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Role of chemical components of resistant and susceptible genotypes of cotton and okra in ovipositional preference of cotton leafhopper

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Abstract. Ovipositional preference of cotton leafhopper, *Amrasca biguttula biguttula* (Ishida) on resistant and susceptible genotypes of cotton and okra was found under the influence of chemical components. The non-reducing sugars, tannins, silica and free gossypol in the leaves showed significant and negative correlation with the number of leafhopper eggs.

Keywords. *Amrasca biguttula biguttula*; oviposition; cotton; okra; biochemicals; resistance.

1. Introduction

Cotton leafhopper *Amrasca biguttula biguttula* (Ishida) causes heavy damage by desapping the leaves (Joyce 1961) in cotton and okra in India (Rawat and Sahu 1973; Bhat *et al* 1984), Thailand (Mabbett *et al* 1984) and Pakistan (Ahmad *et al* 1986). There is very little movement of leafhopper nymphs between leaves (Mabbett *et al* 1984) and remain confined to hatching plants. Ovipositing females also ensure the quality of food for proper growth and development of nymphs (Agarwal and Krishnananda 1976; Singh 1985). The differential survival of the pest on resistant and susceptible varieties has been attributed mainly to nutritional and anti-nutritional factors (Uthamasamy 1986; Singh 1987a; Singh 1988) as well as hairiness of leaves (Tidke and Sane 1962; Batra and Gupta 1970). More number of eggs were laid by females on susceptible genotypes as compared to resistant ones in relation to physical characters of leaf (Yadav *et al* 1967; Agarwal and Krishnananda 1976; Khan and Agarwal 1984). Present investigations were carried out to correlate the ovipositional preference of this pest to host suitability in terms of nutritional and antinutritional factors.

2. Materials and methods

Three genotypes each of cotton *Gossypium hirsutum* Linn. viz. BJR-741 (highly resistant), XG-15 USA (moderately resistant) and Acala 4–42 (highly susceptible) and okra viz. *Abelmoschus moschatus* (Linn.) Medic. (highly resistant), Sel-2 (moderately resistant) and AC-302 (highly susceptible) were used at the peak period (August) of leafhopper incidence (Singh 1985).

2.1 *Ovipositional preference*

Thirty leafhopper adults (female : male, 2 : 1) collected from the susceptible variety of okra in an aspirator were released in muslin cloth cages enclosing the third expanded leaf from the top in the field. In each genotype, 10 leaves on 10 plants were enclosed and exposed to oviposition for 48 h. Then the leaves were plucked and processed in lectophenol solution (Moffitt and Reynolds 1972) to record the number of eggs laid. The experiment was repeated twice at 3 days interval.

2.2 *Biochemical analyses*

Healthy leaves of each genotype of both crops were used to estimate total sugars (Srinivasan and Bhatia 1953; Yemm and Willis 1954), reducing sugars (Somogyi 1952), free amino acids (Barnett and Naylor 1969; Yemm and Cocking 1955), proteins (AOAC 1970), tannins (Burns 1971) and silica through digestion with triacid mixture. In addition, free gossypol was estimated only in cotton leaves (Mathur *et al* 1972). Fresh leaves were also oven dried at 70°C for 48 h to estimate moisture level. Simple correlations were worked out between the number of eggs laid and amount of various phytochemicals.

3. Results

3.1 *Ovipositional preference*

As evident from the data in table 1, leafhopper females laid significantly more number of eggs in highly susceptible Acala 4–42 (57 eggs/leaf) as compared to highly resistant BJR-741 (14 eggs/leaf) in cotton. Moderately resistant genotype XG-15 USA received intermediate number of eggs (25 eggs/leaf) which was on par with BJR-741. In okra also, highly susceptible AC-302 harboured 162 eggs/leaf which were significantly higher than highly resistant *A. moschatus* (9 eggs/leaf).

