Egg deposition by Spiralling whiteflies (*Aleurodicus dispersus*) reduces the stomatal conductance of cassava (*Manihot esculenta*)

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Introduction

Whiteflies are considered a most damaging pest in all cassava-producing regions, as they are responsible for transmitting plant viruses and directly damaging plants via heavy infestation (Reddy, 2015). *Aleurodicus dispersus* Russell (Hemiptera: Aleyrodidae) commonly known as Spiralling whitefly, a native to the Caribbean region and Central America (Reddy, 2015; Waterhouse & Norris, 1987). Over 300 plant species from approximately 77 families have been recorded as hosts of *Aleurodicus dispersus* Russell, worldwide (Lambkin, 1999), and the species is known to have widely spread over North America, South America, Asia, Africa, Australia and in several Pacific Island Countries (PIC). In the South Pacific it is known from Majuro (1986) (Marshall Is), Cook Islands (1984), Fiji (1985), Nauru (1987), Papua New Guinea (1987), Kiribati (June 1988), Tokelau (late 1988) and Tonga (November 1988) (Waterhouse & Norris, 1987).

Whiteflies are considered to be a major agricultural pest, causing damage to crops by altering the growth, photosynthesis, chemical and phenological processes (Boopathi *et al.*, 2015; Nabity *et al.*, 2009). Whiteflies secrete sticky honeydew which at many times results in the formation of dark sooty moulds on leaves. Nymphs also secrete white, waxy flocculent materials which can spread widely. The secretion of honeydews causes premature shedding of leaves, and the sooty moulds hinder photosynthesis by blocking the entry of carbon dioxide into the leaf cells through the stomata, which greatly reduces the photosynthetic product values (Henneberry *et al.*, 2007; McAuslane *et al.*, 2004; University of Florida, 2015).

Stomatal apertures control both the water loss from plant leaves and the uptake of CO_2 for photosynthesis. Measurements of stomatal apertures are important indicators of plant water status and gas exchange, giving an insight of the plant's ability to grow and adapt to the changing environmental conditions. Stomatal conductance gives a numerical measure of the water vapour or carbon dioxide passage rates through the stomata or small pores of the plant. This short study aimed to investigate whether stomatal conductance of cassava leaves was affected by infested of Spiralling whitefly eggs.

Materials and Methods

The Spiralling whiteflies (*Aleurodicus dispersus*) were introduced and bred (3 months after planting) on 6 cassava plants (*Manihot esculenta* (Crantz)) under glasshouse conditions without any exposure to insecticides. The plants were maintained in the glasshouse for appropriately 6-7 months prior to the study. The temperature for the experimental period (September-December) ranged from 25-30°C with the relative humidity of around 80%. Similarly, 6 plants without whiteflies were used as control plants.

The stomatal conductance in mmol m^{-2} s^{-1} was measured on the upper canopy leaves (height =135-150 cm) of the cassava plants using an AP4 Leaf Porometer (Model: AP4 Delta-T Device- Cambridge- UK) between 1100 hours and 1200 hours daily for 7 days. The stomatal conductance was measured as described by Schymanski *et al.* (2013), as high leaf temperature is best captured during sun flecks around 1100 hours. The mature leaves (not too young and too old) were randomly selected for each day taking leaf size and canopy height into account.

To statistically test the difference between the infested and non-infested leaves, an independent sample *t*-test was performed at each time point.

Results

The diurnal stomatal conductance of cassava leaves was significantly affected by *A. Dispersus* egg deposition. Lower conductances were recorded for the infested leaves for all days. The infested leaves had lower mean values of conductance (*M*= 11.90 mmol m^{-2} s^{-1}) while the non-infested leaves were associated with higher mean values (*M*= 17.80 mmol m^{-2} s^{-1}), ($p<0.05$).Within the first 3 days of measurements, the conductance trend was similar for both infested and non-infested leaves showing no significant difference. After 3 days the conductances for the infested leaves were significantly low (Figure 1).

The stomata usually maintain the internal partial CO_2 pressure in relation to the external pressure (Neves *et al.*, 2006; Ramos & Grace, 1990). Figure 2 depicts how the eggs laid by female whiteflies on cassava leaves affect the stomatal pores. It was roughly estimated that an average whitefly egg blocks 36 stomatal pores in cassava leaves.

Discussion

The findings clearly showed a significant decrease in the stomatal conductance of whitefly infested leaves when compared to non-infested leaves. The significant decrease in the stomatal conductance is due to the eggs being laid on the lower surface of the leaves by the female whiteflies (Figure 2); egg deposition covered the stomata thus blocking its access to light and carbon dioxide. Egg deposition hence reduces the effective surface area of the leaf by lowering the overall productivity.

Other studies have also reported a reduction in the rate of photosynthesis by the infestation of whiteflies. For instance, Lin *et al*. (1999) reported that the photosynthesis activity is reduced by 50% after 60 days of the introduction of whiteflies on cotton leaves. It was also noted that Silverleaf whitefly infestation reduced cotton foliar photosynthesis rates, where physiological damage occurred with infestation levels of 10-20 adult whiteflies per leaf (Yee *et al.*, 1996). Touhidul Islam and Shunxiang (2009) reported similar findings in eggplant leaves where they revealed that the whitefly infestation lowered the effective leaf area which significantly reduced photosynthesis. Likewise, the photosynthesis activity was found to be reduced by 30% in rice plants infested with the planthopper *Nilaparvata lugens* (Watanabe & Kitagawa, 2000). Overall, this short investigation shows that whitefly infestation can significantly reduce the stomatal conductance of cassava leaves by blocking stomata by egg deposition. Further research is required to examine the subsequent effect of this stomatal blocking on plant performance and crop yield.

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Figure 1. Diurnal stomatal conductance (mean ±SE; n=3) of *M. esculenta* leaves infested or not infested with *Aleurodicus dispersus.* The mean of 3 replicate measurements between 1100 hours and 1200 hours is shown.

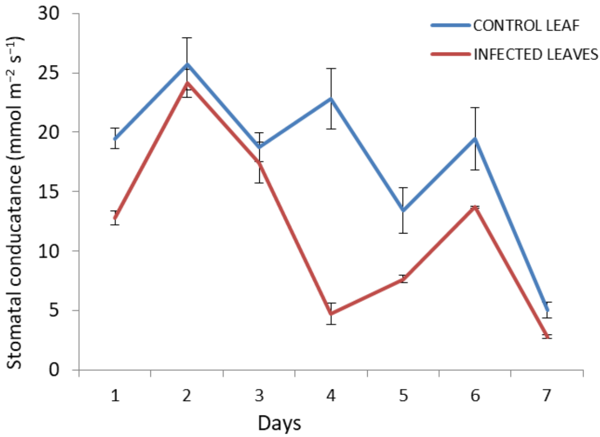

Figure 2. (A) - the stomatal underneath the normal leaf surface and **(B) -** the egg attached on the stomata of infested leaf at 400X Magnification. Clear nail polish was used to strip off stomatal aperture from cassava leaves.