First Report of *Tuta absoluta* (Meyrick) in Zambia

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Abstract: In 2014, the NPPO of Zambia, the Plant Quarantine and Phytosanitary Service (PQPS) initiated a pest risk analysis for *Tuta absoluta* Meyrick (Lepidoptera: Gelechiidae), the tomato leaf miner. This was after increased reports of the pest spreading southwards in Africa and neighboring Tanzania officially reporting the pest in 2013. By 2014, the pest was reported to occur in Algeria, Egypt, Ethiopia, Libya, Morocco, Niger, Senegal, Sudan, Tunisia, Kenya and Tanzania. By end of 2015, farmers in some districts in Zambia reported pest damage and suspected that it could be *T. absoluta*. This posed a serious threat to the Zambian tomato industry as tomato is one of the most important vegetable crops in Zambia grown both on a small scale and commercial scale as a cash crop. It accounts for 86% of the total value of fresh fruit and vegetable sales within the smallholder sector for Zambia. For this reason, PQPS initiated a detection surveillance of the pest in reported areas in February 2016. The Zambia preliminary surveys revealed that the pest is present in Northern, Copperbelt, Lusaka and Central Provinces of Zambia. Identification of the pest was confirmed by observing collected adult moths for key taxonomic features; filiform antennae, brown or silverfish with black spots on the moth wings and moth size. Other factors for identification were characteristic damage on leaves and fruits, pheromone traps catches and consultation of international experts in Tanzania. Introduction of *T. absoluta* to Zambia has devastated the Zambian tomato production industry. A taskforce has been formed to address the threat being caused by *T. absoluta.* Zambia has also updated its phytosanitary import conditions for tomato since this confirmation and drafted the legislation to regulate movement of tomatoes. Notification for the first report has since been sent to the International Plant Protection Convention (IPPC).

Key words: Tomato, *Tuta absoluta*, detection surveillance, Zambia

Introduction

For decades, tomato has been one of the most important vegetable crops in Zambia. It is grown both on a small scale and commercial scale as a cash crop (Mingochi and Jensen 1986; Mnzava and Msikita 1986). Tomato is among the top five crops dominating smallholder systems accounting for 86% of the total value of fresh fruit and vegetable sales within the smallholder sector for Zambia (Tembo and Sitko 2013).

In January 2015, the Zambia National Plant Protection Organization (NPPO), the Plant Quarantine and Phytosanitary Service (PQPS) began working on a proposal to survey the country for *Tuta absoluta* Meyrick (Lepidoptera: Gelechiidae), the tomato leaf miner. This was after the pest was reported in East Africa (CABI ISC, 2014) and predicted to spread southwards (Agripest, 2015; Muniappan, 2013). A year earlier (in 2014), the pest was reported to be present in Algeria, Egypt, Ethiopia, Libya,

Morocco, Niger, Senegal, Sudan, Tunisia, Kenya (IPPC 2014a; IPPC 2014b) and Tanzania (CABI ISC, 2014; Brevault, 2014; Muniappan, 2013). These reports on *T. absoluta* were of concern to PQPS. Subsequently, PQPS initiated a pest risk analysis (PRA). This PRA on *T. absoluta* was not unique to Zambia. Similar PRAs have been conducted by other countries such as the Netherlands on the pest (Potting, 2009). The PRA revealed that there was a high likelihood that *T. absoluta* would enter, establish and spread in Zambia. This result was sufficient to prompt the Zambia NPPO to be on pest alert. By October 2015, farmers had begun noticing and reporting symptoms of *T. absoluta* damage to PQPS, entomology section as well as to the Department of Agriculture. In response to the unofficial farmer reports, by November 2015, PQPS secured a sample of lure 50 Optima pheromone with delta traps from Russell IPM in the UK to facilitate preliminary detection surveillance of the pest.

