COTONS-IMS: AN INSECT AND PLANT DAMAGE MANAGEMENT SYSTEM FOR COTTON

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Introduction

Pest control is one of the main production costs in cotton production. Its importance varies from 10 to 50 percent. Despite this importance few tools has been developed to help farmer to make decision. Insect management has remained a difficult task for computer-assisted decision making. Primary constraints include difficulties in integrating plant-insect systems and the determination of the role of multiple species acting simultaneously, as well as the timely collection of field data and its input into the computer system. Further, in the US cotton-growing belt, there are more than twenty other pest species associated with cotton, which can be considered key pests on a yearly basis.

For example the management of the bollworm/budworm complex and of the boll weevil is key to the production of cotton in the United States. In this country, the bollworm/budworm complex along with the boll weevil are responsible for millions of tons of insecticidal products applied every year. In addition to attacking cotton, many key pests also attack corn, tomatoes, soybeans, grain sorghum, alfalfa, and other crops. *Heliothis* spp. have a range of more than 200 plant hosts of known economic importance. Management strategies that optimize efficient control and minimize chemical sprays while maintaining productivity are a top insect management priority.

Our research has taken a two-pronged approach to the assessment of the damage of pest species to the cotton crop. The first is a simulation-based approach discussed elsewhere and the present damage-based approach.

The COTONS-IMS System

COTONS-IMS is based on the mechanistic COTONS model. This model is a physiologically detailed simulation model of the growth and the development of the cotton plant. It is based on the GOSSYM model and it includes a plant model and a soil model. Weather information, some cultural practices and genetic characteristics drive the plant model. Plant development is limited by water and nitrogen supply and also by soil water potential status. When the plant grows its shade limits soil water evaporation, but at the same time the plant uptakes water and nitrogen. From GOSSYM, the plant sub-model of COTONS includes two important concepts: "materials balance" and the use of different stresses (N, H2O, C) to regulate plant growth. The model runs on a daily basis.

Each day, the model first calculates carbohydrate supply based on external factors (light, temperature, water supply, etc), canopy structure and plant water status. For example, plant height, plant width, row spacing and the Leaf Area Index are used to estimate the proportion of light going through the canopy, and intercepted by the canopy. The size of the canopy and its age also affect the plant photosynthesis. COTONS sub-model of carbohydrate production allows the simulation of light competition for plants growing in parallel. Second, the system calculates the carbohydrate demand for Growth, Respiration and plant Maintenance based again on external factors and plant status. The model estimates potential growth for the different parts of the plant based on the weight and/or area of each organ, its age, the temperature, the plant water status and the use of growth regulators. The sum of the organ potential growths corresponds to the carbohydrate potential plant demand. The model compares this plant demand with the carbohydrate supply and the demand/supply ratio [0, 1],'representing carbon stress', is then used for adjustment of growth potentials by plant organ type. Third, the system partitions the carbohydrate supply to the different organs based on their demand and priority levels with fruit having the highest priority and storage the lowest. In this modeling process it is assumed that there are no other limiting factors than those link to weather and soil conditions. For example pest protection is assumed to be maximal and there are no insect damage.

The Insect and Plant Damage Management System (IMS) overcome the above assumption and it simulates the plant's response to insect and plant damage using the COTONS model. Specifically, the dynamic responses of the cotton crop to attacks by direct pests (e.g., boll weevil, bollworm, cotton fleahopper) and indirect pests (aphids, whiteflies, armyworms, various leaf feeders) are simulated. In addition, response to leaf damage, such as produced by hail, is also supported. The power behind this software is that it enables the user of COTONS to 'correct' the simulation of the plant to account for external damage. The model responds by simulating the effect of damage depending on the physiological status of the plant. The decisions of a farmer as to whether or not to apply a control decision are supported by allowing him to run simulations with and without damage.
Damages are stored in a file with the following basic format:

- Observation date

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- Type of organ
- Growth Stage
- Percent of Damage

These information are typed via a very simple interface (see figure 1 and 2). By concentrating on the plant response aspect of damage, COTONS-IMS avoids emphasizing models that 'harvest insects' (i.e., emphasize insect dynamics as opposed to damage/response insect/host interactions). COTONS-IMS keeps the final production output as the goal. All insect data is entered into the system in terms of damage to the plant. For example, damaged bolls, damaged squares, and leaf damage expressed as a percentage. The input user interface makes the data gathering stage straightforward and efficient.

