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Dynamics and Seasonal Variability of *Bemesia tabaci* Colonies in Cassava

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Abstract: The Cassava Mosaic Desease (CMD) still a threat to the successful production of cassava in East African countries especially in Burundi. This unknown virus in South America where cassava takes his origin preoccupies the scientific community but little research are dedicated to its vector *Bemisia tabaci*, an insect homoptera. In this study, our main objective was to understand the dynamics of this pest and his seasonal variability in cassava.

We have conducted field experiments and we have found that the population of this pest reaches its higher level in dry season and remain low in rainy season. Our study showed that *B.tabaci* is very active during the morning with a high capacity of flight whereas at noon and in the evening this insect is less active. We found a strong correlation between the relative humidity and the flying distance and flying time of *B.tabaci* individuals.

This study contributed to the knowledge of the behavior ecology of this insect that could be exploited to control this pest in African cassava fields.

Key words: *Bemisia tabaci*, cassava, seasonal variability, population dynamics

1. Introduction

Cassava (*Manihot esculenta*) is a staple root crop for over 500 million people living throughout the tropics [1, 2] particularly in sub-Saharan African Countries [3]. Introduced in Africa from his origin in south American [4, 5], Cassava is an economic crop and plays a role of food security for poorest farmers in East Africa countries by offering 60% daily calorie [6].

The most serious problem of that crop in East Africa is cassava mosaic disease (CMD) caused by a complex of at least ten Cassava Mosaic Gemini viruses (CMGs) [6, 7]. The Cassava Mosaic Desease affects foliar damage and reduces the ability of cassava plants to produce enough food to be stored in the roots by stopping photosynthesis. In addition, it reduces the growth of plants, the number of tuberous that can form and the ability of the latter to grow and mature for the good harvest [8]. The disease is transmitted by an insect vector whitefly; *Bemesia tabaci* (Hemiptera; Aleyrodidae) [8-10].

In recent years the Cassava Mosaic Desease (CMD) has become a persistent and significant threat to cassava production and food security in Burundi [11]. Although many studies has been conducted on CMD in East African region [10, 12-16] little attention has been given to the biology of its vector: *B.tabaci* particularly the behavior ecology of that insect in Burundi.

Recent evidence suggests that *B.tabaci* represents a complex species with numerous biotypes (Thomas M. 2001). Although earlier studies on cassava have focused on field surveys and the infestation patterns by *B.tabaci* in the region [17-19], little is known about the specific interactions between local microclimate and

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seasonal fluctuation that could influence whitefly oviposition, its suitability for nymphal development and therefore the size of the colony or dynamism in cassava field.

The main objective of this study was to understand the dynamics of this pest and its seasonal variability of their colonies in cassava field according to relative humidity. We have conducted field experiments with two hypothesis: First, the seasons and humidity have an influence on the population size of *B.tabaci*, vector of the cassava mosaic disease. Second, the times of the day are favorable to the dispersion of the insect.

2. Materials and Methods

2.1 Fields Trials

Field experiments were conducted at three sites located in west region of Burundi. Site 1 was located at Nyabagere and site 2 at Winterekwa and site 3 at Muyaga in the locality of Gihosha, north of Bujumbura. In each site, two sample fields were chosen after investigation of mosaic symptoms. Leaves of 45 shoots of cassava plants per field were analyzed. Sampling was carried out successively in March to May 2014 corresponding to the rainy season and August and September 2014 corresponding to the dry season in Burundi.

2.2 Evaluation of the Size of B.tabaci Colonies

B.tabaci feed and live preferentially on the underside of youngest immature leaves [20, 21]. For each cassava plant, five youngest apical leaves of the uppermost shoot were examined and we count individuals present on each leaf using Fargette (1985) method. It consists to gently raise the petiole and to count individuals observed underside of each leaf and of each shoot of cassava plant. Counts were made between 08.00 and 11.00. We performed three repetitions on each site of cassava plant field. For each sampling, we also recorded the relative humidity of the corresponding study site at the time of the experiment using a hygrometer.

2.3 Studies on the dispersal dynamics of B.tabaci

To conduct the study, we divided the day into three moments: Morning (7:00 to 8:00 AM) noon (12:00 AM to 1:00 PM) and at the Afternoon (5:00 PM to 6:00 PM). The insect has three flight events: take off, theft and landing.

