INFLUENCE OF CHEMICAL AND PHYSICAL FACTORS ON THE VARIETAL PREFERENCE OF *RETITHRIPS SYRIACUS* (MAYET) (PANCHAETOTHRIPINAE : THYSANOPTERA) ON DIFFERENT CULTIVARS OF COTTON

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ABSTRACT

The varietal preference of *Retithrips syriacus* was analysed using five different varieties of cotton among which Suvin and LRA 5166 were susceptible to thrips infestation on account of very short trichomes arranged sparsely and high levels of primary metabolites. These were found to significantly influence the growth and reproductive efficiency of thrips which were further confirmed through life table analysis. In contrast, MCU 7, MCU 11 and TCHB varieties were not infested by *R. syriacus* due to high trichome density and the high levels of secondary metabolites particularly gossypol, tannins, and flavonoids.

Key words : *Retithrips syriacus, Gossypium hirsutum*, trichome density, primary, secondary metabolites.

INTRODUCTION

The ability of *Retithrips syriacus* to overcome plant defenses while feeding on such hosts as *Ricinus communis, Eucalyptus globulus* and *Manihot utilissima* has been discussed by Ananthakrishnan *et al.*(1991). Infestation of *Retithrips syriacus* on cotton was earlier reported by Ananthakrishnan (1955 and 1971), but the ability of this thrips to infest different cotton cultivars, demonstrating varietal preference appear significant. Earlier reports on the interactions of thrips with the cultivars of cotton pertain to *T. tabaci* that was found to infest cotton migrating from *Convulvulus arvensis* (Willcocks and Bhagat, 1937). The degree of infestation varied in the cultivars (Abul Nasr, 1960; Hawkins *et al.,* 1966) which also depend on the developmental stages of the host. Further studies by Gawaad and Shazili (1969) confirmed host selection as very specific, relating suitability of the host that determined the extent and duration of development. As such an attempt has been made to investigate the varietal preference in terms of the cotton cultivars Suvin, LRA 5166, MCU 7, MCU 11, and TCHB, taking into consideration not only the primary and secondary metabolites of the hosts, but also the physical barriers such as the density and distribution of trichomes so as to provide an overall assessment of the mechanisms of interactions.

MATERIALS AND METHODS

The study was conducted over a period eight weeks commencing December 1990 till the end of January 1991. Populations and other growth parameters of *Retithrips*

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syriacus were analysed under field conditions on five cultivars of *Gossypium hirsutum*, viz., Suvin, LRA 5166, MCU 7, MCU 11, and TCHB. The host plants are cultivated in the field laboratory of the Entomology Research Institute. The infested and uninfested leaves of the same age were analysed for their biochemical profiles including proteins (Lowry *et al.*, 1951), carbohydrates (Dubois *et al.*, 1956) amino acids (Moore and Stein, 1948) and nitrogen (Humphries, 1956). Total phenols and flavonoids (Bray and Thorpe, 1954; Shinoda, 1928) were also estimated. The relative proportions of carbohydrates, nitrogen, proteins and moisture content were also determined as ratios. Assays for the levels of activity of phenylalanine ammonia lyase and tyrosine ammonia lyase (Higuchi, 1966), polyphenol oxidase (Palmer, 1963) and peroxidase (Loebenstein and Linsey, 1961) were performed. The levels of gossypol and tannins were estimated according to the method of Swain and Hillis (1959). The individual phenols and flavonoids were identified on the basis of spectral properties (Harborne, 1973). The distribution of trichomes on the leaf surface was measured in terms of their length and intertrichome distances as indices of density and their prevalence as physical barries to thrips colonization.

Initial observations revealed the total avoidance of three cultivars viz., MCU 7, MCU 11 and TCHB by *Retithrips syriacus*. In order to confirm the hosts's non-suitability, the adult thrips and larvae were transferred with the aid of a brush on to the leaves with the aim of artificially inducing infestation. These attempts did not in anyway initiate thrips colonization in these three cultivars. Biochemical profiles in order to identify the factors that contributed to the cultivar's resistance were also analysed.

All data were subjected to statistical analysis in order to assess the degree of correlation between the independent variables such as the levels of metabolites and the dependant variable, namely the degree of infestation by thrips. Life table analysis for such parameters as intrinsic rate of natural increase and related elements as indices of reproductive ability was also carried out (Birch, 1948) in order to assess the extent to which the thrips were affected by the nature of the substrate.

