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Effect of okra fruit blocks, seeds and pericarp on post-embryonic development of *Earias vittella* (Fab.) in relation to some phytochemicals of selected okra genotypes

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Abstract. Post-embryonic development of the spotted bollworm, *Earias vittella* (Fab.) studied on pericarp, seeds and fruit blocks of 8 okra genotypes, revealed significant differences in larval survival, larval period, pupation and adult emergence among genotypes as well as fruit components. First instar larval survival on fruit components was in the order of fruit blocks > seeds > pericarp > axil. Mean total developmental period was 24·20, 21·33 and 21·09 days on pericarp, seeds and fruit blocks, respectively. Likewise pupation was 25·30, 65·42 and 71·58% on pericarp, seeds and fruit blocks, respectively. Primary phytochemicals, like protein, free amino acids, total sugars, non-reducing sugars and moisture content in pericarps were in higher concentrations in comparison to seeds and whole fruits. These compounds also differed significantly among genotypes. There were positive correlations between the pest survival and these nutritional compounds. Tannins were 0·35, 0·23 and 0·29% in pericarp, seeds and whole fruits, respectively. Tannin content was significantly higher in pericarps of tolerant genotypes and showed significant negative correlation ($r = -0·81$) with fruit borer survival.

Keywords. Okra; *Earias*; phytochemicals; pericarp; post-embryonic; genotype; antibiosis; nutrition.

1. Introduction

Okra (*Abelmoschus esculentus* (L.) Moench), an important vegetable grown in India, is attacked by over 37 insect species (Nayar *et al* 1976). Among these, shoot and fruit borer (*Earias vittella* (Fab.)) also popularly known as spotted bollworm of cotton is the most ubiquitous, causing damage to okra fruits to the extent of 90% (Krishnaiah *et al* 1976). Okra fruit components like epicarp, seeds, cut pieces and whole fruit have been reported to affect developmental behaviour and reproductive potential of this pest (Vishwapremi and Krishna 1974a, b). The poor reproductive potential of this fruit borer on epicarp was attributed to less number of free amino acids and lower concentration of water soluble proteins in epicarp when compared to seeds (Mani *et al* 1986). The present study report the influence of different okra fruit components on survival and development of *E. vittella* in relation to some phytochemicals of susceptible and tolerant okra genotypes.

2. Materials and methods

The okra genotypes, viz KS-305 and Line 14–78 which had tolerance and the genotypes, viz Pusa Sawani, Lam hybrid, AC-302, AC-333, Vashalivadu and Sel-2 which

had the susceptible reactions to the attack of this borer under field conditions (Singh 1985) were selected to carryout the following studies.

2.1 *Insect survival and development*

Survival of first instar larvae was studied on 4 different components viz pericarp, seeds, axil (placenta) and fruit blocks (2 cm long) of 4–5 day old fruits in separate aerated plastic containers (10 × 5 cm) in 3 replications. Freshly hatched 10 larvae per container were released and kept in BOD incubator at 30 ± 1°C. The food was changed on alternate days and observations on surviving larvae were recorded after 4 days of their release. In another set, similarly rearing of first instar larvae was carried out till pupation. Data were then recorded on larval, pupal, total (larval + pupal) developmental periods, pupation and adult emergence. Growth indices for larval and total developmental periods were calculated by the following formulae (Sharma *et al* 1982).

$$\text{Larval growth index} = \frac{\text{Pupation (\%)}}{\text{Mean larval period (days)}}$$

$$\text{Total developmental growth index} = \frac{\text{Adult emergence (\%)}}{\text{Mean total developmental period (days)}}$$