3.2 *Biochemical analyses*

Highly susceptible genotype Acala 4–42 of cotton had higher amounts of reducing sugars (2·55%), proteins (18·49%), free amino acids (10·15 mg/g) as compared to highly resistant BJR-741 containing 1·63% reducing sugars, 13·45% proteins and 6 mg/g free amino acids (table 1). In addition, highly susceptible genotype also had significantly lower amounts of antinutritional factors like tannins (15·30 mg/g), free gossypol (6·13 mg/g) and silica (0·7%) as compared to resistant genotypes. In okra also highly susceptible AC-302 contained significantly higher amounts of proteins (26·36%) and free amino acids (8·8 mg/g) and lower amounts of non-reducing (1·94%) and total sugars (2·19%), tannins (13·33 mg/g) and silica (2·1%) as compared to resistant genotypes. Moisture content in both crops did not vary significantly among genotypes.

3.3 *Correlation studies*

Among the principal nutrients (table 2) only non-reducing sugars had significant negative correlation with leafhopper eggs in cotton ($r = -0{\cdot}72$) and okra

Table 1. Quantitative variations in the phytochemicals in leaves of cotton and okra genotypes in relation to ovipositional preference of leafhopper.

Host	Genotype	Average no. of eggs/leaf	Moisture (%)	Sugars (%) Reducing	Sugars (%) Non-reducing	Sugars (%) Total	Protein (%)	Free amino acids (mg/g)	Tannin (mg/g)	Free gossypol (mg/g)	Silica (%)	Rating
Cotton	BJR-741	14	71·47	1·63	1·33	2·96	13·45	6·00	23·03	24·01	2·1	HR[a]
	XG-15 USA	25	74·33	1·25	1·27	2·52	16·52	6·83	32·70	36·89	1·7	MR[b]
	Acala 4-42	57	71·55	2·55	0·13	2·68	18·49	10·15	15·30	6·13	0·7	HS[c]
	SE	5·2	NS	0·04	0·09	0·08	0·42	0·25	0·23	0·37	0·07	
	CD ($P=0·05$)	12·5	—	0·13	0·26	0·24	1·27	0·75	0·70	1·12	0·21	
Okra	*A. moschatus*	9	80·90	0·22	5·17	5·39	19·80	4·70	32·05	—	6·0	HR[a]
	Sel-2	40	82·48	0·45	3·94	4·39	19·14	4·30	17·45	—	4·3	MR[b]
	AC-302	162	83·27	0·25	1·94	2·19	26·36	8·80	13·33	—	2·1	HS[c]
	SE	10·0	NS	0·01	0·11	0·11	0·36	0·31	0·42		0·14	
	CD ($P=0·05$)	25·6	—	0·04	0·35	0·34	1·11	0·94	1·29		0·30	

[a]HR, Highly resistant; [b]MR, moderately resistant; [c]HS, highly susceptible.
NS, Not significant.

Table 2. Correlation of leaf phytochemicals with leafhopper eggs in cotton and okra genotypes.

	Cotton		Okra	
Phytochemical	*r* value	Regression equation	*r* value	Regression equation
Moisture	0·04	—	0·10	—
Reducing sugars	0·12	—	0·01	—
Non-reducing sugars	−0·72[b]	Y = 59·29 − 29·96X	−0·65[a]	Y = 242·47 − 46·73X
Total sugars	−0·08	—	−0·25	—
Protein	0·31	—	0·29	—
Free amino acids	0·42	—	0·38	—
Tannins	−0·62[a]	Y = 72·47 − 1·71X	−0·71[a]	Y = 208·85 − 6·64X
Free gossypol	−0·81[b]	Y = 57·08 − 1·123X	—	—
Silica	−0·25	—	−0·63[a]	Y = 231·96 − 39·10X

n = 72 (4 independent estimations in each of 3 replications in 6 genotypes).
[a]Significant at 5% level. [b]Significant at 1% level.

($r = -0{\cdot}65$). Tannin content in cotton ($r = -0{\cdot}62$) and okra ($r = -0{\cdot}71$) and free gossypol content in cotton leaves ($r = -0{\cdot}81$) deterred egg laying showing significant negative correlations. Adverse effects of silica in both crops were also pronounced.

4. Discussion

An array of factors govern the maintenance of insect host plant relations (Kogan 1975). Of these, physical and chemical plant factors play key role in selecting a suitable host plant for oviposition, feeding and shelter (Beck and Schoonhoven 1980; Brewer *et al* 1984). Under caged conditions, leafhopper females exhibited marked difference between nutritionally inferior and superior genotypes for oviposition.