OBSERVATIONS

Retithrips syriacus was found to selectively adapt to the cultivars Suvin and LRA 5166. The other three cultivars viz., MCU 7, MCU 11, and TCHB were totally avoided by the thrips, thus revealing infestation, based on host selection. The levels of carbohydrates ranged from 28 mg to as high as 78 mg among the cultivars (Table 1). Suvin showed consistantly high levels of all the primary metabolites wherein the equivalent ratios were also high. The phenols and flavonoids showed a decreasing trend relative to the levels of the primary metabolities. Gossypol and tannins varied in inverse proportions.

The levels of metabolites were significantly higher in the infested plants in both varieties. The activities of such enzymes as PAL, TAL, PO and PPO associated with secondary metabolism varied significantly which increased subsequent to infestation in the cultivars (Table 2). Gallic acid and syringic acid were present in TCHB, MCU 7, and MCU 11 alongwith such flavonoids as naringin and naringenin. On the contrary kaempferol, gentisic acid, and phloroglucinol were seen only in Suvin

Levels of primary and secondary metabolites in the cultivars of cotton (mg/g)

	Carbohydrates		Proteins		Amino acids		Total N_2		% Moisture	
	Uninfested	Infested	Uninfested	Infested	Uninfested	Infested	Uninfested	Infested	Uninfested	Infested
Suvin	78	86	20.2	26	2.4	2.8	3.23	4.16	85	72
LRA 5166	56	71	16.7	19	1.8	2.3	2.67	3.04	72	66
MCU 7	44	—	15.4	—	1.3	—	2.56	—	68	—
MCU 11	36	—	12.8	—	1.1	—	2.04	—	60	—
TCHB	28	—	11.6	—	1	—	1.85	—	51	—

Table 1b

Levels of primary and secondary metabolites in the cultivars of cotton (mg/g)

	C/N ratio		H_2O/N_2 ratio		C/P ratio		Total phenols		Flavonoids		Gossypol		Tannins	
	Un-infested	Infested	Un-infested	Infested	Un-infested	Infested	Un-infested	Infested	Un-infested	Infested	Un-infested	Infested	Un-infested	Infested
Suvin	24.13	20.6	26.2	17.3	3.86	3.3	2.2	2.9	0.3	0.37	2.45	4.6	0.93	1.07
LRA 5166	20.95	23.3	26.9	13.3	3.35	3.73	3.2	3.6	0.7	0.86	2.91	4.95	0.88	0.96
MCU 7	17.8	—	27.5	—	0.06	—	4.0	—	0.7	—	4.1	—	0.67	—
MCU 11	17.5	—	29.2	—	2.81	—	4.3	—	0.81	—	4.23	—	0.59	—
TCHB	15.08	—	27.47	—	2.41	—	4.7	—	0.93	—	5.37	—	0.42	—

Pyrogallol and luteolin were detected in LRA 5166 prior to infestation. Chrysoeriol was found in all the cultivars. Subsequent to infestation in Suvin and LRA 5166 the constitution was altered to resorcinol, p-hydroxy benzoic acid, luteolin, chrysoeriol and apigenin.

Table 2

Changes in enzyme activity in relation to secondary metabolites in the cultivars of cotton

Cultivar	State	Phenylalanine ammonia lyase g/ cinnamic acid/hour/100 mg protein	Tyrosine ammonia lyase g/ coumaric/acid/ hour/100 mg protein	Peroxidase units as OD increase/minute/ 100 mg protein	Polyphenol oxidase units as OD increase/ hour/100 mg protein
Suvin	Un-infested	0.1537	3.47	2.7	0.210
	Infested	0.6148	6.148	3.6	0.820
LRA 5166	Uninfested	0.286	6.99	3.8	0.3741
	Infested	0.979	8.65	4.2	0.9876
MCU 7	Uninfested	1.032	4.11	5.1	1.08
MCU 11	Uninfested	1.187	4.37	5.7	1.19
TCHB	Uninfested	1.196	4.84	6.8	2.61

Analysis of the life table parameters of the thrips in the two susceptible varieties viz., Suvin and LRA 5166 revealed Suvin to be a more suitable host, wherein the developmental durations were significantly lesser and maturity for reproduction was attained in half the time as in LRA 5166. The net reproductive rate was three fold higher with lesser mean generation time. The intrinsic rate of population increase, larval growth index and index of susceptibility were also higher with a proportionate finite rate of increase. Negative correlations were obtained for the LGI & TGI with reference to gossypol and tannin content.

