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Whiteflies species distribution and abundance on cassava crop in different agro-ecological zones of Kenya

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Abstract
A survey was carried in most agro-ecological zones of Kenya to determine most common whitefly species found on cassava in the coastal, western and eastern parts of the country. The two common species were *Bemisia tabaci* (Gennadius) and *Trialeurodes vaporariorum* Westwood, found on cassava in all agro-ecological zones of coastal lowlands (CL 3-5), low midlands (LM 1-5) and upper midlands (UM 2, 3). *Bemisia tabaci* was highest in the low midlands (LM 1-5) followed by upper midland regions (UM 1-4). On the other hand *T. vaporariorum* was highest in CL 3. The agro-ecological zone with the least *T. vaporariorum* was the UM 2 and UM 3. Altitude above sea level had no effect to abundance of whiteflies on cassava. Higher whitefly density on cassava did not result to higher cassava virus disease incidence. Altitude level in the different agro-ecological zones did not correlate to disease incidence.

Keywords: Whitefly, incidence, species, occurrence, density

Introduction

The Family Aleyrodidae (Insecta: Homoptera: sternorrhyncha) includes insects which are commonly referred to as whiteflies [1, 2]. They are small inconspicuous phytophagous bugs often overlooked despite their abundance on the lower surface of leaves [3]. They are not true flies but belong to the Order Homoptera which includes aphids, scales and psyllids [4]. Out of 1500 known species *Bemisia tabaci* is very common species causing severe losses to crop and transmission of plant viruses in tropical regions [5]. This problem is exacerbated by its polyphagous feeding nature across many plant species [6, 7].

In the Americas several species of whitefly (*Aleurotrachelus socialis* and *Trialeurodes* variabilis) are considered to be among the major cassava pests while in Africa and South Asia *Bemisia tabaci* is the most prominently cited species with *Aleurodicus dispersus* and *Bemisia afer* being other species present in Africa [8, 9]. The species *A. dispersus* may be causing yield loss in Asia though no conclusive information documented [8]. The species complex has been found to differ in host range, insecticide resistance and plant populations [10, 7, 11-13]. It is generally accepted that *B. tabaci* populations are geographically delimited [14, 15].

Both cassava mosaic virus disease (CMVD) and cassava brown streak virus disease (CBVD) are economically important in cassava root production which feeds millions of people in Africa [16]. Kenya and the larger East African region continue to be constrained in cassava production by CMVD and CBSVD spread by whitefly vectors [17-19]. It is believed that more than one species of whitefly may be involved in transmitting the two diseases (CMVD and CBSVD) and this is reflected by the presence of more than one species in the specific locality [18, 19].

The size of the whitefly populations has also been positively correlated with virus spread about one month after invasion, which corresponds to the time necessary for symptom development [16]. It is generally accepted that *B. tabaci* populations are geographically delimited [6, 14, 15]. It has been pointed out that while populations of whitefly corresponds to disease incidence it must also be appreciated that visual presence of disease symptoms might not necessarily reflect number of whitefly at that particular time [18].

This study aimed at determination of species identity and level of corresponding CMVD and CBSVD on cassava crop across different agro-ecological zones of Kenya.

Materials and Methods

Survey areas

The areas to be surveyed were selected based on available data on cassava production within the country and diversity in terms of agro-ecological zones. The eastern region was surveyed in March-May while coastal was June-July and western was September-October in 2014. The Eastern counties surveyed were Embu and Meru (upper midlands) and Machakos, Makueni and Tharaka-Nithi (low midlands) of bimodal rains where the upper parts receive 1000-2000mm annually and lower parts receiving 300-1000mm annually and mean temperature of 16-24 °C and 22-28 ºC, respectively. Coastal counties were Kwale and Kilifi, receiving 1000-2000mm annually and mean temperatures of 22-30 ºC while the western counties were Bungoma, Kakamega, Kisumu, Migori and Siaya receiving 950-1500mm and mean temperature of 18-25 ºC (http://www.infonet-biovision.org/default/ct/690/agrozones). The survey locality areas and cultivar preference in the different altitude regions are shown in Table 1 below.