To determine the dispersal distance; *B.tabaci* individuals were targeted for each site of cassava field. For this experiment, the insect were stimulated by slightly shaking the cassava plant. Dispersal distance of this whitefly was evaluated in meters from the takeoff point cassava plant to landing cassava plant. The relative humidity were also measured by using a hygrometer.

2.4 Statistical Analysis

Data were analyzed with GraphPad InStat Version 3 to compare the *B.tabaci* colony size during the dry season and the rainy season and the dynamics using ANOVA after controlling normality. The correlation between the relative humidity and the size of the colony or flying capacity was analyzed.

3. Results

3.1 Size of B.tabaci Colony

In Nyabagere cassava field, the results show that the size of the colony of *B.tabaci* is 17.8 ±5.3 (Mean ±SD) individuals per leaf of cassava in the dry season while in the rainy season the size of the Colony is 10.2 ±3.7 individuals per leaf of cassava plant (Fig. 1). We found a significant difference ($P = 0.0012$; $t = 3.539$, $df = 34$) between the Colony size during dry season and rainy season (Fig. 1).

The results on the site Winterekwa show that the size of the colony of *B.tabaci* is 15.2±3.9 (Mean ±SD) during dry season per leaf of cassava plant while in the rainy season the size of Colony is 9.3±4.2 individuals per leaf of cassava plant. Statistical analysis showed also a significant difference between the size of the colony of *B.tabaci* found in the dry season and rainy season (P = 0.008, t = 0.40) (Fig. 1).

On the site of Muyaga, the size colony is 16.4±5.1 per leaf of cassava plant during the dry season and 10.8±5.3 individuals during the rainy season. We found a significant difference between the number of individuals of *B.tabaci* in the dry season and rainy (P = 0.008, t = 0.40) (Fig. 1).

The results of two-way ANOVA revealed that size of *B.tabaci* colony is influenced by the season ($F_{5,141}$ = 10.362 P < 0.0001). Therefore, we used Turkey-Kramer procedure to detect differences in size of *B.tabaci* colony at different sites of experiment and season. The results show a significant difference in size colony during dry season than rainy season (Fig. 1).

Additionally, we observed a significant correlation between the relative humidity and the size of *B.tabaci* colony ($F_{1,58}$ = 34.448 P < 0.0001) with a Correlation coefficient (r) = 0.6104 (Fig. 2).

