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Population dynamics and infestation level of *Tetranychus evansi* Baker and Pritchard, 1960 (Acari: Tetranychidae) over two tomato planting seasons in Burkina Faso

E. Drabo [1,2]*, F. Traoré [2], A. Waongo [2], L. C. Dabiré-Binso [2] and A. Sanon [1]

[1]Laboratoire d'Entomologie Fondamentale et Appliquée, UFR/SVT, Université Joseph KI-ZERBO, Burkina Faso.
[2]Laboratoire Central d'Entomologie Agricole de Kamboinsé, Institut de l'Environnement et de Recherches Agricoles (INERA), 01 BP 476 Ouagadougou 01, Burkina Faso.

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***Tetranychus evansi* is an invasive pest of Solanaceae in West Africa. It causes severe damage and economic losses in tomato production. This study, conducted in four sites (Loumbila, Ouagadougou, Pabré and Tanghin-Dassouri) in the central zone of Burkina Faso, assessed the density of *T. evansi* over two growing seasons and evaluated the infestation levels through the tomato growth cycle from planting up to harvest. Mite's population was assessed weekly from March to May durinrg the dry season and from August to October for the rainy season in Burkina Faso. We found a high density of *T. evansi* during the hot and dry periods, corresponding to increase temperatures. The Loumbila, Pabré, and Tanghin-Dassouri sites show a similar density of the mite's population and generally have an average of fewer than 20 individuals per leaf compared to the site in Ouagadougou with a density of more than 80 individuals per leaf. In contrast, during the rainy season, which is characterized by high humidity, densities of *T. evansi* were as low as 10 individuals per leaf. We also found that, when climatic and environmental conditions are favorable, all growth stages of the tomato are attacked by the pest.**

Key words: *Tetranychus evansi*, dynamics, density, tomato, seasons.

INTRODUCTION

Tomato cultivation is an important source of employment and income for many producers in urban and peri-urban areas in Sub-Saharan Africa (MAH, 2018). This sector is becoming increasingly important from a socio-economic point of view due to the number of actors who benefit directly or indirectly (Son, 2018). Unfortunately, in Burkina Faso, as in most tropical countries in Africa, this crop is increasingly under threat from infestations by the red spider mite *Tetranychus evansi* (Baker and Pritchard, 1960) (Acari: Tetranychidae) (Drabo et al., 2020; Azandémè-Hounmalon, 2015). Due to their small size, spider mites like *T. evansi* go unnoticed until their presence is revealed by plant damage (Migeon et al., 2009). Attacks result in very significant yield losses,

*Corresponding author. E-mail: draboedouard@gmail.com.