2.2 *Phytochemical estimations*

Okra fruits, 4–5 days old, were sampled during last week of August at peak period of insect incidence. Along with whole fruits, pericarp and seeds were oven dried separately at 60°C for 48 h. These were ground in a Willey grinding mill to pass them through 20 mesh seive. Axil portion of the fruit was not collected for phytochemical estimations, because it constitutes less than 10% of the total fruit weight (Singh 1985) and is also of less importance in influencing insect incidence. Moisture content was estimated by drying the fresh fruits and their components in an oven at 70°C for 48 h. Total sugars were extracted in distilled water by following the method of Srinivasan and Bhatia (1953) and estimated according to the method of Yemm and Willis (1954). Reducing sugars were estimated by the method of Somogyi (1952). Free amino acids were extracted according to Barnett and Naylor (1969) and estimated by Yemm and Cocking (1955). For proteins estimation, initially total nitrogen was determined by micro-Kjeldahl's method (AOAC 1970) and nitrogen percentage was multiplied by 6·25. Tannin content was estimated according to the method of Burns (1971). These phytochemicals were expressed as per cent of dry weight of the sample taken. The data were analysed and simple correlations of phytochemicals were worked out with pest survival.

3. Results

3.1 *Insect survival and development*

Table 1 shows that mean survival of first instar larvae was maximum (67·49%) on okra fruit blocks followed by seeds (59·58%), pericarp (28·33%) and axil (10·42%).

Table 1. Survival of first instar larvae of bollworm on different fruit parts of okra genotypes.

Genotype	Larval survival (%)			
	Pericarp	Axil	Seeds	Fruit block
Pusa sawani	26·67 (30·94)	13·33 (21·14)	63·33	66·66
Lam hybrid	63·33 (52·78)	26·67 (30·94)	46·66	76·66
AC-302	36·67 (37·22)	0·00 (3·63)	76·66	86·66
AC-333	33·33 (35·22)	23·33 (28·78)	66·66	76·66
Sel-2	33·33 (35·22)	6·67 (13·49)	66·66	73·33
Vashalivadu	26·67 (30·99)	13·39 (21·14)	70·00	70·00
KS-305	6·67 (12·29)	0·00 (3·63)	43·33	46·66
Line 14–78	0·00 (3·63)	0·00 (3·63)	43·33	43·33
Average	28·33	10·42	59·58	67·49
SEM	(2·23)	(2·46)	3·12	3·24
CD at 5%	(6·78)	(7·47)	9·46	9·84

Figures in parantheses are angular values.

Hence axil portion was least suitable in all genotypes with no larval survival on KS-305, Line 14–78 and AC-302. Larval survival on pericarpic region of tolerant genotypes was specifically poor where it ranged from 0·0–6·67% only. Pericarpic region of Lam hybrid was most suitable, where larval survival was upto 63·33%. Seed portion of all genotypes supported 43·33–76·66% larvae to survive. However, best survival of the larvae was recorded on fruit blocks.

The results of elaborate studies on the post-embryonic development of the pest are given in table 2. Feeding of larvae on pericarp of tolerant genotype KS-305 prolonged total developmental period to the extent of 5 days in comparison to Vashalivadu. None of the larvae survived on pericarp of Line 14–78. The per cent pupation (40) and adult emergence (95) were recorded to be the highest on Lam hybrid. As a result, this genotype also manifested highest total growth index (4·15). Poorest growth index (1·87) was observed on tolerant KS-305. Total developmental period on seeds of different genotypes ranged from 19·15–22·86 days. Tolerant genotypes showed slightly longer developmental period than susceptible ones. Pupation ranged from 20–90·65%, adult emergence 52·50–96·0% and total growth index 1·78–4·93 in different genotypes. Total developmental period on fruit blocks of test genotypes varied between 18·25 (Lam hybrid) and 25·25 (Line 14–78) days. Pupation (30·35%), adult emergence (30·00%) and total growth index (1·00) were also lowest on tolerant genotype Line 14–78. Highest adult emergence (100%) and total growth index (5·48) were recorded on Lam hybrid.

