Relationship between the Incidences of Sugarcane White Leaf Disease and the Population Dynamics of Its Vector, *Deltocephalus menoni* (Homoptera: Cicadellidae), in Sri Lanka

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ABSTRACT

This paper evaluates the seasonal variations of *Deltocephalus menoni* vector population and White Leaf Disease (WLD) incidence in different sugarcane-growing areas in Sri Lanka and determines the effect of the former on the latter to develop an efficient management program for the disease. *D. menoni* populations and WLD incidence in Uda Walawe, Sevanagala (irrigated and rain-fed sectors), Pelwatte, Hingurana and Passara plantations were recorded during 2013. Simple linear regression analysis was carried out to determine the relationship between vector population and disease incidence. *D. menoni* was recorded in all sugarcane-growing areas. Except in Hingurana and Passara, the quarterly *D. menoni* population in all sugarcane-growing areas was significantly different within the year 2013. Uda Walawe and Pelwatte recorded the highest populations of *D. menoni*. The maximum population buildup of *D. menoni* was recorded during the first quarter of the year. The highest WLD incidence was recorded in the rain-fed sector at Sevanagala and the lowest in Passara area. The population levels of *D. menoni* showed a significant effect on WLD incidence in four weeks after their presence in Uda Walawe and Hingurana areas. This information can be used to implement an integrated management programme for the disease, and high priority should be given to avoid spreading the disease in Hingurana and Passara areas where disease inoculum is low, but the vector is present.

Keywords: *Deltocephalus menoni*, Population dynamics, Sugarcane White Leaf Disease, Sri Lanka, Vector

INTRODUCTION

Sugarcane White Leaf Disease (WLD) is one of the most destructive sugarcane diseases in Sri Lanka, caused by sugarcane white leaf phytoplasma (Kumarasinghe and Jones, 2001). WLD in Sri Lanka was first recorded in 1972 in sugarcane plantations at Kantale, in the Eastern province. Severe crop losses were recorded in the same area in 1991 (Seneviratne *et al.*, 2006). Since the control programme was not very effective, the disease spread to other sugarcane-growing areas of the country, i.e., Sevanagala, Pelwatte and Hingurana (Kumarasinghe and Jones, 2001).The disease is now prevalent in all commercial sugarcane-growing areas of the country causing heavy losses to the sugar industry.

WLD spreads primarily due to use of infected seedcane by sugar industries and farmers (Seneviratne *et al.*, 2006). The insects associated with the aerial parts of sugarcane are responsible for the secondary transmission of the disease. *Deltocephalus menoni* (Homoptera: Cicadellidae) has been identified as the sole natural vector species of WLD in Sri Lanka, and experimental data suggested that the transovarial transmission of WLD phytoplasma does not occur in *Deltocephalus menoni* (Seneviratne *et al.*, 2008).

WLD phytoplasma could be controlled by hot-water treatment of seedcane at 54^{0}C for 50 minutes. The roughing out of the infected plants has also been constrained due to the logistical limitations in large-scale commercial cultivations. Since the insect vector *D. menoni* is one of the most important factors contributing to the spread of WLD, development of strategies for the management of this vector has become an urgent requirement to manage the disease. This study was undertaken to analyse the seasonal variation of the vector population and WLD incidence in different sugarcane-growing areas in Sri Lanka to gather information to devise an efficient management programme for WLD.

MATERIALS AND METHODS

Study locations

The study was conducted in all commercial sugarcane-cultivating areas, namely, Uda Walawe, Sevanagala (irrigated and rain-fed sectors), Pelwatte, Hingurana and Passara during 2013. Geographical information, climatic factors and type of cultivations of each location are shown in Table 1.

Field selection and data collection

Sugarcane fields (about 0.5ha) with less than six-month old crops were selected for the study. At least 0.25km distance was maintained in between two selected fields. Application of insecticides for controlling pests was withheld throughout the study period.

From each field, 25m x 10m-sized three plots were selected randomly for data collection. The total number of sugarcane clumps and the number of WLD-infested clumps were counted at weekly intervals in Uda Walawe and monthly intervals in other locations. The number of vectors captured per 2000 sweeps (sweep-net Diameter: 35cm) was recorded in each plot at weekly intervals. The sweep net sampling was done from 6.00am to 9.00am. In each selected field, foliage was thoroughly swept for vector collection, and the captured vectors were collected using a pooter.

