Survival of the *Deltocephalus menoni* (Homoptera: Cicadellidae), the Vector of Sugarcane White Leaf Disease in Sri Lanka on Alternative Host Plants

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ABSTRACT

Deltocephalus (Recilia) *menoni* (Hemiptera: Cicadellidae) is the only identified insect vector of sugarcane White Leaf Disease in Sri Lanka. Field and laboratory experiments were conducted from January 2013 to December 2014 in sugarcane-growing areas to study the ability of *D. menoni* to survive on other plant species present in and near the sugarcane plantations to design a vector management programme. Field surveys were conducted in randomly-selected four disease-infected fields, 0.5ha each from each location. All available weeds in randomly-selected nine weedy spots with ten-metre long from each field were recorded and the weeds with frequency > 0.25 were identified up to species level. The available intercrops with the disease-infected sugarcane and other annual crop species adjacent to the disease fields were recorded in all study locations during *Yala* and *Maha*. Museum data and literature were collected. Field and laboratory studies were conducted using identified plant species to study the ability of the vector to survive on those plant species. The number of days of survival of the vector on each plant species was recorded and statistically compared with that on *Saccharum* hybrids. Two (02) wild relatives of the *Saccharum* hybrids, twenty nine (29) weed species, fourteen (14) intercrops and six (06) annual crops were recorded and identified during the field surveys. *Sorghum bicolor* and *Saccharum spontaneum* were found as alternative host plants for *D. menoni*. Both plant species were feeding and breeding hosts. Hence, *D. menoni* has monophagy feeding habit; it prefers feeding on plant species belong to the family, Poaceae.

Keywords: Alternative host, *Deltocephalus menoni*, *Saccharum* hybrids, Sri Lanka, Sugarcane, Vector, White Leaf Disease

INTRODUCTION

Management of alternative host plants can be used to reduce the vector populations and the disease incidences in some cropping systems (Weintraub and Wilson, 2010). *Deltocephalus* (Recilia) *menoni* (Hemiptera: Cicadellidae, Subfamily: Deltocephalinae) is the only confirmed insect vector responsible for spreading the White Leaf Disease (WLD) of sugarcane, which is the most serious Phytoplasma disease of sugarcane in Sri Lanka. The vector should be managed with integrated vector management strategies, as there is a significant relationship between the population levels of the vector and the disease incidence in commercial sugarcane plantations in the country (Seneviratne, 2008; Chanchala *et al.*, 2014). The feeding habits of the members of the subfamily Deltocephalinae ranges from monophagy to polyphagy (Weintraub and Wilson, 2010), and several number of plant families have been identified as feeding and breeding hosts of family Cicadellidae*viz.*,Solanaceae, Leguminaceae,Cucurbitaceae,Commelinaceae, etc. (Lamp *et al.*, 1994; Marques *et al.*, 2012; Eziashi *et al.*, 2013). Therefore, those plants facilitate the survival and longevity of the Cicadellids which exist within the cropping areas even without their major hosts.

Several weed species, intercrops and other annual crops are present in and near the sugarcane plantations in Sri Lanka. Therefore, information on the ability of *D. menoni* to survive on those plant species are useful to design a vector management programme to reduce the crop losses due to WLD while protecting the sugarcane-growing environment for sustainable sugarcane production. Therefore, this study was conducted with following two objectives:

i. to identify the weed species (with more than 0.25 frequency), inter crops and other annual crops in and near the WLD-infected sugarcane plantations
ii. to study the ability of *D. menoni* to survive on identified weed species, inter crops and other annual crops

MATERIALS AND METHODS

Identification of weed species, inter crops and other annual crops in and near the WLD-infected sugarcane plantations

Field surveys were conducted in five locations,*viz.*, Research Farm, Sugarcane Research Institute (SRI) at Uda Walawe and commercial sugarcane plantations at Sevanagala, Pelwatte, Hingurana (in the dry zone-annual rainfall 1,300 – 1,600 mm) and Passara (intermediate zone- annual rainfall 1,750 – 2,500mm) of Sri Lanka from January 2013 to December 2014.