Subsequent to the aforementioned reports, a capacity building program was initiated by the NPPO to expedite detection of *T.absoluta*. Firstly, a *T. absoluta* expert from Tropical Pesticides Research Institute (TPRI) in Tanzania was invited to train Plant Health Inspectors (PHIs) of the Zambian NPPO. The training mainly focused on identification and management of the pest. The training program was sponsored by the Africa Solidarity Trust Fund (ASTF) Project titled "Strengthening Controls of Food Safety Threats, Plant and Animal Pests and Diseases for Agricultural Productivity and Trade in Southern Africa" implemented by the Food and Agriculture Organization (FAO). The expert also viewed suspected *T. absoluta* moths caught on pheromone traps and verbally confirmed the identity of the pest. A preliminary survey was then conducted between February and April 2016. During the survey, the pheromone traps were placed in the areas where the pest was reported.

T.absoluta has a number of biological characteristics (Brevault 2014; Desneux *et al.,* 2010) that make it a successful invasive pest (Desneux et al. 2010; Desneux et al. 2011). Some of the most important ones are its short lifecycle of 30 - 40 days with twelve generations in a year, the ability of larvae to pupate in soil or stem and the fact that the female lays an average of 260 eggs (Desneux *et al*., 2010).The major host for *T. absoluta* is tomato (*Solanum lycopersicum)* but it can complete its life cycle in other solanaceous plants (Mohammed et al., 2015; Pereyra and Sanchez, 2006) such as potato and eggplant (NAPPO, 2013). In tomato, foliage attacked by *T.absoluta* larvae show irregular lines on leaf surface, damaged leaves shriveled leaves and decreasing photosynthetic activity (Desneux *et al*., 2010).

The presence of *T.absoluta* has had a negative impact on the Zambian tomato industry and threatens food security and the economy in Zambia. PQPS therefore conducted this important activity with the sole objective of establishing the status of *T. absoluta* in Zambia. Thirteen districts from four provinces of Zambia were surveyed with a total of 35 farms sampled.

Materials and Methods

Surveillance of *T.absoluta* was incorporated into donor funded PQPS surveillance programs for maize between February and April 2016. The surveillance followed (but was not restricted to) guidelines provided in International Standards for Phytosanitary Measures (ISPM) Number 6 (FAO 1997), the North American Regional Plant Protection Organization surveillance protocol for tomato leaf miner (NAPPO 2013), Caparros *et al*., (2013) and Chidege *et al*., (2016). The survey was conducted in selected areas

of Zambia where the pest was reported. Specifically, the survey targeted 35 tomato farmers and two tomato market places. The detection survey was conducted by Officers from the Plant Protection and Quarantine Division (PPQD), ZARI in conjunction with agricultural extension staff of the Department of Agriculture (DoA) under the Ministry of Agriculture (MoA). The areas included Lusaka, Chongwe, Kafue, Chilanga, Serenje, Kabwe, Kapiri Mposhi, Ndola, Kasama, Mpulungu, Mbala and Chingola districts. PHIs were sent to affected areas to work with district staff in setting up pheromone traps and interviewing farmers. Sampling was random and based on farmers who had informed extension officers or plant clinic in their area of the infestation. During farm visits, farmers were interviewed on when they saw the pest, infestation levels, chemicals used, whether the chemicals were effective and which ones and how the pest infestation affected them. These were short qualitative interviews as this was a preliminary survey. District agriculture extension officers and farmers were made aware of specific identification and management of the pest and how to set up the pheromone traps as recommended by Russell IPM and Caparros *et al*., (2013). The pheromone traps consisted of delta traps with Optima lures. Traps were hang at a height of 1-1.5 m from tomato stakes or suitable structures with 2 traps per hectare, in sampled areas after consent from the farmers or market chairperson. The traps were left in the field for a period of 3 – 7 days before being sent back to the PQPS laboratories for counting.