Data analysis

Seasonal variation of the population of *Deltocephalus menoni* and WLD incidence

Mean value of the *D. menoni* population and WLD incidence within the four quarters of the year in each location was calculated and compared using Turkey's Studentized Range test to identify the time periods with the highest populations of *D. menoni* and WLD incidence. The mean and the median value of the *D. menoni* population and WLD incidence in each location throughout the year were calculated

Table 1 Climatic parameters, elevation and the types of cultivations in the study locations

Location	Ave. Temperature (°C)	Relative Humidity (%)	Rainfall (mm)	Elevation from mean sea level (m)	Type of cultivation
Uda Walawe	17-36	72	1300-1600	76	Irrigated and Rain-fed
Sevanagala	23-32	78	1600-1700	91	Irrigated and Rain-fed
Pelwatta	25-35	75	1400-1500	161	Rain-fed
Hingurana	24-36	77	1500-1800	130	Irrigated
Passara	16-30	86	1500-1900	680	Rain-fed

Source: Local meteorological stations in each sugar industry area and those values were compared using Wilcoxon score test to assess the locational variation of the insect vector and the disease.

The effect of *Deltocephalus menoni* population on WLD incidence

Simple linear regression models were fitted separately for the percentage of WLD incidence (Y axis) and number of insect vector per 2000 sweeps (X axis) in six different time periods (immediate incidence of WLD and WLD incidence in 1, 2, 3, 4, 5 weeks lag periods) of the first quarter of the year in each location to identify the relationship between population levels of *D. menoni* and the WLD incidence.

RESULTS AND DISCUSSION

Seasonal variations of the population of *D. menoni* and WLD incidence in different sugarcane-growing areas

Population levels of *D. menoni*

D. menoni was recorded throughout the year in all sugarcane growing areas during 2013. Except at Hingurana and Passara, the *D. menoni* population levels in all locations were significantly varied within the year. The highest populations at Uda Walawe, Sevanagala and Pelwatte were recorded during the first quarter of the year (Table 2).The results of the present study are in agreement with those of a previous study conducted by Seneviratne (2008). The highest population levels of *D. menoni* have been recorded in the first and the fourth quarter of the year 2005 and 2006 in Sevanagala and Pelwatte sugarcane plantations.

With regarded to the locational variation of the population levels of *Deltocephalus menoni*, Pelwatte and Uda Walawe areas recorded a significantly higher population level of the vector than Hingurana and Passara areas in the year 2013. Moderate populations were recorded in both irrigated and rain fed sectors at Sevanagala (Table 3). Long-term studies on population levels of the insect vector are needed to determine the seasonal variations in different locations.

Seasonal variation of WLD incidence

Except in Passara area, WLD was recorded throughout the year in all sugarcane-growing areas. WLD incidence levels significantly varied within year 2013 at Uda Walawe, rain-fed sector at Sevanagala and Hingurana (Table 2).

According to the results of the analysis for locational variation of the WLD incidence, significantly higher incidence were recorded in the rain-fed sector at Sevanagala. In Passara area, the WLD incidence was significantly low (Table 3). According to Weintraub *et al.* (2004), if plants materials infected with phytoplasma are introduced to an area where the disease is absent, potential vectors present in the area will spread the disease throughout the area. High priority should be given to supply phytoplasma-free seedcane to Passara area where potential vectors of WLD are present to contain further spread of WLD.

The effect of *Deltocephalus menoni* population on WLD incidence

According to the results, the level of population of the insect vector has an effect on the disease incidence. Population levels of *D. menoni* showed a significant effect on WLD incidence in four weeks after their presence in Uda Walawe area ($P \leqslant 0.01$, $y = 0.0939x + 0.2877$, $R^2=0.6448$) (Figure 1) and in Hingurana area ($P \leqslant 0.05$, $y = 0.022x + 0.0099$ $R^2 = 0.8473$). There was no significant effect of the population level of the vector on WLD incidence in four weeks after the presence of vector in other locations. However, a significant effect of the vector population on the disease incidence was found at Pelwatte ($R^2=0.6079$) and irrigated ($R^2=0.3219$) and rain-fed sectors ($R^2=0.802$) at Sevanagala.

Table 2 *Deltocephalus menoni* population (Number of vectors / 2000 sweeps) and WLD incidence percentage in each study location during the four quarters of the year 2013

LOCATION	Vector Population	WLD Incidence
Uda Walawe		
1st quarter	3.42 a	1.96 b
2nd quarter	0.92 b	0.49 c
3rd quarter	1.25 b	1.37 cb
4th quarter	1.33 b	3.4 a
Sevanagala (Irrigated sector)		
1st quarter	3.67 a	6.05 a
2nd quarter	1.08 b	2.36 a
3rd quarter	0.25 b	2.61 a
4th quarter	0.33 b	5.34 a
Sevanagala (Rain-fed sector)		
1st quarter	3.58 a	5.23 ba
2nd quarter	0.91 ba	0.64 b
3rd quarter	0.42 b	1.35 b
4th quarter	0.33 b	14.86 a
Pelwatte		
1st quarter	9.42 a	1.65 a
2nd quarter	1.00 b	1.11 a
3rd quarter	0.67 b	0.52 a
4th quarter	0.58 b	10.99 a
Hingurana		
1st quarter	0.75 a	0.15 a
2nd quarter	0.41 a	0.01 b
3rd quarter	0.67 a	1.92 a
4th quarter	1.25 a	1.89 a
Passara		
1st quarter	0.25 a	0.58 a
2nd quarter	0.00 a	0.03 a
3rd quarter	0.00 a	0.00 a
4th quarter	0.25 a	0.00 a

