Distribution and host range of *Bemisia tabaci* and other whitefly species in major horticultural production areas in Kenya

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Abstract: Horticulture is the second most important export earner to Kenya after tea. The sector is faced with several challenges with pests and diseases being ranked as the most important. Whitefly, *Bemisia tabaci* Gennadius (Hemiptera: Aleyrodidae) is an important pest of many horticultural crops. Kenya has had several produce interceptions in international markets due to the presence of *B. tabaci*, which is a quarantine pest in most territories including the European Union. A survey was undertaken to determine the distribution of *B. tabaci* in major horticultural areas in Kenya. A total of 26 districts were visited during the survey and whitefly samples were collected from different crops. Collected samples were submitted to the plant quarantine station Muguga laboratories for analysis. Five whitefly species were identified: *Bemisia tabaci* (62.4%), *Trialeurodes vaporariorum* (25.9%), *Aleurodicus species* (9.8%), *Aleurodicus disperses* (1.6%) and *Aleurocanthus woglumi* (0.1%). *Bemisia tabaci* and *T. vaporarium* were observed in most plants while the rest had a limited host range. *Bemisia tabaci* and *T. vaporariorum* were collected in almost all the districts surveyed indicating that the two whitefly species are distributed in most of the horticultural production areas.

Key words: *Bemisia tabaci*, whitefly, *Trialeurodes vaporariorum*, Quarantine pest, Interception, horticultural production

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Introduction

Bemisia tabaci (Gennadius) (Homoptera: Aleroidae)(tobacco whitefly) is an important pest of many agricultural crops worldwide and is widely distributed throughout the tropical and subtropical regions (Mckenzie *et al*., 2004, Lima *et al*, 2000). *B. tabaci* is polyphagous in nature with a wide host range of about 600 plant species, additionally it has a high fecundity with more generations within a year (Qui *et al*., 2009). This compounded with the ability to quickly develop resistance to most of the chemicals makes its management difficult (Cahill *et al*., 1996). The emerging pest resistance to pesticides and great ecological tolerance suggest that *Bemisia tabaci* has the capacity of becoming widespread in the country and affecting the horticultural sector significantly. In this case it may create a challenge to Kenya's floriculture industry which is estimated to directly employ about 100,000 people and generates US$ 200million (Varela, *et a*l., 2005).

Due to its wide host range and ability to vector a wide range of viruses, *B. tabaci* is considered a quarantine pest and of phytosanitary concern in most countries. For instance in the European Union, all propagation material imported into the territory should have been produced in areas free from *B. tabaci* three weeks prior to export (EU directive 2009\20\EC). *Bemisia tabaci* has several biotypes of which the B biotype has been reported to pose a great risk in Europe where crop production is done in controlled environments throughout the year. Although this biotype has not been reported in Kenya, any other existing haplotype in Kenya significantly limits markets access of horticultural commodities (Antony *et al*., 2006).

However, more important is the ability of *B. tabaci* to transmit viruses. *Bemisia tabaci* is known to vector at least 111 plant viruses in the genera Begomovirus (Geminiviridae), Crinivirus (*Closteroviridae*) and Carlvirus or Ipomovirus (Potyviridae) most of which are of quarantine importance in Kenya and also to the country's trading partners (Jones 2003; Antony *et al*., 2006). For instance, the *Bean Common Mosaic Virus*, *Cowpea mild mottle virus*, *Lettuce infectious yellow virus*, *Pepper mild Tigre virus*, *Squash leaf curl virus*, *Euphorbia mosaic virus* and *Florida tomato virus* are of quarantine importance to the EU as listed in the council directive (2000/29/EC). Begomoviruses account for the largest group of viruses transmitted by *B. tabaci* and have been reported to cause crop yield losses of between 20% and 100% (Brown and Bird, 1992; Glick *et al*., 2009). Moreover, heavy infestation by *Bemisia tabaci* may reduce host vigor and growth, cause chlorosis, sooty mold and uneven ripening.