Four WLD-infested sugarcane fields, 0.5 ha each, were selected randomly from each location and data were collected at monthly intervals. Randomly-selected nine (09) weedy spots, each with ten metre (10m) length, were marked using a rope in each field. All available weeds along the rope were recorded to calculate the frequencies of each species according to Witharama *et al.* (1997). Weed species with frequency above 0.25, were collected and preserved and the preserved specimens were identified up to species level using published literature and reference samples in the weed collection of SRI.

The available intercrops with the sugarcane during *Yala* (Mid-March - Mid September) and *Maha* (Mid-September - Mid March) seasons of the year were recorded in all study locations. The annual crop species which were cultivated near the disease-infected sugarcane fields were also recorded and identified.

Studying the ability of *Deltocephalus menoni* to survive on identified weed species, inter crops and other annual crops

Studies were conducted in four steps,*viz.*,collection of museum data, literature survey, field studies and laboratory tests.

Collection of museum data

The available specimens of leaf hopper species in the museum of the Horticultural Research and Development Institute, Gannoruwa, Sri Lanka were checked to identify whether the *D. menoni* has been recorded on other plant species.

Literature survey

Literature on the host range of the *D. menoni* was collected from the peer-reviewed journals and the previous records available in the Sugarcane Research Institute, Uda Walawe.

Field studies

All insects present on weeds (frequency > 0.25), intercrops and other annual crops were collected at three-month intervals at Uda Walawe and Sevanagala. Five plots of 25m x 10m size were selected randomly from each plant species in both locations. All insects present in those plots were collected using

sweep net as 500 sweeps per plot. The insects collected were checked for the presence of *D. menoni*. At the same time, five plants from each species in each location were enclosed separately using a sweep net and each plant was observed for the presence of the *D. menoni* within the enclosure.

Laboratory tests

Adults of *D. menoni* were collected using a sweep net and a pooter from the sugarcane plantations below six months old in the research farm, Uda Walawe. The collected insects were reared in insect-rearing cages in the laboratory of SRI at Uda Walawe according to the protocol developed by Senevirathne (2008).

Studying surviving ability of the vector on test plant species

No choice tests were conducted to study surviving ability of the vector by arranging test plants in Completely Randomised Design (CRD) with three replicates. Young and healthy plants from each selected weed species were uprooted from the natural environment, and they were planted in plastic pots (Diameter: 12cm) with sterilised soil after confirming the absence of living insects, cocoons and eggs of any insect species.

Seeds or vegetative propagative materials of the recorded intercrop and annual crop species were planted in pots in the same way. The potted plants were acclimatised under laboratory conditions (26-27 ^{0}C, 70-72% RH with 12h photoperiod) for a period of one week and were placed in the insect-proof laboratory cages. The potted sugarcane plants of the variety SL 96 328 were used as the control. Five adult vectors (Female: Male - 3:2) were introduced to each potted plant in insect-proof cages.

Studying feeding of the vector on test plant species

Three plants from each selected plant species were grown in insect-proof cages. Leaf or leaf portion from each plant encircled with Para film sachet and a water-starved young female vector was introduced to each sachet. Each vector left in sachet for a 6-hour period for feeding, and the amount was measured using following two tests;

Honey dew test

Honey dew in sachet collected with the bromocresol green-treated filter papers and strained area (blue) measured using squire millimetre grid printed on transparent paper.

Erythrosine dye test

Leaf portions where insect fed on were cut and dipped in staining solution of 0.1% erythrosine dye for 10-15 min. Then, the leaf portions were examined under a microscope and stained (pink/red) stylet sheaths were counted in each plant species.

