Scientific Research Publishing

Advances in Entomology, 2023, 11, 143-155
https://www.scirp.org/journal/ae
ISSN Online: 2331-2017
ISSN Print: 2331-1991

# Diversity, Host Plant Range and Distribution of *Thrips* spp. (Thysanoptera: Thripidae) in Three Vegetable Production Basins in Burkina Faso

**Madi Nacanabo[1], Issaka Zida[2], Wendnéyidé Mathieu Sawadogo[3], Maxime Ouattara[3], Rémi Dabiré[2], Babo Boniface Bakouan[1], Souleymane Nacro[4*]**

[1]Centre Agricole Polyvalent de Matourkou, Bobo-Dioulasso, Burkina Faso
[2]Direction Régionale de Recherches Environnementales et Agricoles de l'Ouest, Bobo-Dioulasso, Burkina Faso
[3]Institut du Développement Rural, Université Nazi Boni, Bobo-Dioulasso, Burkina Faso
[4]Centre Régional de Recherches Environnementales, Agricoles et de Formation de Kamboinsé, Ouagadougou, Burkina Faso
Email: *snacro2006@yahoo.fr

**How to cite this paper:** Nacanabo, M., Zida, I., Sawadogo, W.M., Ouattara, M., Dabiré, R., Bakouan, B.B. and Nacro, S. (2023) Diversity, Host Plant Range and Distribution of *Thrips* spp. (Thysanoptera: Thripidae) in Three Vegetable Production Basins in Burkina Faso. *Advances in Entomology*, **11**, 143-155.
https://doi.org/10.4236/ae.2023.113011

**Received:** April 15, 2023
**Accepted:** July 22, 2023
**Published:** July 25, 2023



## Abstract

Onion is the most important vegetable produced in Burkina Faso. It contributes to food and nutrition security and is a source of income for farmers. Thrips, which feed on the leaves of the plant, are the main insect pest of onion. The objective of this study was to access the diversity, the host range and the distribution of *Thrips* spp. in three main onion production areas in Burkina Faso. Three sites were chosen in each vegetable production basin, and plant species present were sampled and inspected to determine their thrips' infestation status. Seventeen cultivated or wild plant species were attacked by thrips. The incidence of attacks was highest on zucchini plants followed by cucumber, eggplant, and onion, respectively. Six thrips species were recorded of which *Thrips tabaci* (Lindemman) represented more than 70% of the total. The average density of *Thrips* spp. per plant varied significantly between production basins and plant species. The highest average number of *Thrips* spp. per plant was recorded on zucchini (40.28 ± 10.28; 17.43 ± 13.48 and 14.33 ± 7.11 respectively in the North, Hauts Bassins, and Central Plateau). This study provided basic information that can lead to further research and the development of control methods.

## Keywords

Onion, Thrips, Diversity, Host Plants, Burkina Faso

## 1. Introduction

In Burkina Faso, agriculture is one of the pillars of economic and social development. It is the main source of income for rural populations and the pillar of food security [1]. According to [2], vegetable production is the main occupation of rural populations during the long dry season that the country experiences. In 2010, it was practiced on over 4800 sites [2] and on over 55,342 ha in 2018 [3]. Onion (*Allium cepa*) is the leading vegetable crop in Burkina Faso [4] both in terms of area cultivated and quantities produced. According to [3], the national production of bulb onions in 2018 was 362,480 tons, or just over 38% of total crop production. According to [5], onion production in Burkina Faso reaches at least 30% of total vegetable production. According to [6], onion production in Burkina Faso represents 34.2% of total crop production. The same source indicates that national bulb onion production was 362,480 tons or just over 38% of total vegetable production. However, onion production faces several constraints, including insect pests' pressure. This pressure is mainly reflected in the decrease in yields, the loss of product quality, and the threat to human and animal health and the environment due to the large quantities of pesticides used each year to protect this vegetable. *Thrips* spp. are the most important insect pest associated with onion [7] [8]. This insect pest can cause significant damage to onion, garlic, and cabbage crops. Damage is caused by both larvae and adults. Thrips use the rough parts of their mouths to scrape the surface of the leaves and suck the juice exuded by the plant. Persistent attacks lead to leaf deformation, followed by wilting, browning, and premature lodging. In severe attacks, high infestation rates of thrips can lead to a reduction in bulb weight of up to 60% [9] [10] [11] [12] [13]. In New York State, a 30% - 50% reduction in bulb yield (smaller bulbs) can occur due to severe thrips damage [14]. Thrips' attacks weaken the plant and predispose it to bacterial rot and fungal diseases. In addition to feeding directly on plants, onion thrips are also vectors of several onion diseases [15]. Indeed, viruses, such as Tomato Spotted Wilt Virus (TSWV), Impatiens Necrotic Spot Virus (INSV), and Iris Yellow Spot Virus (IYSV), are transmitted by *Thrips tabaci* to the onion plant [16]. In addition, the food intake of *T. tabaci* provides entry points for bacterial infection [17] [18] [19] [20]. Studies have evidenced the polyphagous nature of *T. tabaci* [16] [21] [22]. In Burkina Faso, very little data is available regarding the species diversity and the host plant range of this economically important insect pest. This study aims at: 1) inventorying the host plants for *Thrips* spp. in three vegetable production basins in Burkina Faso and 2) accessing the diversity, the incidence of attacks and the degree of infestation of the onion by *Thrips* spp.

