Feeding Responses of the Cotton Spotted Bollworm, *Earias fabia* STOLL (Lepidoptera : Noctuidae) in Relation to its Establishment on Various Plants

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Feeding responses of *Earias fabia* larvae to various plants and the factors involved were studied to understand differences in the degree of their infestation. The fruits of *Abelmoschus esculentus*, *Gossypium hirsutum*, *Urena lobata* and the inflorescence of *Brassica oleracea botrytis* elicited higher feeding responses than the fruits of *Althaea rosea* and *Zea mays*. There was hardly any response to the fruits of *Pisum sativum*, *Solanum melongena* and *Citrullus vulgaris fistulosus*.

The factors which influenced feeding were certain physical and chemical characters of the plants. The moisture content and texture of a substrate influenced the feeding responses of the insect. The chemical constituents in the test parts of malvaceous plants, the developing seeds of *Z. mays*, the fruit of *C. vulgaris fistulosus* and the inflorescence of *B. oleracea botrytis* favoured feeding whereas those in the fruits of *P. sativum* and *S. melongena* inhibited it. The essential oils, steroids and terpenoids in the developing seeds of *A. esculentus* and *G. hirsutum* acted synergistically and the sugars and amino acids therein had an additive effect in eliciting high feeding responses of *E. fabia* larvae. The interaction of these factors affected the extent of infestation of different plants by the insect.

INTRODUCTION

Earias fabia is a pest of cotton and a few other malvaceous plants (KHAN and RAO, 1960; SOHI, 1964) but all are not equally infested. These differences in infestation may be because the insect can establish itself better on some than on other plants. The prerequisites for establishment on a plant include its suitability for oviposition by the adult insect and its acceptance as food by the larvae emerging from the eggs. Differences in the suitability of various plants for oviposition by *E. fabia* have already been reported (MEHTA and SAXENA, 1970). The extent to which they are accepted as food may be determined by the feeding responses of the larvae to them. The feeding responses of *E. fabia* larvae to various plants and the factors influencing them have therefore been investigated in this work.

MATERIAL AND METHODS

E. fabia was cultured on the developing seeds of okra (*Abelmoschus esculentus*) under laboratory conditions, as described by MEHTA and SAXENA (1970). Groups of 10

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1st instar larvae within 24 hrs of emergence were taken for different experiments.

For studying the feeding responses to plants, the larvae were offered test plant parts on a pad of moist cotton wool in glass jars (10×7.5 cm) at $28-29^\circ\text{C}$ for 24 hrs and then examined under a binocular microscope for the presence of food in the gut which was visible through their translucent integument. For studying the factors governing feeding responses of the insect, the larvae were offered the test substrate coloured with either phenol red or bromophenol blue at four diametrically opposite stations in glass chambers (1.5×5 cm) at 30°C in the dark for 1 hr. When two substrates were tested simultaneously, they were placed alternately and given different colours which were interchanged in different replicates. The red or blue colour of the dye in the larval gut indicated the type of substrate fed. Each experiment was replicated 10 times. The percentage of larvae fed on the test substrate indicated the insect's feeding response to it.

The following plants were tested.

Malvaceae: *Abelmoschus esculentus* MOENCH, *Althaea rosea* CAV., *Gossypium hirsutum* L., *Urena lobata* L.

Gramineae: *Zea mays* L.

Leguminosae: *Pisum sativum* L.

Cruciferae: *Brassica oleracea botrytis* L.

Solanaceae: *Solanum melongena* L.

Cucurbitaceae: *Citrullus vulgaris* SCHRAD. *fistulosus* DUTH. & FULL.

RESULTS

1. Feeding Responses to Plants

Among the malvaceous plants, *A. esculentus* fruit elicited maximum feeding response of the insect (Table 1). The response to the fruits of *G. hirsutum* and *U. lobata* was identical to that for *A. esculentus* fruit but that to *A. rosea* fruit was two third in its comparison. Among the non-malvaceous plants, *B. oleracea botrytis* inflorescence elicited nearly as much feeding response as *A. esculentus* fruit (Table 1). The response to *Z. mays* fruit was next in order. The fruits of *P. sativum*, *S. melongena* and *C. vulgaris fistulosus* were hardly fed.

Table 1. FEEDING RESPONSES OF 1ST INSTAR LARVAE OF *E. fabia* TO DIFFERENT PLANT PARTS

Plant	Part	% larvae fed
<i>A. esculentus</i>	fruit	60.0 ± 6.3
<i>G. hirsutum</i>	"	56.0 ± 6.7
<i>A. rosea</i>	"	42.0 ± 5.8
<i>U. lobata</i>	"	56.0 ± 5.1
<i>Z. mays</i>	"	40.0 ± 3.1
<i>P. sativum</i>	"	0.0 ± 0.0
<i>S. melongena</i>	"	0.0 ± 0.0
<i>C. vulgaris fistulosus</i>	"	0.0 ± 0.0
<i>B. oleracea botrytis</i>	inflorescence	50.0 ± 3.1
l.s.d. at $p=0.01$:		16.3

2. Factors Governing Feeding Responses

The above mentioned differences in the feeding responses of *E. fabia* larvae to different plants could be due to those in their physical and/or chemical characters. The role of both these factors has been investigated.

