THE INFLUENCE OF THE OKRA-LEAF CHARACTER OF COTTON ON THE NUMBERS AND WITHIN-PLANT DISTRIBUTION OF *HELIOTHIS* EGGS.

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INTRODUCTION.

The development and release of SIOKRA, the new okra-leaf variety, has created considerable interest with respect to pest management. The altered leaf shape of this cultivar, which results in a more open canopy, has led many growers to expect differences in its attractiveness to *Heliothis* in particular, and to other insect pests in general. Indeed, many growers and consultants have commented on the apparent reduction in *Heliothis* and in the number of sprays applied to SIOKRA crops. The SIRATAC database confirms this trend.

While okra leaf has been shown to confer resistance against some pests, eg. whitefly and mites, it has not been seen as a direct mechanism of resistance against *Heliothis*. Nevertheless, it is possible that the change in leaf shape may influence the oviposition behaviour of *Heliothis* females, either causing them to lay fewer eggs on okra leaf plants or to lay them on different structures within the plant. Either change may reduce the efficiency of sampling procedures currently used to estimate egg densities on normal leaf varieties. For example, the SIRATAC program uses a relationship between the proportion of plants infested with eggs and the mean number of eggs per plant to estimate egg densities per metre. This relationship was developed over several seasons from sampling studies on normal leaf cultivars (DP16, DP61). A change in the distribution of eggs between plants on SIOKRA may alter the form of this relationship and so necessitate some modification to tailor the procedure for this variety. Similarly a change in the within-plant distribution of eggs may reduce the validity or accuracy of terminal sampling. As part of a project examining the behaviour of female *Heliothis* in cotton crops we have measured the relative abundance and distributions of *Heliothis* eggs on adjacent commercial blocks of SIOKRA and DP90. These results are presented here.

METHODS.

Egg densities were estimated from whole plant counts on 25 plants in adjacent blocks of SIOKRA and DP90 at 3 sites (ie. 75 plants of each variety each sampling day). Crops were sampled daily from early January to late February and at 2-3 day intervals at other times. This work provided estimates of the proportion of plants infested and the mean number of eggs/plant.

The within-plant distribution of eggs was determined for both varieties throughout the season. Single eggs or groups of eggs were collected into individual containers labelled with the plant number and structure on which the eggs were laid. Eggs were then identified to species using electrophoresis. Seven categories of plant structure were recognised as oviposition sites; upper and lower surfaces of young leaves (UYL,LYL), upper and lower surfaces of old leaves (UOL,LOL), squares (SQ), growing tip (TIP) and stem (STEM). Old and young leaves were distinguished by colour, surface texture and the degree of blade expansion. The category SQUARE includes other fruiting structures such as open flowers and small green bolls, while TIP refers only to the unexpanded or partially expanded leaves surrounding the growing terminal. A total of 2699 eggs were identified and their positions mapped.

RESULTS and DISCUSSION.

Figure 1 shows the relationship between the proportion of plants infested (transformed to LOG_e (1- (1/propn.infested)) and mean eggs per plant, as currently used in SIRATAC, for SIOKRA and DP90. There was no significant difference in the form of this relationship between the varieties. Thus the estimation of egg densities from presence/absence sampling seems equally applicable to normal leaf and okra leaf varieties.

There were, however, significant differences in egg densities between the two varieties (Table 1). Figure 2 gives an example of the seasonal pattern of oviposition on both varieties at one site. At all 3 sites, SIOKRA received significantly fewer eggs than DP90 over the season. Overall there were 26% fewer white eggs and 35% fewer total eggs (white + brown) on SIOKRA, suggesting there may also have been higher mortality of eggs on that variety. Despite these differences, flush counts of moths sheltering in the crops showed similar numbers in each variety (Table 1). Although the numbers of moths flushed need not relate directly to the numbers active during the night, this result suggests that the reduced egg densities on SIOKRA may have resulted from individual females laying fewer eggs on that variety, rather than from fewer moths remaining in these crops.

