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RESEARCH ARTICLE

Seasonal whitefly (*Bemisia tabaci*) abundance infesting tomato (*Solanum lycopersicum*) monitored on yellow sticky traps

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Abstract

Background and Objective: *Bemisia tabaci*, commonly known as Silverleaf Whitefly, is among the most damaging crop pest on crops such as tomato in Nigeria, but little is known about when these economically significant species are most abundant in the study area. This experiment was carried out to determine the abundance of *B. tabaci* on tomatoes during the dry and rainy seasons at the Teaching and Research farm in Kebbi, Nigeria (Latitude 12º 11' N; Longitude 40 16' E) of the Kebbi State University of Science and Technology. The area is located in the Sudan Savannah Agro-ecological zone of Nigeria, which is marked by irregular and little rainfall.

Materials and Method: Two field studies were conducted in the field during the rainy and dry seasons of 2017 and 2018 in a Randomized Complete Block Design (RCBD) to examine the abundance of whiteflies on tomato plants. Yellow sticky traps were used in field monitoring research on the incidence of *B. tabaci*, the traps provide an easy means for estimating insect pest population density at lower cost that require less skilled labour.

Results: Significantly higher whitefly abundance resulted in the dry seasons than in the rainy seasons in both years. Temperature and relative humidity significantly correlated positively with whitefly abundance in the experimental field with the exception of rainfall that correlated negatively with the whitefly abundance on tomato plants in both seasons throughout the research period.

Conclusion: It was concluded that the deployment of yellow sticky traps proved to be an excellent tool used in field monitoring of *B. tabaci* in the study location. Yellow Sticky Traps required less skills and provide an easy means for estimating insect pest population density at lower cost.

It was concluded that tomato suffers more Whitefly infestation in the dry seasons than in the rainy seasons due to higher abundance and the use of yellow sticky traps proved to be an effective whitefly monitoring tool in insect pest management in the field aimed at effective control of *B. tabaci* on tomato.

Keywords: Whitefly, Abundance, Monitoring, Seasons, Tomato, Yellow traps

Introduction

The whitefly, *Bemisia tabaci* Gennadius (Hemiptera: Aleyrodidae), was initially thought to be a tobacco pest in Greece in 1889. However, following outbreaks in cotton farms in India in the late 1920s and early 1930s, as well as in Sudan and Iran in the 1950s and 1960s, the pest is now thought to be a pest of various crops in throughout the world. According to reports, the pest is pervasive throughout the tropics and subtropics and is constantly moving to previously undiscovered locations (Morales and Anderson, 2001; Degiri and Sani, 2015). Around the world, whiteflies are regarded as one of the most significant agricultural pests. Although the insect is a significant crop pest in Nigeria, little is known about the diversity, abundance, and distribution of these devastating insect pest species (Behera et al., 2016). With little information on its peak populations during the dry season and early rains, the insect is a major pest of tomatoes across Nigeria. Adults spread viral diseases on tomato plants, causing significant losses even at low densities because of the variety of plant viruses they can spread (Yaobin et al., 2012; Muhammad et al., 2017). All its stages of growth, especially the late nymphal instars, produce honeydew, thus, heavy colonization of *B. tabaci* can seriously harm this crop indirectly by reducing photosynthesis via the plant leaves. Honeydew buildup on leaves or fruit surfaces promotes the establishment of sooty molds, which has a direct impact on yield in terms of both quantity and quality (Yaobin et al., 2012). This insect is a major sucking pest of cotton, sunflower, melon, tomato, eggplant, and other food and industrial crops worldwide is the *Bemisia tabaci* (Morales and Anderson, 2001; Kaur et al. (2010); Behera et al., 2016). Feeding on the leaves can cause direct harm, such as chlorosis, wilting, and early leaf drop, which ultimately results in plant death (Yaobin et al., 2012). According to Oyelade and Ayansola (2015), the 37 species that make up the genus *Bemisia* are thought to have originated in Asia. Before its morphological variability was identified, *Bemisia tabaci*, which is most likely of Indian origin, was described under a number of names (Shao et al., 2018). Studies were conducted to understand the field Biology and Ecology of Whiteflies in order to control them more effectively (Behera et al., 2016; Shao et al., 2018). A popular technique for tracking the populations of numerous pests is the use of Yellow Sticky Traps. Studies on these traps in recent decades have mostly concentrated on their application in monitoring populations of pest species such Aphids, Leaf miners, and Whiteflies (Yaobin et al., 2012). For pest monitoring and management, trapping provides the most convenient and less costly tools. The use of colored sticky traps shows good results for monitoring and managing Okra's insect pests in subtropical climate conditions. Yellow is the most attractive color to the whitefly, followed by green, purple and black. Adult insects get more attracted to yellow colour and has been known for some time and yellow traps have been used in trapping of different insects (Yaobin et al., 2012). The use of sticky traps used as pest control reduced pesticide usage which lead to less input cost, less human exposure to pesticides and less pesticide leading to phyto-toxicity thereby increasing the quantity and quality of crop yield (Muhammad et al., 2017). A comparative indicator of insect abundance is provided by yellow sticky traps; evaluations of the quantity of adults captured may reveal the existence of pest density and variation. The use of traps is essential for monitoring before damage occurs and are often effective. Using sticky cards can make it easier to spot early pest infestations (Bashir et al., 2014). An essential part of integrated pest management, yellow traps are environmentally beneficial. The goal of the current study was to use Yellow Sticky Traps in Jega, Kebbi State, Nigeria, to monitor the *B. tabaci* population on tomato plants over the wet and dry seasons in connection to environmental temperature, relative humidity, and average rainfall.