Conclusions

COTONS-IMS is the first beltwide system that permits a detailed plant model to respond to the concurrent damage by multiple agents (for example, bollworms and whiteflies, and armyworms at the same time) with no limitation as to area of use. COTONS-IMS is applicable anywhere in the US that COTONS is applicable. Its expected impact is that it will be able to show the precise response of the plant to damage depending on the state of the plant in any given environment. In combination with optimization and management algorithms it will be a central element in cotton insect management. Demonstrating when a plant compensates for damage and the conditions under which a control action may be justified may reduce the use of pesticides. Researchers, students, and cotton producers and consultants can use this software. Researchers may use it for planning and optimization. Further, the system can be easily integrated into a multiple crop, whole farm system since it uses only the standard Windows functionality and written in standard C language.

Key References

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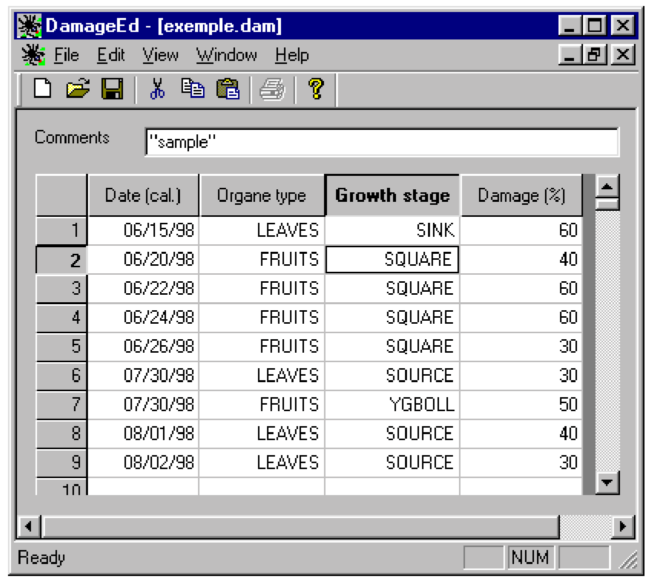

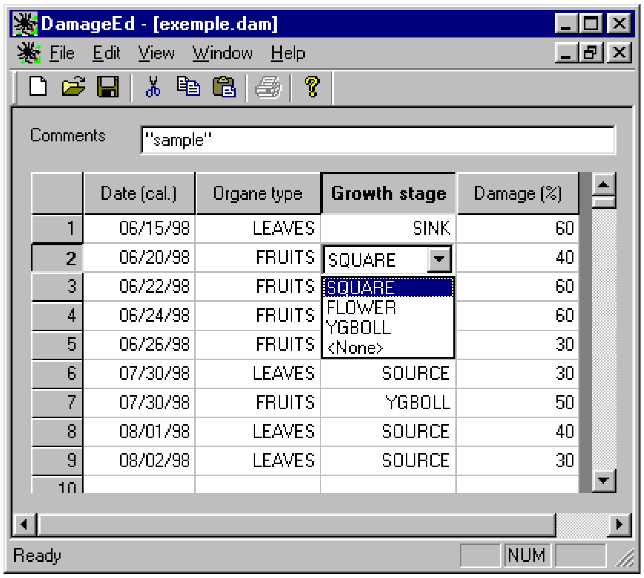
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Date (cal.)
Organe type
Growth stage
Damage (%)
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2 06/20/98 FRUITS SQUARE 40
3 06/22/98 FRUITS 60
4 06/24/98 FRUITS 60
5 06/26/98 FRUITS 30
6 07/30/98 LEAVES SOURCE 30
7 07/30/98 FRUITS YGBOLL 50
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FLOWER
YGBOLL
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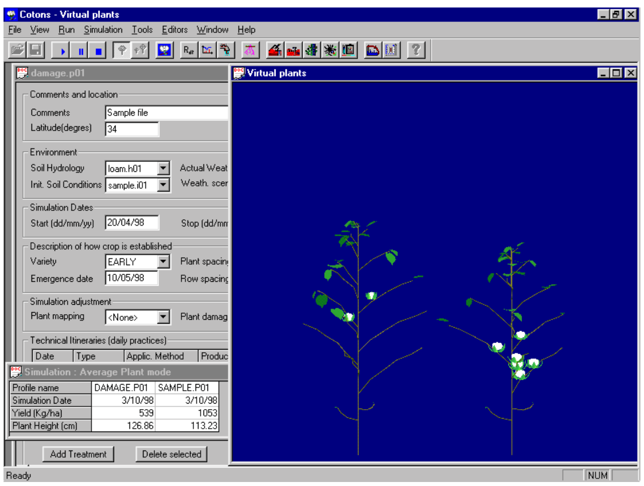
Cotons - Virtual plants
File View Run Simulation Tools Editors Window Help
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Init. Soil Conditions
sample.i01
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Description of how crop is established
Variety
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Emergence date
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Plant mapping
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Date
Type
Applic. Method
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Profile name
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3/10/98
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Add Treatment
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Ready
NUM