COTTON RESEARCH COUNCIL

Project Title: Ecology and behaviour of *Heliothis* and Development of Insect Resistant Cotton.
Project Code: CS13L
Supervisor: Dr. G.P. Fitt

FINAL REPORT

Aims:

(i) to investigate the spatial and temporal patterns of *Heliothis* adult and larval abundance, mortality and host use by each species and their dispersal from other crops into cotton.
(ii) to investigate the oviposition behaviour of *Heliothis* within cotton crops in relation to trap catches and cotton varieties.
(iii) to evaluate the resistance of several cotton genotypes to various insect pests and quantify the interaction of resistance mechanisms.

1. HELIOTHIS ECOLOGY

(a) *Population Dynamics*

The phenology and species composition of *Heliothis* populations in the Namoi Valley were studied using a network of pheromone and UV light traps in combination with regular field surveys of egg and larval abundance. All potential *Heliothis* hosts (cotton, maize, sorghum, sunflowers, etc) were included in these studies which extended outside the main irrigation area to encompass cotton growing areas in the upper Namoi Valley and dryland cropping areas to the north around Edgeroi. Apart from three cotton sites near Myall Vale visited daily, each site was sampled twice per week. This work has provided an essential database on the phenology and spatial patterns of abundance and mortality of local populations which can be correlated with the dynamics of the two species in cotton. When combined with studies of intercrop movement described below this information has provided the basis for the development of *Heliothis* population models.

One factor required by this model will be estimates of adult fecundity. Some preliminary work on this aspect has been completed to quantify the influences of host type, adult size and environmental conditions on pre-reproductive periods, longevity and lifetime fecundity of both species. A separate grant proposal to quantify factors influencing reproductive performance of *Heliothis* adults has been submitted to commence in 1988/89

(b) Studies of Dispersal and Intercrop Movement

To quantify the extent of intercrop movement, wavelength dispersive X-ray spectroscopy (XRF) has been used to produce an elemental profile of individual moths from known hosts. The aim was to determine whether host or site specific variability in this elemental profile (chemoprint) may provide a fingerprint of the crop origin of immigrant moths.

Over three season a database has been collected on the concentrations of between 7 and 13 elements in approximately 4000 moths from a range of crops (eg. cotton, sunflower, sorghum, maize, chickpeas, lucerne, several weeds) and from several sites. Canonical variate analysis has shown that moths from different crops can be discriminated using information on the concentrations of 6-7 elements (2). This suggests that the technique may be useful in quantifying local movement of *Heliothis* adults.

Chemical analyses of moths of unknown origin which have recruited into cotton crops commenced in 1988/89 but have not yet been finalised. It is hoped to analyse moths collected in cotton crops over 2-3 seasons to indicate the proportion of the moth population produced in different crops.

2. HELIOTHIS BEHAVIOUR

a) Relationships Between Trap Catches And Heliothis Activity In Cotton

Studies were completed to examine the relationship between various estimates of adult abundance (pheromone traps, light traps, adult flushes) and egg numbers in an effort to produce relationships which may be useful in the short term prediction of egg laying. The efficiency of pheromone traps as indicators of the species composition of egg lays was also measured and confirmed earlier findings (6) of a consistent bias towards overestimation of the proportion of *H. armigera*. Statistical analyses which also considered climatic variables showed that trap catches explained little of the variance in the species composition of egg lays not already explained by the variable 'day of the season'. By using data from daily measurements of egg density at 3 sites in the 1985/86 season, as well as data collected by P. Room over 3 seasons, a predictive relationship between the number of white eggs on successive days has been developed. This relationship has been incorporated into SIRATAC for the 1986/87 where it now provides a short term prediction of white egg recruitment.

(b) Patterns of Egg Distribution on Cotton.

The sampling procedures and density conversion for *Heliothis* eggs currently used in SIRATAC were developed on the basis of total *Heliothis* eggs with no separation of the species. Major intrinsic differences between the species in their pattern of egg distribution, or in their response to seasonal, agronomic or varietal factors may reduce the efficiency of these relationships when one or other species predominates in the field. This work sought to identify differences in egg dispersion between the two *Heliothis* species, particularly in relation to variety and growth stages of cotton. To date the positions of several thousand eggs on four cotton cultivars have been individually mapped and the eggs then identified using an electrophoretic technique (7). The results show highly significant differences between the species in their distributiou of eggs among plant parts, in the mean group or clutch size of eggs laid on cotton and in the between-plant clumping of eggs. There were, however, no differences between the cultivars DP61 and SICOT 3 in these parameters of egg distribution, though preliminary analysis of this seasons data suggest a significant effect of the okra leaf character of SIOKRA on the numbers and positions of *Heliothis* eggs.

These differences in oviposition behaviour between the species and cotton varieties may lead to significant bias in estimates of egg density based on presence/absence sampling at certain times of the season. This work has formed the basis for a submission to CRC for a specific project to re-evaluate sampling procedures for cotton pests, particularly in relation to new varieties.

3. DEVELOPMENT AND ASSESSMENT OF INSECT RESISTANT COTTONS

Experiments were conducted over three seasons (1986/87-1988/89) to evaluate the impact of four morphological characters of cotton; okra leaf, frego bract, glabrousness and nectariless, both alone and in combination, on crop attractiveness to pests and pest mortality (8). These characters are being used in the development of new cotton varieties with enhanced insect resistance, particularly to *Heliothis*. Some lines arising from this work have been released commercially; SICOT3 (glabrous, frego bract) and SIOKRA (okra leaf).

The comparison of all four characters has been largely completed and data analysis has been completed. The study has identified the okra/ glabrous combination as the most promising having a major influence on *Heliothis* oviposition and in reducing the rate of development of mite populations (see below). In small plot trials the glabrous character has consistently shown significant reductions in *Heliothis* egg numbers of up to 45%, while frego bract has

consistently led to reductions in larval numbers. Unfortunately because of inadequate fibre quality the cultivar containing these two traits (SICOT 3) is no longer available commercially. Studies of the relationship between the proportion of infested plants and mean *Heliothis* eggs/ plant on these varieties showed no significant differences, though there were differences between the species of *Heliothis* in their preferred sites of oviposition. These differences were investigated further in field cage experiments using potted plants which showed that the reduced egg lay on glabrous plants was due to a reduction in the residence time of females on these plants (4,5).

With the commercial release of okra leaf varieties (SIOKRA) more emphasis was given to the influence of this character on the canopy environment (temperature, humidity), on the oviposition behaviour of *Heliothis* females and on the survival and growth of eggs and larvae. Significant effects have been identified in relation to the numbers and placement of eggs. In addition we found differences in the relative abundance of the two *Heliothis* species on commercial blocks of SIOKRA and the normal leaved cultivar (DP90). *H. armigera* laid significantly fewer eggs on Siokra than on DP90, whereas *H. punctigera* did not discriminate between the two (3). Field cage experiments have shown that *H. armigera* lays significantly more eggs on the upper surfaces of old leaves than does *H. punctigera*. Thus the reduced leaf surface area of okra leaves may be less attractive to *H. armigera* females. In addition the okra leaf character has been shown to significantly reduce the proportion of plants infested by two-spotted mites, the rate of increase of mite populations once established and the level of damage suffered by the plant.

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