A MULTI-STATE VALIDATION OF INSECTICIDE TERMINATION RULES BASED UPON THE *COTMAN* PLANT MONITORING SYSTEM: AN OVERVIEW

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Abstract

Cotton Incorporated initiated a multi-state project in 1995 to validate the insecticide termination rules of the COTMAN expert computer program. This paper is an overview of that cooperative project.

Introduction

Knowing when to terminate insecticide treatments is one of the most perplexing decisions a cotton grower faces in managing a cotton crop. High control costs and possible resistance management problems must be balanced with the desire to protect any bolls that might contribute to lint yield. The key to this dilemma is the identification of the last effective boll population and the date when that cohort of bolls have reached physiological maturity and are no longer susceptible to boll weevil and bollworm damage. Decision rules developed in Arkansas suggest that the last effective boll population corresponds to the cohort associated with a Nodes Above White Flower (NAWF) equal to five and that after these bolls have accumulated 350 heat units they are mature enough to sustain a very low probability of insect damage. Thereby, no further insecticide treatments are needed. An expert system, COTMAN, has been developed to facilitate the implementation of these decision rules. This paper gives an overview of a Cotton Incorporated project initiated in 1995 to validate the COTMAN insecticide termination rules at seven locations.

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COTMAN, a Computer-aided Expert System for Cotton Management

The COTMAN system is under development at the University of Arkansas by a multi-disciplinary team of scientists, Drs. Fred Bourland, Phil Tugwell, Mark Cochran and Derrick Oosterhuis. The foundation of the system is based on three components. The first of these is plant monitoring which allows the user to follow the development of the crop (Figure 1). The second is a Target Development Curve which provides a benchmark against which 'earliness' of the crop can be assessed throughout the entire season (Figure 2). The Target Development Curve is defined in terms of nodes of fruiting branches having no flowers in the first position. It has the following characteristics: (1) First square at 35 days after planting; (2) a nodal development rate of one node per 2.77 days; (3) 9.25 nodes above first square by 60 days after planting; and (4) nodes above white flower (NAWF) equal to five at 80 days after planting. A field having these characteristics is said to have an ideal or Type I Growth Pattern. The final component of the COTMAN system is the identification of the last effective boll population. This is the cohort of bolls which will significantly contribute to lint yield and quality.

In COTMAN two sets of decision rules have been established for late-season practices by integrating crop monitoring and weather information. Crop-oriented rules are suitable for the Type I Growth Pattern where plant growth progresses without undue stress in early season and then declines steadily to cutout (Oosterhuis *et al*. 1994; Zhang *et al*. 1993). These rules are largely based upon the growth status of a crop. The key rule is that NAWF = 5 signals cutout. Therefore NAWF = 5 defines the flowering date of the last effective boll population (Bourland *et al*. 1992; Oosterhuis *et al*. 1992). Decision rules for termination of insecticide applications and for timing defoliation are based upon the number of heat units (HU) needed to develop this last effective boll population to specific degrees of maturation. Proper timing of defoliation is when 800 to 900 HU have been accumulated after a field attains NAWF = 5 (Zhang *et al*. 1993; Bourland *et al*. 1994). Results from caged bollworm and boll weevil studies indicated that insecticide applications could terminate when 350-450 HU have been accumulated after cutout (Bagwell & Tugwell 1992) (Figure 3). Bolls reaching this stage of maturity are no longer vulnerable or attractive to the bollworm and boll weevil.

In a Type II Growth Pattern, the crop has been stressed in early season, or is otherwise delayed and exhibits late cutout and maturity (Figure 2). Once a Type II crop occurs, management decisions rely more on historical and current weather information than on plant monitoring. The weather-oriented decision rules reflect a compromise between maturing top bolls and reducing risk associated with poor weather in late season. The latest effective cutout date is defined as the latest date from which accumulation of 850 HU required for boll maturation could be obtained in a certain percentage of historical years within a specific geographical region. For Type II growth patterns, the latest effective cutout date is the flower date for the last effective boll population.

Multi-State Validation of COTMAN Insecticide Termination Rules

Hypothesis. The hypothesis being tested in the Cotton Incorporated project is: Insecticide applications for protection of bolls can be terminated when bolls have accumulated 350-450 HU following cutout at NAWF = 5 with no negative impact on the quantity and quality of lint yields.

Objectives. Objectives of the validation experiments are:

1. Validate the use of plant monitoring techniques to guide insecticide termination in small plot experiments.

2. Implement standardized procedures for terminating insecticide applications in large on-farm plots and compare performance with current farm practices.

3. Evaluate the economic impact of eliminating unnecessary late season insecticide applications when the proposed standardized decision rules are implemented

Standardized Procedures. A set of standardized procedures is_being followed at each of the multiple locations. In the small plot experiments the following treatments are replicated 4 to 6 times in a randomized complete block design.

1. Insecticide applications terminated at NAWF = 5
2. Insecticide applications terminated at NAWF = 5 + 200 HU
3. Insecticide applications terminated at NAWF = 5 + 350 HU
4. Insecticide applications terminated at NAWF = 5 + 500 HU
5. Insecticide applications terminated at NAWF = 5 + 650 HU

Parameters recorded in the small plot experiments include but are not limited to (1) insect infestation and damage, (2) all crop management data, (3) daily maximum and minimum temperatures, (4) NAWF data, (5) general observations on insect damage following insecticide termination, (6) yield and (7) fiber quality.

During the early part of the season several grower fields are monitored in order to locate sites with suitable conditions for large on-farm experiments. Sufficient late season infestations of boll weevil and bollworm are critical to adequately test the system. Strips of 7 to 10 acres each are set aside in the selected fields for these two treatments.