Table 1: County survey areas, agro-ecological zone and cassava cultivars in 2014

County	Agro-ecological zones	Altitude (m)	Cassava cultivar (s) name
Bungoma	Low midlands 1, 2	1283 ± 3.1	Magane; local variety
Busia	Low midlands 2, 3	1229 ± 27.7	Magane; local variety
Embu	Upper midlands 2, 3	1383 ± 131.3	Doro, Mucericeri; local varieties
Kakamega	Upper midlands 1, 2	1231 ± 47.7	Magane (local), KARI (improved)
Kilifi	Coastal lowlands 4, 5	31.5 ± 10.5	Kalezo, Kipanda-meno (local), KARI (improved)
Kisumu	Low midlands 2, 3	1396 ± 152.1	Adhiambo Lera (local)
Kwale	Coastal lowlands 3, 4, 5	34.4 ± 31.7	Ex-Mariakani (local), Karembo (improved)
Machakos	Low midlands 3, 4, 5	1244.9 ± 87.4	Kitwa (local), Mucericeri (local)
Makueni	Low midlands 4, 5	1113.0 ± 131.2	Kitwa (local), Ex-Mariakani (improved)
Meru	Upper midlands 2, 3	1492.5 ± 103.2	Mucericeri, Doro (local)
Migori	Upper midlands 2, 3, 4	1578 ± 85.7	Lumala (local), Magane (local), Waite (local)
Siaya	Low midlands 3	1250 ± 32.1	Adhiambo Lera (local)
Tharaka Nithi	Low midlands 4	1403.8 ± 63.3	Mucericeri (local), Doro (local).

Field data and species collection

In each county (region) an average of 10 fields were randomly sampled where the GPS coordinated of the field were taken together with the details of locality of farm which included county and sub-county names. Choice of plot for sampling included making sure sample plants were young and probably an old cassava field within the vicinity to assure disease inoculum presence. This would ensure transmission of any virus diseases to the young crop. In each field 10 plants were randomly sampled along two diagonals in form of an "**X**". On these plants whitefly populations were estimated and up to 10 whiteflies from the top five leaves were picked using alcohol-wet camel brush and put in 70% alcohol vials for later species identification.

Species identification and data analyses

Whitefly specimens collected from each locality were identified using key and procedures by Martin [20]. Of the 10 specimen species, the type and number was recorded for each locality (county). Data analysis by ANOVA for means separation on number of whiteflies per field, as well as correlation determination in relation to field density-disease incidence was carried out by use of SAS software [21].

Results

Whitefly abundance and disease incidence

The county with significantly ($P< 0.05$) highest whitefly abundance was Migori (26.3 ± 29.4) followed by Machakos (21.2 ± 20.2) of *B. tabaci* species (Table 2). The species *T. vaporariorum* was significantly ($P< 0.05$) present in Kilifi (13.9 ± 9.2) followed by Migori County at 10.4 ± 13.9. Highest whitefly infestation on cassava did not lead to highest disease incidence. The cassava mosaic viral disease (CMVD) incidence was highest in Machakos (27%) followed by a lower similar level in Embu at 24%. Kilifi led with the highest significant ($P < 0.05$) incidence of cassava brown streak virus disease (CBSVD) at 43%, with Kwale (26%) at second position. The spiraling whitefly *Aleurodicus disperses* Russell (Homoptera: Aleyrodidae) was found in two fields in the eastern low midlands in Makueni and three plots in south coastal lowlands in Kwale.

Table 2: Mean number (± S.D) of *Bemisia tabaci* and *Trialeurodes vaporariorum* population in relation to different counties and disease incidence of cassava virus mosaic disease (CMVD) and brown virus streak disease (CBSVD)

County	AEZ	No. *B. tabaci*	No. *T. vaporariorum*	CMD (%)	CBSD (%)
Bungoma	LM 1, 2	6.5 ± 0.7a	2.5 ± 3.5ab	15abc	3ef
Busia	LM 2, 3	12.8 ± 13.0a	6.0 ± 5.0ab	13bc	16cd
Embu	UM 2, 3	9.9 ± 6.77a	1.2 ± 1.3b	24ab	0f
Kakamega	UM 1, 2	11.3 ± 7.6a	6.3 ± 5.1ab	10cd	5ef
Kilifi	CL 4, 5	6.6 ± 4.7a	13.9 ± 9.2a	17abc	43a
Kisumu	LM 2, 3	7.7 ± 4.6a	3.0 ± 0ab	10cd	7ef
Kwale	CL 3, 4, 5	10.0 ± 7.8a	6.6 ± 4.9ab	21abc	26b
Machakos	LM 3, 4, 5	21.2 ± 20.2a	6.0 ± 9.3ab	27a	0f
Makueni	LM 2, 4, 5	12.3 ± 8.8a	8.8 ± 11.1ab	23ab	0f
Meru	UM 2, 3	11.4 ± 8.9a	3.8 ± 3.6ab	20bc	0f
Migori	UM 2, 3, 4	26.3 ± 29.4a	10.4 ± 13.9ab	9cd	21bc
Siaya	LM 2, 3	9.3 ± 7.3a	2.6 ± 2.6ab	14abc	13de
Tharaka Nithi	LM 4	7.0 ± 4.2a	1.0 ± 1.4b	0d	0f