Selected farms were later revisited to collect adult moths for identification using a labelled 200ml killing jar containing cotton wool soaked in 100% alcohol. The labels included name of the farmer, district, name of farm, time and date of collection and number of moths collected in the jar. The farmers were advised to visit their infested field in the early hours of the morning and place the jar over an infested leaf or stem and shake it allowing the moth to fly into the killing jar. Once the moth was in the jar, the farmers would close the lid. Separate jars were recommended in the case of more than one field per farmer. The killing jar and contents were left overnight with the farmers and once the adult moths had been collected, they were taken to the PQPS laboratory. At PQPS, these moth were carefully examined for key morphological characteristics; size, filiform antenna and black ashy bands on the forewings and results recorded.

Results

A total of 35 farms and two market places were surveyed in 12 districts from four provinces of Zambia as shown in Table 1.

Table 1: Number farms in surveyed 12 districts of Zambia.

Province	District	Number of farms	*Moths found on traps (Y/N) *
Central	Chibombo	1	Y
	Kabwe	2	Y
	Serenje	1	Y
Copperbelt	Chingola	3	Y
	Ndola	5	Y
Northern	Kasama	8	Y
	Mbala	5	Y
	Mpulungu	4	Y
	Chilanga	2	Y
	Chongwe	1	Y
Lusaka	Lusaka	1	Y
	Kafue	2	Y

*Numbers of moths recorded are not included because the numbers of moths were not comparable. In some districts, more traps were placed than others and some traps were left in the field for more days than other areas.

Two traps were placed at market places, one in Kasama and one in Serenje. All traps caught *T.absoluta.* Field visits showed highest infestations in Central province as compared to other provinces. Central province had 30% higher infestations than the others. All the pheromone traps in the districts surveyed caught *T. absoluta* as shown in Figure 1.

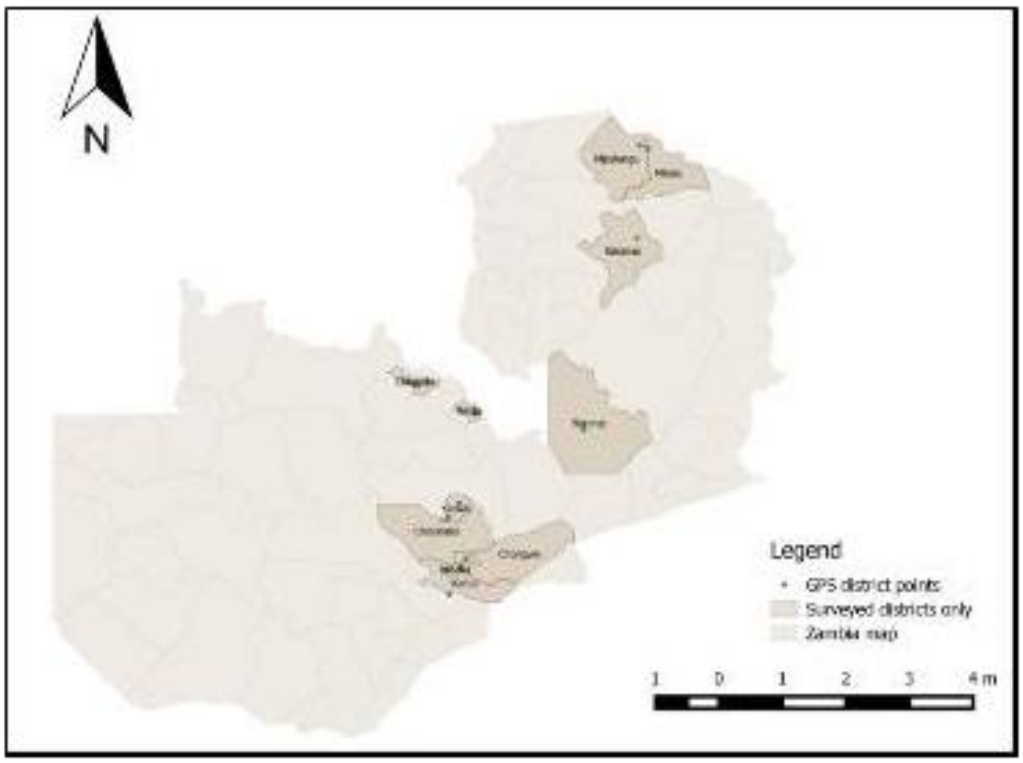

Figure 1: Map of Zambia showing districts where *T. absoluta* was detected in April 2016.

