Tomato leaf miner (*Tuta absoluta*) incidence and severity in Kirinyaga County, Kenya

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Abstract

The tomato leaf miner (*Tuta absoluta*) is a new insect pest of tomato in Kirinyaga County. *Tuta absoluta* can reduce yield and quality of tomato by 80-100% both in field and greenhouse conditions. Farmers have been using synthetic insecticides to combat the insect pest. However, the aggressive nature of the pest, multivoltine character, short generation time, high biotic potential and increased resistance to insecticide use has led to difficulty in its control. This study was aimed to determine the incidence of *Tuta absoluta* through monitoring using pheromone traps and determine its severity in tomato fields' despite chemical insecticides applications for effective designing of ecologically-sound management strategies of *Tuta absoluta* in Kirinyaga County. Field survey was carried out during 2016-2017 growing seasons on a set of 15 tomato fields located in three sites (Kimbimbi, Defathers, and Kariithi). A survey was conducted every three weeks from transplanting to harvest on 30 randomly selected plants in each focal field. Three leaves per plant (lower, intermediate and upper) were carefully inspected for the presence/absence of mines. Sex pheromone traps were used in every focal field to monitor population dynamics of *Tuta absoluta*. *Tuta absoluta* trap catches were found in all sampled sites, captured moths ranged from 120-240, there was a linear increment in the number of captured moths during the surveyed time. *Tuta* *absoluta* mining damage on the leaves was observed in all the 15 focal fields. High infestation was recorded on the lower part of the leaf (73%) at 100 days after transplant. Upper part of the leaf recorded the lowest damage of *Tuta absoluta* among the three sites sampled. Kariithi showed the highest (37%) infestation compared to other sites. Infestation damage increased as the crop advanced in growth and was heaviest at the end of the cropping cycle. Synthetic insecticides have been found to reduce populations of naturally occurring predators and parasitoids of *Tuta absoluta* and increased development of resistant populations of the insect pest. It is therefore imperative to develop alternative nonchemical integrated control programs for a sustainable management of *T. absoluta*.

Key words: *Tuta absoluta*, synthetic chemicals, sustainable management, pheromone traps

Introduction

Tomato (*Lycopersicon esculentum mill*) is one of the most promising commodities for horticultural expansion and development in Kenya. Kenya is among Africa's leading producer of tomato (ranked 6^{th} in Africa) with a total production of 397,000tones (FAO, 2012). Tomatoes contribute significantly to food security and nutrient balance but also are a source of income, foreign exchange earnings and creation of employment (FAO 2012). They are nutritious vegetables that provide high quantities of vitamins A and C; they play an important role in meeting nutritional food requirements for both rural and urban populations in Kenya.

Tomato leaf miner is a major insect pest infesting tomato crops. It has been reported as the most devastating pest of tomato in Argentina, Chile, Colombia, Brazil, Paraguay, Peru, Uruguay and Venezuela (Barrientos *et al.,* 1998; Estay, 2000; Botto, 2011b). In Kenya, *T. absoluta* was first found in early 2014 to infest open field tomatoes. The insect has spread rapidly and is now considered as the most challenging insect pest of Tomato in Kirinyaga County (Nderitu *et al.,* 2018). Under inadequate control, *T.* absoluta has been reported to cause 90-100% yield losses (Estay, 2000). Infestation of tomato plants occurs throughout the entire crop cycle, with females ovipositing preferentially on leaves (73%), and to a lesser extent on leaf veins and stem margins (21%) sepals and green fruits account for 5% and 1% respectively (Estay, 2000).

Chemical control using insecticides is considered as an effective management option of the pest (Silverio *et al.,* 2009). *Tuta absoluta* management in Kirinyaga County is based on chemical insecticides application that range between 9 and 16 applications per growing season (Nderitu *et al.,* 2018). Chemical insecticides are routinely applied as control strategies of the pest however, Farmers are not always aware of the harmful effect that come along with chemical use both to humans and the environment (Picanco *et al*. 1998). Therefore this study aims to determine the incidence of *Tuta absoluta* through monitoring using pheromone traps and determine its severity in tomato fields' despites chemical insecticides applications for the development of ecologically sound, integrated control programs for a sustainable management of *T. absoluta*.

