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Inventory and Impact of Insects on Post-harvest Bulb Onions (*Allium cepa*) in Burkina Faso

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Abstract

Onions are one of the most important vegetable crops in Burkina Faso. However, onion producers report significant economic losses during storage, which limits year-round availability. To investigate the cause of these losses, this study aimed to identify the insects associated with onion bulbs in on-farm storage warehouses. The study was carried out in the Central Plateau Region in 4 storage warehouses. The insects were collected using yellow sticky traps and a random sample of 200 bulbs was taken from each warehouse to assess damage. A total of 11 insect species from to 10 families and 4 orders were identified. The most prevalent species were *Agrotis ipsilon* (Hufnagel 1766) (3077 individuals collected), followed by *Delia antiqua* (Meigen 1826) (2132 individuals) and *Lyctocoris* sp. (Hahn 1836) (138 individuals). Rotten bulbs accounted for the greatest losses, with 23.34%, 21.34%, 11.17% and 7.99% losses in Loumbila, Koassanga, Ziniaré and Poedogo, respectively. The overall loss rate was 22.84% and 30.34% in stores infested with *A. ipsilon* and *D. antiqua,* respectively. This study is the first in Burkina Faso to report the presence of insect pests in onion storage, and it deserves particular attention. These results constitute an essential step toward the developing of an appropriate control strategy to manage these insects in warehouses.

Keywords: Onion; Post-harvest loss; Insect pests; *Agrotis ipsilon*; *Delia antiqua*; Warehouse

Introduction

Onions (*Allium cepa* L.) is a vegetable belonging to the family Amaryllidaceae. The bulbs of mature onions contain starch, significant amounts of sugars, proteins, vitamins A, B and C (Sami *et al.* 2021); and dietary flavonoids (Pareek *et al.* 2017). It contains a wide range of phytochemicals, including flavonoids, fructans and organosulfur compounds, which may confer health benefits in humans and provide protection against various diseases, including cancer (Pareek *et al.* 2017). Onion is one of the most widely traded vegetables in the world (FAOSTAT 2022). In West Africa, Burkina Faso ranks as the fourth largest onion-producing country, after Niger, Senegal and Nigeria (FAO 2008), with an annual production exceeding 240000 tons. It is also the second largest exporter after the Niger country (Guissou *et al.* 2012). Onion cultivation contributes significantly to the country's economy by generating substantial income. In 2010, onion sales generated approximately 24.87 billion CFA francs for producers, representing about 30% of the total value of vegetable sales (DPSSA 2011).

Despite this high onion production, there is a period of vegetable shortage, particularly from August to November. During this time Burkina Faso imports onions from Niger and the Netherlands (Guissou *et al.* 2012). This situation can be explained by the large quantities of unsold onions that saturate markets after the harvest from December to April (Kaboré 2012). Over the past decade, the issue of storage has become increasingly relevant in the onion sector in Burkina Faso (Kaboré 2012), leading to the promotion of varieties such as the “Violet de Galmi” and the establishment of warehouses for better storage.

However, onion production is subject to numerous abiotic and biotic constraints, including attacks by insect pests and difficulties related to post-harvest storage. The main pests of onions in the field are thrips (*Thrips tabaci* Lindeman), bulb mites (*Rhizoglyphus* spp. and *Tyrophagus* spp.), tarsonemid mite (*Tarsonemus* spp.), leaf miner (*Liriomyza sativae* Blanchard), onion maggot (*Delia antiqua* Meigen) and grasshopper (*Atractomorpha sinensis* Bolivar) (Petit 1990; Biao *et al*. 2019; Savadogo *et al.* 2020). These pests can cause yield losses of up to 60% (Anonyme 2019),

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and the whole crop can be destroyed if the attack is done early in fields (Anonyme 2019). Onion thrips are the main vectors of the economically significant tospovirus, Iris yellow spot virus (IYSV) (genus Tospovirus, family Bunyaviridae), which reduces the size and quality of bulbs (Gent *et al.* 2004; Munoz *et al.* 2014). They also transmit bacterial center rot pathogens (*Pantoea agglomerans* and *P. ananatis*) to onion (Dutta *et al.* 2014). Center rot is a significant disease that can impact onions in the field and during storage. However, a key factor in preventing field infestation and lowering insect loads in storage environments can be the use of insect resistant varieties (Berhe *et al.* 2022).