In the field, the damage was characteristic of *T. absoluta* on the leaf. The damaged leaves showed discoloration in the areas that were mined and the fruits showed dark dots on points where the larvae had bored through the fruit (Figure 2).

Figure 2: Left: Mines of *T. absoluta* on tomato leaves on a farm in Kafue district. Right: *T.absoluta* damage on tomato fruit at a farm in Kabwe.

The examined adult moths were between 3mm to 7 mm long. The moths showed characteristic silver grayish scales and black bands on the forewing and filiform antennae. The trained officer with PHIs and entomologists from Zambia Agricultural Research Institute (ZARI) reached a

consensus that the pest was indeed *T. absoluta* on the basis of the following;

1. Key morphological characteristics; size, filiform antenna and black ashy bands on the forewings.
2. Type of damage caused by the pest on tomato which compared favorably with literature.
3. Catches on the pheromone traps – Optima lure is specific to *Tuta absoluta* and only attracts *T.absoluta* males.
4. The host plant –the fact that the moths were found on tomato which is a major host plant of *T.absoluta* according to literature.
5. Tanzania expert opinion upon examining the moths from the pheromone traps.

Discussion

During the survey, most of the farmers reported that they first noticed symptoms of damage on the leaves and then in subsequent weeks began to see damage on fruits. They reported low yields and high rate of infestation once a few moths were observed on the farms. For farmers who could not afford to purchase pesticides, their yields were reduced to zero by the end of the third week. At the time of the surveillance, some of the farms were highly infested with close to 90% damage of the crop. Despite farmers practicing crop rotation, short distances between the farms and poor management practices such as leaving rotten tomatoes on the side of the field may have also facilitated continuous infestations.

Farmers also reported some resistance of the pest to pesticides which compared favorably with literature (Siqueira *et al*., 2016). The few farmers who had managed to reduce pest populations said they had to mix a variety of pesticides to achieve this reduction. It was also noted that some farmers were using the wrong doses of pesticides and wrong pesticides (i.e. fungicides, herbicides and other pesticides prescribed for animals) to spray against the pest. The misuse of pesticides combined with high pesticide applications by farmer causes a food safety risk on the general public.

The identification process of *T.absoluta* during this surveillance was only focused on the adult moth stage and not egg, larva and pupa. This was due to absence of appropriate rearing facilities and equipment in the Entomology laboratory for the pest to facilitate examination of all stages, and lack of funds to build this capacity. The process used herein did allow for adequate identification but compares favorably with methods used in other countries for first reports on *T.abslouta* (Kilin 2010; Pfeiffer *et al.,* 2013; Chidege *et al.*, 2016).

Tuta absoluta was recorded in all surveyed districts and is present across the Lusaka, central, southern and northern parts of country. Inadequate funds for *Tuta* programs at the time of surveillance limited the area and scope for surveillance. Of all the surveyed provinces, Central province showed high infestation compared to the other three provinces. This could be attributed to the fact that this province is a high tomato producing area where most farmers grow tomatoes throughout the year. This means there may have been no break in life cycle for the *T.absoluta* moths once introduced to the area. This is favourable with literature which mentions that *T.absoluta* larvae appear to refrain from entering diapause when there is a constant availability of food (Desneux *et al.*, 2011) and it pupates in the soil (Desneux *et al*., 2010; Desneux *et al*. 2011; Chidege *et al*. 2016). The presence of *T. absoluta* in the surveyed districts confirmed the outcome of the PRA conducted by PQPS in which it reported a high likelihood of pest introduction and its spread. The spread

could be attributed to several factors such as the movement of both seedlings and wooden crates around the country due to the high demand for tomato. Such pathways have been reported to contribute to the spread of the pest (CFIA 2010; Desneux *et al*. 2011; Muniappan 2013; NAPPO 2013).