Materials and Methods

Experimental site

An extensive field sampling was carried out during the 2016-2017 growing season on a set of 15 tomato fields located in three locations, including Defathers, Kariithi and Kimbimbi in Mwea East Sub-county, Kirinyaga County, Kenya. Mwea East sub-county was chosen since it's involved in tomato production throughout the year and tomato farmers rely on irrigation for production. This was aimed at assessing the incidence and extent of damage caused by *T. absoluta* across the tomato fields.

Data collection procedures

A Delta trap containing pheromone lure specific to attract *T. absoluta* male adults (Pherodis, *Tuta absoluta*, Koppert, Kenya) was set up in every focal field to monitor *T. absoluta* incidence and abundance. The pheromone traps were positioned in the middle of the field at a height of 40 cm above ground. The exposed traps were collected from the field after every 6weeks and replaced with new ones. Trap catches were counted and further taken to the Museum of Kenya for identification.

A field survey was conducted every three weeks from transplanting to harvest on 30 randomly selected plants in each focal field. Three leaves per plant (from lower, intermediate and upper canopy) were carefully inspected for presence/absence of mines using the scoring scale where 1- no infestation, 2- up to 25% leaf infestation, 3- 25-50% leaf infestation, 4- 50-75% leaf infestation

5≥75% leaf infestation (Ayalew, 2011). Pest management strategies were applied by farmers and they were based largely on chemical applications which targeted control of *T. absoluta* and other lepidopteron insect pests.

Data analysis

Specimens caught in the pheromone traps were carefully removed and preserved in 96% ethanol and taken to Museum of Kenya for identification.The variability of damage across the different sites and the sampled plant parts was in percentages. The percentage data was subjected to arcsin square root transformation and analysis of variance performed using one way ANOVA in R software. Mean separation was done using turkey's test.

Results

Field sampling for *Tuta absoluta* incidence

Delta traps that were placed in every focal field were collected and replaced every 6 weeks, to monitor the abundance of *Tuta absoluta* in the tomato fields. Across the 15 tomato fields evaluated each had over 120-240 specimens of *Tuta absoluta* (Figure 1). Adult samples were identified at the Museum of Kenya and confirmed as *T. absoluta* species. Based on the Delta trap counts, *Tuta absoluta* catches increased as the crop matured (Figure 1)

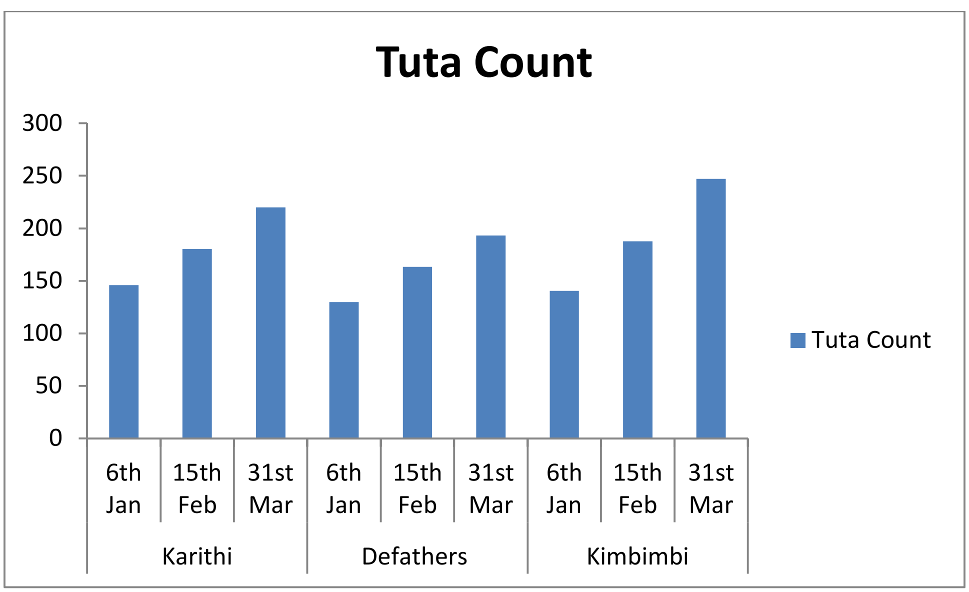

Figure 1: Means of *Tuta absoluta* catches across the three sites during tomato growing season from transplanting to harvest

Field sampling for *Tuta absoluta* Damage

Tuta absoluta mining damage on the leaves was observed in all the 15 focal fields (Figure 2). *T. absoluta* larvae were found between the upper and lower leaf epidermis, feeding on the mesophyll tissues and causing mines. The excreta could also be seen inside galleries.