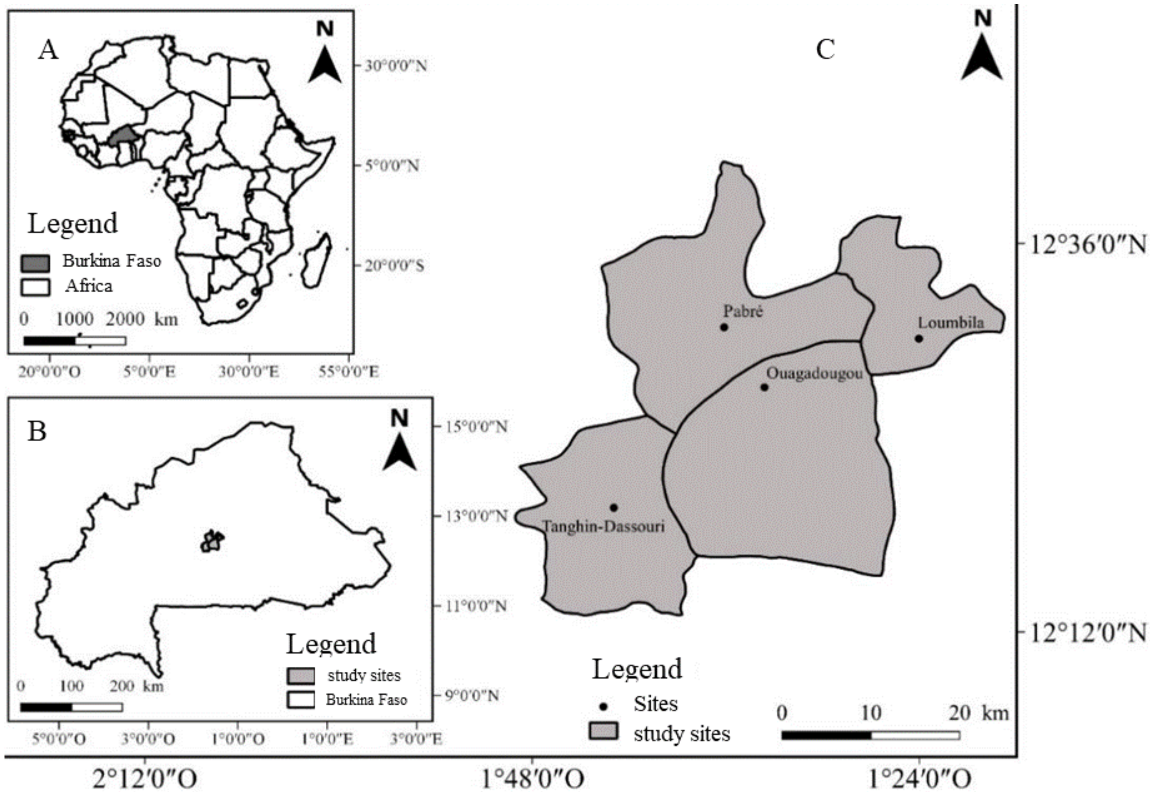

Figure 1. Map showing the location of study sites. Location of Burkina Faso in Africa (A), Sampling location (B) and a zoomed in showing Loumbila, Ouagadougou, Pabré and Tanghin-Dassouri (C).
Source: Drabo (2020)

during hot and dry periods (Santamaria et al., 2017). In Benin, the damages caused by *T. evansi* increase each year and are particularly significant in the dry season (Azandémè-Hounmalon et al., 2014) leading to heavy infestations characterized by the presence of webs, drying and fallen leaves that cause losses and sometimes complete destruction of crops in less than a week if no phytosanitary precautions are taken (Azandémè-Hounmalon, 2015). The initial infestation by *T. evansi* is characterized by a few whitish spots, which is difficult for growers to detect (Ferrero, 2009). As a result, by the time the infestations are noticed by the producers, it is already late for the implementation of plant protection measures. Control and management of *T. evansi* on tomato crops is also very daunting due to its resistance to synthetic pesticides and its ability to rapidly build its population in a short period of time (Toroitich et al., 2014). Earlier on it has been shown that temperature (Bonato, 1999), precipitation (Azandémè-Hounmalon, 2015), and relative humidity (Ferrero, 2009) have a direct influence on the population dynamics of *T. evansi*. For effective and sustainable management of pests such as *T. evansi*, it is therefore imperative to understand the abiotic factors limiting or promoting its development on crops in field conditions.

The aim of this work was to study the population dynamics of *T. evansi* as a function of season and the cycle of the tomato plant (variety Petomech) with the following questions in mind: i) does the population size of *T. evansi* vary with seasons on tomato? ii) How does the plant cycle affect the density of *T. evansi*? iii) At what threshold of infestation should a control intervention for *T. evansi* be implemented in Burkina Faso? We discussed our findings in the light of subsistence farming and the sustainable management of the pest.

MATERIALS AND METHODS

Study sites and producers

The study was conducted in four sites (Loumbila, Ouagadougou, Pabré and Tanghin-Dassouri) in the central zone of Burkina Faso (Figure 1). The choice of site was based on the presence of a water reservoir and an effective and permanent production of tomatoes. One experienced producer was identified per site with the help of the Agricultural extension officers. In each of the sites, a field of tomatoes of the variety Petomech was monitored from transplanting to harvest. The choice of the variety was based on the firmness of the fruit, its yield and acceptance by producers and consumers. Climatic (temperature, rainfall and humidity) data were provided by the meteorological service of the center.

