

SUGARCANE

Antixenotic Effect of Sugarcane Leaves on Feeding and Oviposition by *Pyrilla perpusilla* Walker

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The antixenotic effects of foliar morphological and chemical characteristics, such as spine density, leaf colour, leaf width, hydroxamic acid (Hx) levels, and previous feeding damage, on feeding and oviposition of the sucking pest of sugarcane *Pyrilla perpusilla* Walker were studied. Feeding preference was affected by the leaf colour ($c^2 = 10.2$; $P < 0.05$) and Hx levels ($c^2 = 21.668$; $P < 0.05$); whereas oviposition preference was determined by leaf spine density ($c^2 = 8.959$; $P < 0.05$) and Hx levels ($c^2 = 12.584$; $P < 0.05$). Previously infested leaves showed a resistance to feeding after five days of continuous infestation with *P. perpusilla* ($c^2 = 7.225$; $P < 0.05$). The antibiotic characteristic of a particular cultivar was found to be independent from its antixenotic effects.

KEYWORDS : Sugarcane, damage, *Pyrilla perpusilla*, antixenotic effect

Losses in sugar production of 0.2-50% (Gupta, 1948; Agarwal, 1969; David & Alexander, 1986; Kumarasinghe & Wratten, 1996) as a result of infestation by the sap sucking leaf hopper *Pyrilla perpusilla* Walker (Homoptera: Lophopidae) have led researchers to investigate the possibility of exploiting resistant cultivars. Kumarasinghe & Wratten (1998) and Kumarasinghe *et al.* (2000) for example, investigated the biochemical and morphological bases of resistance to this insect, respectively.

The investigation reported in this paper concerns "non-preference" first describe by Painter (1951). This term denotes the group of plant characters and insect responses that lead to or prevent the use of a particular plant or a variety for oviposition, food, and/or shelter. Kogan & Ortman (1978) introduced the term "antixenosis" as an alternative to non-preference. Plants may be thought of as providing one or more essential resources, including feeding sites, mating sites, egg-laying sites, and/or refugia. Insects have accordingly been described as choosing, selecting, preferring and discriminating among their host plants (Prokopy *et al.*, 1984). The host selection process for feeding and oviposition is a chain of five major steps: a) host-habitat finding, b) host finding, c) host recognition, d) host acceptance and e) host suitability (Panda, 1979).

According to Panda (1979), resistance to oviposition may be elicited by plant characteristics either by failing to provide appropriate oviposition-including stimuli or by providing oviposition-inhibiting stimuli. Orientation of a gravid insect to a prospective host appears to involve chemical characters and, in many instances, visual stimuli. According to Juniper & Southwood (1986), effects such as odour, reflectance (i.e. colour to the insect), and shape are the three main factors that are known to influence the behaviour of an insect in the proximity of a plant for oviposition. Of these factors, the important role of leaf colour in host plant selection has been later observed for feeding of the cabbage root fly *Delia radicum* L. (Prokopy *et al.*, 1983) and for oviposition of the skipper butterfly, *Calpodis ethlicus* L. on canna lilies (Reinert *et al.*, 1983).

Antixenotic mechanisms have helped in some instances to produce resistant cultivars to pests. For example, a cultivar of rice resistant to rice folder *Cnaphalocrocis medinalis* (Guenee) was produced after hybridization of a susceptible cultivar with antixenotic wild rice *Oryza brachyantha* Roehr. (Ramachandran & Khan, 1991). In sugarcane, it has been recorded that females of *Chilo infuscatellus* Snell., prefer 45 day old plants for oviposition, although they show no preference for older plants (Rao, 1962). Similarly, moths of the internode borer, *Chilo sacchariphagus indicus* (K)

prefer to lay eggs on the upper surface of leaves (David & Kalra, 1965). These authors further revealed a high preference by this moth for oviposition on *Saccharum officinarum* L., compared to *Erianthus ciliaries* (Anders.) Jesw., and *S. spontaneum* (Linneus). However, an intermediate response was observed for oviposition on *S. barberi* Jesw.

As there is no information available on the antixenotic effects of sugarcane on *P. perpusilla*, a series of experiments was carried out on different cultivars of sugarcane in order to study possible mechanisms of antixenosis. This paper describes the antixenotic mechanisms observed in sugarcane for feeding and for oviposition of *P. perpusilla* on different cultivars selected using a variety of criteria.