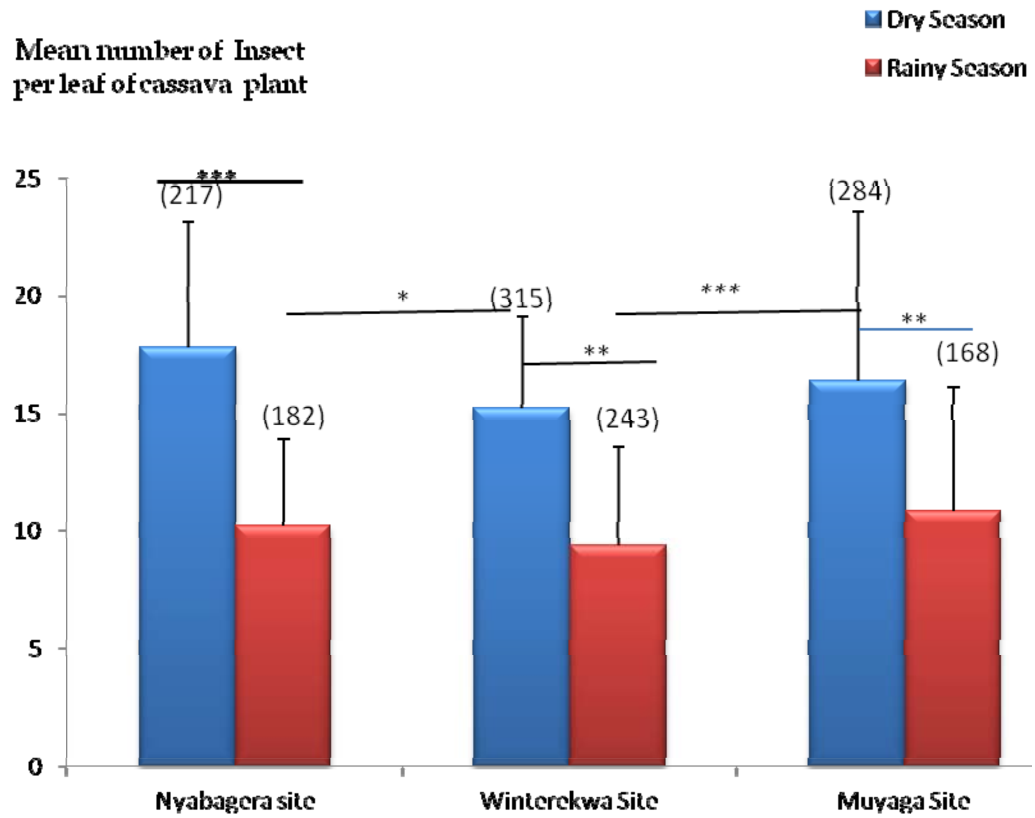

Fig. 1 Mean Number of Insect per Leaf of Cassava Plant during Dry Season and Rainy Season.
(Number in parentheses indicates the number of leaves, Symbol (***), (**), (*) indicates respectively P < 0.001, P < 0.01 and P < 0.05)

3.2 Studies on the Dynamics of Bemisia tabaci

These results show that *B.tabaci* is very dynamic in the morning, each individual are able to fly to a distance of 11.5±4.1 meters (Mean± SD). At noon period the insects are ineffective with the flying distance of 2.8±0.5 meters (n = 87) and in the afternoon the results show that *B. tabaci* are able to fly to a distance of 4.09 ± 0.7 meters. These results show a significant difference in flying of *B.tabaci* between the three day period analyzed (ANOVA $F_{2,157}$ = 36,152, P < 0.0001) (Fig. 3).

For the flying time, the results show that *B. tabaci* is able to stay flying 73±5.1 Sec in the morning, at noon flight time is reduced to 15.5±3.9 Sec, while in the afternoon this time is 27.06±7.3 Sec. We found a significant difference between the flying time during the three day period analyzed (ANOVA, $F_{2,175} = 28.831$, $P < 0.0001$) (Fig. 4).

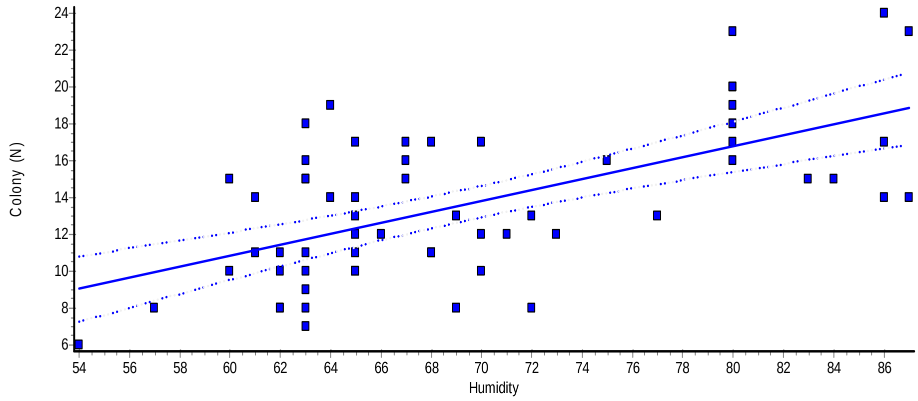

Fig. 2 Correlation between the relative humidity of the site with the size of *B.tabaci* colony.

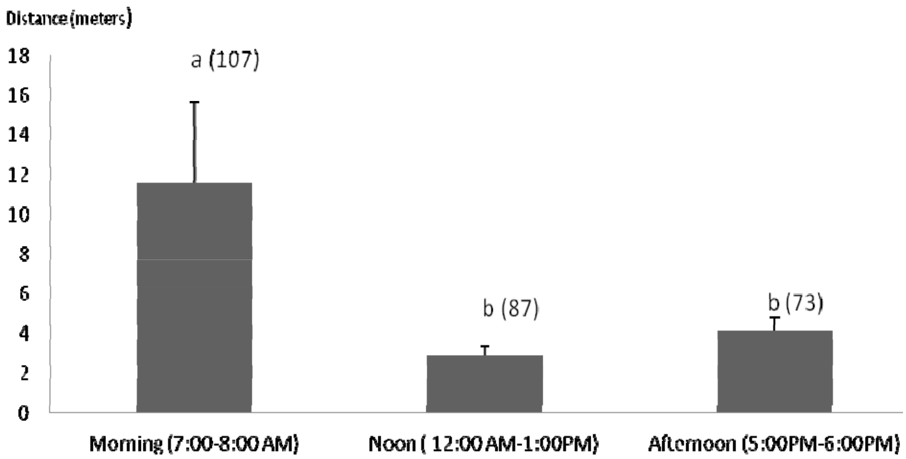

Fig. 3 Variability of dispersal distance of *B.tabaci* during the day.

