THE USE OF ELEMENTAL ANALYSIS AS A TOOL IN THE STUDY OF INTERCROP MOVEMENT BY ADULT *HELIOTHIS*.

Gary P. Fitt - CSIRO Narrabri

INTRODUCTION.

Heliothis spp. have two main attributes which give rise to their pest status and make them difficult to manage (see Fitt this volume). Firstly both species exploit a wide range of host plants in addition to cotton, including most crops (eg. sorghum, sunflower, maize, and many others), and many weeds. Many of these hosts are extremely important in the seasonal dynamics of *Heliothis* populations and past research has identified the sequence in which they are used from spring through to autumn. These hosts represent the source of many of the moths which colonise cotton crops, but at present we have no way of estimating the relative importance of intercrop movement in the dynamics of *Heliothis* on cotton or the contributions of different crops to the local population.

The second important attribute is that *Heliothis* moths are highly mobile. Thus adults which colonise cotton crops may have developed within the local area or alternatively may have migrated from crops many kilometres away. In an attempt to quantify the role of intercrop movement in *Heliothis* dynamics a technique is being developed which may allow us to identify the host origin of adult moths. This work forms part of a larger project which aims to develop methods of predicting the seasonal patterns of *Heliothis* abundance and egg laying activity on cotton.

DESCRIPTION OF TECHNIQUE.

The technique being tested takes advantage of 'natural' chemical markers in adult moths which derive from the foodplants on which they fed as larvae. In some insects different patterns in the concentration of chemical elements such as sodium, magnesium, potassium etc., are associated with differences in their food plants or the locality from which they are collected. Larvae feeding on one plant species may accumulate a different pattern of elements compared to those feeding on another species. These small differences in elemental composition can act as a "signature" or "chemoprint" of the crop origin of adults and so provide us with a natural marker. The technique assumes that a characteristic pattern of elements accumulates in the feeding larvae and that this pattern persists into the dispersive adult phase. It also assumes that variation in the "chemoprint" within a population from a particular crop is less than the variation among populations from different crops.

The first stage of this research is to determine whether *Heliothis* moths reared as larvae on different plants do in fact show differences in their pattern of elements. To do this late instar larvae are collected in the field and reared to pupation on plant material from their collection site. Upon emergence each moth is killed, dried and formed into a flat pellet. The pellet is then exposed in a Wavelength Dispersive X-ray Spectrometer, which measures the concentrations of various elements in each moth. To date the elemental composition of about 1200 moths has been determined. Most of these have been reared from four major *Heliothis* hosts; cotton, sunflower, sorghum and maize, but specimens from other minor crops such as lucerne, chickpeas, safflower, soybeans and linseed and many weeds have also been collected and await chemical analysis.

RESULTS and DISCUSSION.

Table 1 shows some of the preliminary results. For all nine of the elements shown there is significant variation in concentration between crop types. Although the differences may appear slight, a multivariate statistical analysis (Canonical variate analysis), which considers all elements together and which attempts to maximise the degree of discrimination between crop types, indicates that average moths from different crops are highly distinct in their elemental profiles. Figure 1 shows a plot of Canonical Variates which indicates the degree of separation between crop types. Further statistical analysis will allow us to determine the accuracy with which individual moths can be allocated to crop types and which chemical elements are most important in the discrimination. It may be possible, for example, to analyse for only 4-5 key elements rather than all nine.

These preliminary analyses also indicate little difference between the two species of *Heliothis* reared from the same crop. There are, however, some differences between sexes (eg. females have consistently higher concentrations of potassium than males), though these do not mask the differences between crop types.

TABLE 1. The Concentrations (ug/gm) of Nine Elements in *Heliothis* moths reared from four major crops.

	CROP				
	SUNFLOWER	COTTON	SORGHUM	MAIZE	Signif. of
No. of moths	50	154	146	50	Variation
No. of sites	4	6	7	3	between crops
ELEMENTS					
Calcium	1099	1246	1041	865	***
Potassium	17533	16456	15121	17791	***
Chlorine	2444	2278	2108	2360	***
Sulphur	7372	7437	6587	7255	***
Phosphorus	12222	11314	11511	11798	***
Magnesium	4407	4959	4214	4287	***
Sodium	382	704	553	249	***
Iron	84	121	146	105	***
Manganese	59	67	54	57	***

*** $P<0.001$

While these early results are encouraging there are several factors which may complicate the practical use of "chemoprints" in studies of *Heliothis* movement. Firstly the elemental composition of plants is greatly influenced by soil type. Thus moths reared on the same crop but from different soil types may show different patterns of elements. Secondly in some situations larvae may feed on more than one type of plant during their development. This is particularly likely where larvae develop in weedy areas which usually support mixed stands of several species. As the most favoured weeds mature or are consumed, larvae will move onto other species to continue their development. The resulting elemental profile may be complex and not representative of any one plant species. Thirdly, adult moths consume quantities of nectar during their lifetime which they may obtain from various sources. Nectar consumption could alter or mask the pattern of elements accumulated by the larvae from their foodplants. This possibility is of some importance since the technique is aimed primarily at identifying the crop origin of moths caught in cotton crops.