The distribution of trichomes varied significantly in the cultivars. While LRA 5166 contained the longest trichomes, the intertrichome distance was also the highest as against the situation prevalent in Suvin. The other three cultivars contained trichomes of varying lengths and densities.

DISCUSSION

The suitability of the host is governed by the metabolic status which is further altered by changes brought about on infestation. Resistance or susceptibility to thrips infestations are also known to be age correlated events in cotton (Gawaad and Shazili, 1969) indicating the prevalence of certain intrinsic defense mechanisms functional during the 1st 12-15 days of seedling development during which period they were totally resistant to any herbivore attack. The resultant biochemical profile of the hosts governs prolonged colonization or destabilizes the herbivore population (Ananthakrishnan, 1990). Such patterns of changes have been analysed with special reference to infestation by *Retithrips syriacus* on five different cultivars of cotton. Specific to the biochemical nature of the host, the influence of the secondary products

was governed by the levels of the primary metabolities (van Emden, 1972). The present investigation has brought to light the varietal preference of *R. syriacus* highlighting the prevalance of mechanisms of host selection specially that operate in response to even minute change in the levels of the metabolites of the substrate, more so even

Table 3

Phenolics and flavonoids in the cultivars of cotton

	Phenolic acids		Flavonoids	
	Uninfested	Infested	Uninfested	Infested
Suvin	Gentisic acid Phloroglucinol	Resorcinol P-hydroxy benzoic acid	Kaempferol Chrysoeriol	Luteolin Chrysoeriol
LRA 5166	Pyrogallol	Phloroglucinol P-hydroxy benzoic acid	Chrysoeriol Luteolin benzoic acid	Luteolin Apigenin Apigenin
MCU 7	Syringic acid Gallic acid Resorcinol		Hesperidin Hesperitin Chrysoeriol Naringin	
MCU 11	Syringic acid Gallic acid Phloroglucinol		Apigenin Naringenin Chrysoeriol	
TCHB	Gallic acid		Chrysoeriol Apigenin Naringin	

among the different cultivars of the same host plant. This was evidenced by selective inhabitation of *R. syriacus* on only the Suvin and LRA 5166 cultivars. The three other cultivars such as MCU 7, MCU 11, and TCHB were totally avoided by the thrips.

While the levels of carbohydrates were higher in Suvin and LRA 5166 than found in the other cultivars by 21% to 64% the infested plants of the susceptible varieties themselves had higher quantities by 11% and 27%, respectively. Similar was the trend with the levels of proteins, amino acids and total nitrogen which ranged from 7% to 52% increase in the case of plants harbouring the thrips. Statistically significant measures of correlation were obtained for the levels of the primary metabolites and the extent of infestation. On the other hand the levels of total phenols and flavonoids were higher by 45% to almost twice the quantities in the resistant varieties. Accordingly a threshold in the levels of the nutritional substrates could be identified as suitable for the thrips and thus quantities in the resistant varieties could be considered too low to elicit a host acceptance response from the thrips. Upper thresholds beyond 3.6 mg/g in the case of total phenols and 0.84 mg/g of flavonoids effectively deterred the thrips from colonizing as evidenced by the significant inverse correlations and observations on the life table characteristics.

Table 4

Life table data of *Retithrips syriacus* on different cultivars of cotton

Parameter	Suvin	LRA 5166
Developmental time	13 days	17 days
Maturation time	2 days	4 days
Age at first reproduction (α)	16 days	22 days
Net reproductive rate (R_O)	38.82 days	10.88 days
Mean generation time (T)	18.69	29.61
Innate capacity for increase (r_c)	0.09	0.04
Intrinsic rate of natural for increase (r_m)	0.085	0.035
Finite rate of increase(λ)	1.08	1.03
Population size	48	23
Larval growth index (LGI)	18.2	12

