Travel and Conference Participation

Travel

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Part 1 - Summary Project Details

FORM B

Application Financial Year:	2000-01
Related **CRDC Project Number** (CRDC # CSP132C.)	CSP124C
Travel Start Date:	6/1/01
Cease Date:	6/30/01
Travel Destination (< 15 words)	National Institute of Environmental Studies, Tsukuka, Japan
CRDC Project Title (< 15 words)	Predicting and enhancing cotton compensation following pest damage

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FINAL REPORT

Modelling compensatory responses of cotton to pre- and early squaring damage

T Lei
24/09/2001

Background and justification

The development of decision support systems to assist cotton growers is a key part of facilitating sustainable cotton cropping within Integrated Pest Management principles. One system that has been in use in Australia is the SIRATAC/OZCOT simulation model which predicts yield based on agronomy and weather input data. This model is currently undergoing improvements including the incorporation of cotton response to pest damage. Reliable prediction of yield compensation to pest damage will enable growers to improve confidence in the principles and maximise natural recovery and minimise pesticide application and its negative impact.

Over the last several years, field trials at the CSIRO Narrabri have generated a substantial dataset on the growth and yield effects of damage ranging from early season defoliation and tip damage to single and multiple fruit removal events (by Lewis Wilson, Victor Sadras and Tom Lei). It has become clear that reliable prediction of compensation requires the modelling of not only fruit losses but canopy development which can be significantly altered by pre-squaring terminal and leaf damage. To fully account for the process of compensation, we need to include in the model space- and time-specific variations in light interception, carbon assimilation, regrowth and fruiting potential following damage. Specifically, the spatial arrangement of leaves and branching structure should be explicitly accounted for in the mechanistic modelling of pest damage, the response in plant growth, and its consequences in light capture.

To best achieve rapid initiation of the modelling work, I spent one month collaborating with Dr. AkioTakenaka at the National Institute for Environmental Studies (Japan). Dr. Takenaka has an established expertise in modelling the interaction between canopy architecture, light interception and carbon uptake (see a list of his relevant papers below). We will develop a compensation submodel capable of simulating the effect of tip, leaf and early square damage on lateral branch and canopy growth and the consequences of architecture on light interception, carbon assimilation, and fruiting dynamics. Calibration of parameters (e.g., leaf area index, photosynthesis, number of fruiting sites) will be derived from published results (see references below) and recent field data (from CSIRO Narrabri). Although Dr. Takenaka has not worked with cotton, the physiological principles from his research and modelling should apply to cotton and may provide input of new ideas into OZCOT which could assist with future enhancements. We will also explore the possibility for Dr. Takenaka to visit the OZCOT modelling group in future to expand this collaboration if necessary. The linking of the compensation submodel to OZCOT will be done with the approval and support of Dr. Steve Milroy and Dr. Mike Bange who are currently directing the core model revision.

Description of achieved outcomes

The collaboration with Dr A. Takenaka took place in Tsukuba, Japan from May 28 to June 27, 2001. We have successfully produced new code linked to the core OZCOT allowing the simulation of damage occurring during the vegetative stage (pre-squaring) and the fruiting stage of cotton growth. The output achieved is greater than that targeted in the original proposal. Model implementation of pre-squaring damage includes **thrips damage** (suppression of leaf area expansion and subsequent recovery), and **tipping out** (can be caused by *Helicoverpa*, tipworms and mirids). Recovery from thrips damage is largely restricted to the pre-squaring period while that from tip out extends from pre-squaring to the end of the growing season. Also implemented in the new code is **fruit loss** simulating *Helicoverpa* larvae feeding on squares, flowers and bolls. Contrary to thrips and tip out damage, there is no explicit enhancement in recovery from fruit loss. Instead, the crop is allowed to increase fruit production based on existing code which detects an improvement in the status of the plant's carbon balance. Model functionalities achieved for each damage type is listed below.

Modelling tip out pre-squaring

Functionalities achieved

- account for **age-dependent increase in branching** following tip damage
- branching associated **enhancement in leaf area development** prior to first square
- the improvement in light interception resulting from the modified canopy geometry following tip out is not explicitly modelled but is captured in the branching factor and applied to the leaf area and fruit production enhancement factors
- branching associated **enhancement in square initiation** and the corresponding leaf area increase
- delay in branch emergence and in reaching first square implemented
- enhancement factors has the potential to remain in effect through to the end of the season
- allow an input file which includes day of tip damage, maximum branching factor, leaf area enhancement factor, site production enhancement factor, and delay in lateral bud emergence and in timing of first square

Thrips damage causing early season leaf area reduction

Functionalities achieved

- explicitly define the **duration of thrips infestation** and the start time of infestation in terms of plant development stage
- use input value for the amount of daily **suppression of leaf area expansion** due to infestation (could be made a function of thrips number per plant)
- simulate an **enhanced leaf area production** (i.e., recovery) due to higher performance of leaves on the thrips affected plant
- scale the enhancement to the amount of leaf area reduction up to a maximum

- as leaf area recovers (checked against an undamaged reference plant), the amount of enhancement declines
- enhancement ceases on day of first square
- delay in plant development and time of first square due to thrips is implemented

Implementation of fruit loss due to pest damag

Functionalities achieved

- new subroutine to execute the **removal of specified numbers of fruit of various categories on specified dates**
- on removal day, the fraction of fruit to be removed to total fruit number in each category is determined
- distribute % fruit removal equally among all cohorts within a fruiting category
- reduce the remaining fruit number in each cohort for continued development
- in a cohort, marked fruit for shedding after fruit loss is not retained to substitute for lost fruit
- allow a lower boll load (demand) and a larger size of the reserve in carbon carrying capacity (supply) following fruit removal to increase fruit number (fewer marked for shedding) - compensation in the form of greater fruit retention after damage

Summary and industry implications

This collaborative effort has enabled us to implement within the cotton growth model OZCOT the ability to simulate damage caused by different pests and to predict their growth and yield consequences. While the new code has been tested for errors, the key task of validating the performance of the new code with historical data is still continuing. Once the code has been properly validated and refined, it will become an integral part of the decision support system in the management of Australian cotton pests. The new functionality of OZCOT in predicting yield recovery from pest damage will be used to evaluate the justification for spray applications for a given pest type, intensity and timing of infestation. If we can affect a reduction in pesticide use by demonstrating to growers and consultants no predicted loss of yield even in a pest situation that is above current threshold, then this collaborative effort with Dr. Takenaka will have achieved its goal. Publication of the new model together with validation results in industry and crop journals is planned upon completion of the validation work.