## 2. Material and Methods

### 2.1. Study Areas

The study was conducted in three vegetable production basins located in four administrative regions, namely the North, the Central Plateau, the Centre-North,

and the Hauts-Bassins of Burkina Faso (Figure 1). Two criteria guided the choice of these study areas: 1) to cover the three agro-ecological zones of the country and 2) the main onion production areas. The northern production basin is located between the 500 mm and 700 mm isohyets in the Yatenga province. The Central Plateau production basin is located between isohyets 700 mm and 900 mm. It straddles two provinces, Oubritenga and Sanmatenga, which fall under two different administrative regions. As for the Hauts-Bassins production basin, it is located between the 900 mm and 1100 mm isohyets. In 2017, the average annual temperatures were 27.95˚C in Bobo-Dioulasso, 29.1˚C in Ouagadougou and 29.65˚C in Ouahigouya, as compared to 28.2˚C; 28.95˚C and 28.7˚C, respectively, for 2018 [23]. The average annual relative humidity was in the same order of 52.5%; 48.5% and 40.5% for 2017 then 55%; 48.5% and 41.5% in 2018.

## 2.2. Study Sites

In each of the three production basins, three village sites were selected based on their potential for onion production, but also according to the diversity of other crops found there. In each site village, three plots per crop were selected for data

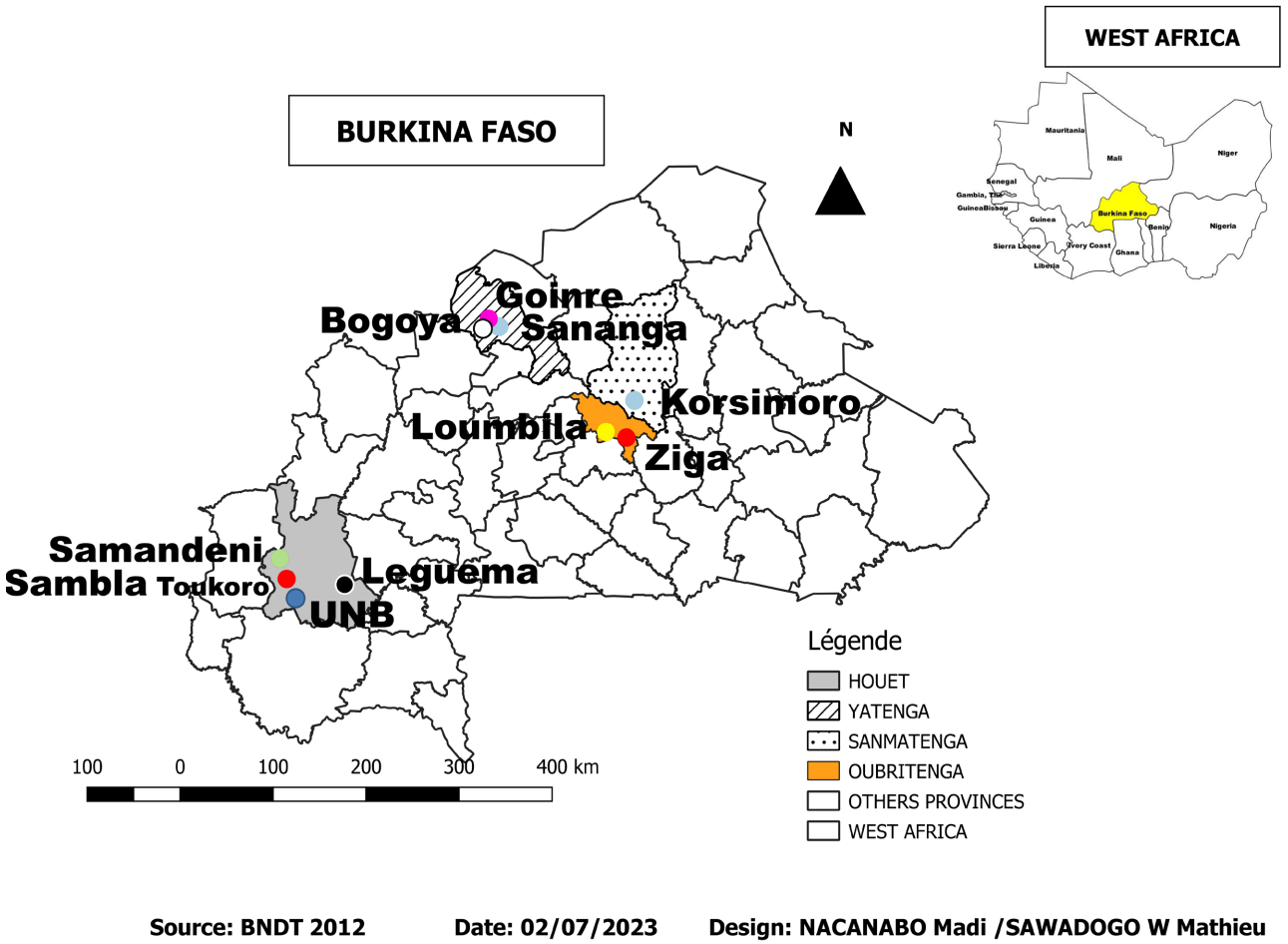


Figure 1. Location of ponds and vegetable production sites where plants associated with *Thrips* spp. were inventoried, Burkina Faso.

collection. A total of 222 plots were identified for this study. The plant material encountered on these plots consisted mainly of cultivated plant species such as onion, cabbage, okra, purple eggplant, potato, zucchini, cucumber, watermelon, green bean, maize, tomato, and amaranth. Weeds present in or around the cultivated plots were also surveyed to identify thrips. These were *Gynandropsis gynandra* L., *Boerhavia diffusa* L., *Heliotropium indicum* L., *Cassia occidentalis* L., and *Trianthema portulacastrum* L.