1. .Insecticide applications terminated at NAWF = 5 + 350-450 HU
2. Insecticide applications terminated at NAWF=5 + > 500 HU representing the grower's normal practices

Ideally, each treatment is replicated 3 times. Parameters listed for the small plots are compared across the strip treatments and with averages for adjoining fields managed under the grower's current pest control practices. In addition to the core program for both the small plots and in-field trials, cooperators add treatments and monitor parameters that fit the environmental conditions and farming practices at their respective location.

Cooperators. Researchers performing the field portions of the project are:

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University of Arkansas
Fayetteville, AR

Louisiana
Dr. Roger Leonard
Research Entomologist
Louisiana State University
Northeast
Winnsboro, LA

Dr. Ralph Bagwell
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Mississippi State University
Mississippi State, MS

Mississippi Delta
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Economic Analsis. Data from the field experiments are submitted for economic analysis to:

Dr. Mark Cochran
Research Economist
Dept. of Agricultural Economics & Rural Sociology
University of Arkansas
Fayetteville, AR

These analyses are performed to rank alternative treatments on the basis of expected net returns and risk efficiency. Conventional enterprise budgeting with standardized prices is used to calculate the net returns. Where appropriate, response surfaces are econometrically estimated to assist in comparisons of pesticide savings and yield losses as termination dates are altered. "Break-even" termination dates are estimated. For treatments whose mean net returns and/or variances are statistically different, Generalized Stochastic Dominance is employed to determine which treatments are risk efficient. Risk efficiency implies an optimal trade-off between average returns and the probability of a significantly low return. Performing the economic analysis is:

In addition to the performing the economic analysis, Dr. Cochran serves as the coordinator and leader for the project. Also, Ms. Diana Danforth (Research Associate, Dept. of Agricultural Economics & Rural Sociology, University of Arkansas) acts as an intermediary with the Systems Development Team for the COTMAN program.

Results

Preliminary results for 1995 from the multi-state validation of the insecticide termination rules of the COTMAN expert system are given in the paper A Multi-State Validation of Insecticide Termination Rules Based upon the COTMAN Plant Monitoring System: Preliminary Results" presented by Dr. Mark Cochran.

Future Plans

In 1996, plans are to follow the same standard procedures as outline above. In addition, adverse events in the 1995 highlighted the need to test the COTMAN insecticide termination rules under a wider range of conditions. Therefore, experiments are being designed that cover the following conditions:

1. Type II Crop Growth Patterns
2. fields of *Bacillus thuringensis* transgenic cotton
3. infestations of late season defoliating pests
4. infestations of high numbers of late season boll-feeding pests

Also, in 1996 the working group will expand to include a greater contingency of Cooperative Extension Service representatives and literature suitable for the various end-user groups will be developed. In future years additional sites will be added to the validation process.

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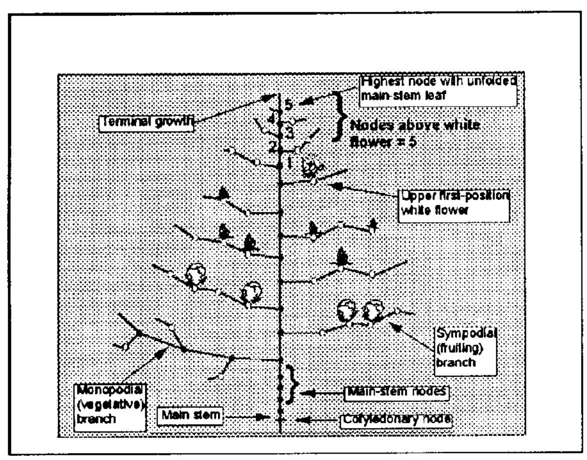

Figure 1. Plant growth monitoring

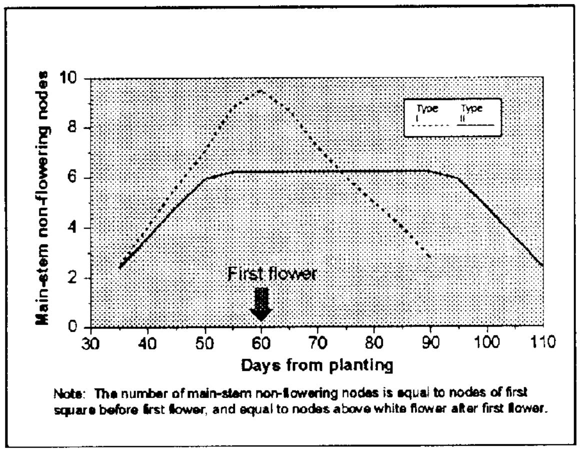

Figure 2. Growth Patterns of Cotton Plants

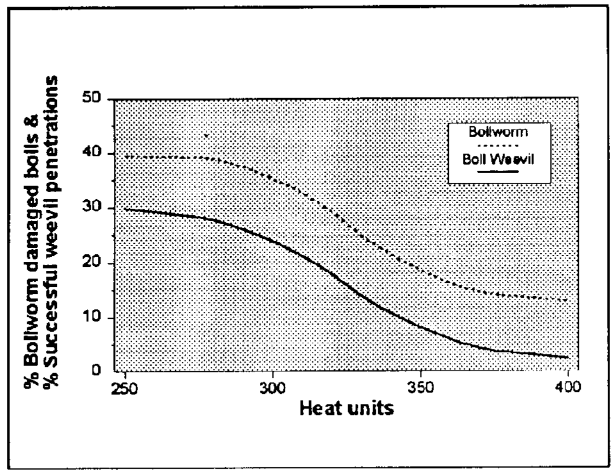

Figure 3. Cotton boll tolerance to boll weevils and third instar cotton bollworms