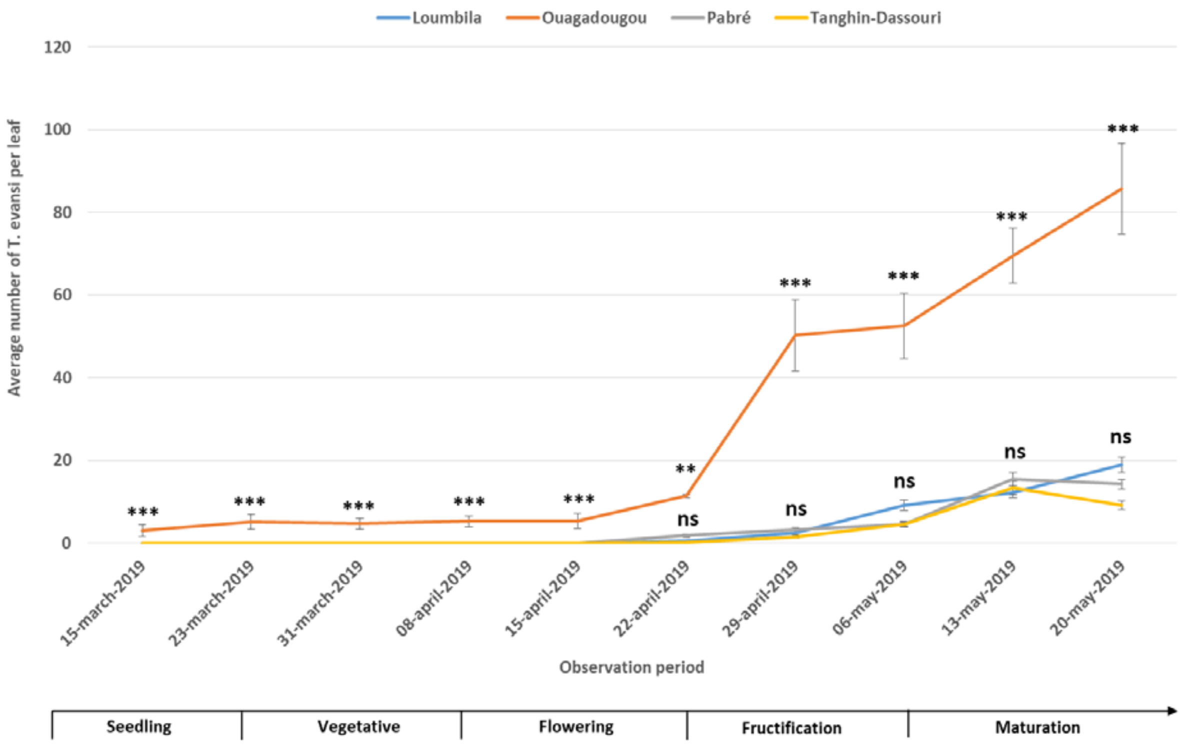

Figure 2. Dynamics of *T. evansi* density in the dry season according to the observation sites (***:p < 0.001, **:p < 0.01, *:p < 0.05, ns : not significant)
Source: Author

Preparation and maintenance of plants

The preparation as well as the maintenance of the seedlings was carried out using standard agronomic practices in all the sites by the producers. Thus, the nurseries were set up in the second week of February and the third week of July for the dry and rainy seasons respectively. Transplanting of healthy seedlings took place in March 2019 for the dry season and August 2019 for the rainy season. Spraying started one week after transplanting the tomato plants and was carried out once a week. During the dry season, plants were irrigated every two days with a motor pump until the fruit ripened. In the rainy season, water was provided during pockets of drought.

Assessing the density of *T. evansi* on plants

The design of the *T. evansi* density assessment was inspired by that reported by Sseruwagi et al. (2004). Briefly, 30 plants were selected and fixed along the two diagonal transects (with 15 plants per transect) in each field of about 1000 m^2. Each transect was 54 m long and the 30 plants to be observed were 3 m from each other. Observations were made on the same plants throughout the study. At each site, observations began one week after transplanting when the plants had at least five leaves. Observations were made every week throughout the season following the method described by Benziane et al. (2003). Briefly, 5 leaves were inspected per plant, at different heights (from top to bottom) to assess the presence of *T. evansi*. Mites were not removed from the plants when counting. The number of mobile forms per leaf was counted with a magnifying glass. The presence of infested leaves is noted. A leaf is considered infested if at least two motile forms of *T. evansi* are detected.