Similar lower case letters denote insignificant (*P*>0.05) mean value of number count of species at different county regions (SNK at 5% level).
Key: LM= Low midlands, UM = Upper midlands, CL = coastal lowlands.

Species occurrence in the agro-ecological zones
Overall *B. tabaci* was found most abundant in low midlands (LMs) but lower in the upper midlands (UMs) and coastal lowlands (Fig. 1). On the other hand *T. vaporariorum* was lowest in the upper midlands of the eastern counties.

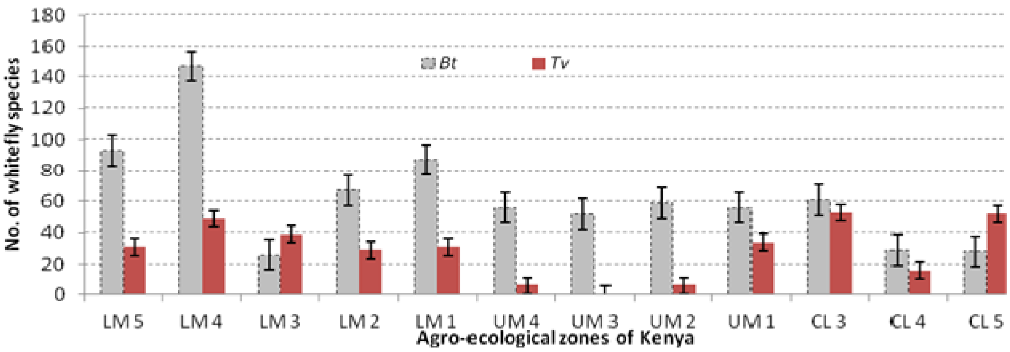

Fig 1: Whitefly species *B. tabaci* and *T. vaporariorum* occurrence and comparison among different agro ecological zones in 2014.

A comparison of the two species response to increased altitude showed that < 10 *B. tabaci* per plant was recorded at 27.60-45.45m above sea level in the coastal areas (Fig.2). It was only from above 1200m above sea level that *B. tabaci* population remained above 10 individual per plant, overall demonstrating a weak correlation (R^2 = 0.1989). Likewise *T. vaporariorum* had > 15 whiteflies per plant at altitude 32.33m in the coastal sites. With increase of altitude, *T. vaporariorum* density dropped to < 10 individuals per plant.

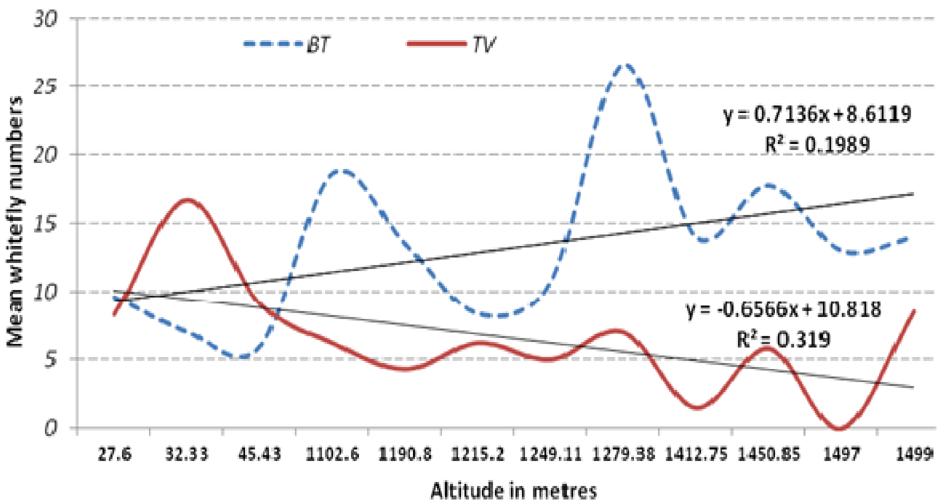

Fig 2: Relationship between altitude and whitefly species density in 2014 survey.