Data collection and analysis

Studying surviving ability of the vector on test plant species

The vectors in the cages were observed at twelve-hour intervals for a one month period. The maximum number of days of survival of the vector on each plant species was determined. After two weeks of adult introduction, the cages were regularly monitored to observe the emergence of the nymphs. The maximum number of days of survival of the vector on each plant species and number of nymphs emerged from the each plant and their ability to survive on particular plant species were also recorded. The average number of nymphs survived on each plant species was compared with that on sugarcane plants, by using Dunnett's test at 0.05 probability levels using SAS (for windows 9.0) software.

Studying feeding of the vector on test plant species

The honey dew-stained area in each species

bits were also compared with those on sugarcane plants, by using Dunnett's test at 0.05 probability levels using SAS (for windows 9.0) software.

RESULTS AND DISCUSSION

Identification of weed species, inter crops and other annual crops in and near the WLD-infected sugarcane plantations

According to the results, two (02) wild relatives of the *Saccharum* hybrids, twenty nine (29) weed species with frequencies more than 0.25, fourteen (14) intercrops and six (06) annual crops were recorded and identified during the field surveys in the year 2013 in all study locations (Table 1).

Ability of *Deltocephalus menoni* to survive on identified weed species, inter crops and other annual crops

According to the museum data and literature survey, there were no any records on alternative host plants for *D. menoni* in Sri Lanka. Also *D. menoni* was not recorded in the collected insects during the field studies on the identified weeds, intercrops and crop species at Uda Walawe and Sevanagala.

The results of laboratory tests indicated that *D. menoni* survived 15 days on *Saccharum* hybrids, 13 days on *Saccharum spontaneum* and *Sorghum bicolor* and 1-4 days on other plant species. The maximum number of survival days of the vector on all other plant species were significantly lower with the *Saccharum* hybrids (Table 1) except *Saccharum spontaneum* and *Sorghum bicolor*.

The amount of honey dew produced by *D. Menoni* after feeding on *Saccharum spontaneum* and *Sorghum bicolor* was significantly higher than that on other test species. The average honey dew production of *D. menoni* on *Saccharum spontaneum* ($12.5mm^2$) and *Sorghum bicolor* ($6.48mm^2$) was lower than that on *Saccharum* hybrid ($19.41\ mm^2$), but significantly higher than that on other test species. There was no honey dew recorded on most of the test species. The amounts recorded on some test species were not significant compared to that on sugarcane.

Stylet sheaths were observed on *Saccharum spontaneum* (3), *Sorghum bicolor* (2), *Zea maise*(9), *Hemidesmus indicus*(7)and *Achyranthes aspera*(5).There was less number of stylet sheeths on *Saccharum spontanium* and *Sorghum bicolor* which act as alternative hosts to *D. menoni* and higher number of stylet sheaths on *Zeamaise, Hemidesmus indicus and Achyranthes aspera* which are do not act as hosts. The higher number of stylet sheaths on those plants is a result of trying of the vector to feed, but failure to feed on that species. These results indicate that *Saccharum spontaneum* and *Sorghum bicolor* act as alternative feeding hosts of *D. menoni.* In Taiwan, several weed species have been identified as alternative host plants for the insect vector of WLD; *Matsumuratettix hiroglyphicus* (Matsumara) (Yang and Pan, 1979).

During the laboratory experiments, we observed that the vector in the rearing cages with *Cleome viscosa* (Cleomaceae) always evaded the *Cleome* plants and confined to the side walls of the rearing cages in all replicates. Also, all the introduced vectors died within the 24 hours. The characteristic odour and the hairy nature of leaves and stem of the *Cleome viscosa* may be the reasons for the above behaviour of the vector on this plant.

