Resistance to Fiji Disease in Sugar Cane: Role of Cultivar Preference by Planthopper Vector *Perkinsiella saccharicida* (Homoptera: Delphacidae)

K. DHILEEPAN[1, 2] AND B. J. CROFT[3]

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ABSTRACT Fiji disease (FD) of sugar cane caused by Fiji disease virus (FDV) is transmitted by the planthopper *Perkinsiella saccharicida* Kirkaldy (Hemiptera: Delphacidae). FD is effectively managed by using resistant cultivars, but whether the resistance is for the vector or for the virus is unknown. This knowledge would help develop a rapid and reliable glasshouse-based screening method for disease resistance. Sugar cane cultivars resistant, intermediate, and susceptible to FD were screened in a glasshouse, and the relationship between vector preferences and FD incidence was studied. Cultivar preference by nymphs increased with an increase in cultivar susceptibility to FD, but the relationship between adult preference and FD resistance was not significant. There was a positive correlation between the vector population and FD incidence, and the latent period for symptom expression declined with the increase in the vector populations. FD incidence in the glasshouse trial reflected the field-resistance status of sugar cane cultivars with known FD-resistance scores. The results suggest that resistance to FD in sugar cane is mediated by cultivar preference of the planthopper vector.

KEY WORDS Fiji disease virus, planthopper vector, *Perkinsiella saccharicida*, sugar cane, resistance, cultivar preference

FIJI DISEASE (FD) caused by Fiji disease virus (FDV) is one of the most important diseases of sugar cane in Australia and several sugar-producing parts of Asia and the Pacific region (Smith 2000). Sugar cane affected by FD shows leaf galls and distortion, death of meristematic tissue, and stunting, resulting in severe yield reductions (Egan and Ryan 1986). FDV is a double-stranded RNA virus of the genus *Fijivirus*, family Reoviridae (Matthews 1982). FD can be transmitted in a persistent manner only by planthoppers of the genus *Perkinsiella* (Hemiptera: Delphacidae) (Hughes and Robinson 1961, Hutchinson and Francki 1973). *Perkinsiella saccharicida* Kirkaldy is the only vector known to transmit FD in Australia (Mungomery and Bell 1933, Francki and Grivell 1972). *P. saccharicida*, a poor phloem feeder and an inefficient vector of FD (Baber and Robinson 1950, Francki et al. 1985), can acquire the virus only during its early nymphal stages (Daniels et al. 1969, Croft and Ryan 1984), and once infected, the planthopper remains so for life (Hughes and Robinson 1961). Nymphs are more efficient vectors than adults (Mungomery and Bell 1933), with <25% of adults transmitting the disease (Egan et al. 1989).

The most effective method to manage FD is through the exploitation of plant resistance (Egan and Fraser 1977, Egan and Ryan 1986, Ryan 1988). Screening for disease resistance was initially carried out in the field when natural levels of infection and vector populations were sufficiently high (Ryan 1988). Later, after the reduction in the prevalence of disease in the field, it became necessary to plant FD-infected sugar cane in the field to provide sufficient inoculum for identifying resistant cultivars (Hughes and Robinson 1961). However, because of low and fluctuating vector populations, consistent and reliable field-resistance ratings were not always obtained (Hussain et al. 1965). Hence, the screening for disease resistance has shifted to glasshouse studies (Hayes 1972, Ledger and Ryan 1977). Glasshouse trials currently involve inoculating test seedlings with viruliferous vectors either as individual plants (no choice) or groups of plants (limited choice) in insect-proof cages (Egan et al. 1989). The glasshouse method has the potential to screen large number of cultivars more rapidly (Daniels et al. 1969) than field trials, the latter of which take several years to obtain results given variable incidences of FD and vectors. However, resistance based on glasshouse studies does not always reflect resistance observed in the field (Reimers et al. 1982), with cultivars highly

[1] Cooperative Research Centre for Tropical Plant Protection, Department of Zoology & Entomology, The University of Queensland, Brisbane 4072, Australia.

[2] Current address: Alan Fletcher Research Station, P.O. Box 36, Sherwood, Qld 4075, Australia (e-mail: dhileepan_k@nrm.qld.gov.au).