Material and Methods

Study location

Field experiments were carried out between February and early May of 2017 (dry season) and late May and September of 2018 (rainy season), at the Kebbi State University of Science and Technology, Teaching and Research Farm in Jega (Latitude 120 11' N; Longitude 40 16' E), Kebbi State, Nigeria. In both seasons, data was gathered for 12 weeks. The region is in Nigeria's Sudan Savannah Agro-ecological zone, which is distinguished by a protracted dry season (October to April) and irregular, little rainfall that lasts for around five months (mid-May to September). With an average annual rainfall of roughly 550 mm-650 mm, the climate is semi-arid. The dry season has a relative humidity of 21%-47%, whereas the rainy season has a relative humidity of 51%-79%. The average temperature ranges from 14°C to 43°C in the dry season and from 27°C to 41°C in the wet season.

Experimental design and treatments

Roma VF tomato variety was planted and replicated four times in four 3 m × 4 m (12 m^2) plot sizes using a Randomized Complete Block Design (RCBD). The certified tomato cultivar seeds were supplied by Birnin Kebbi's Kebbi State Agricultural Supply Company (KASCOM). Seedlings were initially grown in the nursery beds using nursery management techniques, and were transplanted approximately 30 days to 35 days following sowing. Yellow sticky traps, which are rectangular pieces of yellow plastic measuring 45 cm by 20 cm and painted with a sticky, non-toxic glue, were used to capture flying insects in order to track the whitefly population in the field. Once a week, sticky cards were placed vertically on stakes 30 cm above the plant canopy to trap and distinguish the adult whiteflies from other small flying insects that might stick to the traps (Yaobin et al., 2012). Counts were maintained to track population sizes, and sticky cards were replaced. 3/5 foot yellow sticky traps were placed above the plant canopies in each plot to monitor the whitefly infestation on tomatoes in the field. Yellow sticky traps were used to measure the abundance of whiteflies. The adhesive cards (rectangular pieces, 16.5 cm × 21.5 cm) by Chemibond Enterprise, painted with sticky non-toxic glue, were placed vertically on wooden posts 30 cm above plant canopies in each plot, in compliance with the suggested rate of one trap per 5 m^2.