In Africa, subsistence crops such as cassava are affected by Begomoviruses such as African cassava mosaic virus (ACMV). In Kenya, the African cassava mosaic disease (ACMD) vectored by *Bemisia tabaci* can cause losses of up to 70% in tuber yield of plants derived from infected cuttings (Bock, 1982; Fauquet and Fargette, 1990). Other important Begomoviruses in Kenya include; *Tomato mottle virus* (EPPO/CABI, 1996), *Tobacco leaf curl virus* (TLCV), *Sida golden mosaic virus* (SiGMV), *Squash leaf curl virus* (SLCV), *Mungbean yellow mosaic virus*, *Soybean crinkle virus*, *Cotton leaf crumple virus* (CLCV) and *Bean golden mosaic virus* (BGMV). Some of these can cause heavy yield losses in their respective hosts and dual infections have also been shown to occur (Bedford *et al*., 1994).

Morphologically *B. tabaci* is often confused with *Trialeurodes vaporariorum* (greenhouse white fly) and *B. afer* but can be distinguished by several features exhibited at various stages of development which include the egg, nymphal stages and the adult. The ability to survive under different environmental conditions, host range, distribution and the life spans can also be used to differentiate these species. For instance, *B. tabaci* has a wider host range compared to *T. vaporariorum* and it has been reported to occur in Asia, Europe, Africa, North and South America (EPPO, 2006.)

B. tabaci eggs are usually laid in circular groups on the underside of leaves and hatches after 5-9 days at 30°C. Females have been reported to oviposit over 300 eggs during their lifetime. A total of eleven to fifteen generations can occur within one year. On the other hand, *B. tabaci* has four nymphal instars of which only first instar is mobile. The adult emerges through a 'T'-shaped rupture from the puparium which is one of the identification features of these species.

Bemisia tabaci (non-European type) has been documented as a leading cause of interception in Europe between 1995 - 2004 (Aurger-Rozenberg and Rogues, 2006). Kenya is among the leading exporters of plant materials to the European market and there have been documented interceptions due to *B.* tabaci (Europhyt interceptions, 2016). This poses a potential challenge to sustainable market access.

Understanding the current distribution and host preference of *B. tabaci* will be important in the design of sustainable pest management approaches and also aid the National Plant Protection Organisation (KEPHIS) in phytosanitary decision making with the aim of enhancing market access of Kenyan produce.

Material and Methods

Survey in the horticultural production areas

A survey was undertaken in major horticultural production areas in the country between January and March 2010. Four regions with high horticultural activities (Table 1) were visited where several district within each region were surveyed. During the survey, farms were selected randomly basing on the availability of whitefly hosts.

Table 1: Regions that were surveyed during the study

Region	Districts (1999 records)
Rift valley	Laikipia East,Kajiado,Naivasha,Gilgil,
Eastern	Embu, Mbeere North, Meru South, Imenti North, Imenti South, Imenti Central,Tigania, Burii, Machakos, Makueni,
Central	Thika, Laikipia West, Kirinyaga, Kinangop, Nyeri, Nyandarua, Olkalou, Kiambu,
Coast	Kwale, Kilifi, Lamu, Taita Taveta,

Field sampling of *Bemisia tabaci* in farms/sites

Sampling and collection of whitefly species was done as per procedures described by (Legg, 1996). A questionnaire was administered where information on host plant species, GPS reading, weather condition, date, locality, name of the farm, the farmer, and growth stage of the crop were collected. Field observation was done by scouting on fixed transects covering the host range at each farm. Any sighted whitefly samples during the transect sampling were collected using a hand held aspirator and preserved in 70% ethanol as described by Lima et al. (2000) and MacKenzie *et al*. (2004). The samples were submitted to the plant quarantine and biosafety entomology laboratory at KEPHIS for morphological identification. Field survey data on occurrence, host range and distribution of the whitefly species was analyzed using GENSTAT at $P \leq 0.05$ significance level. Arc view/Arc GIS version 9.2 was used to generate distribution maps.