Statistical analysis

For all tests performed, we successively checked the normality and homogeneity of the variances of the *T. evansi* density data in order to orient to the appropriate test according to the data analysis plan proposed by Hervé (2016).

Thus, a permutation ANOVA (non-parametric) followed by a pairwise comparison of means using the pairwise perm. t.test function was used to compare mite density by date of observation in the four departments for each of the dry and rainy seasons. The Kruskal-Wallis test (nonparametric) was performed to compare the variation in total *T. evansi* density between data collection sites by season, followed by Dunn's test for pairwise comparisons of medians. The Fligner-Policello test (non-parametric) was used to compare *T. evansi* density between dry and wet seasons for each of the four departments. The tests were performed with R 3.6.3 (2020) using the packages: RVAideMemoire (Hervé, 2020), FSA (Ogle et al., 2020).

RESULTS

Dynamics of *T. evansi* density in the dry and rainy season

For all observation dates, the mean density of *T. evansi* in the Ouagadougou site was higher than in the other sites (Figure 2). It can be seen that the *T. evansi* population increased differently with an early level of infestation from the first observation period in March

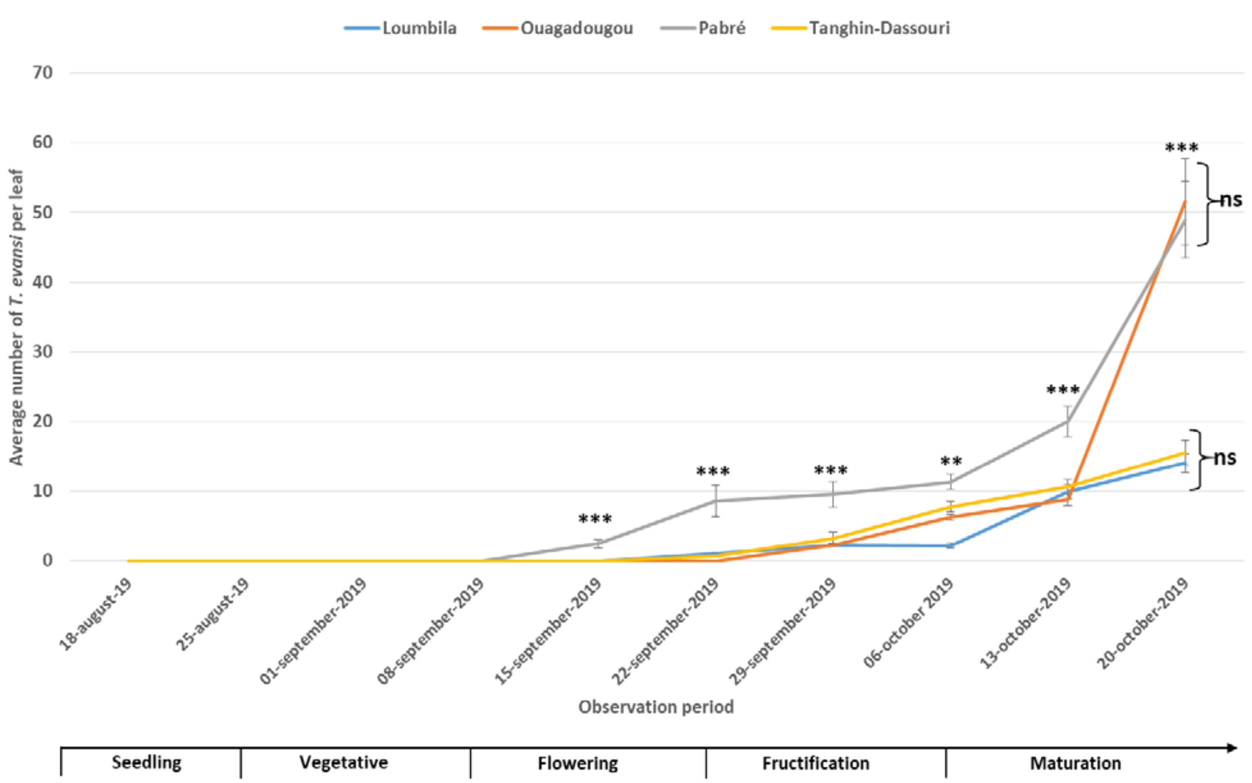

Figure 3. Dynamics of *T. evansi* density in the rainy season according to the observation sites.
Source: Author