BJR-741 a well known leafhopper resistant variety of cotton (Bhat *et al* 1984) with moderate hair density and hair length (Singh 1985) was less preferred for oviposition because of less percentage of proteins and free amino acids and excess of tannins, free gossypol and silica. Allomonic properties of tannins (Chan *et al* 1978; Sharma *et al* 1982; Singh 1987a, b), gossypol (Sharma and Agarwal 1983; Singh 1987a) and silica (Chakravorty and Sahni 1972; Singh 1987a, b, 1988) against various cotton and okra pests have been well established. Moderately resistant XG-15 USA inspite of poor hair density and hair length on leaf lamina as compared to Acala 4–42 (Singh 1987a) was less preferred for oviposition probably due to high concentrations of allomones like tannins and free gossypol which were even higher than BJR-741.

Among the okra genotypes, *A. moschatus* showing high resistance to leafhopper (Sandhu *et al* 1974; Singh 1988) received less number of eggs which was probably due to higher amounts of non-reducing sugars, tannins and silica. High concentration of non-reducing sugars act as phagodeterrents to sap sucking insects (Nuorteva 1952; Jayaraj 1967; Brewer *et al* 1984). But the highly susceptible AC-302 contained higher amounts of proteins and free amino acids which acted as phagostimulants (Jayaraj 1967; Beck and Schoonhoven 1980) and might have stimulated ovipositional preference.

While comparing the contemporary genotypes of both crops, *A. moschatus* of okra received less number of eggs as compared to BJR-741 of cotton, though the former had poor hair density than the latter (Singh 1985). Ovipositional antixenosis in *A. moschatus* might be due to very high amounts of non-reducing sugars, tannins and silica as compared to BJR-741. Further, lower amounts of non-reducing sugars and silica in BJR-741 appeared to be partly compensated through higher quantity of free gossypol. Comparing the highly susceptible genotypes, AC-302 of okra supported 162 eggs/leaf as compared to Acala 4–42 with 57 eggs/leaf. Besides the presence of more number of leaf-veins suitable for oviposition in AC-302 (Singh 1985), it also had higher percentage of moisture and protein contents as compared to Acala-4–42. It is evident that non-reducing sugars, tannins, free gossypol and silica are the key factors in influencing the ovipositional preference of leafhoppers.

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References

Agarwal R A and Krishnananda N 1976 Preference to oviposition and antibiosis mechanisms to jassids (*Amrasca devastans* Dist) in cotton (*Gossypium* spp.); *Symp. Biol. Hung.* **1** 13–22

Ahmad Z, Attique M R and Rashid A 1986 An estimate of the loss in cotton yield in Pakistan attributable to the jassid *Amrasca devastans* Dist; *Crop Protection* **5** 105–108

AOAC 1970 *Official methods of analysis* (Washington: Benjamin Franklin Station)

Barnett N M and Naylor A W 1969 Amino acid and protein metabolism in Bermuda grass during water stress; *Plant Physiol.* **41** 1222–1230

Batra G R and Gupta D S 1970 Screening of varieties of cotton for resistance to jassid; *Emp. Cotton Grow. Rev.* **47** 285–291

Beck S D and Schoonhoven L M 1980 Insect behaviour and plant resistance; in *Breeding plants resistant to insects* (eds) F G Maxwell and P R Jennings (New York: John Wiley) pp 115–136

Bhat M G, Joshi A B and Singh M 1984 Relative loss of seed cotton yield by jassid and bollworms in some cotton genotypes (*Gossypium hirsutum* L.); *Indian J. Entomol.* **46** 165–173

Brewer J W, Capinera J L and Cates R G 1984 The defences of plants against insects; in *Insect biology* (ed) H E Evans (Massachusetts; Addison–Wesley Publishing Company) pp 236–251

Burns R E 1971 Method for estimation of tannin in grain sorghum; *Agron. J.* **63** 511–512

Chakravorty S C and Sahni V M 1972 Biochemical basis of resistance to jassids (*Empoasca* spp.) in *Gossypium hirsutum* cotton; *Indian Agric.* **16** 45–48

Chan B G, Waiss A C and Lukefahr M 1978 Condensed tannin, an antibiotic chemical from *Gossypium hirsutum*; *J. Insect Physiol.* **24** 113–118