Role of physical factors

The influence of moisture content and hardness of the substrate on feeding responses of the insect was examined.

Influence of moisture content: The larvae were given dry and moist powders of cellulose and the developing seeds of *A. esculentus* in the form of discs (2×5 mm). The moist powder of each was obtained by adding distilled water (57–65% w/w) to the dry powder. The larval feeding response to the moist powder of each was higher than that to its dry powder (Table 2). This indicated higher suitability of the former for feeding by the insect.

Influence of hardness: The larvae were offered dry powder of the developing seeds of *A. esculentus* in the form of soft and hard pellets (5 mm diam.). The latter were prepared by moistening a lump of dry powder with distilled water and then drying it. The feeding response to the soft pellet was much greater than that to the hard pellet (Table 2) suggesting higher suitability of the former for feeding.

Role of chemical factors

Tests were made with the chemical constituents in different plant parts obtained by either crushing them finely or extracting them with different solvents.

When finely crushed plant parts were offered as pellets (5 mm diam.) to the larvae, the fruits and the developing and mature seeds of *A. esculentus* and *G. hirsutum* and the fruits of *A. rosea* and *U. lobata* elicited high and identical feeding responses (Table 3). The response to the developing seed of *Z. mays* was slightly higher but that to *B. oleracea botrytis* inflorescence identical to that for the developing seed of *A. esculentus*. The responses to the fruits of *C. vulgaris fistulosus*, *S. melongena* and *P. sativum* were low.

In order to know the chemical constituents which elicited high feeding responses of the insect, the developing seeds of *A. esculentus* and *G. hirsutum* were dried, pulverized and extracted with different solvents (Fig. 1). Each fraction was impregnated in cellulose powder so that its concentration per unit weight of cellulose was the same as in the test plant part. The cellulose impregnated with the test extract was dyed and moistened to form pellets (5 mm diam.) which were offered to the larvae with similar pellets of unimpregnated cellulose powder as blank. The relative feeding response of the insect to each test fraction was indicated by the percentage of larvae fed on it

Table 2. FEEDING RESPONSES OF 1ST INSTAR LARVAE OF *E. fabia* TO SUBSTRATES DIFFERING IN PHYSICAL CHARACTERS

Test substrate	% larvae fed	l. s. d. at p=0.05
Dry powder of cellulose	0.0±0.0	5.5
Moist powder of cellulose	9.0±2.4	
Dry powder of the developing seeds of <i>A. esculentus</i>	64.0±3.0	7.3
Moist powder of the developing seeds of <i>A. esculentus</i>	73.0±1.2	
Soft pellet of <i>A. esculentus</i> developing seed powder	64.0±2.9	6.6
Hard pellet of <i>A. esculentus</i> developing seed powder	0.0±0.0	

Table 3. FEEDING RESPONSES OF 1ST INSTAR LARVAE OF *E. fabia* TO FINELY CRUSHED PARTS OF PLANTS

Malvaceous plant parts	% larvae fed	Non-malvaceous plant parts	% larvae fed
<i>A. esculentus</i> fruit	79.0±6.9	<i>A. esculentus</i> developing seed ^b	61.0±5.5
<i>A. esculentus</i> developing seed	61.0±5.5	<i>Z. mays</i> developing seed	79.0±1.0
<i>A. esculentus</i> mature seed ^a	53.0±7.5	<i>P. sativum</i> fruit	6.0±1.8
<i>G. hirsutum</i> fruit	45.0±5.2	<i>S. melongena</i> fruit	17.4±4.6
<i>G. hirsutum</i> developing seed	62.0±3.7	<i>C. vulgaris fistulosus</i> fruit	46.0±2.4
<i>G. hirsutum</i> mature seed ^a	62.0±3.7	<i>B. oleracea botrytis</i> inflorescence	54.0±2.9
<i>A. rosea</i> fruit	62.0±4.9		
<i>U. lobata</i> fruit	62.0±3.7		
l.s.d. at p=0.01:			13.2

^a soaked in water.^b included for comparison.

Fig. 1. Scheme of extraction of the test plant part with different solvents.

in excess of that on the blank.

Among different fractions of the developing seeds of *A. esculentus* and *G. hirsutum*, the fraction A (extracted with petroleum ether b.p. 40–60°C) containing essential oils, steroids and terpenoids (Table 4) and fraction Bb1 (extracted with 80% ethanol) containing sugars and amino acids (Table 4) elicited much higher feeding response than the blank (Table 5). The response was low for the fraction Ba or the residue (fraction Bb2) left after 80% ethanol extraction (Table 5). Petroleum ether soluble constituents of both the test plant parts were further fractionated by column chromatography (Fig. 1) to obtain fraction Aa containing the essential oils and fraction Ab1 containing the steroids and terpenoids (Table 4). The feeding response to each of these fractions was considerably lower than that for the parent fraction A (Table 5).