3.2 *Phytochemical variations*

Data on biochemical analysis are given in table 3. The concentrations of phytochemicals in pericarps varied significantly except moisture level, where proteins ranged from 13·85–17·90, free amino acids 2·52–4·05, total sugars 5·00–10·75, reducing sugars 1·75–3·75, non-reducing sugars 3·25–7·08, moisture content 90·85–92·60 and tannins 0·20–0·61% in tested genotypes. In seeds, proteins varied from 13·25–18·37, free amino acids 1·92–3·04, total sugars 4·35–10·50, reducing sugars

Table 2. Effect of feeding on okra fruit components on post-embryonic development of spotted bollworm in okra genotypes.

Fruit component	Genotype	Developmental period (days) Larval $\bar{X} \pm SE$	Pupal $\bar{X} \pm SE$	Total $\bar{X} \pm SE$	Pupation (%)	Larval growth index	Adult emergence (%)	Total growth index
	Pusa sawani	12·42 ± 0·4	11·23 ± 1·6	22·79 ± 2·1	10·70	0·86	90·50	3·80
	Lam hybrid	11·33 ± 0·7	10·67 ± 0·8	22·90 ± 1·4	40·00	3·53	95·00	4·15
Pericarp	Vashalivadu	11·24 ± 0·3	10·63 ± 0·4	22·00 ± 1·6	30·00	2·67	70·80	3·22
	AC-302	11·44 ± 0·6	12·50 ± 1·2	24·74 ± 1·4	35·50	3·10	90·50	3·66
	AC-333	12·86 ± 0·6	11·33 ± 0·7	24·38 ± 1·4	20·50	1·54	60·60	2·49
	Sel-2	13·79 ± 0·2	12·67 ± 1·1	25·79 ± 2·4	15·40	1·12	80·00	3·10
	KS-305	13·63 ± 0·2	12·50 ± 0·4	26·80 ± 0·9	25·00	1·83	50·00	1·87
	Line 14–78	0·00	0·00	0·00	0·00	0·00	0·00	0·00
Average		12·39	11·65	24·20	25·30	2·09	76·77	3·18
	Pusa sawani	9·25 ± 0·2	10·14 ± 0·6	19·75 ± 1·2	65·50	7·00	95·30	4·82
	Lam hybrid	9·45 ± 0·3	12·35 ± 0·8	22·70 ± 1·4	70·40	7·45	90·50	3·98
Seeds	Vashalivadu	8·50 ± 0·2	10·32 ± 0·4	19·15 ± 1·3	85·50	10·06	80·00	4·18
	AC-302	8·20 ± 0·4	10·45 ± 0·3	19·45 ± 1·4	90·00	10·98	96·00	4·93
	AC-333	10·90 ± 0·2	11·50 ± 0·2	22·79 ± 1·6	75·35	6·91	70·40	3·09
	Sel-2	10·33 ± 0·8	10·41 ± 0·4	21·25 ± 2·1	90·65	8·78	94·00	4·42
	KS-305	10·55 ± 0·7	12·65 ± 0·6	22·86 ± 1·3	25·50	2·42	40·60	1·78
	Line 14–78	9·90 ± 0·2	12·70 ± 0·8	22·70 ± 1·8	20·50	2·07	52·50	2·31
Average		9·63	11·31	21·33	65·42	6·96	77·41	3·69
	Pusa sawani	9·75 ± 0·6	12·24 ± 0·7	21·75 ± 2·7	80·25	7·13	80·00	3·33
	Lam hybrid	8·50 ± 0·5	9·50 ± 0·2	18·25 ± 1·3	84·65	9·96	100·00	5·48
Fruit	Vashalivadu	8·50 ± 0·2	9·55 ± 0·2	18·55 ± 1·3	65·40	7·69	96·40	5·20
blocks	AC-302	9·25 ± 0·2	12·20 ± 0·9	22·20 ± 2·6	90·45	9·78	94·00	4·23
	AC-333	8·20 ± 0·2	9·60 ± 0·8	18·63 ± 1·4	85·50	10·43	100·00	5·37
	Sel-2	9·10 ± 0·8	10·15 ± 0·7	20·10 ± 1·7	70·50	7·75	98·50	4·90
	KS-305	11·25 ± 0·1	12·25 ± 0·8	24·00 ± 2·4	65·60	6·73	85·50	3·93
	Line 14–78	12·50 ± 0·3	13·15 ± 0·6	25·25 ± 3·2	30·35	2·43	30·00	1·00
Average		9·63	11·08	21·09	71·58	7·74	85·55	4·18

