

HEAPS

HEliothis Armigera and Punctigera Simulation model

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Need For A Model

Resistance in *Heliothis armigera* to organochlorine, and more recently synthetic pyrethroid insecticides, poses a major threat to the sustainability of cotton growing in Australia. In light of this, SIRATAC should be seen to benefit not only users through maximizing returns in the short term, but also to benefit all growers by helping to reduce the selection pressure for resistance. This will manifest itself in an extended life for the insecticides that remain useful to us.

An underlying aim of SIRATAC, and indeed all decision-support systems, is to provide the grower with information that will enable him to make the best possible management decision. One limitation of SIRATAC in its current form is that the management options recommended are based on a projection of the fate of only those eggs and larvae already on the crop. Yet ideally we would also wish to base management decisions on a prediction of egg laying several days into the future. That SIRATAC cannot do this reflects our lack of understanding of *Heliothis* population dynamics. The range of the "Heliothis population" is not just the cotton field, or even the Valley, but much of eastern Australia. At this level, a single field of cotton is seen by the *Heliothis* populations as only a small part of a mosaic of potential host fields. At any time, the chance that eggs will be laid in that field depends not only on the attractiveness of that crop but also

the relative attractiveness of surrounding fields, the proximity of source crops, and the number of moths flying at that time.

To understand, and predict, *Heliothis* dynamics on cotton, along with changes in resistance levels, we must understand their dynamics on other hosts and the patterns of movement from these to cotton. The level of complexity is too great to consider conceptually and so a simulation model is necessary.

What HEAPS Will Help Us Do

We believe the model will help us in 5 ways:

1. To provide a basis for the regional management of *Heliothis* populations,
2. To predict the timing, density and species composition of eggs laid on cotton throughout the growing season,
3. To determine how cultural practices (eg. type and variety of crop and changes in the diversity of crops grown in the region) will affect *Heliothis* numbers overall and on particular crops such as cotton,
4. To predict the effect of management practices on resistance levels in *H. armigera*,
5. To pinpoint areas for research that are critical for an understanding of *Heliothis* dynamics and about which we know little.

How Does HEAPS Differ From Other *Heliothis* Models?

SIRATAC already contains a model for the development and survival of *Heliothis* on cotton. A model for population dynamics must also consider alternative host plants and movement.

Two models already exist for *Heliothis* population dynamics in cotton growing regions of the USA: MOTHZV-2 (Hartstack *et al.* 1976); and HELSIM (Stinner *et al.* 1974,1977). Like these, HEAPS considers the numbers of all pest life stages on a range of crop hosts, and uses temperature to drive the development of the pest and hosts. It also incorporates the actions of a range of mortality factors, some of which are crop specific, which will reduce the density of the pests.

The basic structure of these existing models is not, however, appropriate for a *Heliothis* simulation model in the Namoi Valley. MOTHZV-2 does not consider the spatial arrangement of host crops or therefore movement, and cannot be run from one season to the next. HELSIM has a spatial component but this is much simpler than is required in HEAPS. Firstly, in the region of North Carolina where it was developed, field size is relatively uniform at 2-3 ha, whereas in the Namoi fields can range from this level up to 100's ha. Secondly, crop types are arranged in a random pattern so that once the mean distances between crops are known the populations on each crop can be simulated without considering the actual location of each field. This simplifies the simulation of moth movement, as moths simply fly to the most attractive fields.

These characteristics are not appropriate for the Namoi Valley where crop distribution is not random and so the actual spatial arrangement of fields is important. Moving from east to west down the valley the cropping pattern changes from dryland mixed cropping with some irrigated cotton to a virtual cotton monoculture. Along the same gradient average temperatures increase and rainfall decreases. Therefore the position of a crop within the valley influences its susceptibility to *Heliothis* attack, and the fate of the infesting

populations. Consequently, the predictions of our model will depend much more on moth behaviour during dispersal than does HELSIM.

Model Structure

The spatial structure of the cropping system of the Namoi Valley is represented in the model by dividing the area into simulation units (SU). These are of variable size and define a field or number of fields containing, at any one time, a homogeneous resource for *Heliothis*. For example: SU1 may contain 1 x 300 ha field of mature dryland Hysun-33 sunflowers while SU 2 contains 5 x 100ha adjacent fields of flowering irrigated Siokra cotton. The position of each SU is given by the latitude and longitude of its centre, thus the distances between SU's and their relative positions can easily be calculated. *Heliothis* within each SU are treated as separate subpopulations that develop and die at rates modified by the status of the host plant. These subpopulations are linked through the movement and oviposition subroutines of the model.

The model is written in Vax-Fortan, a superset of Fortran-77 (Fig. 1). The modules completed so far run on the Vax 11/750 minicomputer cluster at the Myall Vale Research Station.

Moth Movement

The movement of moths is one of the most important yet poorly understood aspects of *Heliothis* population dynamics. Movement is, therefore, a major focus of *Heliothis* research in CSIRO through techniques such as elemental analysis, night observations, and radar. The challenge in modelling movement is to combine facts with 'gut feelings' in a set of rules that define movement realistically and are

easy to modify when new data come to light. At this stage we have made several assumptions about the effects on movement of: moth age class, weather (especially wind direction), and crop attractiveness. As research continues these will be modified. Also test runs of the model will show where errors exist - if, for example, by January 1st all moths in a simulated western Gwydir Valley are on Colly Farms we'll know either our model or their management is at fault. Presumably the former!

Validation.

The model must be validated by comparison of predicted and observed *Heliothis* numbers in some of the SU's. The model has the capability to read in field data, compare these with simulated numbers and then to replace values or report differences as required. Problems will arise where, during one run, the model's predictions are accurate for some SU's and not for others. These anomalies will become fewer as we learn more of what field data are needed to initialise the model.

Time Scale

The aims of HEAPS cannot be achieved overnight. At present the model is only partially written and we predict the process of model development and validation will not be completed until the end of the 1989/90 season. At the earliest, predictions from the model would be available to growers in the 1991/92 season.

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References

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Fig 1. Flow chart for HEAPS