MATERIALS AND METHODS

Selection of cultivars

Antixenotic effect of antibiotically different cultivars on feeding and oviposition

The cultivars RAGNAR, SL 8606, LF 72-1455, LF 74-3152 and Co 775, which showed different antibiotic effects for 3rd instars of *P. perpusilla*. (without considering other morphological and chemical characteristics), (Kumarasinghe *et al.*, 2001) were selected for the experiments (Table 1).

Table - 1 : Antibiotically different cultivars selected for experiment on the antixenotic effect on feeding and oviposition of *P. perpusilla*.

Cultivars	MRGR ($\mu\text{g}/\mu\text{g}/\text{day}$)
RAGNAR	0.0740 \pm 0.31
SL 8606	0.0830 \pm 0.13
LF 72-1455	0.0927 \pm 0.13
LF 74-3152	0.1022 \pm 0.26
Co 775	0.1115 \pm 0.80

The plants were grown in separate polysterene pots (diameter 30cm) filled with John Inns No. 2 sterilized compost. The temperature of the glass house was maintained at $26\pm 3^\circ\text{C}$ at 70% RH with 12h photoperiod throughout the growing period. Plants were irrigated once in three days.

Antixenotic effects of leaf colour, hydroxamic acid levels, spine density and the leaf blade width on feeding and oviposition

Cultivars for the experiments on leaf colour, hydroxamic acid levels, spine density and leaf blade width were selected according to the chemical and morphological characteristics of the second leaf. The method of selection of cultivars for each experiment is given in Table 2. The cultivars selected for experiments are given in Table 3.

Testing of antixenotic effects of leaf colour,

hydroxamic acid levels, spine density and the leaf blade width on feeding and oviposition.

For the experiments five month old plants of different cultivars grown in polystyrene pots (diameter 30 cm) filled with John Innes No. 2 sterilized compost were used. The temperature of the glasshouse where the plants were kept was maintained at $26\pm 3^\circ\text{C}$ and 70% RH with a 12h photoperiod throughout growth. The plants were provided with necessary NPK fertilizers levels at the stages of planting and third month after planting.

The cultivars for these two series of experiments were selected according to the Mean Relative Growth Rate (MRGR) levels (for 3rd instar nymphs) that they supported, Hydroxamic acid (Hx) concentrations, spine densities and the width of the leaf blade recorded for the antibiosis experiments (Kumarasinghe *et al.*, 2001). The colours (*i.e.* (i) the *hue* referring to wave length in the spectrum, (ii) the *whiting* referring to the amount of white added to the hue, changing it from saturated to unsaturated colours, and (iii) the *Chroma* which can be changed and diminished by adding black to the hue) of the second leaf of the six cultivars were defined by using the Munsell colour charts (Munsell, 1976); (ASTM designation: D 1535-80) (Table 3).

Preference for feeding

Experiments were conducted to measure the effect of leaf colour, hydroxamic acid levels, spine density and the width of the leaf blade on preference for feeding. During the preference for feeding experiments, the second leaf (from the top) of a plant of one cultivar was offered with the second leaf of another cultivar to ten 1-2 d. old adult insects inside a chamber (35 x 22 x 12cm) where the top of the chamber was covered with a mosquito net mesh and other parts were made with transparent perspex sheets. The selection of cultivars for feeding by the insects was determined by recording the number of insects feeding on each cultivar at the end of a 12h period. This procedure was repeated four times for all the combinations of cultivars offered.

Table - 2 : The method of cultivar selection for the antixenosis experiments.

Experiment on the effect of	Characteristics of cultivars selected			
	Leaf colour	Hx acids	Spine density	Width of the leaf blade
Leaf colour	different	similar	similar	similar
Hx acids	similar	different	similar	similar
Spine density	similar	similar	different	similar
Width of the leaf blade	similar	similar	similar	different
Previous damage	similar	similar	similar	similar

Table - 3 : Cultivars selected for the experiments on antixenotic effect on feeding and oviposition of *P. perpusilla*.