Significantly higher enzyme activity levels were recorded subsequent to infestation indicative of enhancement of induced defense of the host plant (Harborne 1988). Analysis of the individual phenolic acids as plant defense substances showed that gallic acid on account of its presence in MCU 7, MCU 11 and TCHB would have been primarily responsible for the uninfested state; the toxicity of gallic acid having

Table 5

Life table and age specific fecundity analysis of *Retithrips syriacus* cotton cultivars

Pivotal age (X)		Survival of females at different age intervals (lx)		Average number of eggs per female (mx)		Age schedule for female birth (lxmx)		X lx mx	
Suvin	LRA 5166	Suvin	LRA 5166	Suvin	LRA 5166	Suvin	LRA 5166	Suvin	LRA 5166
0-13								Egg & post embryonic development	
14		1.0							
15		1.0						Pre-oviposition period	
16		1.0		10.8		10.8		172.80	
17	0-17	1.0		10.2		10.2		173.40	Post embryonic development
18	18	0.8	1.0	9.8		7.84		141.12	
19	19	0.6	1.0	8.4		5.04		95.76	Pre oviposition period
20	20	0.4	1.0	6.4		2.56		51.20	
21	21	0.4	1.0	4.9		1.96		41.16	
22	22	0.2	1.0	2.1	6.4	0.42	6.40	9.24	140.80
23	23	0.1	0.7	0.0	5.2	0.00	3.64	0.00	83.72
	24		0.3		2.8		0.84		20.16
	25		0.1		0.0		0.00		00.00

been demonstrated while accounting for host response as defense against infestation by *R. syriacus* in castor, eucalyptus and tapioca (Ananthakrishnan *et al.*, 1991). However in the case of Suvin and LRA 5166 the phenolic profiles are altered to less toxic states (Luckey, 1968) and hence the observed infestation.

Flavonoids are normally present in the bound state in order to prevent autotoxicity (Rosenthal and Janson, 1979). They have been implicated as secondary compounds that are normally activated to function as defense compounds effectively reducing the pressure due to herbivory (Harborne, 1988). The flavonoids encountered in the susceptible hosts were luteolin and chrysoeriol along with apigenin. The constitution included kaempferol in the infested state. The resistant varieties contained hesperidin, hesperitin, narigin and naringenin in addition to chrysoeriol and apigenin accounting for the inherent resistance (Horowitz, 1964; Sutter *et al.*, 1975, and Beladi *et al.*, 1977). Yet another means of defense in the cotton cultivars is the prevalence of gosypol identified as pigments and tannins (Chan *et al.*, 1978) deterring herbivores (Lukefahr and Martin, 1966). In quantities beyond 2.91 mg the thrips were significantly affected as evidenced from drastically reduced life cycle durations and retarded intrinsic rate of growth of populations. Gossypol in levels above 4.1 mg synergising with low levels of primary substances as was seen in varieties totally resistant to thrips, could be considered a major factor of resistance against *R. syriacus*. The physical basis of resistance in the cultivars can be attributed to the density and length of the pointed trichomes distributed on the leaf surface (Beck, 1965; Chapman, 1977). Suvin had the shortest of the trichomes with moderate intertrichome distances; whereas the longest trichomes were recorded in LRA 5166 also spaced widest apart. In either cases the short length and less dense nature respectively, could enable easier colonization as compared to the maximum density seen in MCU 11. This was followed by MCU 7 and finally TCHB where in the trichome length and distance apart correlated directly, (Carter, 1982; Cardenas, 1982), thus suggesting pubescence as a means of lowering the level of susceptibility (Terry and Barstow, 1988).

Table 6

Trichomes and stomata in the cultivars of cotton

Length of the trichomes(μ)		Intertrichome distance (μm)	Number of Stomata/mm^2 surface of the leaf	
			Dorsal	Ventral
Suvin	399.9	542	15	15
LRA 5166	1228.55	1057.12	5	5
MCU 7	599.9	429.56	17	15
MCU 11	857.13	342.85	13	15
TCHB	628.56	657.13	10	6

Several plant-derived allelochemicals are known to significantly alter the survival and growth of herbivores (Feeny, 1975; Ananthakrishnan *et al.*, 1990) and as the foregoing results thus indicate, such an inhibitory effect of either the low levels of primary substance along or in conjunction with toxic phenolic acids is obvious even in the case of *R. syriacus*, the infestation diversity of which is accordingly shown to be a function of the bio-chemical and physical nature of the host.

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