Results

The incidence of *B. tabaci* was high in all the provinces surveyed as compared to the other whitefly species except in the Rift valley where *T. vaporariorum* was the most dominant species at 52%. *Bemisia tabaci* populations in Eastern province were at 97%, Central province at 68%, Coast at

60%. Rift valley province had the highest level of *B. tabaci* at 31% while Central province had the least incidences at 20%. *Trialeurodes vaporariorum* was reported in all provinces surveyed except in coast, while *Aleurodicus* spp was reported in coast and Eastern provinces only. *Aleurodicus dispersus* was found in the coastal and Rift Valley provinces. *Aleurocanthus woglumi* was only found in the Rift Valley (Fig. 1).

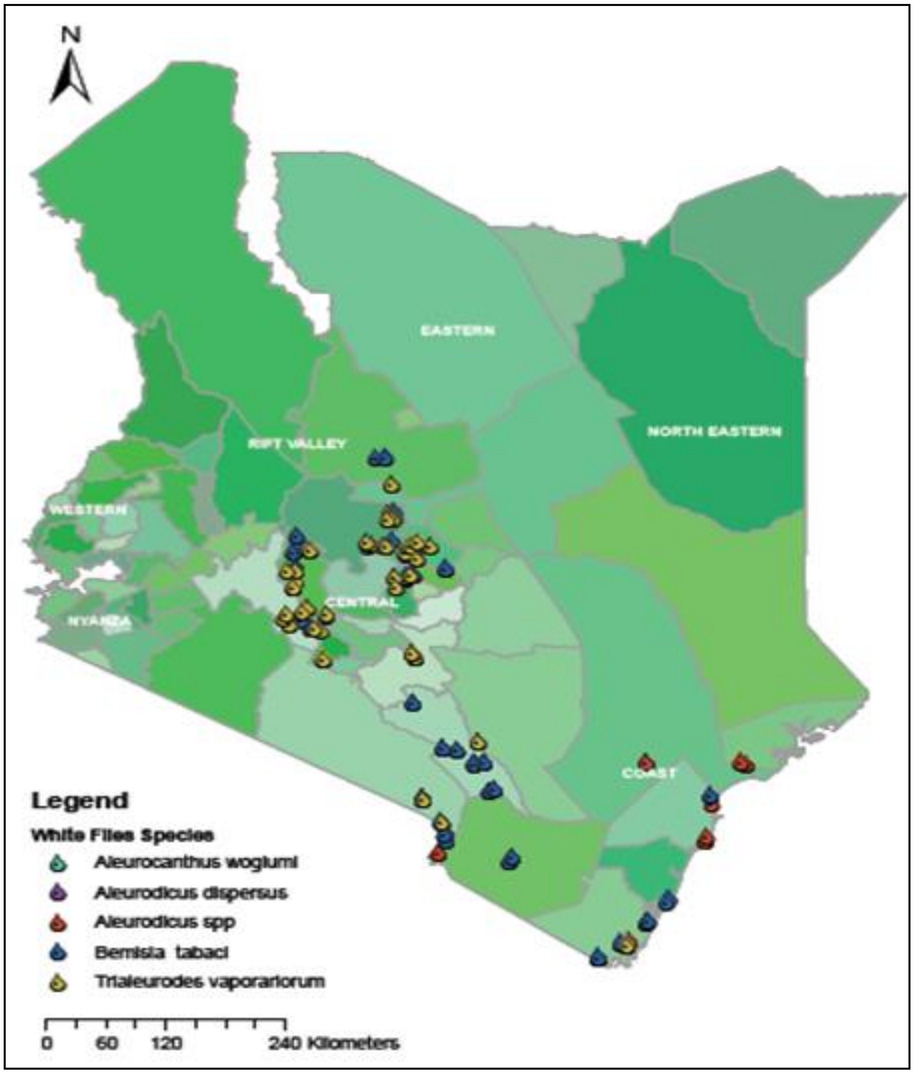

Figure 1: Distribution map of whitefly species in selected regions in Kenya.

There was a significant difference in the species identified on different host plants (F= 5.08, P= 0.02). *Bemisia tabaci* infested most of the crops that were sampled compared to the other whitefly species whereas *A. woglumi* had the least population and was only found on oranges. The highest *B. tabaci* population was recorded on tomato and cassava (Fig. 2).