In order to minimize the spread of *Tuta absoluta*, PQPS and the entomologists have taken some management measures. Currently, ZARI through PQPS and the entomology section is working with extension officers to create awareness on *Tuta absoluta* to farmers and apply phytosanitary measures in affected areas. In addition, a taskforce was formed to address the issue on *Tuta absoluta*. The members to the taskforce include the Ministry of Agriculture, Zambia National Farmers Union (ZNFU) and Zambia Environmental Management Agency (ZEMA) and agrochemical companies (ZNFU 2016). With support from the taskforce and additional funding from the ASTF –FAO project, a wider surveillance on *Tuta absoluta* has been completed and results are being compiled. Zambia has also updated its phytosanitary import conditions for tomato since this confirmation and a Statutory Instrument was drafted to regulate movement of tomatoes across the country. Zambia has also notified the IPPC and Southern Africa Development Community (SADC).

Conclusions and Recommendations

In conclusion, this is the first report of *T.absoluta* in Zambia. *Tuta absoluta* is present in Zambia and this report will help trading partners to update their phytosanitary import requirements.

Recommendations are (i) increased awareness creation on importance of IPM, (ii) appropriate use of pesticides and food safety to farmers, (iii) increased collaboration on management of the pest and resistance studies between academic, field researchers and private sector and (iv) more research on bio pesticides.

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References

Agripest. (2015). *Tuta absoluta* and the risk to farmers in Sothern Africa. Retrieved September 6, 2015, http://www.tutaabsoluta.com/reports/216/tuta-absoluta-and-the-risk-to-farmers-in-sothern-africa.

Brevault, T., Sylla, S., Diatte, M., Bernadas, G., & Diarra, K. (2014). *Tuta absoluta* meyrick (Lepidoptera: Gelechiidae): a new threat to tomato production in Sub-Saharan Africa. *African Entomology*, 22, 441-444.

Caparros Megido, R., Haubruge, E., & Verheggen, F. (2013). Pheromone-based management strategies to control the tomato leafminer, *Tuta absoluta* (Lepidoptera: Gelechiidae). A review. *Biotechnologie, Agronomie, Société et Environnement Biotechnology, Agronomy, Society and Environment 17* (3), 475-482.

CFIA (2010). Tomato leaf miner- *Tuta absoluta* Pest Fact Sheet. Retrieved September 19, 2015, from http://www.inspection.gc.ca/english/plaveg/pestrava/tutabs/tech/tutabse.shtml.

Chidege,M,, Al-zaidi, S., Hassan, N., Abisgold J., Elialilia K. & Mrogoro, S. (2016) First record of tomato leaf miner *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) in Tanzania (2016). *Agriculture & Food Security* 17, 5-17

CSO. (2008). CSO/MACO/FSRP *Supplemental Surveys 2008*. Central Statistics Office, Lusaka, Zambia.

Desneux, N.,Wajnberg E., Wyckhuys, K. A.G., Burgio, G., Arpaia, S. Narváez-Vasquez, C.A., González-Cabrera J., Catalán Ruescas, D., Tabone, E., Frandon, J. Pizzol, J. Poncet, C. Cabello, T.& Urbaneja.A. (2010). Biological invasión of European tomato crops by Tuta absoluta: ecology, geographic expansion and prospects for biological control. *Journal of Pest Science,* 83, 197-215.

Desneux, N.,Luna M.G., T. Guillemaud, & Urbaneja. (2011). The invasive South American tomato pinworm, *Tuta absoluta*, continues to spread

Mnzava, N.A. & Msikita, W.W. (1986). Performance of Tomato Varieties under Irrigation in Zambia. *Acta Hortic.* 190, 571-580.