Data sampling of *B. tabaci*

Sampling was conducted in both dry (February-June) and rainy (July - October) seasons to monitor insect abundance and fluctuations on the Yellow Sticky Traps (YST). Monitoring of insect pests commenced one week after transplanting and lasted for a total time duration of 12 weeks. Three sticky cards (rectangular piece (16.5 cm × 21.5 cm) by Chemibond Enterprise, painted with sticky non-toxic glue) per plot were placed vertically on wooden stakes 30 cm above plant canopies at the recommended rate of one trap per 5 m^2. The number of *B. tabaci* adults that sucked on the traps were counted on weekly basis for 12 weeks and recorded according to plot. Traps were removed for counting and were replaced by new traps every week (Yaobin et al., 2012). For correlation investigations, weekly averages of the mean number of *B. tabaci* were recorded (Mansoor et al., 2012). The Meteorological Station of the Department of Soil and Engineering Sciences, Faculty of Agriculture, Kebbi State University, Aliero, Nigeria, provided the daily data on mean temperature, relative humidity, and average rainfall recorded during the study period.

Statistical analysis

SAS Soft Ware version 9.4 SAS Institute Inc., 2014 was used to analyze the data by performing the regression and correlation analysis. Weather factors (mean weekly temperature, mean weekly relative humidity, and mean weekly rainfall) while the mean weekly Whitefly counts were the independent variables, and Pearson's correlation and multiple regression analysis were employed.

Results

Seasonal *B. tabaci* abundance on tomato plants in the field

As shown in tab. 1, the research's findings indicated that Whitefly abundance on tomatoes in the field was significantly ($p<0.05$) higher during the dry seasons than during the rainy ones in both 2017 and 2018. Additionally, whitefly abundance was higher in 2017 than in 2018 when all seasons were combined.

Table 1. Seasonal *B. tabaci* abundance on tomato plants in the field.

Insect	2017	2018	Combined
Dry season abundance	44.12 ± 3.01^a	41.42 ± 1.54^a	42.77 ± 1.99^a
Rainy season abundance	29.44 ± 1.31^b	26.11 ± 1.18^b	27.77 ± 1.22^b

Means across columns.

B. tabaci abundance on tomato plants in the dry and rainy seasons of 2017 and 2018

In both the dry and wet seasons of 2017 and 2018, there was a significant positive correlation between Whitefly abundance, temperature and the relative humidity. In both the 2017 dry season (0.70) and the 2018 wet season (0.78), there was a strong positive correlation between temperature and whitefly abundance (Tab. 2 and 3). During the 2017 and 2018 wet seasons, there was a highly significant positive association between temperature and whitefly abundance (0.81 and 0.86, respectively). Whitefly abundance and relative humidity also showed a significantly positive relationship (0.73) during the 2017 dry season and (0.84) in 2018. However, as depicted in tables 2 and 3, there was a significant negative association between the Whitefly population and rainfall in 2017 (-0.87) and 2018 (-0.90), indicating that rainfall greatly decreased the Whitefly population during the rainy season. The Yellow Sticky Traps (YST) on tomato plants in the field were used to measure Whitefly abundance, and the results indicated favorable interactions between weather conditions, specifically temperature and relative humidity with *B. tabaci* abundance.

Table 2. Correlation and regression estimates for *B. tabaci* abundance against seasonal factors in 2017.

Season	Predictor variable	Parameter		
		Intercept	R^2	r
Dry Season	Relative Humidity	6.96	0.47	0.7
	Temperature	65.23	0.53	0.73
Rainy Season	Relative Humidity	4.55	0.65	0.81
	Temperature	2.77	0.72	0.85
	Rainfall	7.66	0.76	-0.87

Table 3. Correlation and regression estimates for *B. tabaci abundance* against seasonal factors in 2018.

Season	Predictor variable	Parameter		
		Intercept	R^2	r
Dry Season	Relative Humidity	6.23	0.61	0.78
	Temperature	80.34	0.7	0.84
Rainy Season	Relative Humidity	4.55	0.74	0.86
	Temperature	1.42	0.32	0.56
	Rainfall	7.67	0.81	-0.90*

Discussion

B. tabaci population on tomato plants

This result is in conformity with the findings of Mathur et al. (2012); Yaobin et al. (2012); Shao et al. (2018), who reported that all stages of an insect's life cycle are affected by the climatic factors especially the environmental temperature dictated by rainfall patterns and the relative humidity. Yellow sticky traps have been used as both for control and in monitoring of Whiteflies in Greenhouse and in the fields as an effective tool in the study of insect pest population in relation to climatic factors such as temperature, wind, rain and relative humidity that play important roles in the population changes on insect such as Whiteflies (Atakan and Canhilal, 2004; Khuram et al., 2012; Yaobin et al., 2012; Lu Y et al., 2012). This result contradicts with the findings of (Ofori et al. (2014), who find out that a significant negative correlation existed between Whitefly adults and nymphs and maximum and minimum temperature. Similarly, Kedar et al. (2014), reported a negative correlation between Whitefly population and weather factors particularly temperature, relative humidity and precipitation and further supported by the works of Khuram et al. (2012). The present findings are also similar to the results obtained by