A comparison of CMVD occurrence on cassava showed no correlation to altitude change while a positive correlation was observed on corresponding CBSVD disease (Fig. 3).

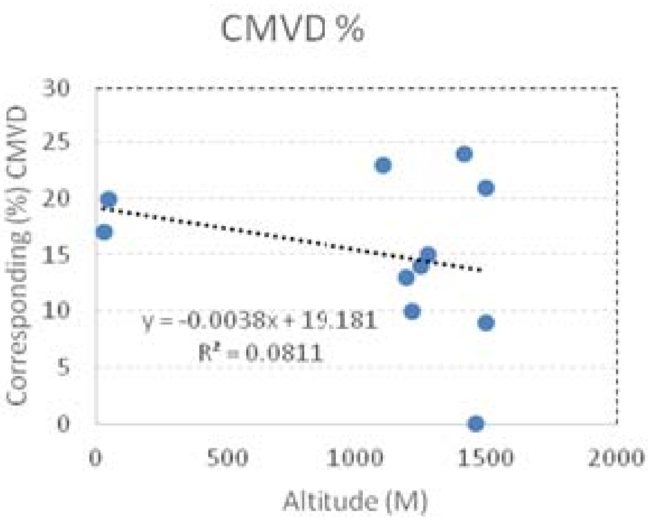

Fig 3: Relationship between altitude and corresponding occurrence of cassava geminivirus diseases.

Discussion

The results of the present study have shown that the species *B. tabaci* was abundant in the low midlands (LM 1-5) covering western and eastern Kenya county localities of Machakos and Migori. While Machakos led on the incidence of CMVD the latter (Migori) had low incidence of the disease but relatively high level of CBSVD. Kilifi County of the coastal lowlands (CL 4, 5) led with the highest density of CBSVD incidence at 43% per field. Absence of CBSVD was noted in the upper midlands (UM 2, 3) of counties of Embu and Meru. In some cases the low midlands (LM 3, 4, 5) regions of Makueni County had CBSVD presence.

The present work presents the first information on whitefly infestations on cassava in Kenya in varied agro-ecological zones. While density level of whitefly vectors of the two geminivirus diseases (CMVD and CBSVD) at any time cannot be considered as the resultant indication of disease incidence on cassava plants, it nevertheless points to the possible causal agents present. It has been reported that field disease incidence presence is not matched by the number of whitefly on cassava plants [18]. The same scenario has been observed in the present study from the different regions where whitefly higher density did not result to higher disease incidence of either CMVD or CBSVD. Consideration of disease expression on the plant after infection in the fact that it takes some time before symptom manifestation and depending on the variety level of tolerance [22, 23]. Time of disease infection and plant age would also lead to specific time of full phenological manifestation [24]. Earlier history on disease status of the vegetative propagules as source for the planting material could also be considered for early or late disease manifestation on the plant [25].

Kenya's cassava production regions are mainly the western and coastal lowlands [26]. The present study has revealed that the two geminivirus diseases CMVD and CBSVD continue to devastate cassava in the two regions of coastal and western as noted in the counties of Migori, Siaya, Busia, Kilifi and Kwale of the low midlands and low coastal lands, respecively. This depicts a possibility of food insecurity in future in those regions where cassava production is important. Reports from other workers show that *B. tabaci* is the major vector of the two diseases [16, 19]. As observed in earlier studies, CBSVD is no longer considered a disease of the coastal strip but continue to devastate cassava in all production agro-ecological zones of this important crop [19]. In the present study CBSVD has been noted missing in the eastern upper midlands in the localities of Meru and Embu and some areas of Machakos in the low midlands. Probably this was as a result of lack of disease inoculum presence of the geminiviruses on the cassava cultivars in such areas. Of concern was the fact that CMVD was fairly higher in eastern midlands showing 20 and 24% incidence in the counties of Embu and Machakos. If the vector for CBSVD was *B. tabaci*, then a gap exists on what population results to efficient transmission of the diseases [19, 25]. Whether other species like *T. vaporariorum* and *A. disperses* transmit these geminiviruses of cassava there is need to carry out a study and explore various control mechanisms before development of disease resistant/ tolerant cultivars which are elusive at the moment [18, 27]. As noted from the present study farmers still prefer their local cultivars to the improved varieties hence the need to develop a sustainable control of the vector whitefly species.

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