Note: The figures with the same letter in each column are not significantly different at 5% probability.

Table 3 Variation of *Deltocephalus menoni* population and WLD incidence in each study location during year 2013

Location	*D. menoni* population			WLD Incidence		
	Mean	Median	SD	Mean	Median	SD
Uda Walawe	1.73	1	2.08	1.81	1.33	1.66
Sevanagala (Irrigated sector)	1.33	0	2	4.09	3.9	3.69
Sevanagala (Rain-fed sector)	1.31	0	2.76	5.52	1.59	11.65
Pelwatte	2.92	1	7.38	3.56	0.76	10.87
Hingurana	0.77	0	1.34	0.99	0.08	1.83
Passara	0.12	0	0.39	0.15	0	0.9

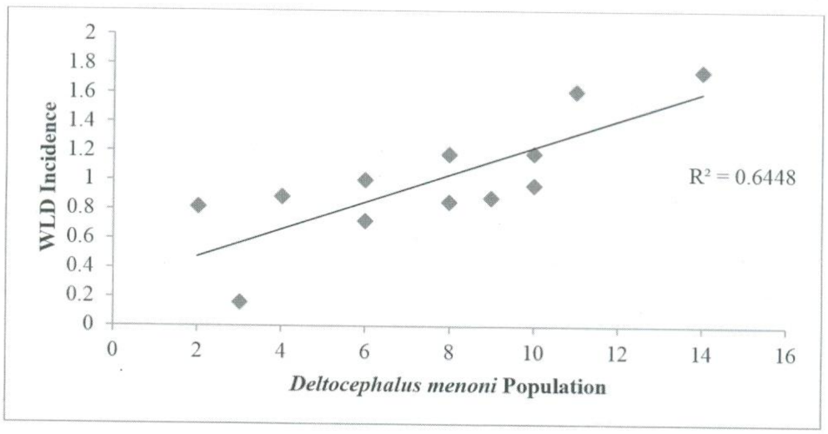

Figure 1Relationship between *Deltocephalus menoni* population and WLD incidence in four-week lag period in Uda Walawe area during the first quarter of the year2013

Generally, phytoplasma requires incubation period from disease infection to symptom appearance. According to Seneviratne *et al.* (2008), WLD phytoplasma in Sri Lanka requires at least 10-week incubation period under well-maintained laboratory conditions. Difference between the times taken for the disease appearance may be due to the harsh environmental conditions in the field conditions, since water stress and high temperature are favourbale for appearance of the disease. In the present study, we found that, disease symptoms appeared after four weeks in Uda Walawe and Hingurana areas in the first quarter of the year. This may be due to the different environmental conditions and the condition of sugarcane crop in different areas as incubation periods of phytoplasma diseases varies in different cropping seasons (Matsumuto *et al.*, 1960; Lee *et al.*, 1970; Hibino *et al.*, 1987; Jung *et al.*, 2003; Morone., 2007) due to different environmental factors (light intensity, temperature, precipitation) and the age and condition of the host (Maramorosch, 1953; Chiykowski, 1981). Field surveys in sugarcane plantations at

Sevanagala and Pelwatte from 2005 to 2006 have been indicated an upward trend of the WLD appearance from June to September in 2005. This may be a result of high water stress condition and high temperature during this period (Seneviratne *et al.*, 2008). Also in Taiwan, similar observation on WLD incidence has been reported by Chen (1980). However in Pelwatte and Sevanagala plantations, the disease has appeared at the same time with the high insect population present in the area. Other than the effect of the vector, the disease has been appeared earlier due to the usage of phytoplasma-infected seed cane.

Conclusions

The results of this study highlighted the need for establishing an integrated approach for the management of WLD and its vector *Deltocephalus menoni* and the priority should be given to the Sevanagala and Pelwatte plantations, where WLD incidence is high. The information on the variation of the population levels of *D. menoni* can be used for designing the IPM programme. Attention need to be given to use disease-free planting material. High priority should be given to avoid spreading the disease in Hingurana and Passara areas where the disease incidence is low, but the vector is present.

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