## 2.3. Inventory of Host Plants and Estimation of Thrips' Abundance

### 2.3.1. Identification of Host Plants

The exercise consisted in observing and searching for the different crops encountered on the selected plots to ensure that they might host thrips. This allowed us to observe thrips waste, to physically see some thrips as well as the damage associated with them. On crops where observation and digging did not ensure the actual presence of thrips (often due to low infestation levels), shaking the plants over a blank leaf was sometimes used [24]. In general, this technique allowed thrips to be observed moving over the white paper sheet.

### 2.3.2. Counting of Thrips on Crops

Once the presence of thrips was proven in a plot, it proceeded to the evaluation of the populations of these pests. For this purpose, plant sampling was carried out for each crop in all the selected plots in order to proceed to a thorough collection and counting of insects.

On each plot, three quadrats of 1 $m^2$ each were delimited along one of the diagonals using a string. From each quadrat, four or five plants per plant species were randomly sampled depending on the planting density. Onion plants and herbaceous species were sampled at a rate of five plants per $m^2$ and other crops were sampled at a rate of four plants per $m^2$. For each quadrat, the plants collected were individually packaged in plastic bags. Some very large volume species such as Cucurbitaceae or okra plants were not conditioned but were shaken directly in the field over a blank sheet of pad paper [24]. This allowed the thrips to be pulled out and then collected and counted. Each thrips that felt on the white paper was counted individually. The conditioned plants of the same quadrat were put together in an envelope designed for this purpose. All the envelopes from the same plot were in turn placed in a large plastic bag and transported to the regional office of the plant clinic where they were counted. The different bags and envelopes were labelled so that the site, plot, quadrat, and plant collected could be identified. At the time of counting, each plant was shaken over a white sheet, followed by counting of thrips that fell on it and their collection in pillboxes. The collection of thrips consisted of collecting about 40 thrips from each plot, storing them in a pillbox containing 70% alcohol, and identifying them later in the laboratory. Each pillbox was labelled to allow identification of the sites and plots from which thrips were collected. Also, the vari-

ous crevices of the plant were examined with a magnifying glass to detect and account for possible hidden thrips larvae and adults. For each plant, the number of thrips (adults and larvae) was recorded. A data collection form designed for this purpose was used to record information related to the date and place of collection, the crop, the variety, the plot number, the number of the sampled plant, the number of thrips (adults and larvae) on the plant and especially the surrounding crops.

#### 2.3.3. Identification of Thrips Collected on Each Crop

The collected thrips were morphologically identified in the laboratory. They were identified with a binocular magnifying glass according to their morphological characteristics using the identification key developed by [25]. On an identification card, information such as the names of the site and the specimen, the species and number of adult thrips, the number of larvae, as well as the plot number were recorded. When the number of *T. tabaci* individuals for a given plot was known, their proportion to the total population was determined. This proportion was applied to the total population counted from each plant and plot to determine the number of *T. tabaci* individuals on the plot.

#### 2.3.4. Data Processing and Analysis

The number of thrips-infested plants of each cultivated or wild plant species was recorded per site and per production basin. For each infested plant, the number of thrips individuals was counted. The parameters measured were the incidence of attacks and the degree of infestation. The incidence of attack is considered as the number of thrips-infested plants out of the total number of infested plants per plant species. The degree of infestation refers to the average number of thrips individuals per foot of the plant species considered. Statistical analyses were performed with [26]. The homogeneity of variances was verified with Bartlett's test. The comparison of the degrees of infestation according to the sites of the collection was carried out with the pairwise test. The non-parametric Kruskal Wallis test was used to check the effect of factors (production basins, sites, and host plants) on the variables "incidence of attacks" and "degree of infestation" of *T. tabaci*.

## 3. Results and Discussion

### 3.1. Results

#### 3.1.1. Thrips' Diversity and Associated Host Plants in the Three Production Basins

Six species were encountered. These were *T. tabaci*, *Frankliniella occidentalis*, *Haplothrips leucanthemi*, *H. gowdeyi*, *H. hawaïensis*, and *Hercinothrips* sp. *Thrips tabaci* appeared to be the dominant species in all three onion production basins, followed by *F. occidentalis*. *Thrips* spp. were associated with 17 cultivated and wild plant species belonging to 12 botanical families. The most represented families were Cucurbitaceae and Solanaceae with three species each. Among the

thrips host plants, 11 are cultivated while 6 are wild grasses found in or around vegetable production plots (Table 1). According to the production basins, 11, 10, and 10 host plants were identified respectively in the Hauts-Bassins, the North, and the Central Plateau (Table 1). Of the 17 host plants, six were non-cultivated herbaceous plants that were mainly in the Hauts-Bassins (3 wild species) and Central Plateau (4 wild species) basins. No wild species were sampled in the Northern Basin for the estimation of *Thrips* spp. tabaci. Six host plants were common in all three production basins: *C. pepo* (zucchini), *C. sativus* (cucumber), *S. melongena* (eggplant), *A. cepa* (onion), *S. lycopersicum* (tomato), and *A. esculentus*.