During onion storage, RECA-Niger (2014) reported annual yield losses of up to 30%. According to Andriamparanony and Lesoa (2011), these losses are due to bulb weight loss, germination, and rot. Previous studies have shown that increased nitrogen fertilization increases the incidence of bacterial bulb rot and reduce onion bulb quality (Diaz-Perez *et al.* 2003).

In Burkina Faso, although, previous studies have shown the distribution and damage associated with onion thrips across different agro-climatic zones (Savadogo *et al*. 2020), little is known about the arthropods and insects associated with onion bulbs in storage warehouses, or about the nature and extent of losses, specifically in the Central Plateau region, which are areas of high onion cultivation. This study was conducted to address this gap by identifying the insects associated with onions during storage in rural areas.

Material and Methods

Study area

The study was conducted from June to September 2024 at four onion storages sites in Ziniaré (Koassanga and in the city of Ziniaré) and Loumbila (Poedogo and in the city of Loumbila) in the North Sudanian zone of Burkina Faso in the province of Oubritenga, one of the country's main onion production areas and storage. Each structure has a storage capacity of 10 tons of onions. The climate is tropical, with two seasons in both study zones: a dry season (October to April) and a rainy season (May to September), with a mean annual rainfall ranging from 600 to 900 mm (Zampaligré *et al.* 2014; Ilboudo *et al.* 2020). The vegetation is dominated by savanna with annual growing grass, trees and shrubs (Fontès and Guinko 1995; Sambaré *et al.* 2011; Barthelemy *et al.* 2017). The average temperatures and relative humidity levels ranged from 26.3°-30.6°C and 57 to 78 RH during the study period (ANAM 2022).

Data collections

After the onion bulbs were stored in storage warehouses following harvest, three yellow sticky traps were set up in an equidistant triangle in each warehouse, following the method described by Mignon *et al.* (2003), Lozano *et al.* (2013) and Yattara and Francis (2013). Insects were collected weekly and preserved in 70°C alcohol for identification. Larvae found in rotten onions and pupae were also collected and brought back to the laboratory for rearing until adulthood for identification. The temperature and relative humidity were recorded every day at 6 a.m., 12 p.m. and 6 p.m. in each warehouse. To evaluate the losses recorded in various storage warehouses, a sample of 200 onion bulbs was selected at random from the onion bulbs contained in each warehouse. These samples were stored in the same storage warehouses. Then, every 10 days, according to the method described by Housseini *et al.* (2020), the number of rotten and sprouted onion bulbs was recorded.

Identification of insects

Insects collected from the onion storage area were counted and identified in the laboratory under a binocular microscope using previously identified specimens by a taxonomic entomologist. They were also identified based on morphological characteristics described in various entomological classification keys (Delvare and Aberlenc 1989; Autrique and Ntahimpera 1994; Koehler *et al.* 2006; Chinery 2012; Dino 2014; Mignon *et al.* 2016) and technical publications (Bordat and Arvanitakis 2004; Poutouli *et al.* 2011). The identified insects were grouped into the following functional groups: pests, predators, parasitoids and others.

Data analysis

Statistical analyses were performed on the sites using R software version 4.0.3. Frequency was calculated according to the site, and temperature, relative humidity, and loss rate were tested globally using ANOVA, and also using Tukey's pairwise mean comparison tests at the threshold of $P = 0.05$. Frequency: $F = \frac{n}{N} \times 100$, n: is the number of individuals of a given species; N: The total number of individuals; Loss rate $T = (n_i/N) \times 100$, ni = Number of rotten or sprouted bulbs, N = Total number of bulbs.

Results

Diversity of insects in onion conservation stores

Eleven insect species belonging to 10 families and 4 orders were identified in the 4 onion bulb storages (Table 1). The dominant species reported in the study was *Agrotis ipsilon* (3077 individuals collected), followed by *Delia antiqua* (2132 individuals collected), *Lyctocoris* sp. (138 individuals collected), *Musca domestica* (99 individuals), *Musca sorbens* (75 individuals) and *Orius laevigatus* (16 individuals). A highly significant difference was observed in insect diversity among the different storage stores ($P = 2.2e^{-16}$). The Koassanga and Loumbila warehouses were more infested by *A. ipsilon*, whereas the Poedogo and Ziniaré warehouses were infected by *D. antiqua*.