Figure 2: *Tuta absoluta* mining damage

SEVERITY OF *Tuta absoluta* ACROSS THE THREE SITES AND ON SAMPLED PLANT PARTS

In all the sites, the lowest part of the leaf was highly infested and damaged with the highest range of damage appearing at Karithii site while the lowest range was at Kimbimbi (Fig. 3). The trend was different for the intermediate and upper part of the leaf where the highest range value of damage was observed at defathers and Kimbimbi, respectively and the lowest was observed at Kimbimbi and defathers, respectively. Generally, the upper part of the leaf recorded the lowest damage of *T. absoluta* among the three location of the leaf sampled. The box plots also depicts the infestation data at Defathers and Kimbimbi to be highly negatively and positively skewed, respectively. On the other hand, Karithii showed a mild skewness.

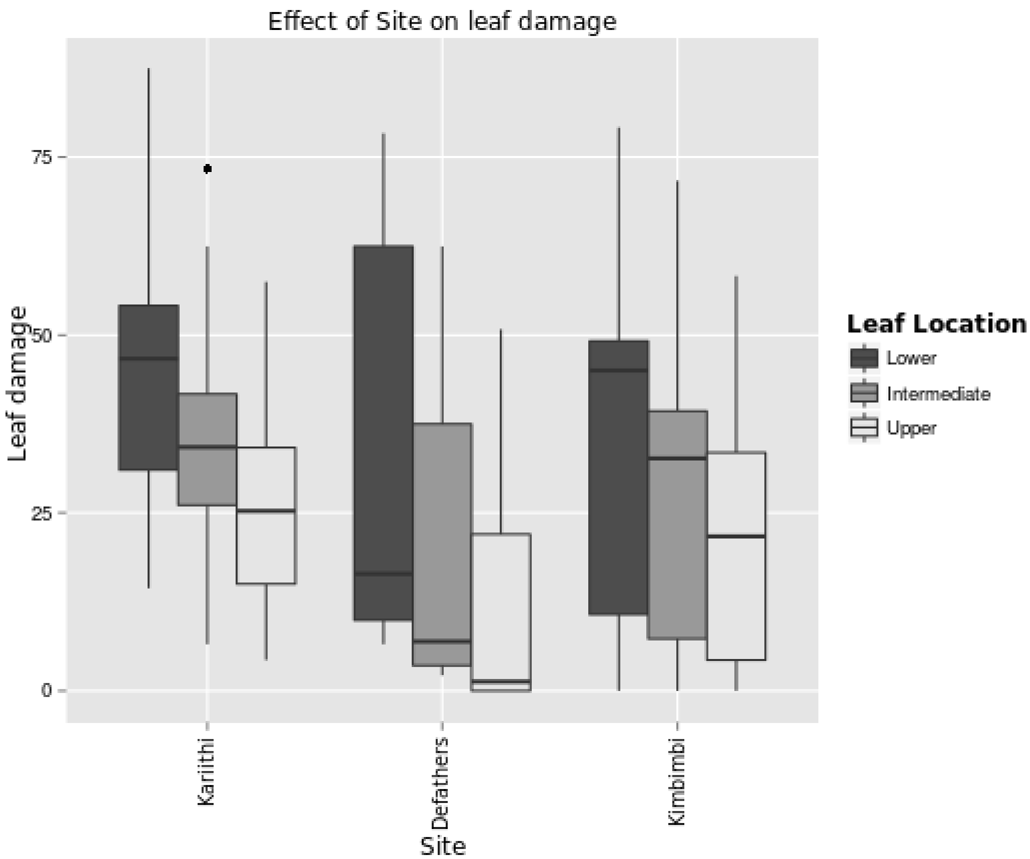

Figure 3: Percentage leaf damage by *Tuta absoluta* across the three sites.