Experiment	Cultivars	Total Hx (mmol/Kg)	Leaf colour			Spine density (400 × 600 cm)	Width of the leaf blade (cm)
			hue	whiting	chroma		
Leaf colour	PH 84-1096	1.3473 ± 0.13	5 GY	3	6	31 ± 2	3.40 ± 0.05
	Q 68	1.3474 ± 0.13	7.5 GY	4	4	32 ± 2	3.40 ± 0.07
	SL 7116	1.3475 ± 0.13	5 GY	4	4	31 ± 3	3.40 ± 0.05
	LF 74-4482	1.3379 ± 0.17	7.5 GY	5	4	33 ± 2	3.45 ± 0.07
Hydroxamic acids	SL 8601	5.6751 ± 1.374	5 GY	3	6	38 ± 5	2.80 ± 0.05
	LF 72-775	1.4911 ± 0.804	5 GY	3	6	39 ± 1	2.80 ± 0.30
	VOMO	1.2853 ± 0.151	5 GY	3	6	36 ± 2	2.80 ± 0.10
	M 1156-6	0.0676 ± 0.017	5 GY	3	6	36 ± 3	2.85 ± 0.05
Spine density	SL 8302	0.9455 ± 0.289	7.5 GY	4	4	32 ± 2	2.60 ± 0.10
	M 550-60	0.9259 ± 0.422	7.5 GY	4	4	27 ± 2	2.65 ± 0.13
	M 305-51	0.9450 ± 0.317	7.5 GY	4	4	10 ± 1	2.70 ± 0.00
	F 148	0.9350 ± 0.184	7.5 GY	4	4	19 ± 2	2.60 ± 0.05
Leaf Blade width	SL 7103	0.6490 ± 0.007	5 GY	5	4	33 ± 1	4.40 ± 0.10
	SL 8611	0.6529 ± 0.010	5 GY	5	4	34 ± 2	2.90 ± 0.07
	LF 76-5958	0.6332 ± 0.008	5 GY	5	4	34 ± 3	1.80 ± 0.00
	M 1227-62	0.6325 ± 0.008	5 GY	5	4	34 ± 4	2.10 ± 0.04
Previous damage	SL 8601	5.6751 ± 1.374	5 GY	6	6	38 ± 5	2.80 ± 0.05
	M 1156-6	0.0676 ± 0.017	5 GY	6	6	36 ± 3	2.85 ± 0.05

Preference for oviposition

As in the feeding experiments the effect of the leaf characteristics *i.e.* colour, hydroxamic acid levels, spine density and the width of the leaf blade (Table 3) on preference for oviposition was tested. For this series of experiments, cultivars were selected using exactly the same procedure employed for the feeding experiments and the tests were carried under the same arrangement. Pairs of leaves were offered to four gravid females for oviposition. The observations were made until all four females completed oviposition. Completion of oviposition was decided on observing the protective cover laid by the female over the egg masses. The selection of cultivars for oviposition by the insects was determined by recording the number of egg masses laid on each cultivar. This procedure was repeated four times for all the combinations of cultivars offered.

Testing of antixenotic effect of previous damage on feeding and oviposition.

Five month old plants of the cultivars SL 8601 and M 1156-6 which are similar in colour of the second leaf, spine densities and width of the leaf blades but which differ in Hx levels were selected for the experiment (5.6751 and 0.0676 mmol/kg respectively). Two separate experiments were conducted on each cultivar. The second leaves of six plants of each cultivar were separately subjected to infestation by 20 adult insects for 24, 48, 72, 96, 120 and 144h in perspex

chambers as described above. The second leaf of six undamaged plants of the same age was then separately exposed for 24, 48, 72, 96, 120 and 144h with previously damaged leaves. Tests for effects on feeding and oviposition were conducted as described above. This regime was replicated four times for each leaf damage period.

All above feeding and oviposition experiments were conducted at the room temperature of 26±3°C, 70%RH and 12h photoperiod.

Analysis of data

In experiments of antixenotic effects of antibiotic difference, leaf colour, hydroxamic acid levels, spine density and the leaf blade width, the c² analysis was used to analyze the results of four replicates of each combination to determine whether there was a significant difference in preference by insects for each cultivar for feeding or oviposition. For each experiment, tests of preferences for cultivars within each combination and for any cultivars in the group were conducted. In the test of previous damage, there is no comparison between cultivars, so only the four replicates of each combination of the effect of previous damage were analyzed. The c² test was used to determine whether there was a significant difference in preference by insects for each category of plants for feeding or oviposition.