Furthermore, we observed a searching behaviour of the vector on *Panicum maximum* (Poaceae) plants for feeding in addition to the resting behaviour on it. Also, they survived for four days on *Panicum*

Table 01: Maximum insect survival days, honey dew excretion, number of salivary sheaths and population build-up of D. *menoni* on test plant species and *Saccharum* hybrids

	Scientific name	Family	maximum number of	honey dew	Number of salivary	Population
1	*Saccharum* hybrids	Poaceae	15	19.22	1	30
Wild relatives of *Saccharum* hybrids						
2	*Saccharum officinarum*	Poaceae	13	13.33***	2.33	21
3	*Erianthus arundinaceous*	Poaceae	3***	1.00***	0.00 ***	0.00 ***
Weed species						
4	*Achyranthes aspera*	Amaranthaceae	2 ***	0.00 ***	4.66	0.00 ***
5	*Amaranthus viridis*	Amaranthaceae	2***	0.33 ***	0.00 ***	0.00 ***
6	*Aerva lanata*	Amaranthaceae	2***	0.66***	0.00 ***	0.00 ***
7	*Hemidesmus indicus*	Apocynaceae	2***	0.25***	0.00 ***	0.00***
8	*Asparagus racemosus*	Asparagaceae	1***	0.00 ***	0.00 ***	0.00 ***
9	*Tridax procumbens*	Asteraceae	2***	0.00 ***	0.00 ***	0.00 ***
10	*Cyanthillium cinereum*	Asteraceae	2***	0.00 ***	0.00***	0.00 ***
11	*Micania scandeus*	Asteraceae	2***	0.00 ***	0.00 ***	0.00 ***
12	*Calyptocarpus vialis*	Asteraceae	2***	0.41***	0.00 ***	0.00 ***
13	*Emilia sanchipolia*	Asteraceae	1***	0.00 ***	0.00 ***	0.00 ***
14	*Cleome viscosa*	Cleomaceae	1***	0.00 ***	0.00 ***	0.00 ***
15	*Commelina benghalensis**	Commelinaceae	1***	0.00 ***	0.00 ***	0.00 ***
16	*Cyperus rotundus*	Cyperaceae	1***	0.00 ***	0.00 ***	0.00 ***
17	*Euphorbia heterophylla**	Euphorbiaceae	1***	0.00 ***	0.00 ***	0.00 ***
18	*Euphorbia hirta*	Euphorbiaceae	1***	0.00 ***	0.00 ***	0.00 ***
19	*Acalypha indica*	Euphorbiaceae	1***	0.00 ***	0.00 ***	0.00 ***
20	*Alysicarpus vaginalis*	Fabaceae	1***	0.00 ***	0.00 ***	0.00 ***
21	*Phaseolus lathyroides**	Fabaceae	3***	0.16 ***	0.00 ***	0.00 ***
22	*Mimosa pudika*	Fabaceae	2***	0.91***	0.00 ***	0.00 ***
23	*Desmodium triflorum*	Fabaceae	3***	0.00 ***	0.00 ***	0.00 ***
24	*Ocimum sanctum*	Lamiaceae	3***	0.00 ***	0.00 ***	0.00 ***
25	*Leucas zeylanicus*	Lamioideae	3***	0.00 ***	0.00 ***	0.00 ***
26	*Sida acuta*	Malvaceae	3***	0.00 ***	0.00 ***	0.00 ***
27	*Urena lobata*	Malvaceae	2***	0.00 ***	0.00 ***	0.00 ***
28	*Abutilon Indicum*	Malvaceae	3***	0.00 ***	0.00 ***	0.00 ***
29	*Boerhavia coccinea*	Nyctaginaceae	2***	0.00***	0.00 ***	0.00 ***
30	*Phylanthus viridis*	Phyllanthaceae	1***	0.00 ***	0.00 ***	0.00 ***
31	*Scorpia dulcis*	Plantaginaceae	1***	0.00 ***	0.00 ***	0.00 ***