Muhammad et al. (2017), and Saini (2014), that a mean temperature of 32°C and lower relative humidity encouraged the growth and abundance of *B. tabaci*.

This study also supports the findings of Saini (2014) and Sharma et al. (2017), who reported that rainfall and humidity (both maximum and minimum) had a negative relationship with the number of Whiteflies in the field. Higher relative humidity (80%-90%) and rising temperatures (36°C-38°C) were directly linked to an increase in the number of Whiteflies in September and October, according to related research by Shao et al. (2018) and Saini (2014). This was because these conditions accelerated the development of the juvenile stages by reducing the growth duration of each stage. Rainfall has the physical beating impacts on smaller insects like Whiteflies and the unfavorable lower humidity levels during rainfall may be the reason of these inverse relationship between Whitefly population, rainfall and the relative humidity during the rainy seasons, which kills *B. tabaci.*

This finding is consistent with Singh et al. (2011), who finds out that high temperatures and heavy rains had a significant negative impact on the adult Whitefly population, resulting in a decrease in the abundance of adult Whiteflies and is further supported by the findings of Umar et al., (2003); Mehra and Krishna (2017). The present study is also in line with Khan et al. (2011), who found out that rainfall had a negative, non-significant impact on the incidence of Whitefly in relation to the maximum temperature. A similar study by Khalid et al. (2006), found that the mean temperature significantly boosted the number of *B. tabaci* nymphs that resulted in higher abundance.

In addition to this, Mathew and Olalekan (2005), confirmed this by stating that there was a non-significant inverse relationship between Whitefly abundance and rainfall, temperature, and relative humidity. This is further corroborated by another research by Yaobin et al. (2012), Saini (2014), and Oyelade and Ayansola (2015), who found out that the adult population of Whiteflies had a significant positive correlation with temperature and relative humidity when comparing various weather parameters with Whitefly, *B. tabaci* nymphs and adults.

The findings of Yaobin et al. (2012), Sani (2014), and Oyelade and Ayansola (2015); Wagan TA et al., (2017), who conducted correlation analyses between various weather parameters and *B. tabaci* nymphs and adults, further supported this study. They found that the Whitefly adult population had a significant positive correlation with temperature (r=0.650) and relative humidity (r=0.455).

More effective pest control techniques based on ecological environment manipulation in sustainable pest management will be possible with a better understanding of the seasonal population fluctuations.

Conclusions

According to the study's findings, the Whitefly population monitored using the Yellow Sticky Traps was higher during the dry season than during the rainy one. The decline in the field's whitefly population is mostly due to heavy rainfall during the wet seasons. By producing favorable environmental circumstances that are favorable for whitefly growth and development or otherwise, temperature and relative humidity have a positive impact on the population of whiteflies. It is advised that more of similar researches should be conducted at the study site with Yellow Traps on additional cultivated crops affected by *B. tabaci* and other insect pests over the course of more than two years in the study location to widen the scope.

This study is aimed at understanding the time and seasons of the abundance of *B. tabaci* as the insect affects tomato production in the study area, this will certainly allow for proper and efficient tomato pest control measures at the right time which will greatly assist in reducing the effect of *B. tabaci* infestation on tomato plants leading to increase in tomato yield for more profitable production.

Significant Statement

The study revealed the seasonal population variation patterns and the peak population time of *B. tabaci* in the study area, which had previously been unknown to researchers in the study location. This work will greatly aid researchers and farmers in planning an efficient whitefly management and control strategy at the right time for more tomato crop yields that will significantly lead to higher profitable production. For the first time in the research area, this study also demonstrated that Yellow Sticky Traps are a useful and efficient as a monitoring tool for Whitefly population on the cultivated crops in the study area.

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