(Numbers in parentheses indicate N and letters show the differences with an ANOVA at 0.05 significant).

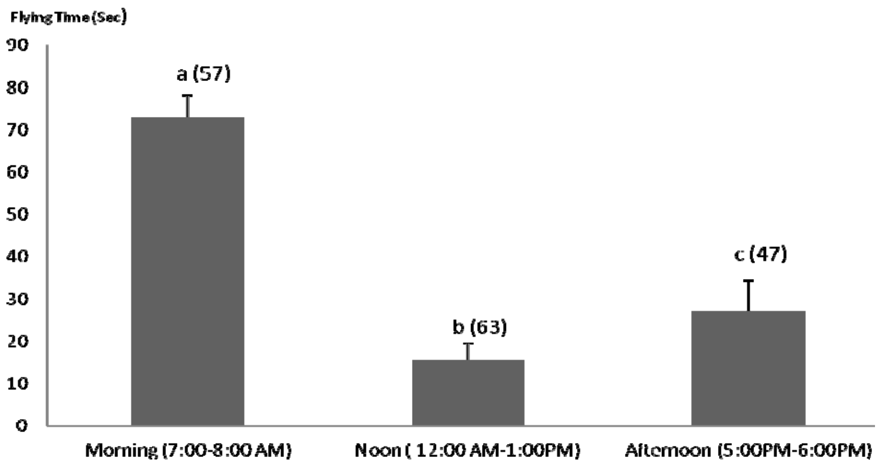

Fig. 4 Variability of flying time of *B. tabaci* during the day.

(Numbeeses indicate N and letters show the differences with an ANOVA at 0.05 significant).

3.3 Influence of Relative Humidity on Flying Distance

The results show a significant correlation between the relative humidity and the flying distance of *B.tabaci* individuals ($F_{1,28}$ = 17.768 P < 0.0001) with a correlation coefficient (r) = 0.6231 (Fig. 5).

We also found a significant correlation between the relative humidity and the flying time of *B.tabaci* colony ($F_{1,25}$ = 38.271 P < 0.0001 with a correlation coefficient (r) = 0.7777 (Fig. 6).

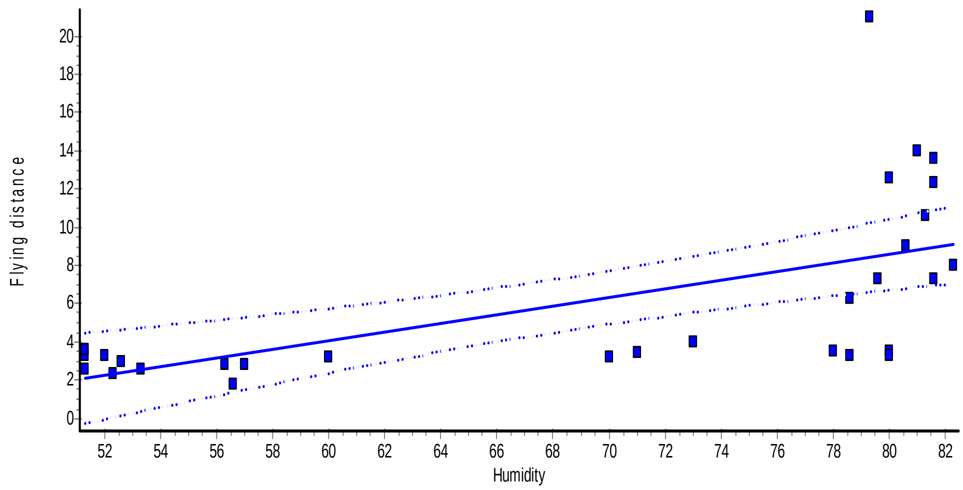

Fig. 5 Correlation between the relative humidity of the site with the flying distance of *B.tabaci*.