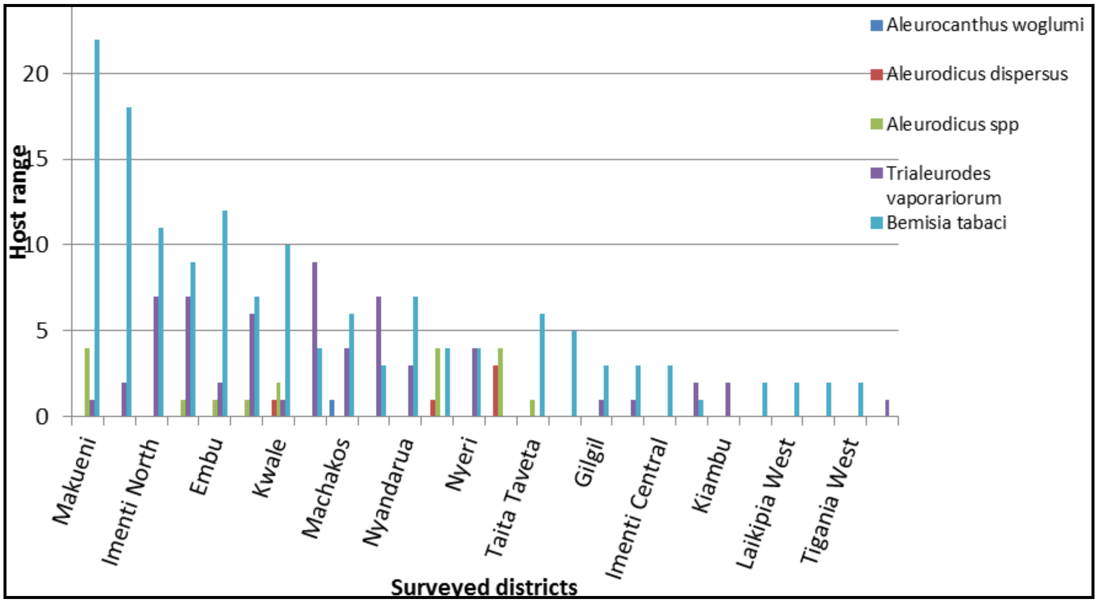

Figure 2: Host range of whitefly populations per district.

Comparison of whitefly populations with crop age

Bemisia tabaci recorded the highest population at all crop growth stages as compared to the other whitefly species. It was found to be more prevalent at vegetative stage and less prevalent at the fruiting stage (Fig. 3).