FIGURE 1. The relationship between the proportion of plants infested (transformed to LOG_e (1-(1/propn. infested)) and the mean number of eggs per plant for Siokra and DP90.

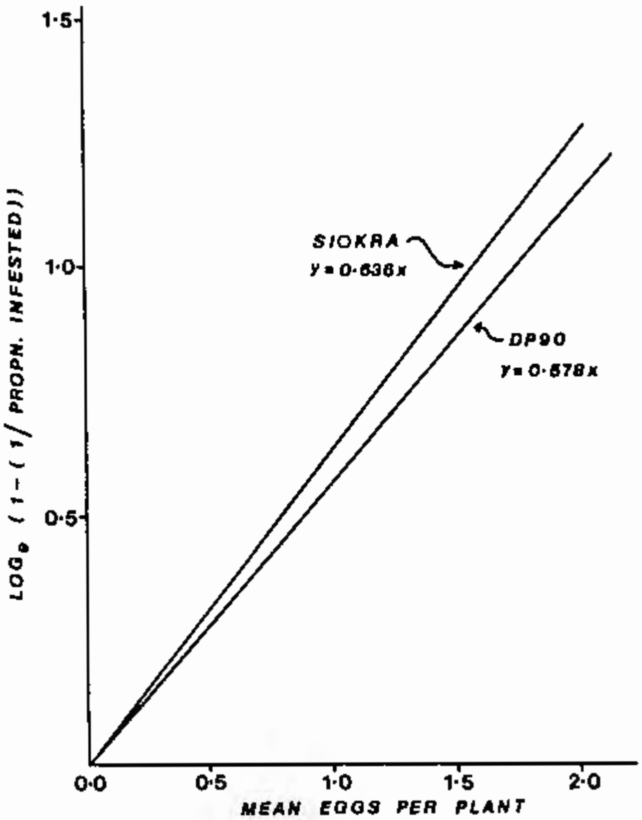


FIGURE 2. Seasonal abundance of *Heliothis* eggs (both species combined) on Siokra and DP90 at Site 1; 1985/86 season.

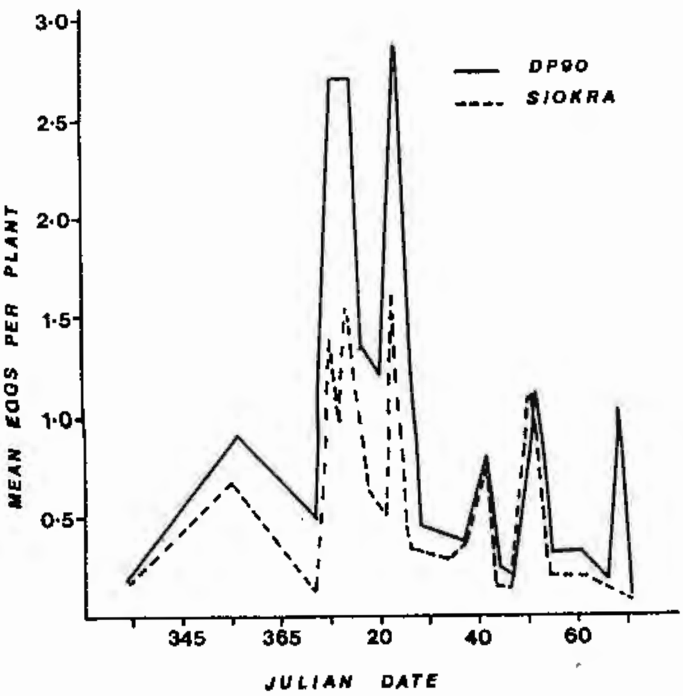


TABLE 1. The average and maximum densities of *Heliothis* eggs (both species) on SIOKRA and DP90 crops at 3 sites.