RESULTS

Antixenotic effects of antibiotically different cultivars on feeding and oviposition

There were significant preferences for feeding for the cultivar Co 775 over RAGNAR and SL 8606 (Table 4) although overall selection of cultivars for feeding was not dependent on antibiotic effects ($c^2 = 2.75$; $P > 0.05$). Preferences between combinations of cultivars were significant when the difference between MRGR's were relatively high (0.0375 $\mu\text{g}/\mu\text{g}/\text{day}$ and 0.0285 $\mu\text{g}/\mu\text{g}/\text{day}$ respectively) compared with other combinations. RAGNAR and SL 8606 were categorized as cultivars which expressed antixenotic effects on feeding compared with Co 775.

Difference in oviposition preferences were observed between the cultivars LF 74-3152 (MRGR: 0.1022) and SL 8606 (MRGR: 0.0830) ($c^2 = 9.0625$; $P < 0.05$) (Table 4). Overall, there were no significant preferences for oviposition over the five cultivars tested ($c^2 = 6.687$; $P > 0.05$). Therefore, SL 8606 can be categorized as a cultivar which has antixenotic effects, compared to SL 8601, on oviposition.

Antixenotic effect of leaf colour on feeding and oviposition

P. perpusilla preferred cultivar PH 84-1096 over Q 68 and SL 7116 for feeding (Table 5). The c^2 analysis for total preference confirmed significant overall differences in preference for feeding ($c^2 = 10.2$; $P <$

Table - 4 : Results of the experiment on the antixenotic effect of antibiotically different cultivars on feeding and oviposition of *P. perpusilla*

Combination of cultivars offered		Feeding				Oviposition			
(a)	(b)	% Preference		c^2 value	c^2 for total selection	% Preference		c^2 value	c^2 for total selection
		(a)	(b)			(a)	(b)		
RAGNAR	× SL 8606	47	53	0.025	2.750	50	50	0.062	6.687
RAGNAR	× LF 72-1455	53	47	0.025		38	62	1.062	
RAGNAR	× LF 74-3152	53	47	0.025		44	56	0.312	
RAGNAR	× Co 775	30	70	5.625		56	44	0.312	
SL 8606	× LF 72-1455	45	55	0.225		38	62	1.062	
SL 8606	× LF 72-1455	58	42	0.625		12	88	9.062*	
SL 8606	× Co 775	32	68	4.225*		31	69	2.312	
LF 72-1455	× LF 72-1455	47	53	0.025		38	62	1.062	
LF 72-1455	× Co 775	42	58	0.625		50	50	0.062	
LF 72-1455	× Co 775	47	53	0.025		50	50	0.062	

*Significantly different at $P = 0.05$

Table - 5 : Results of the experiment on the antixenotic effect of leaf colour in sugarcane on *P. perpusilla*

Combination of cultivars offered		Feeding				Oviposition			
(a)	(b)	% Preference		c^2 for		% Preference		c^2 for	
		(a)	(b)	individual combinations	total preference	(a)	(b)	individual combinations	total preference
PH 84-1096	× Q 68	67	33	4.225*	10.20*	56	44	0.062	0.250
PH 84-1096	× SL 7116	70	30	7.225*		50	50	0.062	
PH 84-1096	× LF 74-4482	62	38	2.025		37	63	0.562	
Q 68	× SL 7116	52	48	0.025		50	50	0.062	
Q 68	× LF 74-4482	57	43	0.625		50	50	0.062	
SL 7116	× LF 74-4482	52	48	0.025		63	37	0.562	

*Significantly different at $P = 0.05$

0.05). Significant differences were recorded between PH 84-1096 and Q 68 ($c^2 = 4.225$; $P < 0.05$) and between PH 84-1096 and SL 7116 ($c^2 = 7.225$; $P < 0.05$).

No differences in preference for oviposition were observed (Table 5). ($c^2 = 0.250$; $P > 0.05$). The c^2 tests for individual combinations of cultivars also failed to indicate any significant differences ($c^2 = 0.062$ and 0.562 ; $P > 0.05$) in preference for oviposition.

Antixenotic effect of the Hx levels in leaves on feeding and oviposition

P. perpusilla exhibited a preference for feeding on the cultivars LF 72-775 and VOMO over SL 8601 (Table 6). c^2 analysis for total preference revealed differences in preference for the four cultivars ($c^2 = 21.668$; $P < 0.05$). *P. perpusilla* preferred LF 72-775, VOMO and M 1156-6 over SL 8601 ($c^2 = 9.025$, 9.025 and 11.025 respectively; $P < 0.05$). Differences in Hx level between significantly different cultivars were greater than 4.184 mmol/Kg.