[3] Bureau of Sugar Experiment Stations, Woodford, Qld 4515, Australia.

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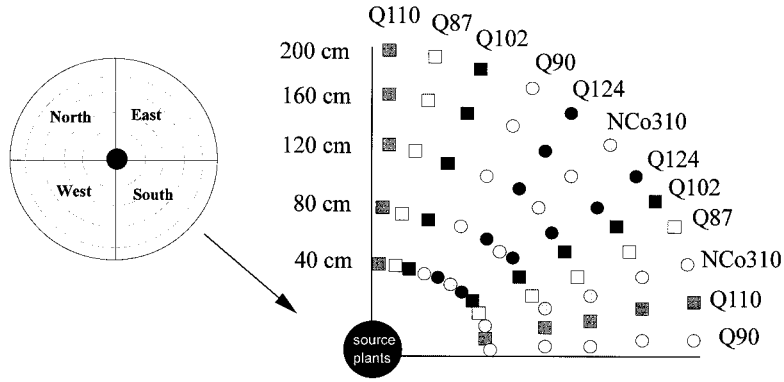

Fig. 1. Experimental plan for evaluating cultivar preference of *P. saccharicida* in the choice test.

susceptible under glasshouse conditions sometimes appearing to be resistant or tolerant in the field.

Currently, there is no reliable glasshouse-based resistance screening method available to screen new cultivars. Because of difficulties in identifying cultivars resistant to the vector (Ryan 1988), both field and glasshouse studies to date have focused mainly on plant resistance to the disease, with limited attention to whether plant resistance is to the vector or the virus. Tanaguchi et al. (1980) reported no relationship between FD-resistance ratings and survival and development of *P. saccharicida* nymphs. Studies on the feeding patterns of the vector show that the susceptibility of cultivars to FD is related to the proportion of time spent on phloem feeding by *P. saccharicida* (Chang and Ota 1978). Because the glasshouse trials only test for disease resistance, the importance of cultivar preference and feeding behavior of the planthopper on disease resistance has been seldom studied. To identify FD resistance in the glasshouse correctly, a two-component method, one addressing resistance to the disease and the second addressing resistance to the vector, is required. In this work, we study the preference of *P. saccharicida* for cultivars resistant, intermediate, and susceptible to FD to understand the role of preference by the vector in FD resistance. This information is vital to develop a glasshouse-based FD-resistance screening method to obtain resistance scores that reflect field-resistance status.

Materials and Methods

Sugar Cane Cultivars. Sugar cane cultivars resistant (Q110, Q87), intermediate (Q90, Q124), and susceptible (NCo310, Q102) to FD with known field-resistance scores were used in the study. On a scale of 1 (resistant) to 9 (susceptible), the field-resistance scores for cultivars Q110, Q87, Q90, Q124, NCo310, and Q102 are 1, 2, 4, 6, 8, and 9, respectively (Greet 2001). Single-eye setts of sugar cane cultivars harvested from disease-free plots were planted upright in 8-cm paper cups (Jiffy, Ryomgaard, Denmark) containing commercial potting mix and grown for 6 wk. Single plants (3–4 leaf stage) were transferred to 12-cm pots for use in the study. The potted plants in the glasshouse (24–37°C) received irrigation twice per day and controlled release fertilizer (Osmocoat, Scotts, Australia) at 45-d intervals (5 g/plant).

Planthopper Vector. A *P. saccharicida* colony maintained on FD-infected susceptible (NCo310) and tolerant (WD1) sugar cane cultivars, in a glasshouse at Bureau of Sugar Experiment Stations (BSES, Woodford, Australia), was used in the study. These were originally collected from FD-infected sugar cane plants at Woodford in 1999. Nymphs were 55% of the population used in the study ($N = 1283$). More than 95% of adults ($N = 394$) were macropters, and the sex ratio was 1.06 male:1 female.