### 3.1.2. Incidence of Thrips' Infestations

The incidence of thrips attack on host plants is presented in Table 2. The non-parametric Kruskal Wallis test showed a significant difference in the incidence of thrips attack by plant species in the Northern ($\chi^2$ = 49.70, df = 9, p = 1.22e−07), Central Plateau ($\chi^2$ = 43.53 df = 9, p = 1.72e−06), and Hauts-Bassins ($\chi^2$ = 22.13, df = 10, p = 0.01) production basin. Among the plant species regularly collected

Table 1. Host plants of *Thrips* spp., Burkina Faso.

| Species | Production Basins | | |
|---|---|---|---|
| | North | Hauts Bassins | Central Plateau |
| ***Solanum lycopersicum*** | 90.4% ± 17.9% | 96.29% ± 11.40% | 79.63% ± 25.03% |
| ***Solanum melongena*** | 100% | 98.14% ± 6.67% | 97.22% ± 10.59% |
| ***Solanum tuberosum*** | 84.25% ± 20.97% | - | - |
| ***Cucumis sativus*** | 100% | 100% | 100% |
| ***Cucurbita pepo*** | 100% | 100% | 98.14% ± 6.67% |
| ***Citrillus lanatus*** | - | 100% | - |
| ***Cassia occidentalis*** | - | - | 100% |
| ***Phaseolus vulgaris*** | 96.29% ± 15.03% | - | - |
| ***Allium cepa*** | 98.52% ± 7.69% | 93.33% ± 12.40% | 96.29% ± 9.67% |
| ***Abelmoschus esculentus*** | 100% | 96.29% ± 11.40% | 88.89% ± 16.01% |
| ***Zea mays*** | 100% | 100% | - |
| ***Boerhavia diffusa*** | - | 100% | 95.55% ± 8.47% |
| ***Brassica oleracea*** | 96.29% ± 11.40% | - | - |
| ***Amaranthus* sp.** | - | 100% | - |
| ***Gynandropsis gynandra*** | | 100% | |
| ***Heliotropium indicum*** | - | - | 88.89% ± 14.52% |
| ***Trianthema portulacastrum*** | - | - | 73.34% ± 23.09% |

Table 2. Incidence of thrips' attacks according to host plants in the three production basins, Burkina Faso.

| Host Plants | | Production Basins | | |
|---|---|---|---|---|
| Scientific Name | Common Name | Hauts Bassins | North | Central Plateau |
| ***Solanum lycopersicum* L.** | Tomato | + | + | + |
| ***Solanum melongena* L.** | Aubergine | + | + | + |
| ***Solanum tuberosum* L.** | Sweat Potato | − | + | − |
| ***Cucumis sativus* L.** | Cucumber | + | + | + |
| ***Cucurbitae pepo* L.** | Courgette | + | + | + |
| ***Citrullus lanatus* L.** | Watermelon | + | − | − |
| ***Cassia occidentalis*** | Fake Kinkeliba | − | − | + |
| ***Phaseolus vulgaris* L.** | French Been | − | + | − |
| ***Allium cepa* L.** | Onion | + | + | + |
| ***Abelmoschus esculentus* (L.) Moench** | Okra | + | + | + |
| ***Zea mays* L.** | Maize | + | + | − |
| ***Boerhavia diffusa* L.** | Pig Grass | + | − | + |
| ***Brassica oleracea* L.** | Cauliflower | − | + | − |
| ***Amaranthus* sp.** | Amarante | + | − | − |
| ***Gynandropsis gynandra* (L.) Briq.** | Cat Mustache | + | − | − |
| ***Heliotropium indicum* L.** | Indian Sunflower | − | − | + |
| ***Trianthema portulacastrum*** | Trianthema Pourprier | − | − | + |

from the three production basins, cucumber plants were the most attacked followed by zucchini, eggplant, onion, okra, and tomato, respectively. The lowest incidence of attack was recorded on plants of the wild herb, *T. portulacastrum* in the Central Plateau production basin (Table 2).

The density of *Thrips* spp. individuals per foot of host plant is presented in Figure 2. The most infested plants were *C. pepo* (zucchini), *C. sativus* (cucumber) and *A. cepa* (onion) in all three production basins. In the Hauts-Bassins and Nord production basins, the highest densities were observed on zucchini (17.43 ± 13.48 and 40.28 ± 10.28, respectively) followed by cucumber (16.30 ± 8.82 and 30.93 ± 10.78, respectively) and onion (11.66 ± 5.67 and 27.82 ± 12.17, respectively). In the Central Plateau production basin, zucchini has the highest degree of infestation (14.33 ± 7.11) followed by onion (13.29 ± 5.36) and cucumber (12.23 ± 5.67) respectively. Among the species regularly encountered in the three basins, *S. lycopersicum* (tomato) has the lowest average number of *Thrips* spp. individuals per plant (Figure 2). *Gynandropsis gynandra* was the non-crop plant that recorded the highest density of *Thrips* spp. per plant (6.31 ± 1.95) in the Hauts-Bassins production basin (Figure 2).