month at Ouagadougou compared to other sites that recorded no *T. evansi* until the 5th observation period in April month. Thus, the Loumbila, Pabré, and Tanghin-Dassouri sites show a similar dynamic of mites and generally have an average of less than 20 individuals per leaf at the end of the season compared to the Ouagadougou site, which reaches more than 80 individuals per leaf at the end of observations.

The first infestations in the rainy season were observed on the 5th observation time in September month at Pabré and only by the 6th observation time in September month at the other sites (Figure 3). From the latter date, the average number of spider mite individuals changes increasingly between the Pabré site and the other sites that remained similar until the 9th observation time in October month. The Ouagadougou population also grew to the size of the Pabré population by the end of the season.

T. evansi density values by site and season

We found significant difference in *T. evansi* density values between sites (Figure 4) over the two study seasons. Thus, the Ouagadougou and Pabré sites had the most abundant individuals in the dry ($\chi2$ = 116.21, df = 3, p-value < 0,001) and wet ($\chi2$= 19.365, df = 3, p-value < 0.001) seasons, respectively (Figure 4). In contrast, when comparing seasons by site, only the Ouagadougou site showed significant density (U* = 6.6987, p-value = 0,001) in the dry season (Figure 5).

Rate of leaf infestation by the mobile forms of *T. evansi*

Leaf infestation by *T. evansi* began towards the end of flowering at most sites in both seasons (Table 1). However, at Ouagadougou, a leaf infestation rate of 13.33% was noted from the first observations (seedling stage) in the dry season. Leaf infestation rate by the mobile form of *T. evansi* increased across all study sites from the fruiting stage onwards, almost all sites showed high rates of leaf infestation (Table 1).

Density of *T. evansi* according to the cycle of the plant

The dry season as a whole shows a greater of the mites with infestations of plants that started as early as the seedling stage (Figure 5). During the rainy season, infestations started at the end of the vegetative stage and increased from the flowering stage towards maturity. The