Multiple- and No-Choice Tests. Cultivar preference by *P. saccharicida* and its impact on FD incidence were evaluated in a glasshouse using multiple-choice and no-choice tests, which were conducted simultaneously. In the multiple-choice test, four FD-infected sugar cane plants (≈120-cm-tall plants in 20-cm pots) supporting a high vector population (>4000 adults and nymphs) placed in the center of the glasshouse were used as source plants for both the virus and the vector. Occurrence of FD in these source plants was confirmed by leaf-gall symptoms. Six-week-old potted test plants of the six cultivars were arranged radially around the source plants in four quadrants (East, West, North, and South) with two rows (samples) of five plants of each cultivar at 40, 80, 120, 160, and 200 cm from the source plants in each quadrant (Fig. 1). Within each quadrant, the six cultivars were arranged randomly. A total of 40 plants (2 samples × 5 distances × 4 quadrants) of each cultivar were tested. The source plants with various developmental stages of the vector were maintained in the glasshouse for 2 wk, and populations of *P. saccharicida* adults and nymphs were counted on the 240 test plants on days 2, 3, 4, 7, 8, 9, 11, 13, and 14. Vector populations were counted in the morning (8–10 a.m.) when they are less active. In the no-choice test, plants ($N = 10$) of each cultivar were individually exposed to 10 planthoppers (5 adults and 5 nymphs collected from FD-affected plants) in an insect-proof nylon bag for 2 wk in the

Table 1. ANOVA table showing the interaction between sugarcane cultivars, distance from FD-infected source plants with vectors, and block effects on population of *P. saccharicida* nymphs, adults and oviposition sites

Source of variation	df	Nymphs/plant		Adults/plant		Oviposition sites	
		F	*P*	*F*	*P*	*F*	*P*
Cultivar	5	26.35	<0.001	18.20	<0.001	3.51	0.027
Distance	4	259.51	<0.001	70.82	<0.001	16.79	<0.001
Block	3	1.24	0.331	7.14	0.003	3.65	0.037
Cultivar × distance	20	6.53	<0.001	2.90	<0.001	1.26	0.236
Sample	1	0.03	0.860	1.40	0.239	0.30	0.584
Total	239						

glasshouse. On day 14 of the multiple and no-choice tests, the planthoppers were removed from the test plants and the number of oviposition sites were recorded along with each plant's height (from soil level to emerging point of youngest leaf) and total number of fully opened leaves. The test plants were then transferred to 20-cm pots in a different glasshouse and sprayed with Imidacloprid (250 mg active ingredient in 5 liters of water) using an aerosol applicator (DynaFog, Westfield, IN) during the first and second weeks to kill any newly emerging nymphs. The test plants were monitored at weekly intervals, and plants showing gall symptoms were removed. After 6 mo, the remaining symptomless plants were cut at soil level and allowed to regrow. The regrowth was monitored for disease symptoms over a 4-mo period.

Data Analysis. Variation in the proportion of test plants with *P. saccharicida* nymphs, adults, and oviposition sites, and the number of *P. saccharicida* nymphs, adults, and oviposition sites per test plant, in relation to sugar cane cultivar, distance from virus and vector source plants, and quadrant effects were analyzed using three-way analysis of variance (ANOVA) with means separated using the Tukey test. Regression analysis was employed to study the interaction between field FD-resistance scores and the number of *P. saccharicida* adults and nymphs per plant; field FD-resistance scores and percentage of test plants with FD infection; number of *P. saccharicida* adults and nymphs per plant and percentage of test plants with FD infection; and the number of *P. saccharicida* adults and nymphs per plant and latent period (weeks from vector feeding) for disease symptom expression in test plants.

Variation in plant height and number of leaves among plant cultivars was analyzed using one-way ANOVA, and the means were separated using a Tukey test. To minimize the variation in *P. saccharicida* preference because of variations in plant size, the number of *P. saccharicida* nymphs, adults, and oviposition sites on individual plants were corrected for the plant height using the following equation:

$$\frac{\text{Nymphs, Adults or Oviposition sites}}{\text{Individual plant height}} \times \text{Average plant height}$$

The relationship between field FD-resistance scores and the corrected number of *P. saccharicida* adults, nymphs, and oviposition sites was studied using linear and polynomial regression analysis. Because of limited number of test plants in the no-choice test, no statistical analysis was performed.