P. perpusilla preferred cultivars VOMO and M 1156-6 to SL 8601 for oviposition ($c^2 = 5.062$ and 7.562 respectively; $P < 0.05$) (Table 6). There were significant differences in preference among the four cultivars ($c^2 = 12.584$; $P < 0.05$). Among significantly different cultivars, differences in Hx levels were greater than 4.390 mmol/Kg.

Antixenotic effect of spine density of the leaf surface on feeding and oviposition

No differences in preference for feeding by *P. perpusilla* were observed (Table 7) ($c^2 = 0.334$; $P > 0.05$). The c^2 tests for individual combinations of cultivars also failed to indicate any significant differences ($c^2 = 0.025$ and 0.225 ; $P > 0.05$).

P. perpusilla preferred M 305-51 (lowest spine density cultivar)(10) over high spine density cultivars SL 8302 (27) and M 550-60 (32) for oviposition ($c^2 = 5.062$; $P < 0.05$) (Table 7). The c^2 analysis for total preference confirmed significant overall differences in preference for oviposition ($c^2 = 8.959$; $P < 0.05$).

Table - 6 : Results of the experiment on the antixenotic effect of hydroxamic acids in sugarcane on *P. perpusilla*

Combination of cultivars offered			Feeding				Oviposition			
(a)	(b)		% Preference		c^2 for		% Preference		c^2 for	
			(a)	(b)	individual combinations	total preference	(a)	(b)	individual combinations	total preference
SL 8601	×	VOMO	25	75	9.025*		19	81	5.062*	
SL 8601	×	M 1156-6	22	78	11.025*		12	88	7.562*	
LF 72-775	×	VOMO	47	53	0.025		50	50	0.062	
LF 72-775	×	M 1156-6	45	55	0.225		56	44	0.062	
VOMO	×	M 1156-6	50	50	0.025		56	44	0.062	

*Significantly different at $P = 0.05$

Table - 7 : Results of the experiment on the antixenotic effect of spine density in sugarcane leaves on *P. perpusilla*

Combination of cultivars offered			Feeding				Oviposition			
(a)	(b)		% Preference		c^2 for		% Preference		c^2 for	
			(a)	(b)	individual combinations	total preference	(a)	(b)	individual combinations	total preference
SL 8302	×	M 305-51	55	45	0.225		19	81	5.062*	
SL 8302	×	F - 148	55	45	0.225		50	50	0.062	
M 550-60	×	M 305-51	50	50	0.025		19	81	5.062*	
M 550-60	×	F - 148	50	50	0.025		44	56	0.062	
M 305-51	×	F - 148	53	47	0.025		62	38	0.562	

*Significantly different at $P = 0.05$

Antixenotic effect of the size of the leaf blade on feeding and oviposition

No differences in preference for feeding were observed (Table 8). The c^2 analysis for overall preference ($c^2 = 1.101$; $P > 0.05$) as well as the c^2 tests for individual combinations of cultivars ($c^2 = 0.025$ and 0.225 $P > 0.05$) failed to indicate any significant differences in preference for feeding. *P. perpusilla* did not exhibit any preference between any of the cultivars offered for oviposition (Table 8) ($c^2 = 0.751$; $P > 0.05$). The c^2 tests for individual combinations of cultivars also failed to indicate any significant differences ($c^2 = 0.062$ and 0.562 ; $P > 0.05$).

Antixenosis effect of previous damage on feeding and oviposition

P. perpusilla exhibited a preference for undamaged leaves for feeding, over the leaves continuously damaged for 120h and 144h, for low and high Hx cultivars, respectively (Table 9). Significant differences in preference were observed for five day (120 h) ($c^2 = 7.225$; $P < 0.05$) and six day (144 h) ($c^2 = 9.025$; $P < 0.05$) damaged leaves of high Hx cultivars and only six day ($c^2 = 4.225$; $P < 0.05$) damaged leaves of low Hx cultivars.