Site	Variety	No. of checks	Mean WEGGS/ metre	Mean TOTEGGS/ metre	Max. TOTEGGS/ metre	Mean no. moths/200m of row
1	SIOKRA	42	4.05	5.67	16.20	12.51
	DP90	46	5.50	8.15	30.00	11.54
2	SIOKRA	41	2.68	4.39	15.10	9.20
	DP90	46	3.63	6.12	28.90	8.92
3	SIOKRA	33	2.95	4.12	19.22	11.28
	DP90	36	2.92	4.76	30.05	12.90
Mean	SIOKRA	116	3.25	4.78	16.84	10.96
	DP90	128	4.10	6.47	29.65	11.01

There were also highly significant differences between the varieties and between species of *Heliothis* in the distribution of eggs among plant structures (Table 2). Most eggs of both species were laid on either young, newly unfurled leaves (about 35% of all eggs) or older fully, expanded leaves (32%), with the greatest proportion on the upper surfaces. While many of these eggs laid on 'young' leaves were within the terminal area of the plant (the area normally checked for eggs), the high proportion laid elsewhere on the plants, particularly on the older leaves, was surprising. The next most important structures were fruiting points, predominantly squares. However, on SIOKRA both species laid a higher proportion of eggs on the squares and fewer on young leaves, perhaps because of the reduced leaf area and more exposed position of the squares. In addition, *H.armigera* was found to lay significantly more of its eggs on the upper surfaces of old leaves than does *H.punctigera*, while the reverse was true on TIPS and STEMS. This difference between species occurred on both varieties and has also been found on DP61 and SICOT3 (Fitt unpublished results).

TABLE 2. The distribution of eggs by *Heliothis* spp. among plant structures of SIOKRA and DP90 in the field.

Variety	Species of Helio.	UYL	LYL	UOL	LOL	SQ	TIP	STEM	Total eggs
				Plant Structure *					
SIOKRA	H.a %	24.5	2.8	38.0	3.5	25.7	2.4	3.0	460
	H.p %	25.6	8.5	18.7	2.3	24.9	12.4	7.6	727
DP 90	H.a %	31.1	3.1	40.6	3.1	16.7	2.7	2.7	711
	H.p %	32.7	10.5	20.5	4.2	14.5	9.6	8.0	801

* Defined in text. Total eggs 2699

Although overall there were fewer eggs laid on SIOKRA, a surprising result made possible by identifying the eggs, was that the two species of *Heliothis* appear to discriminate between okra-leaf and normal-leaf varieties differently. Measurements of egg density and of the species composition of egglays allowed the egg density of each species to be calculated. This analysis, based on 42 collections spanning the period from mid-December to early March, showed that while *H.punctigera* did not discriminate significantly between the varieties (Table 3), *H.armigera* laid significantly ($p<0.01$) fewer eggs on SIOKRA than on adjacent DP90 crops. The pattern was not restricted to a particular growth stage of the crop, nor to particular sites but occurred consistently throughout the season (Fig.3), even though the proportion of *H.armigera* increased progressively from 15.0% to over 85.0% over the season (Fig. 4). Such differential

FIGURE 3. Mean density (eggs/ plant) of *H. armigera* eggs on Siokra and DP90 crops over the 1985/86 season.