Results

Preference by Nymphs. In the multiple-choice test, *P. saccharicida* nymphs moved to 52% of test plants within 1 d, and in 2 wk 70% of test plants had nymphs. The proportion of plants without *P. saccharicida* nymphs on a sampling day differed significantly among cultivars ($F_{5,120} = 2.46, P = 0.04$), and increased with the increase in field FD-resistance scores ($r^2 = 0.79$, $P = 0.03$). Cultivar and distance from source plants had a significant impact on the number of *P. saccharicida* nymphs per test plant (Table 1). The number of *P. saccharicida* nymphs in test plants declined with the increase in the distance from source plants ($r^2 = 0.94$, $P = 0.04$). There were significantly more *P. saccharicida* nymphs on cultivar Q102 than on the other cultivars, and Q110 and NCo310 had the lowest numbers of *P. saccharicida* nymphs (Fig. 2). The number of *P. saccharicida* nymphs did not differ significantly among cultivars Q87, Q90, and Q124, but was significantly higher on these cultivars than on the cultivars Q110 and NCo310. There was no relationship between observed number of *P. saccharicida* nymphs per plant and field FD-resistance scores (Fig. 3). The plant height ($F_{5,234} = 88.65$, $P < 0.001$) differed significantly between cultivars, and the number of nymphs per plant ($r^2 = 0.09$, $P = 0.04$) increased with the increase in the plant height. There was a positive correlation between corrected number of *P. saccharicida* nymphs per plant and the field FD-resistance scores (Fig. 3), at all distance levels with different densities of *P. saccharicida* nymphs per plant (Table 2). In the no-choice test, the number of *P. saccharicida* nymphs recovered per plant after 2 wk increased with the increase in the field FD-resistance scores ($r^2 = 0.73$, $P = 0.03$), but did not differ significantly between cultivars ($F_{5,54} = 1.27$, $P = 0.29$).

Preference by Adults. In the multiple-choice test, *P. saccharicida* adults moved to 17% of test plants within 1 d, and in 2 wk 94% of test plants had adults. *P. saccharicida* adults were recorded on all plants except 5% of Q110 plants, but the proportion of plants without *P. saccharicida* adults on any sampling day differed significantly between cultivars ($F_{5,120} = 14.77$, $P < 0.001$). However, there was no relationship between the proportion of plants with *P. saccharicida*

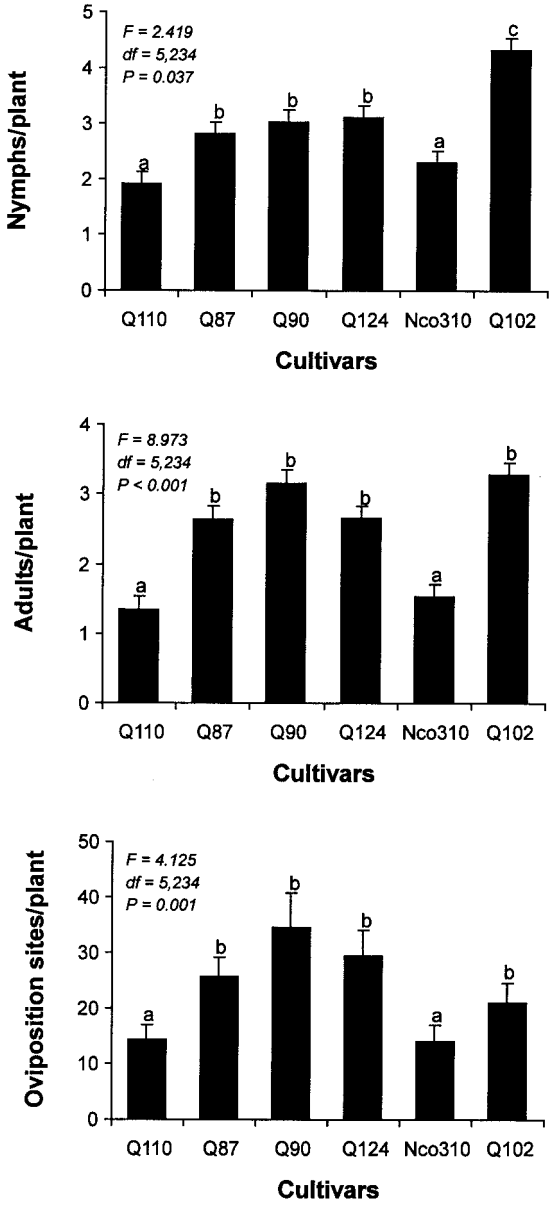

Fig. 2. Mean number of *P. saccharicida* nymphs, adults, and oviposition sites on six sugar cane cultivars resistant, intermediate, and susceptible to FD. Tukey test: means followed by the same letter are not significantly different ($P > 0.05$). Vertical bars represent standard error.