Among the three sites where tomatoes were planted and percentage leaf damage by *Tuta absoluta* measured, Kariithi showed the highest (37%) infestation of the pest compared to the other sites (Table 1). The damage at Kariithi was greatly significant to the two sites which recorded the lowest damage. There was no significant differences between the two sites, defathers (22%) and Kimbimbi (28%), in terms of percentage damage by the pest.

Table 1: Severity of *Tuta absoluta* damage (in percentage) on tomato leaves in three different sites. Means marked with the same lowercase letters are not significantly different (mean ± standard deviation, $p > 0.05$, tukey test)

Location (site)	Damage
	Percentage (%)
Kariithi	37 ± 19 a
Defathers	22 ± 23 b
Kimbimbi	28 ± 23 b

Comparing the time period from transplanting to maturity of the tomatoes, *Tuta absoluta* damages to the lower, intermediate and upper part of the leaf were least observed at 20 and 40 days after transplant (Fig. 4). The percentage damage increased after 60 days which were signigicantly higher to 20 and 40 days, across the plant parts. The trend was the same at 80 and 100 days after transplant, where at 100 days the damages was significantly higher than all other counting periods across the leaf parts. Overall, the highest leaf damaged (73%) by *Tuta absoluta* was observed on the lower leaf part at the 100 days after transplant whereas the lowest damage (5%) was observed on the upper leaf part after 40 days of transplanting.

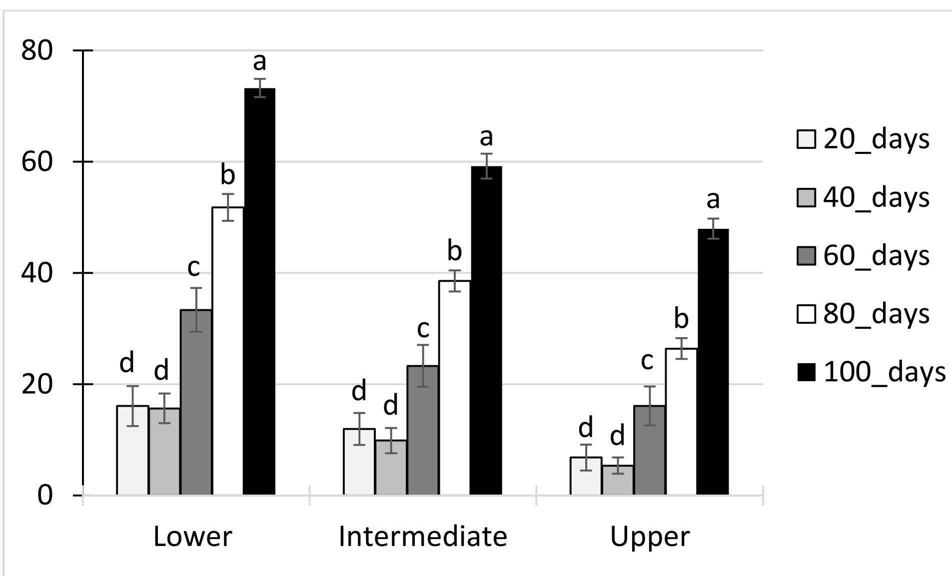

Fig 4: Severity of *Tuta absoluta* damage (in percentage) on tomato leaves based on time of plant growth and the location of the leaves on the plant. Means marked with the same lowercase letters are not significantly different (standard error bars, $p > 0.05$, tukey test)

Discussion

The presence of *T. absoluta* was evident in this study, pheromone trap catches of adult *T. absoluta* were collected across the 15 focal fields distributed in 3 sites. Our results show an already established population of *T. absoluta* in Kirinyaga County. Pheromone traps have been widely used to monitor, forecast and sometimes control insect pest populations (Prasad and Prabhakar, 2012). Further, pheromone traps can be used to efficiently monitor pest population for correct timing of pesticide application. Despite chemical control of the insect pest, Results revealed an increase in *T. absoluta* population as the crop advanced in growth. This could have been attributed to the availability of the crop and therefore there was enough food supply that promoted reproduction and multiplication. Allache et al. (2015) reported similar results where adult *T. absoluta* catches were present throughout the tomato crop cycle. Further, Torres et al. (2001) reported that with availability of host plants, the adult moth continues to oviposite.