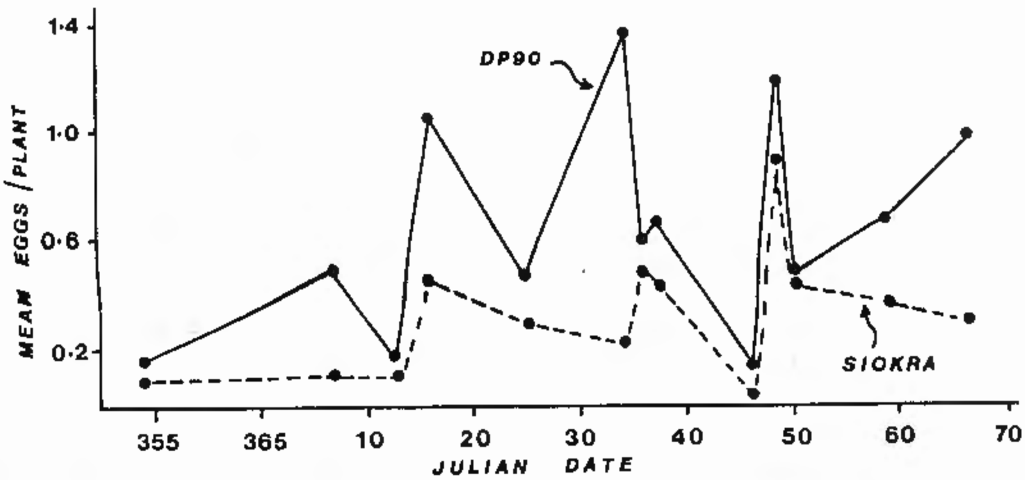
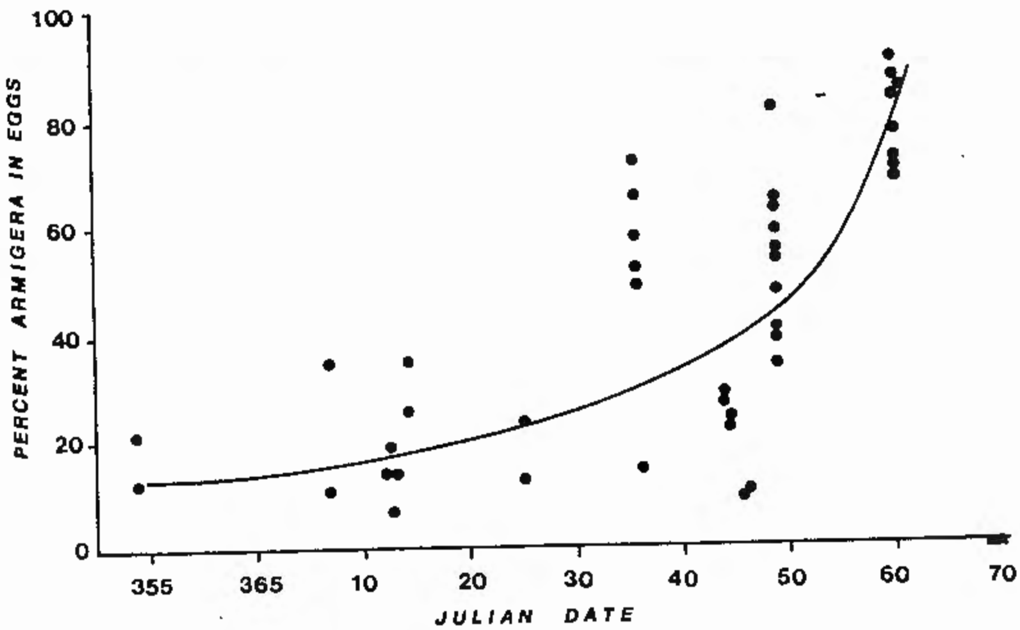


FIGURE 4. The proportion of *H. armigera* in eggs laid on cotton. Namoi Valley, 1985/86 season.



discrimination between varieties has not been noted previously and the underlying mechanism of discrimination is not yet clear. However, it may derive from a combination of *H. armigera's* preference to lay on the upper surfaces of mature leaves (Table 2), and the reduction in leaf area of SIOKRA crops. Okra-leaf reduces the surface area of mature leaves by 30-35%.

TABLE 3. The relative abundance of *H.armigera* and *H.punctigera* eggs on SIOKRA and DP90 cottons.

Variety	Mean % H.armigera over season	Mean Eggs/metre		Relative Density (Siokra/DP90)	
		ARM	PUNC	ARM	PUNC
SIOKRA	37.5	1.64	2.48	0.69 **	0.93 NS
DP90	47.4	2.38	2.68		
% reduction on Siokra		31.10	7.46		

** $p<0.01$, NS = not significant.

While okra-leaf may not confer a high level of resistance against *Heliothis*, these results indicate some interesting and potentially important effects of the okra-leaf character on the behaviour of *Heliothis* moths. The reduced number of eggs laid on the terminals and increased numbers on fruiting structures may necessitate a slight change in the way plants are searched for eggs, with more emphasis on fruiting points. The results also highlight the importance of distinguishing eggs of the two *Heliothis* species in behavioural research.