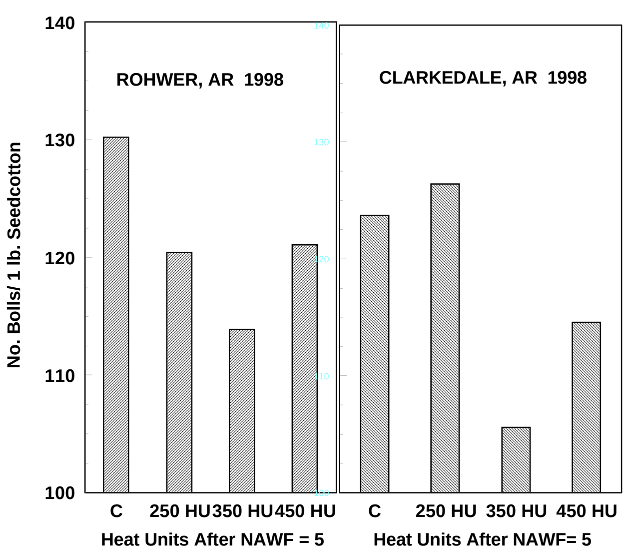

Figure 3. The number of bolls required to make a pound of seed cotton when squares were removed at 250, 350 and 450 heat units after NAWF=5. Rohwer and Clarkedale, 1998.

Table 1. 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. (From Kim, 1998)

Treatment	Boll Dry Weight	dpm	^{14}C translocated[1] (%)
240 HU[2]	3.3	11.4	1.8
351 HU	3.8	10.1	75.4
467 HU	2.8	5.5	44.4
$LSD_{(0.05)}$	0.91	8.40	63.20

[1]Calculated from leaf percent of leaf ^{14}C that moved to the boll.
[2]Squares removed by hand at 247 heat units at NAWF=5.