Tuta absoluta catches were found as early as 2weeks after transplanting this could be attributed to the cultural practices of the farmers. Most of the farmers practice monocropping and after harvest of the crop they left the crop residues at the periphery of their fields; this provides a favourable environment for *T. absoluta* to survive before the crop residues are completely decomposed. Further, *Tuta absoluta* is associated with other solanaceous plants including weeds which are cultivated in Kirinyaga County as indigenous vegetables. Establishment of the insect pest could also have been accelerated by short distance dispersal of the insect pest since most of the farmers in the county are small scale farmers. Ajaya et al. 2016 found that short distance spread of *Tuta absoluta* could occur by flight since the insect pest can fly several kilometers.

Tuta absoluta mining damage was found in all the 15 focal fields throughout the crop growth stages. Larval mining was found in the leaves causing irregular mines; fully grown larvae could be seen inside galleries (Fig. 2). Arno and Gabarra (2011) noted that tomato plants can be infested by *T. absoluta* from seedling to mature plants. *Tuta absoluta* damage was seen as early as 20 days after transplanting and this was found to increase steadily over time while highest mining damage was at 80 to 100 days after transplanting during flowering and fruiting stage. Brahim et al. (2009) reported similar results while assessing population dynamics of *Tuta absoluta* where there was low level of infestation 11 weeks after transplanting but this increased steadily and was highest at 19 weeks after transplanting. This increase in *Tuta absoluta* infestation can be linked to continuous availability of food and favourable environmental conditions to the insect pest. Nayana et al. (2018) revealed a low *Tuta absoluta* infestation level during the first phenologic cycle but by the end of the cropping cycle there was a significant increase in the insect pest density. Further, Leite et al. (2004); Oliveira et al. (2009) reported severe attacks by *T. absoluta* towards the end of the tomato crop cycle.

Extensive mining was seen on the lower leaves (73%) (Fig. 3) followed by intermediate leaves and then upper leaves. Other studies show that leaves were more attractive to female *T. absoluta* and the lower leaves were more infested than upper leaves (Hussein *et al.,* 2015). *Tuta absoluta* has a high preference to lay its eggs on the apical part of the tomato plant as the third and fourth instar larvae were found on leaves of the middle and lower parts of the plants (Asma*et al.,* 2013). Lower leaves had the highest infestation by *Tuta absoluta* across the three sites; this could be attributed to the fact that fourth instar larvae prefer basal leaves awaiting pupation in the leaves or the ground. As the crop advanced in growth *Tuta absoluta* infestation was seen in the intermediate leaves and upper leaves. Trottin-Caudal et al. (2012) revealed similar results where *Tuta absoluta* mining was observed more on the lower part of the plant but as populations increased mining damage was seen on higher parts of the plant as well as green fruits.

Despite insecticide applications by farmers which were mainly calendar based *Tuta absoluta* damage increased over time across the three sites. Most farmers increased the chemical dosage, frequency of spraying and even mixed more than one insecticide with different modes of action when there was reduced efficacy in the control of the insect pest (Nderitu et al., 2018). However, frequent use of synthetic insecticides have been found to reduce populations of naturally occurring predators and parasitoids of *Tuta absoluta* and increased development of resistant populations of the insect pest (Anastasios *et al.,* 2014; Ajaya *et al.,* 2016). Garzia et al. (2012) reported a rapid adaptation of T. absoluta to different environments and heavy infestations when unsuitable or untimely control measures are applied.

Conclusion

It is evident from this study that *T. absoluta* is established in Kirinyaga County. Pheromone traps have been found to be effective in monitoring and identifying the presence and abundance of the insect pest early in the season. *Tuta absoluta* was found to cause sizeable damage despite chemical insecticide application. It is therefore imperative to develop ecologically sound integrated pest management strategies for *T. absoluta* sustainable control.

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