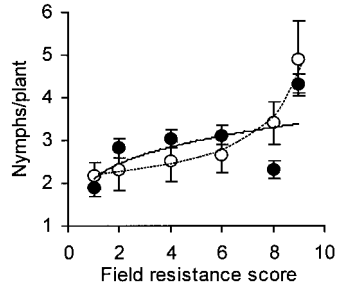

Fig. 3. Relationship between FD-resistance scores and mean number of observed (●) and corrected (○) *P. saccharicida* nymphs per plant. Regression between FD-resistance score (x) and observed (solid line) ($y = 0.16x + 2.13$, $r^2 = 0.43$, $P = 0.20$) and corrected (dotted line) ($y = 0.06x^2 \times 0.35x + 2.63$, $r^2 = 0.92$, $P = 0.03$) population of nymphs (y). Vertical bars represent standard error.

adults and field FD-resistance scores ($r^2 = 0.02$, $P = 0.79$). The number of *P. saccharicida* adults per plant differed significantly between cultivars and distance from source plants (Table 1). The number of *P. saccharicida* adults in test plants declined with the increase in the distance from source plants ($r^2 = 0.99$, $P < 0.001$). More *P. saccharicida* adults were recorded on cultivars Q102, Q124, Q90, and Q87 than on cultivars Q110 and NCo310 (Fig. 2). The number of *P. saccharicida* adults per plant ($r^2 = 0.12$, $P < 0.001$) increased with the increase in the plant height. However, there was no relationship between observed ($r^2 = 0.19$, $P = 0.58$) nor corrected ($r^2 = 0.24$, $P = 0.29$) numbers of *P. saccharicida* adults per plant and field FD-resistance scores. In the no-choice test, the number of *P. saccharicida* adults recovered per plant after 2 wk did not differ significantly between cultivars ($F_{5,54} = 1.27$, $P = 0.29$), and there was no relationship between the number of adults recovered per plant and field FD-resistance scores ($r^2 = 0.16$, $P = 0.43$).

Preference for Oviposition. The proportion of test plants without oviposition sites by *P. saccharicida* in the multiple-choice test ranged from 2.5 to 5% and did not differ significantly between cultivars ($F_{5,234} = 0.27$, $P = 0.93$). There was no significant relationship between the proportion of test plants without oviposition sites and field FD-resistance score ($r^2 = 0.06$, $P = 0.64$). Cultivars and distance from source plants had a significant impact on the number of oviposition sites by *P. saccharicida* (Table 1). The number of oviposition sites in test plants declined with increasing distance from the source plants ($r^2 = 0.79$, $P < 0.05$). The number of oviposition sites per plant differed between cultivars (Fig. 2) and was significantly lower in resistant Q110 and susceptible NCo310 cultivars than in the remaining cultivars. The number of oviposition sites was dependent on the number of *P. saccharicida* adults per plant ($r^2 = 0.39$, $P < 0.001$), and increased with the increase in the plant height ($r^2 = 0.11$, $P < 0.001$). There was no linear relationship between the observed ($r^2 = 0.01$, $P = 0.86$) nor corrected ($r^2 = 0.11$, $P = 0.53$) number of oviposition sites per plant and field FD-resistance scores.