Jayaraj S 1967 Studies on the effect of leafhopper infestation on the metabolism of carbohydrate and nitrogen in castor varieties in relation to their resistance to *Empoasca flavescens* (F.); *Indian J. Exp. Biol.* **5** 156–162

Joyce R J V 1961 Some factors affecting numbers of *Empoasca lybica* de Berg (Homoptera: Cicadellidae) infesting cotton in the Sudan Gezira; *Bull. Entomol. Res.* **52** 191–232

Khan Z R and Agarwal R A 1984 Oviposition preference of jassid, *Amrasca biguttula biguttula* Ishida on cotton; *J. Entomol. Res.* **8** 78–80

Kogan M 1975 Plant resistance in pest management; in *Introduction to insect pest management* (eds) R L Metcalf and W H Luckmann (New York: John Wiley) pp 103–146

Mabbett T H, Nachapong N, Monglakul K and Makdaeng J 1984 Distribution on cotton of *Amrasca devastans* and *Ayyaria chaetophora* in relation to pest scouting techniques for Thailand; *Trop. Pest. Manage.* **30** 133–141

Mathur J M S, Sharma N D and Singh M 1972 A rapid spectrophotometric method for determining free gossypol in cotton seeds; *J. Food Sci. Technol.* **9** 138–139

Moffitt H R and Reynolds H T 1972 Bionomics of *Empoasca solana* De long on cotton in southern California; *Hilgardia* **41** 247–297

Nuorteva P 1952 Die Nahrungapflanzenwhl der insekten im Lichte unternuchungen an Zikaden; *Ann. Acad. Sci. Fenn.* **19** 1–90

Rawat R R and Sahu H R 1973 Estimation of losses in growth and yield of okra due to *Empoasca devastana* and *Earias* spp; *Indian J. Entomol.* **38** 293–295

Sandhu G S, Sharma B R, Singh B and Bhalla J S 1974 Source of resistance to jassid and whitefly in okra germplasm; *Crop. Improv.* **1** 77–81

Sharma H C, Agarwal R A and Singh M 1982 Effect of some antibiotic compounds in cotton on post embryonic development of spotted bollworm (*Earias vittella* F.) and the mechanisms of resistance in *Gossypium arboreum*; *Proc. Indian Acad. Sci.* (*Anim. Sci.*) **91** 67–77

Sharma H C and Agarwal R A 1983 Role of some chemical components and leaf hairs in varietal resistance in cotton to jassid, *Amrasca biguttula biguttula* Ishida; *J. Entomol. Res.* **7** 145–149

Singh R 1985 *Behavioural antibiosis mechanisms to jassid, Amrasca biguttula biguttula* (*Distant*) *and spotted bollworm, Earias vittella* (*Fabricius*) in malvaceous crops, Ph.D. thesis, Indian Agricultural Research Institute, New Delhi

Singh R 1987a Bases of resistance in cotton to *Amrasca biguttula biguttula* (Ishida); *J. Cotton Res. Dev.* **1** 131–140

Singh R 1987b 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; *Proc. Indian Acad. Sci.* (*Anim. Sci.*) **96** 361–367

Singh R 1988 Bases of resistance in okra to *Amrasca biguttula biguttula*; *Indian J. Agric. Sci.* **58** 15–19

Somogyi M 1952 Notes on sugar determination; *J. Biol. Chem.* **195** 19–23

Srinivasan M and Bhatia I S 1953 Carbohydrates of Agave Var Cruz MIPP; *Biochem. J.* **55** 286–289

Tidke P M and Sane P V 1962 Jassid resistance and morphology of cotton leaf; *Indian Cotton Grow. Rev.* **16** 324–327

Uthamasamy S 1986 Studies on resistance in okra *Abelmoschus esculentus* (L) Moench to the leaf hopper, *Amrasca devastans* (Dist.); *Trop. Pest. Manage.* **32** 146–147

Yadav H C, Mittal R K and Singh H G 1967 Correlation studies between leaf mid rib structure and resistance to jassid (*E. devastans* Dist.) in cotton; *Indian J. Agric. Sci.* 37 495–497

Yemm E W and Cocking E C 1955 The determination of amino acids with ninhydrin; *Analyst* **80** 209–213

Yemm E W and Willis A J 1954 The estimation of carbohydrates in plant extracts by anthron; *Biochem. J.* **57** 508–514