Muniappan R. (2013). *Tuta absoluta*: The Tomato Leaf miner. Integrated Pest Management (IPM IL) - Virginia Tech University. Paper presented at the *Tuta absoluta* Workshop, International Association for the

NAPPO. (2013). Surveillance Protocol for the Tomato Leaf Miner, *Tuta*

in Afro-Eurasia and beyond: the new threat to tomato world production. *Journal of Pest Science,* 84 (4), 403-408.

FAO (1997) ISPM 6. (1997). Guidelines for surveillance. Rome, IPPC, FAO.

IPPC. (2014a). New pest in Kenya: Preliminary surveillance report on *Tuta absoluta* - preliminary report by Kenya. IPPC Official Pest Report, No. KEN-01/2. Rome, Italy: FAO. Retrieved July 5, 2015 from https://www.ippc.int

IPPC. (2014b). *Tuta absoluta*. IPPC Official Pest Report, No. CRI-06/1. Rome, Italy: FAO. Retrieved July 5, 2015 from https://www.ippc.int/

Kilin,T. (2010). First record of *Tuta absoluta* in Turkey. *Phytoparasitica* 38, 243–244.

Mingochi, D.S. & Jensen, A. (1986). Pests and Diseases in Tomato Cultivars in Zambia, their Seasonal Occurrence and Possible Control. *Acta Hortic.,* 190, 131-138.

Mohamed, E. S. I., Mahmoud, M. E. E., Elhaj, M. A. M., Mohamed, S. A., & Ekesi, S. (2015). Host plants record for tomato leaf miner *Tuta absoluta* (Meyrick) in Sudan. *EPPO Bulletin, 45(1)*, 108-111.

absoluta, for NAPPO Member Countries. Retrieved from May 7, 2015.

https://www.aphis.usda.gov/import_export/plants/plant_exports/downloads/Tuta_absoluta_surveillanceprotocol_08-06-2012-e.pdf

Pereyra, P. C., & Sanchez, N. E. (2006). Effect of two solanaceous plants on developmental and population parameters of the tomato leaf miner (*Tuta absoluta* Meyrick)

(Lepidoptera: Gelechiidae). *Neotropical Entomology,* 35, 671 – 676.

Pfeiffer D. G., R. Muniappan, Dienaba Sall, Paterne Diatta, A. Diongue & E. O. Dieng. (2013).First Record of *Tuta absoluta* (Lepidoptera: Gelechiidae) in Senegal. *Florida Entomologist,* 96(2), 661-662.

Potting, R. (2009). Pest risk analysis, *Tuta absoluta*, tomato leaf miner moth. Plant protection service of the Netherlands, 24 pp. Retrieved October 7, 2015 from www.minlnv.nl.

Siqueira, H. A. A., Guedes, R. N. C., Fragoso, D. D. B., & Magalhaes, L. C. (2001). Abamectin resistance and synergism in Brazilian populations of Tuta absoluta (Meyrick) (Lepidoptera: Gelechiidae). *International Journal of Pest Management,* 47(4), 247-251.

Tembo, S., & Sitko.N. (2013). *Technical compendium: Descriptive agricultural statistics and analysis for Zambia*.Retrieved August 8, 2015 from http://www.saipar.org:8080/eprc/handle/123456789/196

USDA–APHIS. (2011). New Pest Response Guidelines: Tomato Leaf miner (*Tuta absoluta*). United States Department of Agriculture–Animal Plant Health Service, PPQ–EDP Emergency Management, Riverdale, Maryland. Retrieved August 9, 2015 from http://www.aphis.usda.gov/import_export/plants/manuals/emergency/downloads/Tutaabsoluta.Pdf

ZNFU. (2016). Taskforce Tuta absoluta formed. Retrieved June 27 2016 http://www.znfu.org.zm/article/taskforce-tuta-absoluta-formed