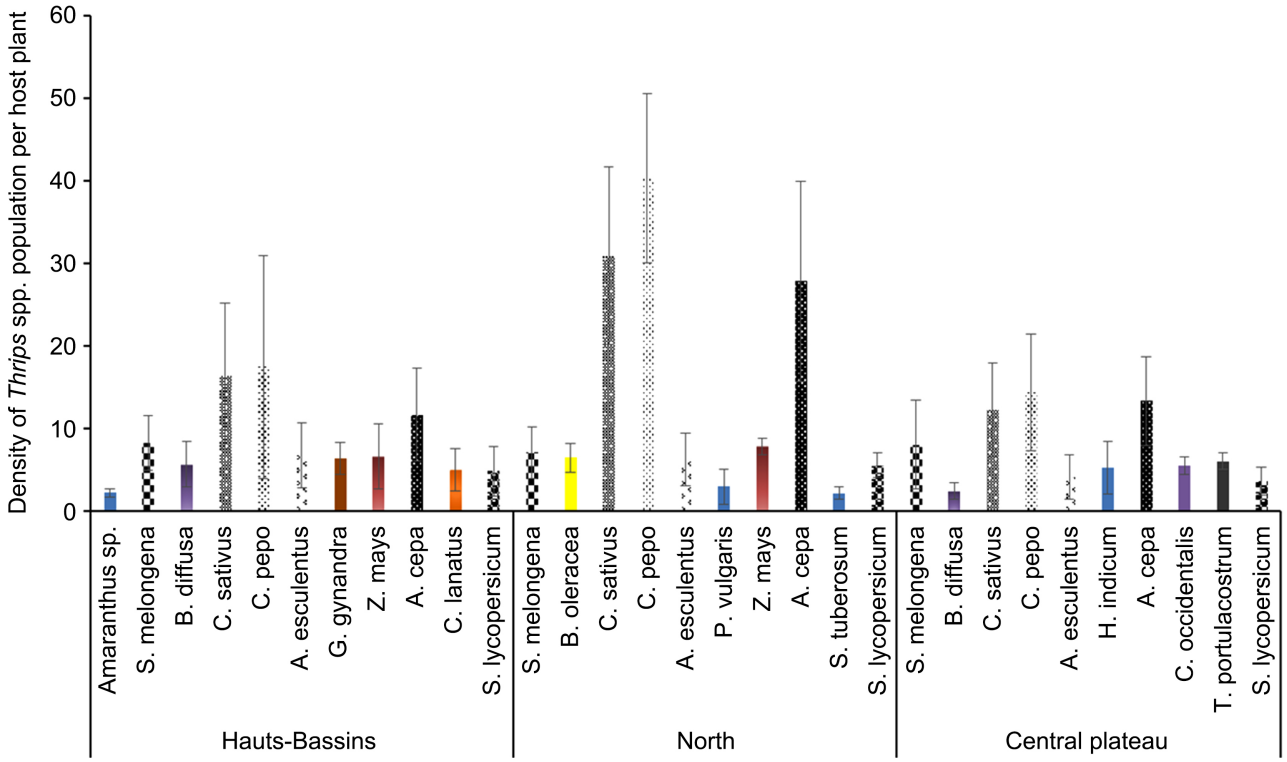


**Figure 2.** Density of *Thrips* spp.' population per host plant, Burkina Faso.

### 3.1.3. Density of *Thrips* spp. per Host Plant by Production Basin and Study Sites

Statistical analyses showed that the density of *Thrips* spp. per host plant varied significantly among production basins ($\chi^2$ = 8.90, df = 2, p = 0.01). The highest number of *Thrips* spp. per plant (14.39 ± 15.12) was recorded in the Northern production basin as compared to the Hauts-Bassins (9.15 ± 7.86 individuals per plant) and the Central Plateau basin (8.00 ± 6.28 individuals/plant).

A significant difference in the density of *Thrips* spp. per plant was also observed between study sites ($\chi^2$ = 17.69, df = 8, p = 0.02). In general, the highest densities were recorded at the study sites in the Northern production basin. Thus, comparison of the density of *Thrips* spp. per plant recorded at each site showed a highly significant difference between the sites of Bogoya and Goinré (Northern production basin) and the sites of Loumbila, Ziga, and Korsimoro (Central Plateau production basin) and Léguéma, Sambla Toukoro, and Samandéni (Hauts-Bassins production basin) (Table 3).

## 3.2. Discussion

Six species of thrips are associated with vegetable crops in Burkina Faso. *Thrips tabaci* was the main species and represented more than 70% of thrips populations encountered in vegetable production basins. A total of 17 cultivated and wild plant species harbored thrips populations. *Thrips* spp. were encountered on all these 17 plants confirming its polyphagous character highlighted by several authors [16] [21] [22] [26] [27]. Onion thrips are native to the Mediterranean

**Table 3.** Results of the *Thrips* spp. density comparisons (pairewise-t-test) per plant and between study sites, Burkina Faso.