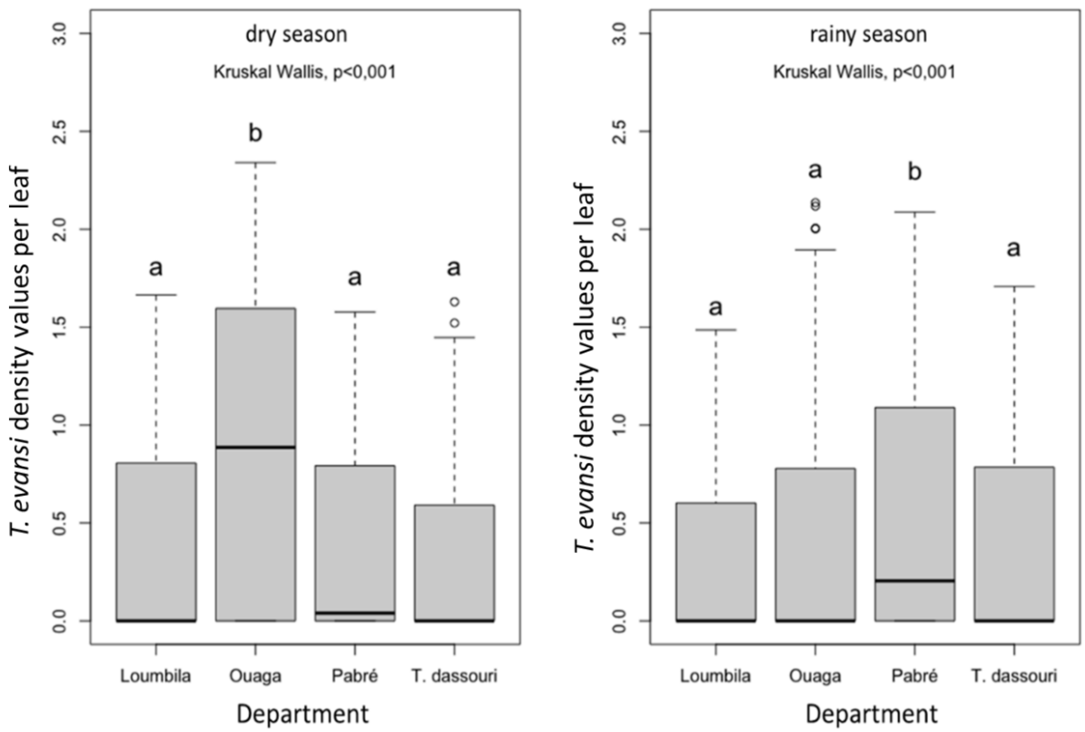

Figure 4. *T. evansi* density values per leaf as a function of seasons and sites from (Loumbila, Ouagadougou, Pabré and Tanghin-Dassouri).
Source: Author

Table 1. Leaf infestation rates of mobile forms of *T. evansi* on dry and rainy seasons' tomato crops.

Seasons	locations	Percentage of leaf infestation according to plant cycle									
		Seedling		Vegetative		Flowering		Fructification		Maturation	
Dry season (15 March-20 May)	Loumbila	0.00	0.00	0.00	0.00	0.00	3.33	33.33	93.33	96.67	100.00
	Ouagadougou	13.33	16.67	33.33	40.00	50.00	50.00	93.33	100.00	100.00	100.00
	Pabré	0.00	0.00	0.00	0.00	0.00	30.00	53.33	80.00	100.00	100.00
	Tanghin-Dassouri	0.00	0.00	0.00	0.00	0.00	0.00	33,33	70.00	100.00	93.33
Rainy season (18 August-28 October)	Loumbila	0.00	0.00	0.00	0.00	0.00	16.67	60.00	53.33	100.00	96.67
	Ouagadougou	0.00	0.00	0.00	0.00	0.00	0.00	60.00	100.00	100.00	100.00
	Pabré	0.00	0.00	0.00	0.00	36.67	63.33	60.00	83.33	100.00	100.00
	Tanghin-Dassouri	0.00	0.00	0.00	0.00	0.00	20.00	60.00	96.67	96.67	96.67

Source: Author

observations between flowering and fruiting show *T. evansi* is more abundant in the dry season than in the rainy season, but at the end, it was similar (Figure 6).

DISCUSSION

Monitoring the population dynamics of *T. evansi* over two seasons of the year has shown that it is a serious tomato pesto with a high potential for invasion in Burkina Faso. Indeed, our results show that densities are higher during the dry season in Ouagadougou site. Similarly, during the rainy season, following the early cessation of rains from mid-September, the density of *T. evansi* increased in the month of October, which would probably be due to the decrease in humidity and rainfall. Earlier on, Ferrero (2009) shows that high relative humidity decreases the activity and development of spider mites while its development is favored by low humidity. According to Azandémè-Hounmalon (2015), rainfall plays a key role in