FD Incidence. In the multiple-choice test, FD incidence increased with higher numbers of *P. saccharicida* nymphs and adults per plant (Fig. 4), but there was no linear relationship between the number of oviposition sites per plant and FD incidence ($r^2 = 0.43$, $P = 0.16$). The latent period for expression of disease symptoms declined with higher numbers of *P. saccharicida* nymphs and adults per plant (Fig. 5). Incidence of FD (y) declined with the increase in the distance (x) from source plants ($y = 75.21 - 10.86x$,

Table 2. Regression analysis between the average number of corrected *P. saccharicida* nymphs per plant and field FD-resistance scores at different distances from source plants, with different observed densities of nymphs per plant

Distance from source plants (cm)	Nymphs/plant (observed)	Regression	r_2	F	P
40	8.33	$y = -0.19 + (7.13x) - (1.79x_2) + (0.13x_3)$	0.97	18.82	0.05
80	3.53	$y = 3.47 - (0.58x) + (0.07x_2) + (0.003x_3)$	0.96	17.78	0.05
120	1.48	$y = 2.02 - (0.50x) + (0.08x_2) + (0.002x_3)$	0.90	6.07	0.12
160	0.64	$y = 0.20 - (0.11x)$	0.62	6.48	0.06
200	0.60	$y = 0.76 - (0.24x) + (0.05x_2) + (0.002x_3)$	0.87	4.28	0.20

y = Average number of nymphs (corrected) per plant.
x = FD-resistance score.

$r^2 = 0.84$, $P = 0.03$). This was because of reduction in the number of *P. saccharicida* nymphs ($y = 5.16 - 0.024x$, $r^2 = 0.73$, $P = 0.02$) and adults ($y = 4.98 - 0.021x$, $r^2 = 0.98$, $P < 0.001$) per plant with the increase in the distance (x) from source plants. FD incidence in the multiple-choice test differed significantly between cultivars ($F_{5,18} = 6.91$, $P < 0.001$) and was lowest in Q110, the most resistant cultivar. The FD incidence in cultivar NCo310 was lower in the multiple-choice test, and no disease was recorded in the no-choice test. In both multiple and no-choice tests, when cultivar NCo310 was excluded from the analysis, there was a positive relationship between FD incidence in the glasshouse and the field FD-resistance scores (Fig. 6). In the no-choice test, there was a positive correlation between the average number of *P. saccharicida* nymphs (x) recovered after 2 wk and FD incidence ($y = -3.5 + 12.84x$, $r^2 = 0.73$, $P = 0.03$), but there was no relationship between the average number of *P. saccharicida* adults recovered and FD incidence ($r^2 = 0.16$, $P = 0.43$). Latent period for symptom expression in all cultivars declined with the increase in field FD-resistance scores ($r^2 = 0.80$, $P = 0.04$), but did not differ significantly between cultivars ($F_{5,96} = 1.23$, $P = 0.30$).

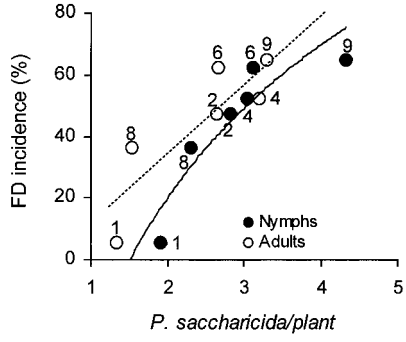

Fig. 4. Relationship between FD incidence and mean number of *P. saccharicida* nymphs (●) and adults (○) per plant. Regression (solid line) between the number of nymphs (x) and FD incidence (y): $y = -21.14 + 22.6x$, $r^2 = 0.73$, $P = 0.03$. Regression (dotted line) between the number of adults (x) and FD incidence (y): $y = -11.23 + 22.92x$, $r^2 = 0.75$, $P = 0.03$. Numbers 1–9 refer to the FD-resistance score of cultivars (Q110 = 1; Q87 = 2; Q90 = 4; Q124 = 6; NCo310 = 8; Q102 = 9).

Discussion

Our primary aim is to understand the roles of dispersal pattern and feeding preference of *P. saccharicida* on FD resistance in sugar cane cultivars. In our experiment, *P. saccharicida* nymphs moved more readily than adults. Among the six cultivars tested, the cultivar most resistant to FD (Q110) was the least preferred by *P. saccharicida* nymphs, and the cultivar most susceptible to FD (Q102) was the most preferred by *P. saccharicida* nymphs. In contrast, the preferences of *P. saccharicida* nymphs and adults for NCo310, a cultivar highly susceptible to FD, were both very low. Earlier studies indicated that NCo310 is a highly preferred cultivar for *P. saccharicida* (Bull 1977, 1981). Low numbers of *P. saccharicida* adults and nymphs and oviposition sites recorded on NCo310 in our study were possibly because of the 25–48% shorter plant height and 5–11% fewer leaves in NCo310 than the other cultivars screened. The preference for feeding and oviposition by *P. saccharicida* was influenced by plant size. Hence, we corrected the number of *P. saccharicida* nymphs, adults, and oviposition sites on individual plants for plant height. To minimize the variation in *P. saccharicida* preference because of variations in plant size, we suggest that in future glasshouse screening trials, uniform-sized plants be used