| Bogoya | Goinré | Korsimoro | Léguéma | Loumbila | Samandéni | Sambla-Toukoro | Saninga |
|---|---|---|---|---|---|---|---|
| Goinré | 1.00000 | — | — | — | — | — | — |
| Korsimoro | 0.00242 | 4.3e−05 | — | — | — | — | — |
| Léguéma | 0.03638 | 0.00109 | 1.00000 | — | — | — | — |
| Loumbila | 0.00451 | 7.2e−05 | 1.00000 | 1.00000 | — | — | — |
| Samandéni | 0.17169 | 0.00803 | 1.00000 | 1.00000 | 1.00000 | — | — |
| Sambla-Toukoro | 0.02582 | 0.00071 | 1.00000 | 1.00000 | 1.00000 | 1.00000 | — |
| Saninga | 1.00000 | 0.40301 | 0.29803 | 1.00000 | 0.52415 | 1.00000 | 1.00000 |
| Ziga | 0.01350 | 0.00037 | 1.00000 | 1.00000 | 1.00000 | 1.00000 | 0.79235 |

region but have become important insect pests of agricultural crops in most countries of the world [28] [29]. Severe damage to various crops has been reported in Africa, Asia, Europe, North and South America, and Australia [29] [30]. *Thrips tabaci* has an extremely wide host range compared to other thrips species. The host range varies from over 140 plant species in more than 40 families [22] to over 355 species of flowering plants [21]. Authors have shown that in addition to onion, *T. tabaci* attacks plants such as *Medicago sativa*, *Asparagus officinalis*, *Phaseolus vulgaris*, *Beta vulgaris*, *Rubus fruticosus*, *Brassica oleracea*, *Daucus carota*, *Apium graveolens*, *Gossypium* spp., *Cucumis sativus*, *Allium sativum*, *Brassica alboglabra* L.H. Bailey, *Allium ampeloprasum* var. porrum, *Lactuca sativa*, *Petroselinum crispum*, *Pisum sativum*, *Ananas comosus*, *Solanum tuberosum*, *Cucurbita maxima*, *Cucurbita* spp., *Fragaria ananassa*, *Ipomoea batatas*, *Brassica rapa* var. rapa, *Solanum lycopersicum* and virtually all small grains [31] [32] [33] [34]. Plant species such as *P. vulgaris*, *Solanum tuberosum*, *Cucumis sativus*, *Solanum lycopersicum*, and *Brassica oleracea* were identified as host plants of *Thrips* spp. during our study.

Six wild herbaceous species were identified as host plants for *Thrips* spp. in or around vegetable production sites during this study. Previous studies have also shown that *T. tabaci* attacks wild grasses [13] [35] [36] showed that *T. tabaci* was associated with 25 wild grasses in New York State.

The incidence of attacks and the degree of infestation varied among plant species. Indeed, the incidence of attacks was higher on crops, such as zucchini, eggplant, and onion. The species that held the average number of *Thrips* spp. individuals per plant across the three production basins was zucchini followed by cucumber and onion respectively. According to [15], the extent and frequency with which *T. tabaci* damages crops varies among plant species. We can hypothesize that the leaves of cucurbits and solanaceous plants being larger than those of onions might protect thrips populations from wind and water droplets from watering. These results contradict those of [37] who reported that *T. tabaci* prefers alliums.

Furthermore, these results partially confirm those of [19] [38] who also showed that thrips are the major insect pests of onion in Ethiopia. Furthermore, the density of *T. tabaci* was higher on cultivated species such as zucchini, cucumber and onion than wild plant species. [36] showed that *T. tabaci* populations were denser on onion plants than on wild grasses in western New York. *Thrips tabaci* attacks potatoes, sweet potatoes, and mustard, but none are damaged to a level that would regularly cause economic damage [39].

A significant difference in thrips density per plant was observed between sites and vegetable production basins. *Thrips* spp. density was significantly higher at sites in the northern production basin compared to sites in the other two production basins. These results confirm those of [8] who also showed that *Thrips* spp. populations were denser in the Northern production basin compared to the Boucle du Mouhoun and Central Plateau basins. Differences in climatic conditions in the different regions of the study could largely explain these results. Indeed, the three production basins are located in different agro-ecological zones. The Northern production basin receives the least amount of rainfall compared to the other two. It is located in the South-Sahelian phytogeographic sector with an average annual rainfall ranging from 500 to 700 mm and a number of rainy days ranging from 40 to 50 per year. The Central Plateau basin is in the phytogeographic sector with an average annual rainfall ranging from 700 to 900 mm. The number of rainy days per year ranges from 40 to 70. The Southern Sudanian phytogeographic sector, which includes the Hauts-Bassins production basin, receives the highest rainfall in the country. Average annual rainfall varies from 900 to 1100 mm with a number of rainy days between 70 and 90 [39]. Yet, according to [15], onion thrips reproduce asexually by parthenogenesis and the rate of reproduction depends on environmental conditions. Under warm, dry conditions, the oviposition rate of *T. tabaci* increases and generation time decreases, resulting in rapid population growth [11] [15]. [40] noted a significant reduction in *T. tabaci* numbers on onions after rain and hail. [41] and [42] reported that heavy rainfall is responsible for the destruction of a large portion of thrips populations. In addition, the Northern region has the largest number of vegetable production sites with 842 sites out of an estimated 4844 sites, *i.e.* 17.4% of the total sites in the country. It is followed by the Hauts-Bassins region with 561 sites (or 11.6% of sites) [2]. It can, therefore, be suggested that the abundance of host plants, which varies according to the production basin, has also influenced the density of *Thrips* spp. populations. This is all the more likely since the Hauts-Bassins region, which is the rainiest, recorded a higher density of thrips populations than the Central Plateau basin, which nevertheless presented warmer and drier climatic conditions.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

## References


[1] DPSAA (Department of Public Service and Administration) (2012) Equipments and Agricultural Infrastructures: Analysis Report. DPSAA, Ouagadougou, 31 p.