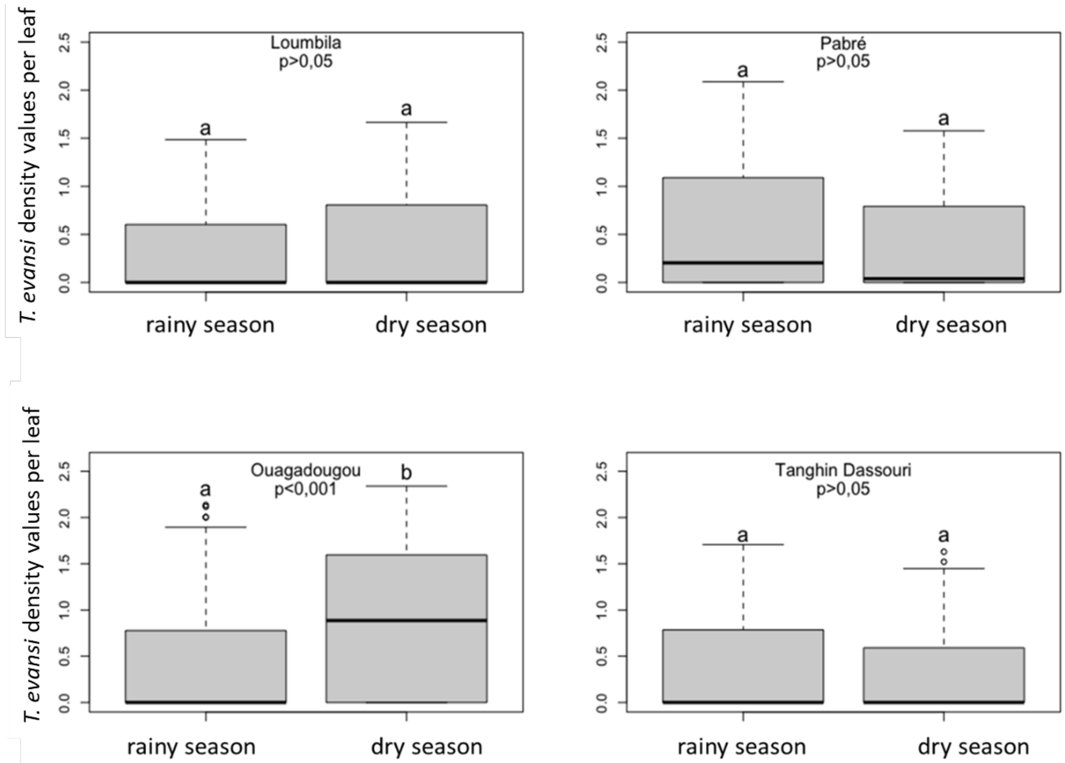

Figure 5. *T. evansi* density values in dry and rainy seasons from Loumbila, Ouagadougou, Pabré and Tanghin-Dassouri.
Source: Author

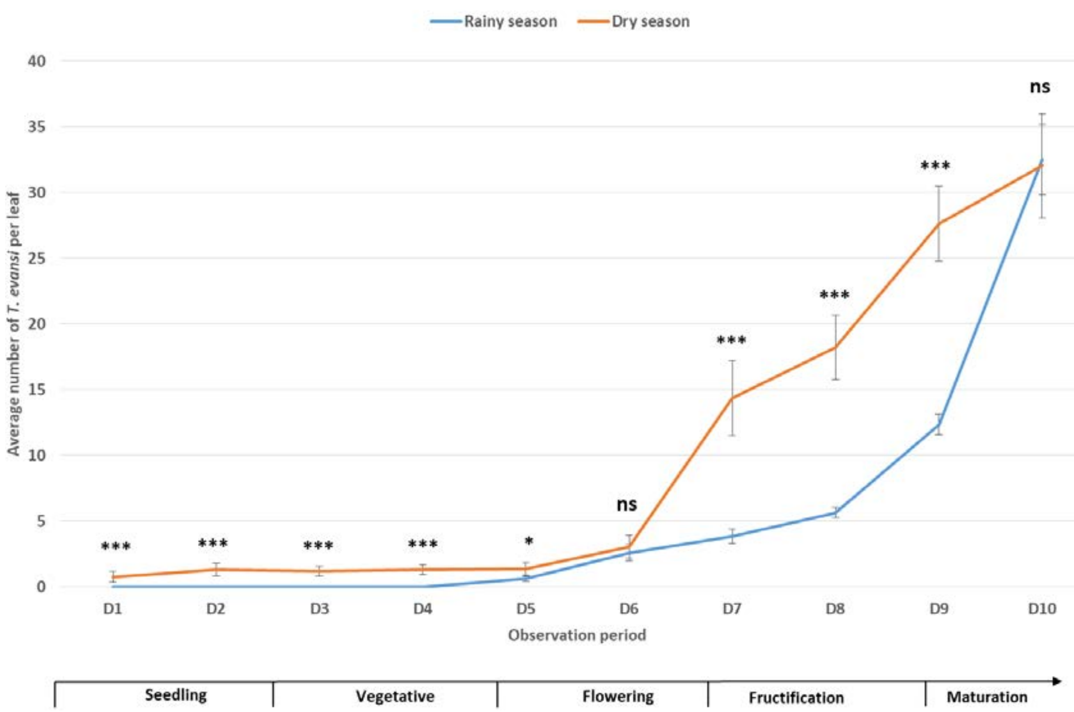

Figure 6. Seasonal dynamics of average populations of *T. evansi* according to the plant cycle (D : observation day).
Source: Author