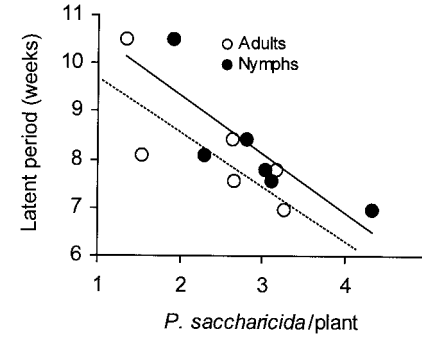

Fig. 5. Relationship between latent period for expression of FD symptoms (weeks) and mean number of *P. saccharicida* nymphs (●) and adults (○) per plant. Regression (solid line) between the number of nymphs (x) and latent period (y): $y = -1.21x + 11.76$, $r^2 = 0.68$, $P < 0.001$. Regression (dotted line) between the number of adults (x) and latent period (y): $y = -1.14x + 11$, $r^2 = 0.58$, $P < 0.001$.

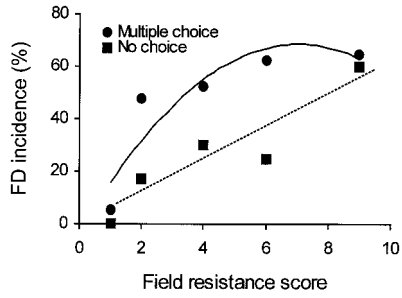

Fig. 6. Relationship between field FD-resistance scores (x) and FD incidence (y) in multiple-choice (●) and no-choice (■) tests. Multiple-choice test (solid line): $y = -1.46x^2 + 20.48x - 3.39$, $r^2 = 0.83$, $P = 0.36$. No-choice test (dotted line): $y = 6.39x - 1.71$, $r^2 = 0.87$, $P = 0.02$.

and/or individual plant heights recorded and corrected for.

Preference for feeding and oviposition by *P. saccharicida* differed significantly between cultivars with different FD-resistance scores. There was no relationship between *P. saccharicida* adult preference and FD-resistance scores. However, preference by *P. saccharicida* nymphs increased with the increase in the FD susceptibility, indicating that nymphs are important in mediating FD resistance/susceptibility in sugar cane. Varietal preference of *Perkinsiella vitiensis* Kirkaldy also influenced the FD susceptibility ratings of sugar cane in Fiji (Hussain et al. 1965), and Bull (1977) reported high *P. saccharicida* nymph populations on NCo310, a cultivar highly susceptible to FD. Candy et al. (2001) reported that resistance to FD in sugar cane is not mediated via a gene-for-gene system, and suggested that it could be mediated either via resistance to the planthopper vector or via a more general biotic/abiotic response mechanism. A similar situation occurs with plant resistance to gall mite vector (*Cecidophyopsis ribis* Westwood) in blackcurrant (*Ribes nigrum* L.) that provides a high level of protection against blackcurrant reversion disease (Jones et al. 1998). The increase in FD susceptibility with the increase in the feeding preference of *P. saccharicida* nymphs appear to be because of more frequent phloem feeding by the nymph than by the adult vector (Baber and Robinson 1950). Varietal preference in planthoppers appears to be because of specific probing stimulants in the host plant, which facilitate phloem location (Cook and Denno 1994). FD is acquired only by early stages of *P. saccharicida* nymphs (Croft and Ryan 1984), and hence, preference by nymphs has significant implications on FD resistance/susceptibility.