[2] MAH (Ministry of Agriculture and Hydraulics) (2011) General Report on Vegetables. MAH, Ouagadougou, 318 p.

[3] DGESS (2020) Directory of Agricultural Statistics 2018. MAAH, Ouagadougou, 268 p.

[4] PDCFL (2017) Reference Situation of the Fruit and Vegetable Crop Development Program (PDCFL), 2018-2022 Phase. Ministry of Agriculture and Hydraulic Development, Ouagadougou, 61 p.

[5] FAO (Food and Agriculture Organization) (2012) African Food and Agricultural Policy Monitoring Project (AFAPMP). Analysis of Incentives and Penalties for Onion in Burkina Faso. Technical Note, FAO, Ouagadougou, 39 p.

[6] Invest in Burkina (2021) Onion: The Most Profitable Vegetable Crop in Burkina Faso. https://www.investirauburkina.net/

[7] Leblanc, M. (2010) Onion Thrips: A Difficult Insect to Control. Agriculture, Fisheries and Food, Québec, 6 p.

[8] Savadogo, A., Bakouan, B.B., Sawadogo, M.W., Nébié, K., Dabiré, R., Son, D., Somda, I., Bonzi, S., Dabiré, G., Kambiré, H., Legrève, A., Verheggen, F.J. and Nacro, S. (2020) Distribution and Damage Associated with Onion Thrips, *Thrips tabaci* L. (Thysanoptera: Thripidae) According to the Agro-Climatic Zone in Burkina. *International Journal of Biological and Chemical Sciences*, **14**, 2037-2048. https://doi.org/10.4314/ijbcs.v14i6.9

[9] Kendall, D.H. and Capinera, J.L. (1987) Susceptibility of Onion Growth Stages to Onion Thrips (Thysanoptera: Thripidae) Damage and Mechanical Defoliation. *Environmental Entomology*, **16**, 859-863. https://doi.org/10.1093/ee/16.4.859

[10] Fournier, F., Boivin, G. and Stewart, R.K. (1995) Effect of *Thrips tabaci* (Thysanoptera: Thripidae) on Yellow Onion Yields and Economic Thresholds for Its Management. *Journal of Economic Entomology*, **88**, 1401-1407. https://doi.org/10.1093/jee/88.5.1401

[11] Rueda, A.F., Badenes-Perez, R.A. and Shelton, M. (2007) Developing Economic Thresholds for Onion Thrips in Honduras. *Crop Protection*, **26**, 1099-1107. https://doi.org/10.1016/j.cropro.2006.10.002

[12] Waiganjo, M.M., Gitonga, L.M. and Mueke, J.M. (2008) Effects of Weather on Thrips Population Dynamics and Its Implications on the Thrips Pest Management. *African Journal of Horticultural Science*, **1**, 82-90.

[13] Diaz-Montano, J., Fuchs, M., Nault, B.A., Fail, J. and Shelton, A.M. (2011) Onion Thrips (Thysanoptera: Thripidae): A Global Pest of Increasing Concern in Onion. *Journal of Economic Entomology*, **104**, 1-13. https://doi.org/10.1603/EC10269

[14] Nault, B.A. and Shelton, A.M. (2008) Insecticide Efficacy and Timing of Sprays for Onion Thrips Control. *Proceedings of the Empire State Fruit and Vegetable Expo*, Syracuse, 12-14 February 2008, 52-56.

[15] Gill, H.K., Garg, H., Gill, A.K., Gillett-Kaufman, J.L. and Nault, B.A. (2015) Onion Thrips (Thysanoptera: Thripidae) Biology, Ecology, and Management in Onion Production Systems. *Journal of Integrated Pest Management*, **6**, Article No. 6. https://doi.org/10.1093/jipm/pmv006

[16] Alston, D.G. and Drost, D. (2008) Onion Thrips (*Thrips tabaci*). ENT-117-08PR. Utah Pests Fact Sheet, Utah State University Extension. Utah State University Extension

and Utah Plant Pest Diagnostic Laboratory, Logan.
http://extension.usu.edu/files/publications/factsheet/ent-117-08pr.pdf

[17] Dutta, B., Barman, A.K.R., Srinivasan Avci, U., Ullman, D.E., Langston, D.B. and Gitaitis, R.D. (2014) Transmission of *Pantoea ananatis* and *P. agglomerans*, Causal Agents of Center Rot of Onion (*Allium cepa*), by Onion Thrips (*Thrips tabaci*) through Feces. *Phytopathology*, **104**, 812-819.
https://doi.org/10.1094/PHYTO-07-13-0199-R

[18] Dutta, B.R., Gitaitis, A., Barman, K., Avci, U., Marsigan, K. and Srinivasan, R. (2016) Interactions between *Frankliniella fusca* and *Pantoea ananatis* in the Center Rot Epidemic of Onion (*Allium cepa*). *Phytopathology*, **106**, 956-962.
https://doi.org/10.1094/PHYTO-12-15-0340-R

[19] Haile, B., Babege, T. and Hailu, A. (2016) Diseases and Insect Pests of Onion (*Allium cepa* L.) in Masha District of Sheka Zone, South-West Ethiopia. *Academia Journal of Agricultural Research*, **4**, 629-632.