The above results suggest synergism among the essential oils, steroids and terpenoids and an additive effect of the 80% ethanol soluble substances of the test plant parts in eliciting high feeding responses of *E. fabia* larvae.

Table 4. CHEMICAL CONSTITUENTS DETECTED IN CERTAIN FRACTIONS EXTRACTED FROM THE TEST PLANT PARTS

Type of compounds	Reagents	Test fractions ^a							
		Developing seed of <i>A. esculentus</i>				Developing seed of <i>G. hirsutum</i>			
		A	Aa	Ab ₁	Bb ₁	A	Aa	Ab ₁	Bb ₁
Terpenoids, Steroids, Essential oils	20% antimony pentachloride in carbon tetrachloride (BOBBITT, 1963)	+	+	+	—	+	+	+	—
Terpenoids	1% vanillin in conc. sulphuric acid (BOBBITT, 1963)	+	—	+	—	+	—	+	—
Diterpenoids	0.25% aqueous potassium permanganate (BOBBITT, 1963)	+	—	+	—	+	—	+	—
Triterpenes, Cardiac aglycones	Chlorosulphonic acid-acetic acid (1 : 2) (BOBBITT, 1963)	+	—	+	—	+	—	+	—
Steroids	Antimony trichloride-acetic acid (1 : 1) (BOBBITT, 1963)	+	—	+	—	+	—	+	—
Reducing sugars	Benzedine-trichloro acetic acid (BLOCK <i>et al.</i> , 1958)	—	—	—	+	—	—	—	+
Aldehydes, Ketones	1% <i>o</i> -dianisidine in acetic acid (BOBBITT, 1963)	—	—	—	+	—	—	—	+
Amino acids	0.25% ninhydrin in acetone (BLOCK <i>et al.</i> , 1958)	—	—	—	+	—	—	—	+

^a names of fractions as in Fig. 1.Table 5. RELATIVE FEEDING RESPONSES OF 1ST INSTAR LARVAE OF *E. fabia* TO CHEMICAL CONSTITUENTS EXTRACTED FROM CERTAIN PARTS OF PLANTS

Test fractions ^a	Relative feeding response ^b	
	Developing seed of <i>A. esculentus</i>	Developing seed of <i>G. hirsutum</i>
Whole plant part	+60.0±12.6	+38.0± 2.0
Fraction A	+88.8± 7.0	+53.3±13.5
Fraction B	+10.6± 1.9	+15.3± 1.8
Fraction Aa	—17.5± 1.0	—20.6± 2.5
Fraction Ab ₁	—44.6± 1.4	—26.6± 4.1
Fraction Ba	—82.9± 2.5	—70.8± 3.2
Fraction Bb	+17.6± 1.5	+19.0± 4.8
Fraction Bb ₁	+93.3± 6.7	+43.5± 7.0
Fraction Bb ₂	—80.3± 1.4	—71.1± 3.2
l.s.d. at p=0.01:	11.1	22.8

^a names of fractions as in Fig. 1.^b expressed as: (% larvae fed on the test substrate) — (% larvae fed on blank). + value denotes higher and — value lower feeding response to the test substrate in comparison to the blank.

DISCUSSION

Acceptance of plants as food by a phytophagous insect is a prerequisite for its maintenance and propagation and hence its establishment on them. The physical and chemical characters of a plant which influence its feeding responses would therefore affect the degree of infestation of that plant. The physical characters of a plant do permit or inhibit feeding by insects (THORSTEINSON, 1960; BECK 1965) but its chemical characters are regarded to play a more important part (DETHIER, 1966). The extent to which the physical and the chemical characters of plants interact to influence feeding responses of *E. fabia* larvae may be considered in the light of the present work.

Among the physical characters of plants, the moisture content promotes feeding by *E. fabia* larvae but it can hardly be responsible for their susceptibility or resistance as most of them are identical in this respect. Differences in texture and chemical constituents of plants may however explain differences in the insect's feeding responses to them. The texture and chemical constituents of *A. esculentus*, *G. hirsutum*, *A. rosea* and *U. lobata* help to elicit high feeding responses of *E. fabia* and hence make these plants susceptible. The physical and chemical characters of *Z. mays* and *B. oleracea botrytis* though favourable for feeding, the failure of *E. fabia* larvae to grow on both (unpublished observations) may check their infestation. Comparison of the feeding responses of the insect to the whole and finely crushed fruit of *C. vulgaris fistulosus* suggests that its physical texture may offer resistance to its infestation. On the other hand, the unfavourable texture and the chemical inhibitors for feeding in *P. sativum* and *S. melongena* render them resistant.

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