P. perpusilla did not exhibit any preference for either damaged or undamaged leaves for oviposition. The c^2 analysis for individual combinations also failed to indicate any significant differences in preference in both

Table - 8 : Results of the experiment on the antixenotic effect of the size of the lead blade of sugarcane on *P. perpusilla*

Combination of cultivars offered			Feeding				Oviposition			
(a)	(b)		% Preference		c^2 for		% Preference		c^2 for	
			(a)	(b)	individual combinations	total preference	(a)	(b)	individual combinations	total preference
SL 7103	×	LF 76-5958	47	53	0.025		69	31	0.062	
SL 7103	×	M 1227-62	47	53	0.225		50	50	0.062	
SL 8611	×	LF 76-5958	53	47	0.025		56	44	0.062	
SL 8611	×	M 1227-62	45	55	0.225		62	38	0.562	
LF 76-5958	×	M 1227-62	50	50	0.225		44	56	0.062	

*Significantly different at $P = 0.05$

Table - 9 : Results of the experiment on the antixenotic effect of previous damage of sugarcane leaves on feeding and oviposition of *P. perpusilla*

Cultivar	Combination of leaves offered		Feeding			Oviposition		
	(a) Un damaged	(b) damaged for	% Preference		c^2 value	% Preference		c^2 value
			(a)	(b)		(a)	(b)	
	×	48h	50	50	0.025	50	50	0.062
	×	72h	57	43	0.625	56	44	0.062
	×	96h	57	43	0.625	37	63	0.062
	×	120h	72	28	7.225*	37	63	0.562
	×	144h	75	25	9.025*	31	69	1.562
M 1156-6	×	24 h	50	50	0.025	50	50	0.062
	×	48h	47	53	0.025	44	56	0.062
	×	72h	47	53	0.025	56	44	0.062
	×	96h	57	43	0.625	44	56	0.062
	×	120h	65	35	3.025	37	63	0.562
	×	144h	67	33	4.225*	31	69	1.562

*Significantly different at $P = 0.05$

low and high cultivars ($c^2 = 0.062, 0.562$ and 1.562 ; $P > 0.05$ respectively) (Table 9).

No insect mortality was recorded during any of the above feeding or oviposition studies.

DISCUSSION

The results of these experiments revealed a significant role of antixenotic host plant resistance mechanisms of sugarcane to *P. perpusilla* when more than one cultivar is available for feeding or oviposition. The results of the experiments with cultivars of different antibiotic effects (without considering the chemical, physiological or morphological characteristics of the leaves) showed that although there is no significant difference in preference by *P. perpusilla* for antibiotically high or low cultivars, the insect has the ability to avoid certain cultivars with higher levels of antibiotic effects for feeding or oviposition. According to Panda (1979) the reason for this behaviour could be the role of plant-emitted physical (mechanical and visual) or chemical sensory stimuli in determining the orientational and feeding responses of different plant-infesting insects.

Although the results of the experiment on the antixenotic effect of leaf colour showed that colour of leaves did not have any effect on preference of *P. perpusilla* for oviposition, leaf colour was found to be one of the important antixenotic factors which is involved in determining the host choice for feeding. Cultivars with higher whiting and lower chroma values (Q 68 and SL 7116) appeared to have an antixenotic effect on feeding compared to the cultivar PH 84-1096, with its lower whiting and higher chroma values. The effect of plant colour in selecting cultivars for feeding has been recorded before for other insects species. For example, aphids in general are known to be attracted to yellowish-green, pale leaves reflecting a light intensity of 500nm, regardless of the species of plant (Kennedy *et al.*, 1961; Moericke, 1955, 1969; Muller, 1958; Thorsteinson, 1960; Cartier, 1966). The moths of the shoot borer *C. infuscatellus* in sugarcane were found to prefer clones with dark green leaves for oviposition and avoid those with pale green foliage (Rao, 1962; Rao & Rao, 1965). The orientation of corn earworm moths, *Helicoverpa zea* (Boddie), to corn plants was also shown to be influenced by the wave length and intensity of light reflected from plant foliage (Callahan, 1957). Horber (1955) demonstrated the influence of visual responses in greenhouse experiments in which the incident light passed through selective filters. This altered the relative attractiveness of subject varieties confirming the quality of light reflected from the foliage exerted an important influence on the orientation of the fly *Meromyza americana* Fitch to the plant.

As in sugarcane, leaves of many preferred and non preferred plants are almost of the same colour. Therefore, doubts are sometimes expressed whether

plant colour may act as a non specific stimulus, in spite of its inability to guide insects to discriminate different plants. However, Moericke (1969) and Finch (1986) considered the role of three parameters of colour; (i) the *hue* referring to wave length in the spectrum, (ii) the *tint* (saturation) referring to the amount of white added to the hue, changing it from saturated to unsaturated colours, and (iii) the *intensity* which can be changed and diminished by adding black to the hue (which is almost similar to the method used in the present experiments). According to Moericke (1969), foliage colour in different plants does not differ much in hue which oscillates generally around yellow green (about 550 nm) but differs in tint and intensity. Moericke's (1969) explanation agreed with ours that phytophagous insects may show preference for a specific tint or specific intensity of colour in their preferred plant.

