K90 ✓

Jan 88 – Dec 90

Project Title: **CS51L ECONOMIC OPTIMISATION IN SIRATAC**

CSP4L

Final Report

P.G. Cox
CSIRO Cotton Research Unit

5th June, 1991

Objective

The objective of this project was to look at economic optimisation within the SIRATAC framework.

Background

SIRATAC is an on-line computer-based pest management system for irrigated cotton. It makes recommendations for insect control on the basis of samples collected from individual management units.

During the 1980s, the SIRATAC methodology was marketed through SIRATAC Ltd. A reimplementation of SIRATAC was initiated in 1986 (SIRATAC Plus).

However, by 1988, it had become clear that on-line management systems were an evolutionary deadend. SIRATAC Ltd went into liquidation in mid-1989. The SIRATAC Plus project was abandoned in early 1990.

During the 1989/90 and 1990/91 cotton seasons, SIRATAC was operated by a newly-formed User Group (SUG).

The collapse of the SIRATAC framework coincided with the initiation of Project CS51L, *Economic optimisation in SIRATAC*.

The abandonment of the SIRATAC framework also coincided with increasing doubt concerning the ability of cotton to compensate for early insect damage. This circumscribed the usefulness of the SIRATAC crop model for formal optimisation.

Thus, during the course of the project, the emphasis shifted from mathematical optimisation using validated simulation models towards the development of a novel approach to decision support as a replacement for SIRATAC.

Pest management

The action thresholds used in historical SIRATAC are not equivalent to short-term economic thresholds (Cox 1991).

The cotton crop and *Heliothis* models used in SIRATAC can be used to define economic thresholds for pesticide application against *Heliothis* (Cox, Marsden, Brook, Talpaz and Hearn 1991).

The SIRATAC framework can be simplified substantially. A prototype of a pest management decision support system, entomoLOGIC, was written for a microcomputer (Cox, Griffin and Brook 1991). entomoLOGIC was calibrated and validated against historical SIRATAC. Although entomoLOGIC does not incorporate any of the simulation models used in SIRATAC, the recommendations which it generates are remarkably similar. An expert systems shell was used to make the rule base explicit.

The cost of losing access to endosulfan (Cox, Forrester and Brook 1990) and the economics of the Resistance Management Strategy (Cox and Forrester 1991) were both examined.

Water management

Other management problems can be solved using models in different ways. The area of irrigated cotton to grow when water is short can be structured using an optimising algorithm (linear programming) in a spreadsheet (Cox and Hearn 1990).

Value of earliness

The cost of harvest delay, one component of the value of earliness, was investigated using a simple simulation model (Cox and Thomson 1989; Cox 1990a; Cox, Wells and Thomson 1990).

Summary of Conclusions

• SIRATAC action thresholds used in pest management are not economic thresholds.

• Economic thresholds can be defined for *Heliothis* on cotton using the crop and *Heliothis* models developed under the SIRATAC programme.

• The main problems with defining economic thresholds in this way are uncertainties to do with:-

(1) the ability of the cotton crop to compensate for early season insect damage

(2) the valuation of earliness

(3) the justification for incorporating considerations other than private costs and benefits into the definition of the thresholds.

• The prototype of entomoLOGIC demonstrated that a pest management decision support system can be developed without the use of simulation models.

• The development of entomoLOGIC is already constrained by the conventions of historical SIRATAC to do with:-

(1) the limited size of the rule base, especially the problem of how to manage combinations of pest species

(2) the definition of action thresholds.

• An analysis of the Resistance Management Strategy suggested that the economic benefit of that project was substantial and social factors were important to its success.

Recommendations for Further Research

• There is a continuing need for an economics input into the Management Systems research programme at Myall Vale.

• The economics input should operate at three levels:-

(1) Farming Systems Research

(2) economic optimisation

(3) cost-benefit analysis of research projects.

• The present limitations of entomoLOGIC (inherited from SIRATAC) might be overcome substantially by a programme of participatory research with active involvement of growers and consultants. This approach would also help with eventual prodnct acceptance.

• Formal optimisation work using the SIRATAC simulation models can continue once the biologists are confident that the behaviour of the models adequately tracks the ability of the cotton crop to compensate for early insect damage.

• The best way of using simulation models (of both crop and insect development) for farm-level decision support needs to be reassessed. A hierarchy of models, with different functions, might be needed.

• A research project on the economic valuation of earliness in cotton should be instigated.

• The economics of alternative approaches to the management of insecticide resistance (including the introduction of transgenic cotton) should to be considered.