reducing mite populations through natural leaching of leaves by water droplets falling on the leaves. In addition, high relative humidity inhibits spider mite activity (Ferrero, 2009) as observed in this study during the rainy season, when the density of *T. evansi* remained very low during the months of August to September, with heavy rainfall. The tomato crop would be naturally protected against red mites during the rainy season by spraying water droplets on the leaves, which contribute to the elimination of a significant number of mites. Apart from this protection, without any precautionary measures, tomatoes are prone to mite attacks throughout their developmental stage. Indeed, all stages of tomato were attacked by *T. evansi*. This is confirmed by the average density of mites per cycle we recorded on the plants. The red spider mite, which lives in the crops, will remain there until the planting of a new crop that will be rapidly colonized (Kimba et al., 2017). This case of early infestation was found at Ouagadougou, where the field was close to refuge crops/alternative hosts invaded by *T. evansi*. The old plants that are kept at the end of cultivation are a potential reservoir of red spiders and represent a real breeding ground for this pest. In order to avoid this, tomato producers should embrace the importance of post-harvest sanitation of infested fields to reduce the population of red spiders and limit the possibility of early infestation. However, these methods of crop control have been neglected among tomato growers in the study area, resulting in an increase in the density of red spider mites. Regardless of the season, we found an increase in the population of *T. evansi* from flowering in all sites. The increase in population of *T. evansi* at this stage of plant development until the end of the season could be the effect of the large size of the plant. Indeed, flowering plants and older plants are bigger and have more resources available for these leaf-eating mites. It may also be an effect related to the nutritional composition or defense capabilities of the plants during the flowering period (Blaazer et al., 2018). These results could indicate the actual measures to be taken in order to correctly synchronize spraying dates to ensure that the tomato is well protected. The average density of *T. evansi* per site shows a very significant difference. This could be because the technique for controlling red mites in tomato fields varied among growers who had different knowledge and resources to control this pest.

Similar studies in Tanzania show that lack of farmer training in pesticide handling and use in tomato production is a serious challenge (Musebe et al., 2014) as the production involves spraying with insecticides. Despite the frequency of spraying per week, insecticides remained ineffective against the red spider mite due to development of resistance. Similar observations were reported by Toroitich et al. (2014). Indeed, the use of broad-spectrum insecticides kills the natural enemies of red mites, thus keeping the pest unchecked as its population grows. Producers face many challenges in spraying required and the resources involved. They also did not use any acaricide and the spraying technique they often employ does consider the lower part of the leaves rendering it inefficient. A similar challenge was also reported amongst smallholder farmers in Zimbabwe. Sibanda et al. (2000) observed that smallholders in Zimbabwe have neither appropriate chemicals nor adequate techniques to effectively control red spider mites that feed on the underside of leaves. The timing of mite control is also beyond the control of farmers. Because of the tiny size of these parasites, their presence is difficult to notice at the beginning of an infestation. High densities characterized by the presence of webs are easily detected by growers (Ferrero, 2009).Spraying at this stage is not likely to significantly reduce the level of damage.

Conclusion

Tetranychus evansi is an invasive pest in the cultivation of tropical tomatoes. The study showed the importance of foliar infestation caused by red mite outbreaks on tomatoes. Without precautionary measures, infestations can lead to the total loss of production. Our results showed that *T. evansi* populations develop best in the dry season. If the climatic and environmental conditions are favorable, *T. evansi* starts its infestation from the nursery and actively feeds by increasing its population until the end of the harvest. It multiplies quickly, which makes it particularly difficult to control. From flowering onwards at all sites, there is an increase in the population of *T. evansi* until the end of the season.

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CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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