The relationship between preferences for oviposition by *P. saccharicida* and FD-resistance scores was nonlinear. It is difficult to relate oviposition preference with preference by nymphs, as preference and performance are not necessarily positively related (Cook and Denno 1994). The ability of nymphs to disperse rapidly enables them to move to its preferred cultivars, even though the preferences of adults for feeding and oviposition differ from the preference of nymphs. We recommend that preference of *P. saccharicida* nymphs is recorded in future FD-resistance screening trials, both in the glasshouse and in the field.

Host-plant resistance has been an effective tool in the management of planthoppers (Hare 1994), but very little information is available on the actual mechanisms of plant resistance (Cook and Denno 1994). In rice, resistance to brown planthopper *Nilaparvata lugens* Stål is mediated by phloem chemistry (Sogawa 1982), and does not appear to be influenced by physical or mechanical interference preventing stylet penetration of the phloem (Cook and Denno 1994). In sugar cane, spine density and thickness of vascular bundle confer resistance to early stage nymphs of the sap-sucking pest *Pyrilla perpusilla* Walker (Kumarasinghe et al. 2001). There was no relationship between FD-resistance scores and spine density, thickness of major and minor vascular bundles, distance of minor and major vascular bundles from epidermis, and width of leaf blade and width of the main leaf vein (K. Dhileepan, unpublished data). Planthoppers probe much more frequently, ingest much less, and excrete very little honeydew on resistant plant varieties compared with susceptible ones (Cook and Denno 1994). *P. saccharicida* adults spend significantly more time in phloem ingestion on cultivars susceptible to FD than on cultivars resistant to FD (Chang and Ota 1978).

Most previous studies have focused on resistance to FD, with little attention on whether the plant resistance acts on the virus or on the vector. Tanaguchi et al. (1980) reported no relationship between survival and development of *P. saccharicida* nymphs and FD-resistance ratings, even though the survival and development of *P. saccharicida* differed significantly between cultivars. In contrast, Chang and Ota (1978) reported a negative correlation between frequency of phloem feeding by *P. saccharicida* adults and the FD-resistance ratings. It appears that the vector feeding behavior, rather than the survival and development of the vector on sugar cane cultivar, influences the FD-resistance status. However, no information is available on the frequency of phloem feeding by *P. saccharicida* nymphs on cultivars resistant and susceptible to FD in sugar cane. In our experiments, plants with higher *P. saccharicida* populations presumably received more virus inoculum, resulting in higher disease incidence and shorter latent periods. Our significant correlation between the number of *P. saccharicida* nymphs per plant and FD incidence suggests that nymphs are more effective vectors than adults, even though both adults and nymphs have the potential to transfer the virus. Mungomery and Bell (1933) reported *P. saccharicida* nymphs as an efficient vector of FD. The FDV confined to gall-phloem and gall-xylem (Hatta and Francki 1976) can be acquired only by the early stages of the nymph (Mungomery and Bell 1933, Daniels et al. 1969, Croft and Ryan 1984), which incidentally feeds more often on phloem than the adults (Baber and Robinson 1950). However, there is no quantitative data comparing the vector potential of *P. saccharicida*

nymphs and adults. Differences in the vector potential between males and females and between macropters and brachypters, and its implications on disease incidence in glasshouse-based FD-resistance screening trials also need to be studied.

In both multiple and no-choice tests, FD incidence in cultivars except NCo310, as expected, reflected the field-resistance status. Results from our multiple-choice test suggest that the variation in FD incidence among different cultivars is because of variation in the vector density, which in turn is because of cultivar preference of the vector. This is further evident from the relationship between FD incidence and the number of *P. saccharicida* nymphs recovered in our no-choice test. In no-choice test, lower number of *P. saccharicida* nymphs recovered from resistant Q110 cultivar (0.29 ± 0.08) than from susceptible Q102 cultivar (4.58 ± 2.05) is possibly because of antibiosis, but further research is required to confirm this. In our multiple-choice test, with the increase in the distance from source plants, the density of vectors per plant declined, resulting in reduced FD incidence. FD incidence was more (70%) in plants, with an average of 8.3 nymphs and 4.2 adults per plant at 40 cm from the source plants than (29–48%) in plants with <3.1 nymphs and 3.3 adults per plant at >80 cm from the source plants. We suggest that in future screening trials, a minimum of eight nymphs and four adults per plant be used.

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