32	*Imperata cylindrica*	Poaceae	1***	0.91 ***	0.00 ***	0.00 ***
33	*Panicum maximum*	Poaceae	1***	0.00 ***	0.00 ***	0.00 ***
34	*Dectyloctenium aegyptinm*	Poaceae	2***	0.00 ***	0.00 ***	0.00 ***
35	*Eleusine indica*	Poaceae	2***	0.00 ***	0.00 ***	0.00 ***
36	*Borreria spp.**	Rubiaceae	2***	0.00 ***	0.00 ***	0.00 ***
37	*Hedyatis corymbosa*	Rubiaceae	3***	0.00 ***	0.00 ***	0.00 ***
38	*Cardiospermum microcarpum*	Sapindaceae	2***	0.33 ***	0.00 ***	0.00 ***
Intercrop species						
39	*Citrullus lanatus*	Cucurbitaceae	4***	0.00 ***	0.00 ***	0.00 ***
40	*Cucumis sativus*	Cucurbitaceae	3***	0.00 ***	0.00 ***	0.00 ***
41	*Cucurbita maxima*	Cucurbitaceae	2***	0.00 ***	0.00 ***	0.00 ***
42	*Benincasa hispida*	Cucurbitaceae	2***	0.00 ***	0.00 ***	0.00 ***
43	*Vigna radiata*	Fabaceae	3***	0.00 ***	0.00 ***	0.00 ***
44	*Vigna unguiculata*	Fabaceae	3***	0.00 ***	0.00 ***	0.00 ***
45	*Glycine max*	Fabaceae	3***	0.00 ***	0.00 ***	0.00 ***
46	*Vigna unguiculata* sub sp sesquipedalis	Fabaceae	2***	0.00 ***	0.00 ***	0.00 ***
47	*Vigna mungo*	Fabaceae	2***	0.00 ***	0.00 ***	0.00 ***
48	*Arachis hypogaea*	Fabaceae	3***	0.00 ***	0.00 ***	0.00 ***
49	*Zea maize*	Poaceae	2***	0.75 ***	8.33***	0.00 ***
50	*Capsicum annum*	Solanaceae	2***	0.33 ***	0.00 ***	0.00 ***
51	*Abelmoschuse sculentus*	Malvaceae	2***	0.00 ***	0.00 ***	0.00 ***
52	*Sesamum indicum*	Pedaliaceae	3***	0.00 ***	1.33	0.00 ***
Associated annual crop species						
53	*Ipomea batata*	Convolvulaceae	3***	0.75 ***	0.00 ***	0.00 ***
54	*Oryza sativa*	Poaceae	2***	0.00 ***	0.00 ***	0.00 ***
55	*Sorgum bicolor*	Poaceae	13	0.00 ***	0.00 ***	18 ***
56	*Vetiveria zizanioides*	Poaceae	2***	6.48 ***	0.00 ***	0.00 ***
57	*Chrysopogon zizanioides*	Poaceae	3***	0.00 ***	0.00 ***	0.00 ***
58	*Eleusine coracana*	Poaceae	3***	0.00 ***	0.00 ***	0.00 ***

maximum plants. This may be due to the more or less similar morphological characters of the *Panicum maximum* plants and *Saccharum* hybrids which belong to the same family Poaceae.

CONCLUSIONS

Saccharum spontaneum and *Sorghum bicolor* act as alternative host plants for *Deltocephalus menoni*. Both plant species feeding and breeding hosts. But these two species showed lesser preference by *Deltocephalus menoni* for feeding and breeding than *Saccharum* hybrids. Three plant species; *Saccharum* hybrids, *Saccharum spontaneum* and *Sorghum bicolor* belong to family Poaceae. Hence, *D. menoni* has monophagy feeding habit, i.e., it prefers feeding on plant species belonged to the same family. Therefore, cultivating or maintaining *Saccharum spontanium* (Wild cane) and *Sorghum bicolor* should not be allowed to practice around fallowing fields and nursery areas since vector can survive on particular plant species and they can serve as harbours to migrating vectors from the infected areas to healthy or newly-established sugarcane plantations. *Cleome viscosa* acts as a repellent to the *D. menoni* and most of other test plant species acts as resting sites for the vector. Behaviour of *D. menoni* on *Saccharum spontaneum* and *Sorghum bicolor was* also similar to that on sugarcane hybrids.

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