Cox, P.G., S.G.Marsden, K.D.Brook, H.Talpaz and A.B.Hearn (1991). Economic optimisation of *Heliothis* thresholds on cotton using a pest management model. *Agricultural Systems* 35 (2) 157-171

ABSTRACT The SIRATAC crop and *Heliothis* feeding models are used to calibrate different ways of specifying economic thresholds for *Heliothis* control on cotton in the Namoi Valley of New South Wales. A substantial increase in expected gross margin is achieved if the threshold is allowed to vary as a function of square and boll numbers, compared with current SIRATAC practice. Much of the increase can be captured by simpler models in which the insect pest threshold is defined either by linear time-dependent segments or a quadratic function of day-degrees from sowing. Use of simpler models such as these may assist in the transfer of pest management technology to growers.

Cox, P.G. and N.W.Forrester (1991). Economics of insecticide resistance management in *Heliothis armigera* (Lepidoptera: Noctuidae) in Australia.

ABSTRACT An Insecticide Resistance Management Strategy (IRM) for *Heliothis armigera* (Hübner) has been operating in Australia since 1983. An *ex post* evaluation is difficult because we are unsure what the outcome would have been had the IRM not been introduced. The actual outcome is compared with the projected outcome of various scenarios which capture the best available opinion concerning what would have happened without IRM or with alternative IRM strategies. The input-saving and economic surplus methodologies for evaluating the investment in IRM are compared. The analysis suggests that the economic benefits of the introduction of IRM have been substantial and that an IRM strategy should be designed to exploit insecticide susceptibility at an optimal rate. In the Australian example, the highest economic return was realized by the permitted use of three pyrethroid sprays per season. The low cost of implementing and maintaining the IRM in relation to its high rate of economic return indicates an excellent opportunity for increased investment in research into alternative IRM approaches. The implementation of IRM is seen as a problem in the management of a common property resource: it is a social technology. But the IRM in Australia is unusual because so many factors worked in its favour. The transfer of IRM technology to different socio-economic situations might well be more difficult.

Cox, P.G., S.L.Griffin and K.D.Brook (1991).
entomoLOGIC, an expert system for insect pest management in cotton: the development of a technology.

ABSTRACT entomoLOGIC is a re-implementation of the SIRATAC cotton pest management system. The use of a microcomputer hardware platform, a graphical user interface, a simple programming language and an expert system shell all helped to speed the development of a prototype of entomoLOGIC. Like SIRATAC, entomoLOGIC makes recommendations for insecticide use on the basis of insect counts in farmers' fields. But the differences between entomoLOGIC and SIRATAC are important. Even though the knowledge content of the two is similar, they are distinct products. A comparison of entomoLOGIC with SIRATAC, and with a previous re-implementation called SIRATAC Plus, suggests that the value of a pest management expert system lies as much in the way it structures a problem as in the details of individual recommendations.

List of Reports

Cox, P.G. (1990a). The cost of harvest delay in cotton. *Poster Paper Proceedings of the International Symposium on Climatic Risk in Crop Production: Models and Management for the Semi-arid Tropics and Subtropics, Brisbane, 2-6 July 1990* pp. 66-67.

Cox, P.G. (1990b). The rôle of economics in Australian cotton research. *Proceedings of the Fifth Australian Cotton Conference, Broadbeach, Queensland, 8-9 August 1990*, pp. 129-133.

Cox, P.G. (1991). Economic thresholds for Heliothis. *Australian Cottongrower* 12 (3) 49-51.

Cox, P.G. and A.B.Hearn (1990). A simple spreadsheet model of the area of irrigated cotton to plant. *Proceedings of the Fifth Australian Cotton Conference, Broadbeach, Queensland, 8-9 August 1990*, pp. 123-127.

Cox, P.G. and N.W.Forrester (1991). Economics of insecticide resistance management in *Heliothis armigera* (Lepidoptera: Noctuidae) in Australia. *J.econ.Entomol.* In review.

Cox, P., N.Forrester and K.Brook (1990). How much would the loss of endosulfan cost? *Australian Cottongrower* 11 (2) 12-14.

Cox, P.G. and S.L.Griffin (1991). Decision support for cotton pest management. *Poster paper for the 9th Biennial Conference on Modelling and Simulation* abstract submitted.

Cox, P.G., S.L.Griffin and K.D.Brook (1991). entomoLOGIC, an expert system for insect pest management in cotton: the development of a technology. In review.

Cox, P.G., S.G.Marsden, K.D.Brook, H.Talpaz and A.B.Hearn (1991). Economic optimisation of *Heliothis* thresholds on cotton using a pest management model. *Agricultural Systems* 35 (2) 157-171.

Cox, P. and N.Thomson (1989). The cost of harvest delay. *Australian Cottongrower* 10 (4) 45-49.

Cox, P., T.Wells and N.Thomson (1990). The implications of harvest weather. *Australian Cottongrower* 11 (2) 42-49.