[20] Grode, A.S. (2017) The Relationship between Onion Thrips (*Thrips tabaci*) and Bacterial Pathogens *Pantoea agglomerans* and *Pantoea ananatis*. Master's Thesis, Michigan State University, East Lansing, 70 p.

[21] Morison, G.D. (1957) A Review of British Glasshouse Thysanoptera. *Transactions of the Royal Entomological Society of London*, **109**, 467-520.
https://doi.org/10.1111/j.1365-2311.1957.tb00334.x

[22] Ananthakrishnan, T.N. (1973) Thrips: Biology and Control. MacMillan, New Delhi, 120 p.

[23] National Weather Agency (2018) Meteorological Data Report. National Weather Agency, Ouagadougou, 50 p.

[24] Mautino, G.C., Bosco, L. and Tavella, L. (2012) Integrated Management of *Thrips tabaci* (Thysanoptera: Thripidae) on Onion in North-Western Italy: Basic Approaches for Supervised Control. *Pest Management Science*, **68**, 185-193.
https://doi.org/10.1002/ps.2243

[25] Mound, L.A. and Kibby, G. (1998) Thysanoptera: An Identification Guide. CAB International, Wallingford, 70 p.

[26] R Development Core Team (2019) R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna.

[27] Mishra, R.K., Jaiswal, R.K., Kumar, D., Saabale, P.R. and Singh, A. (2014) Management of Major Diseases and Insect Pests of Onion and Garlic: A Comprehensive Review. *Journal of Plant Breeding and Crop Science*, **6**, 160-170.
https://doi.org/10.5897/JPBCS2014.0467

[28] Mound, L.A. and Walker, A.K. (1982) Terebrantia (Insecta: Thysanoptera). Fauna of New Zealand No. 1 DSIR, Wellington.

[29] Mound, L.A. (1997) Biological Diversity. In: Lewis, T., ed., *Thrips as Crop Pests*, CAB International, New York.

[30] Boateng, C.O., Schwartz, H.F., Havey, M.J. and Otto, K. (2014) Evaluation of Onion Germplasm for Resistance to Iris Yellow Spot Virus and Onion Thrips, *Thrips tabaci*. *Southwestern Entomologist*, **39**, 237-260. https://doi.org/10.3958/059.039.0218

[31] Pergande, T. (1895) Observations on Certain *Thripidae*. *Insect Life*, **7**, 390-395.

[32] Parella, M. and Lewis, T. (1997) Integrated Pest Management (IPM) in Field Crops. In: Lewis, T., Ed., *Thrips as Crop Pests,* CAB International, New York, 595-614.

[33] Cranshaw, W.S. (2004) Onion Thrips in Onions XXV. Agricultural Experiment Station, Colorado State University, Fort Collins, CO.

http://wiki.bugwood.org/uploads/OnionThrips-Onions.pdf

[34] Shelton, A.M., Plate, J.D. and Chen, M. (2008) Advances in Control of Onion Thrips in Cabbage (Thysanoptera: Thripidae). *Journal of Economic Entomology*, **101**, 438-443. https://doi.org/10.1093/jee/101.2.438

[35] Jenser, G., Lipcsei, S., Szenasi, A. and Hudak, K. (2006) Host Range of the Arrhenotokous Populations of *Thrips tabaci* (Thysanoptera: Thripidae). *Acta Phytopathologica et Entomologica Hungarica*, **41**, 297-303. https://doi.org/10.1556/APhyt.41.2006.3-4.12

[36] Smith, E., Ditommaso, A., Fuchs, A., Shelton, A.M. and Nault, B.A. (2011) Weed Hosts for Onion Thrips (Thysanoptera: Thripidae) and Their Potential Role in the Epidemiology of Iris Yellow Spot Virus in an Onion Ecosystem. *Environmental Entomology*, **40**, 194-203. https://doi.org/10.1603/EN10246

[37] Toussignant, M.E., Champagne, B. and Roullé, N. (2018) Greenhouse Ornamental Crops: Small Fruit Thrips and Onion Thrips. Technical Sheet. Plant Health Warning Network (RAP), Québec, 6 p.

[38] Agegnehu, S., Zegeye, W., Belay, B., Asaregew, F., Worku, A., Belay, D., Mehretu, E. and Alemayehu, G. (2013) Diseases, Insect Pests and Parasitic Weeds of Common Crops and Their Importance under Irrigation Conditions of Rib Areas. *Current Research in Microbiology and Biotechnology*, **1**, 262-265.

[39] Fontes, J. and Guinko, S. (1995) Vegetation and Land Use Map of Burkina Faso. Explanatory Note, French Ministry of Cooperation, Campus Project, Toulouse, 68 p.

[40] Harris, H.M., Drake, C.J. and Tate, H.D. (1936) Observations of the Onion Thrips. *Iowa State College Journal Science*, **10**, 155-172.

[41] Bournier, A. (1983) Thysanoptera of France VII. *Bulletin of the Entomological Society of France*, **88**, 1-9. https://doi.org/10.3406/bsef.1983.18099

[42] Kirk, W.D.J. (1997) Distribution, Abundance and Population Dynamics. In: Lewis, T., Ed., *Thrips as Crop Pests*, CAB International, Wallingford, 217-257.