In this study it was revealed that the levels of Hx acids in plants can affect the feeding and oviposition preference of *P. perpusilla* significantly, although they did not affect the insect antibiotically. Similar observations have been described by Courtney & Kibota (1990), who found that particular chemicals may be recognized by insects as deterrents or as specific positive stimulants, even if the chemicals are otherwise neutral in effect. According to Miller & Strickler (1984), chemicals might not always play the dominant role in mediating each of the phases of host selection (i.e. finding, examining and consuming) but they are usually important mediators of the behaviour during examining and consuming. Furthermore, these results agreed with those of Feeny *et al.*, (1983), Nottingham (1988) and Ramaswamy *et al.* (1987), which explained the effects of plant chemicals on oviposition site selection of butterflies and moths. In the present study, it was found that the effect of Hx on feeding by *P. perpusilla* ($c^2 = 21.668$) is more prominent than the effect on for oviposition ($c^2 = 12.584$). The level of preference was found to be highly significant in both cases when the differences of Hx levels of given cultivars were higher. The explanation of Tukey (1971) that stimulatory or inhibitory compounds identified in the leaf may also be present in the leaf wax due to leaching may be a possible cause for observed significant difference in preference by *P. perpusilla* between cultivars with different Hx levels.

The preference for oviposition by the insect is affected by the spine density, although there is no significant effect on feeding. The reason for avoiding oviposition by the female *P. perpusilla* on leaf surfaces with a higher level of spine density may be due to the antibiotic effect of spines of the leaf surface on the growth of newly emerged first instars (Kumarasinghe *et al.*, 2001). The non-significance of the effect of spine density on feeding of the adults can also be described by the results of the antibiotics experiments, as the growth of the insect in the advanced stages of the life

cycle is not affected by the spine density (Kumarasinghe *et al.*, 2001).

There was no significant antixenotic effect of the size (width) of the leaf blade in the resistance mechanism as seen in results of the antibiosis experiments where this character is correlated positively with MRGR (Kumarasinghe *et al.*, 2001).

To summarize the tests of physical characteristics, *P. perpusilla* preferred cultivars with high chroma and low whiting values for feeding regardless of the spine density and the size of the leaf. The females select cultivars with low spine density for oviposition regardless of the colour or the size of the leaves. According to Willmer (1986) it is interesting to note that the effects of the leaf colour are the reverse of what would be expected from normal physical properties in that highly reflective forms stay colder, while the dark species get hot. *P. perpusilla* may thus prefer cultivars which can provide a hot microclimate during feeding.

P. perpusilla showed an almost equal preference for undamaged leaves and leaves damaged for maximum of four days regardless of the Hx levels of leaves. However, the significant differences observed for cultivars SL 8601 for five and six days ($c^2 = 7.225$ and 9.025 respectively) and M 1156-6 for six days ($c^2 = 4.225$) indicate an antixenotic effect at these stages. Courtney & Kibota (1990) also revealed before that the variations between hosts can be caused by previous damage, resulting in decreased acceptability to subsequent herbivores. The significant difference observed for feeding may be due to increase in the Hx levels of the cultivars because of the continuous damage done by the insects for six days. The significant difference observed only for SL 8601 at the five day stage is further support for this conclusion as this cultivar had higher level of Hx acid in leaves than did M 1156-6. However, the non preference for leaves damaged for five and six days for feeding may also be due to accumulation on the leaf surfaces of waxes exuded by the insects during feeding.

Finally, it can be seen that the antixenotic mechanism in sugarcane for *P. perpusilla* for feeding and oviposition involves a complex of morphological, physiological and biological characters of the plant. This finding is consistent with Panda (1979), who states that, in some instances, the morphological, physiological and biological characters may not act singly but in concert with other factors. Stadler (1986) also confirms that only mixtures of plant compounds together with non-chemical stimuli can explain host plant selection. According to Chesnokov (1961), resistance to pests is a biological property of the plant organism. This property is the result of a complex of morphological, physiological and biological characters of the specific organism.

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