1·28–5·12, moisture 87·63–91·43 and tannins 0·12–0·39% with significant differences among genotypes. However, in seeds, moisture level did not differ significantly. With regard to biochemical analysis of whole fruits, proteins ranged from 13·35–17·25, free amino acids 2·00–3·40, total sugars 4·46–10·31, reducing sugars 1·29–4·92, moisture 88·00–91·80 and tannin content 0·17–0·49% in different genotypes.

4. Discussion

Pericarpic region of okra fruit is very important from the angle of fruit borer attack, because it directly comes into contact with insect eggs, larvae and even adults. Female moths prefer to lay more eggs on hairy surface of pericarp (Singh 1985). Larvae also initially feed and penetrate through this portion. Irrespective of the genotypes, feeding of larvae exclusively on pericarp resulted in poor survival, longer larval period, less pupation and poor larval growth index in comparison to seeds and fruit blocks. These observations are in accordance with that of Vishwapremi and Krishna (1974a, b) who also reported longer larval period and poor reproductive

Table 3. Quantitative variations in biochemicals of okra fruit components in different genotypes.

Fruit component	Genotype	Protein (%)	Free amino acids (%)	Total sugars (%)	Reducing sugars (%)	Non-reducing sugars (%)	Moisture (%)	Tannin (%)
	Pusa sawani	16·12	2·71	8·50	2·50	6·00	92·60	0·24
	Lam hybrid	17·90	3·12	8·20	2·65	5·55	91·19	0·24
Pericarp	Vashalivadu	16·25	4·04	5·00	1·75	3·25	91·58	0·26
	AC-302	16·00	2·64	9·50	2·42	7·08	91·01	0·20
	AC-333	16·50	2·74	8·50	2·55	5·95	90·90	0·20
	Sel-2	14·65	2·84	10·75	3·75	7·00	91·75	0·42
	KS-305	15·25	2·61	7·50	2·48	5·02	90·85	0·60
	Line 14–78	13·85	2·52	6·50	2·45	4·05	91·79	0·61
Average		15·81	2·90	8·06	2·57	5·49	91·46	0·35
SEM ±		0·14	0·05	0·12	0·06	0·14	N.S.	0·01
C D at 5%		0·40	0·16	0·35	0·18	0·56	—	0·04
	Pusa sawani	15·40	1·92	6·50	2·85	3·65	91·43	0·14
	Lam hybrid	14·65	2·46	7·00	2·55	4·45	89·85	0·20
Seeds	Vashalivadu	18·37	3·04	4·35	1·28	3·07	90·88	0·12
	AC-302	16·25	2·06	6·35	2·75	3·60	87·63	0·19
	AC-333	17·25	2·28	6·25	2·84	3·41	89·23	0·13
	Sel-2	13·25	2·12	10·50	5·12	5·38	90·32	0·31
	KS-305	13·75	2·35	6·25	2·75	3·50	89·00	0·39
	Line 14–78	14·50	2·01	5·25	2·25	3·00	89·15	0·35
Average		15·43	2·27	6·56	2·80	3·76	89·69	0·23
SEM ±		0·13	0·06	0·10	0·08	0·11	N.S.	0·01
C D at 5%		0·39	0·21	0·30	0·21	0·36	—	0·03
	Pusa sawani	15·54	2·00	7·01	2·67	4·34	90·70	0·17
	Lam hybrid	15·64	2·65	7·28	2·80	4·48	88·00	0·21
Whole	Vashalivadu	17·25	3·40	4·46	1·29	3·17	91·30	0·17
fruits	AC-302	16·53	2·10	7·08	2·60	4·48	88·10	0·20
	AC-333	16·78	2·44	6·79	2·74	4·05	90·40	0·17
	Sel-2	13·79	2·46	10·31	4·92	5·39	91·80	0·40
	KS-305	14·56	2·43	6·60	2·66	3·94	88·24	0·48
	Line 14–78	13·35	2·32	5·53	2·38	3·15	88·90	0·49
Average		15·43	2·47	6·88	2·76	4·12	89·68	0·29
SEM ±		0·15	0·04	0·11	0·03	0·12	N.S.	0·01
CD at 5%		0·43	0·12	0·34	0·08	0·35	—	0·04