These factors are being investigated in a number of ways. To determine the importance of soil types we have collected specimens from crops growing at a number of sites with differing soil type and cropping history. In addition we collected samples of five major soil types in the Namoi/ Gwydir region and grew three different crops (cotton, sunflower and lucerne) in each soil. *Heliothis* larvae were then reared on each combination of soil and crop and the adults analysed chemically to more accurately measure the interaction of soil and crop in determining elemental profiles. This experiment indicated that the separation between crop types was greater than that between soil types (Figure 2). Thus it may be possible to identify the crop origin of a moth irrespective of the specific area it came from.

The importance of adult feeding on cotton nectar was investigated by allowing some moths reared from a particular crop to feed for 2 days at cotton nectaries, while the remainder of the group were killed without feeding. Chemical analysis of these moths suggests that adult feeding does alter the elemental profile, though at present we have analysed too few specimens to be certain of its significance.

If further work confirms the usefulness of "chemoprinting" for studies of *Heliothis* movement we will begin to analyse moths of unknown origin collected in cotton crops. Thus we would be able to determine throughout the season which crops were contributing most of the adults recruiting into cotton. By collecting information on the distribution of host crops within a region it may also be possible to estimate how far adults have moved. In addition to this general use, the technique will be useful in answering specific questions relevant to the management of Pyrethroid resistance in populations of . armigera. For example, we may ask what proportion of adults present in cotton during Stage 3 of the Pyrethroid Management Srategy were produced in cotton during Stage 2, and so exposed to selection with the insecticide.

The development of a technique to identify the probable crop origin of adult moths is however only one part of the program dealing with *Heliothis* movement. The information it provides must be combined with detailed monitoring of adult populations, using light and pheromone traps and of larval populations by means of field surveys, to allow us to tie together seasonal patterns of population change.

FIGURE 1. Plot of mean values for the 2nd Canonical Variate against the 1st Canonical Variate for moths reared from different crops. (each point represents a collection site)

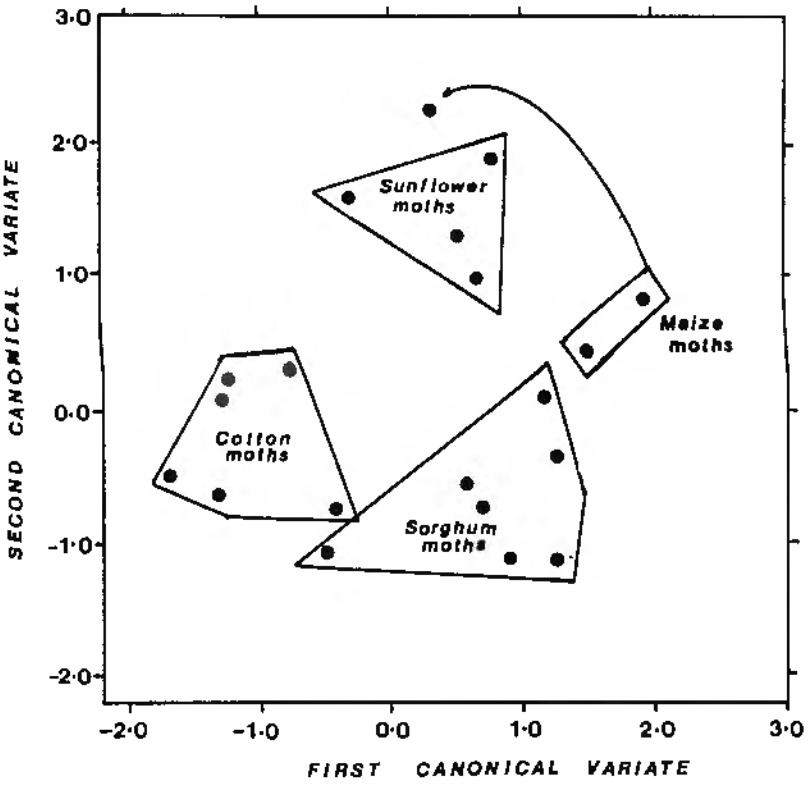

FIGURE 2. Plot of mean values for the 2nd Canonical Variate against the 1st Canonical Variate for moths reared from three crops growing in five soil types; 1 = Namoi Grey, 2 = Namoi red, 3 = Namoi black, 4 = Gwydir grey, 5 = Gwydir red.