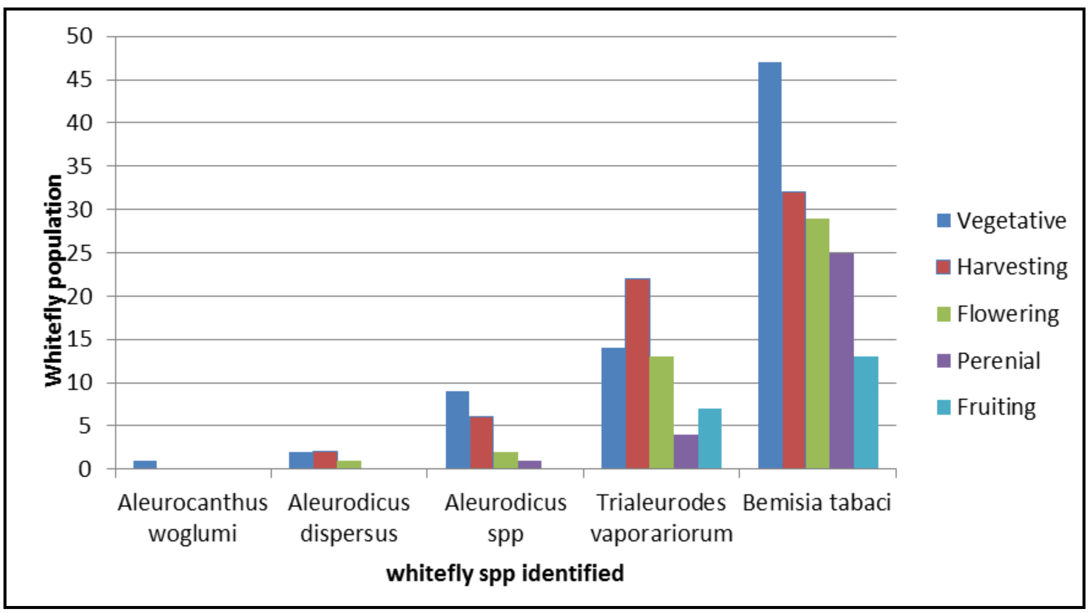

Figure 3: Whitefly distribution in relation to the crop age

Discussion

Bemisia tabaci is a multivoltine insect with no diapauses that maintains population continuity by moving from one host to another over the year. The results of the survey, suggest that *B. tabaci* was predominant in medium to high temperature areas (Machakos, Kajiado, Taita) as compared to *T. vaporarium* which was found to occur in cooler or high altitude areas (Kinangop, Naivasha and Nyandarua). These observations are similar to those reported in studies on biology and ecology of *B. tabaci,* indicating its profound proliferation in warm and humid environments (Fauquet *et al*., 1985; Fargete *et al*., 1993). With a wide host range and suitable environment within the tropics, *B. tabaci* is able to colonize wider agro ecological regions. Long duration flights aided by air currents cannot be ruled out as possible causes for its expansive distribution. This poses a serious threat to the horticultural industry and market access. There is therefore need to put in place integrated measures to minimize the adverse effects of the pest.

The host preference for *B. tabaci* was determined by the physiological age of the host plant. The results of the survey indicate that high incidences of *B. tabaci* were recorded during the vegetative growth stage. A reduction in photosynthates during flowering stages of the host renders preferred feeding parts unfavorable collaborating with other study. This was emphasized by Dengel *et al*. (1981 and Fishpool *et al*. (1995).

Bemisia tabaci had preference for tomato, cassava, sweet potato and curcubits among other hosts. These are hosts for many viruses spread by *B. tabaci*, studies show that plant – pathogen- vector systems comprise of direct and indirect interactions (Belliure *et al*., 2005). These interactions alter host preferences for example; *B. tabaci* Q biotype prefers a tomato plant infected by *Tomato yellow leaf curl virus* unlike the B biotype which has a preference for a healthy plant. Therefore, the presence of some virus may alter the host preferences of its vectors (Belliure *et al*., 2005). Moreover, studies indicate that *Bemisia tabaci* populations found on different host plants vary genetically, in geographical distribution, fecundity, dispersal behaviour and resistance to pesticides (Legg, 1996; McKenzie *et al*., 2004). Hence understanding the genetic diversity of the existing *B. tabaci* populations in Kenya in relation to associated viruses will give an insight into desired pest management options. It is also important to understand the biology of various hosts since several factors such as leaf age, hairiness, number and type of trichoms, cuticle thickness, type of canopy among others make some plants undesired host species for pests (Fekri *et al*., 2013).

The role of *B. tabaci* and other identified whiteflies in virus transmission and modalities for its control cannot be under estimated in ensuring a sustainable and healthy horticultural industry. In this regard more research should be carried out to provide the necessary information that will aid in effective management of the pest and associated diseases and phytosanitary decision making. The role of new whitefly species, *A. woglumi* and *A. dispersus* on plant health should be evaluated.

Conclusion

Most of the whitefly species identified from the survey had a wide distribution in most of the areas targeted. *Bemisia tabaci* recorded the highest numbers in terms of distribution as well as in host crop preference as compared to the other species. Other whitefly species namely; *A. woglumi, A. dispersus Aleurodicus spp* and *T. vaporariorum* were also identified from surveyed areas. The results obtained indicated that tomato and cassava were the most preferred host plants by most of the whitefly species, this could be related to presence of many viruses in the two crops that are vectored by white flies.

In conclusion, this research provides baseline information on whitefly populations in Kenya, which is important for researchers and the national plant protection organization. Future studies should focus on vector and virus interactions, spatial distribution and epidemiological studies for better understanding of whiteflies in Kenya and hence aid in development of control measures. Identification should be carried out using both morphological and other reliable, sensitive and accurate molecular technologies.

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