Table 4. Simple correlation between phytochemicals of okra fruit components and spotted bollworm survival.

	Correlation coefficient (r)		
Phytochemical	Pericarp	Seeds	Fruit blocks
Moisture	0·60	0·58	0·74*
Total sugars	0·45	0·54	0·35
Reducing sugars	0·35	0·39	0·25
Non-reducing sugars	0·55	0·41	0·46
Protein	0·42	0·38	0·36
Free amino acids	0·15	0·11	0·01
Tannin	−0·81*	−0·46	−0·56

potential due to larval feeding on pericarp. To support the normal growth of insect, primary plant chemicals (Hsiao 1974) like proteins, amino acids, sugars and moisture contents appeared to be in sufficient amounts in pericarpic region of okra fruits. In addition, concentrations of total sugars, non-reducing sugars and amino acids were higher in pericarp than seeds and whole fruits which indicated better phagostimulatory activity for the pest. Such facts are in accordance with the views of Thorsteinson (1958). But qualitatively pericarp has been reported to be inferior to okra seeds with respect to free amino acids and water soluble proteins (Mani *et al* 1986). However, there is need to investigate quantitative differences among different essential and non-essential amino acids present in pericarp and seeds. Similar to present studies from sugars point of view, Mani *et al* (1986) also did not find pericarp inferior to seeds. Under utilization of nutritional compounds may also be due to the presence of some antinutritional factors in higher amounts in pericarpic portion. Tannin was found to be higher in pericarp (0·35%) than seeds (0·23%) and whole fruit (0·29%). Antibiosis property of tannins have been reported against a number of pests (Bennett 1965; Maxwell *et al* 1967; Feeny 1968). Tannins react with digestive enzymes and other proteins in insects thereby reducing the nutritive value of the ingested foods (Chan *et al* 1978). They may also act as feeding inhibitors (Sharma and Agarwal 1981). This antibiotic compound was further significantly higher in pericarps of tolerant genotypes in comparison to susceptible ones. However, in present studies, tannin content in okra fruits did not exceed 0·49% which may not be sufficient to induce complete antibiosis. Chan *et al* (1978) reported 3·4% tannin in cotton squares of *Heliothis armigera* F. resistant genotypes. Against *E. vittella*, Sharma *et al* (1982) estimated 1·96% tannin in bolls of least suitable genotype. Hence tannin effects may be supplemented through the inferior quality of free amino acids and water soluble proteins in epicarp as reported by Mani *et al* (1986).

With regard to developmental parameters on seeds and fruit blocks, the overall differences between larval period, pupal and total developmental period and growth indices were negligible. However, pupation on fruit blocks (71·58%) was better than on seeds (65·42%). It was probably due to better pupation site or thigmotactic stimulus offered by fruit blocks. Vishwapremi and Krishna (1974a) also reported shortest pupal period and heaviest pupal weight for the larvae reared on fruit cut pieces in comparison to whole fruit, seeds and epicarp. Contrary to this, okra seeds showed better reproductive potential (Vishwapremi and Krishna 1974b; Ambegaonkar and Bilapate 1982).

Moisture content, total sugars, reducing sugars, non-reducing sugars, proteins and free amino acids of pericarp, seeds and whole fruits of okra genotypes were positively correlated with pest survival (table 4). Among these, only moisture content of whole fruit had positive and significant ($r = 0{\cdot}74$) correlation with fruit borer survival. Tannins of pericarp, seeds and whole fruits showed negative correlation with pest survival.

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