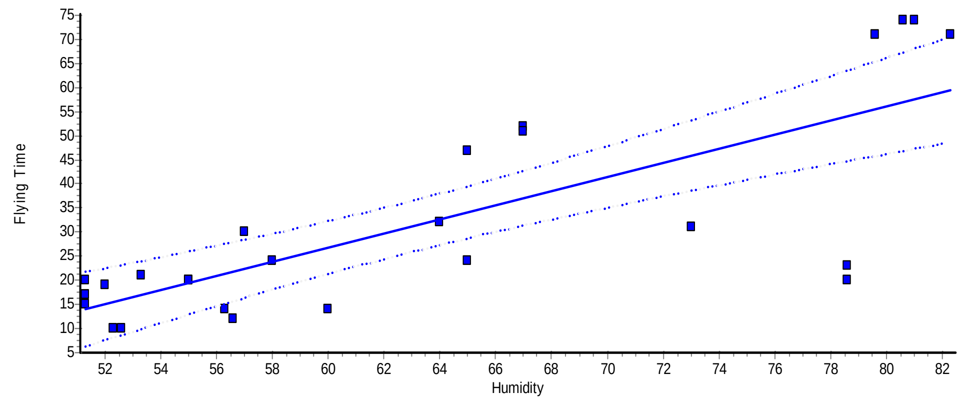

Fig. 6 Correlation between the relative humidity of the site with the flying time in sec of *B.tabaci*.

4. Discussion

The survey conducted to study the seasonal variability and dynamics of *B. tabaci* in cassava field shows that seasons of Burundi had a clear impact on the size colony of *B.tabaci*. We found that the number of *B.tabaci* in the dry season of Burundi (August and September) is high per plant leaf whereas in the rainy season (October and December) the size of colony remains lower in cassava field. The seasonal variability of *B.tabaci* could be explained by three main factors.

The first is the feeding behavior of *B.tabaci*. In fact, the insect is known to feed and live preferentially on the youngest immature leaves [20, 21]. The youngest immature leaves of host plants have a seasonal fluctuations and then *B.tabaci* fluctuations. Von Arx et al. [22] showed that the nutritional value of the host plant is important factors controlling *B.tabaci* life system. In this study, the low size of colony during the rainy season can be explained as a dilution effect which means that *B.tabaci* individuals are distributed among increasing amounts of host plant foliage around the cassava field. The increase of the size of colony in dry season can be explained by the leaves died of many alternative host and then the migration of insect in cassava field [23, 24].

The second factor is the climate factor. Fargette et al. [25] showed that the colony size of *B.tabaci* depends on temperatures, relative humidity and global radiation. Many studies have demonstrated that *B.tabaci* population are favoured by high temperatures and solar radiation with moderate rainfall and relative humidity [26-28]. The High numbers of the insect in the colony in cassava field during dry season is explained by the high temperatures and solar radiation with moderate rainfall and relative humidity during the dry season of Burundi.

The third factor which affects seasonal variability of *B.tabaci* colony is intraspecific competition. The lowest number of individuals during the rainy season could be associated with the presences of natural enemies (parasitoids and predators) which find favorable conditions to develop. The decrease of those natural enemies during the dry season has as consequence the proliferation of *B.tabaci*.

In this study, we have also analyzed the dynamics of *B.tabaci* during the days. Our data shows that *B.tabaci* is very dynamic in the morning with the mean flying distance of 11.57 m in the morning whereas the mean flying distance is 2.89 m at noon and 4.09 m in the evening. The results show the same situation in flying time. Our results show the role of the relative humidity for the dynamism of *B.tabaci* in cassava field. Indeed, we observed a strong correlation between the relative humidity and the flying distance and flying time of *B.tabaci* individuals. We have also found a significant correlation between the size of the colony of *B.tabaci* insect and the relative humidity which means that parameter play an important role in variability and dynamic of *B.tabaci* .

In conclusion, this study shows that *B.tabaci* is active in the dry season corresponding to the higher temperature. We can confirm that *B.tabaci* is a thermophilic insect in cassava field [29]. Our results can be used to develop an adequate strategy of control. Endeed, we have found that the number of *B.tabaci* in the dry season of Burundi (August and September) is high per plant leaf whereas in the rainy season (October and December) the size of colony remains lower in cassava field. That is means an adequate control must to be organized during the dry season. This insect is very dynamic in the morning means that an adequate strategy of control must to be organized not in the morning but at noon period when insects are less active and remain confined to the underside of the cassava leaf.

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