Table 1: Insect species associated with onion bulb in storage area

Order	Family	Species	Functional groups	Number of individuals per area			
				Koassanga	Loumbila	Poedogo	Ziniare
	Muscidae	*Musca sorbens* (Wiedemann 1830)	other	15	29	13	18
		Musca domestica (Linnaeus 1758)	other	30	12	25	32
Diptera	Anthomyiidae	*Delia antiqua* (Meigen 1826)	Pest	0	42	1105	985
	Calliphoridae	*Lucilia sericata (*Meigen 1826)	other	14	12	9	18
	Syrphidae	*Eristalinus* sp. (Fabricius 1787)	other	0	2	0	0
Coleoptera	Nitidulidae	*Carpophilus* sp. (Linnaeus 1758)	Pest	0	1	0	4
	Tenebrionidae	*Tenebrio oscurus* (Fabricius 1792)	Pest	0	2	0	0
Orthoptera	Gryllidae	*Teleogryllus emma* (Ohmachi and Matsuura 1951)	Pest	8	1	3	0
	Noctuidae	*Agrotis ipsilon* (Hufnagel 1766)	Pest	1025	2032	0	20
Hemiptera	Anthocorinae	*Orius laevigatus* (Fieber 1860)	Predator	2	0	5	9
	Lyctocoridae	*Lyctocoris* sp. (Hahn 1836)	Predator	0	0	70	68
Total				1094	2133	1230	1154

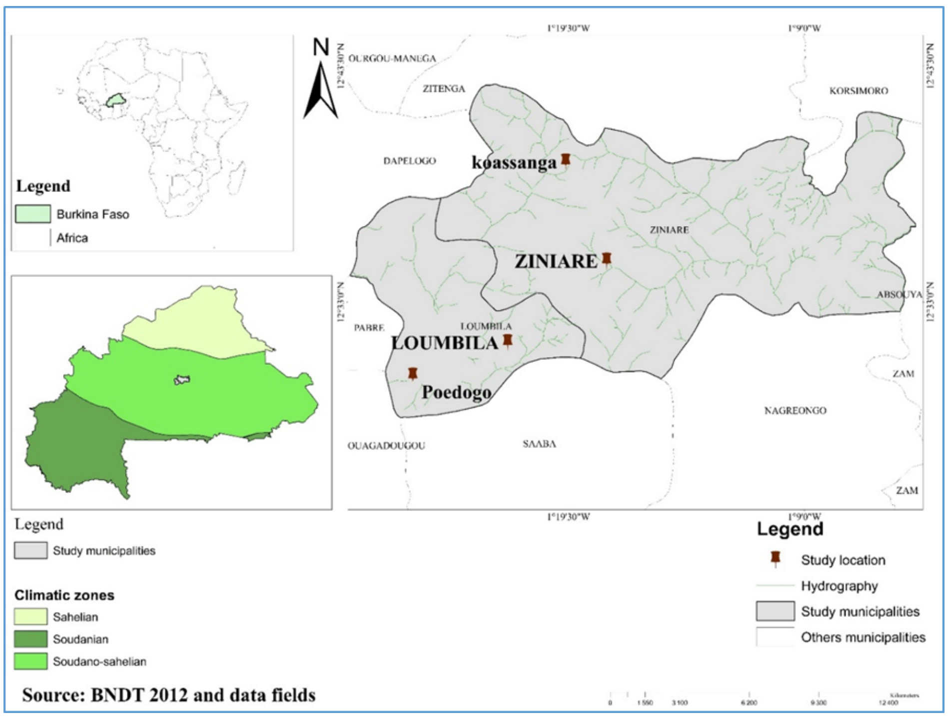

Fig. 1: Map showing the location of study area

Frequency of insects on onion bulbs

The frequency of insects on onion bulbs was very remarkable, especially in the families of Noctuidae and Anthomyiidae (Fig. 1). *Agrotis ipsilon* (Fig. 2) and *D. antiqua* (Fig. 2) were the two most frequent species on onion bulbs, with frequencies of 54.84 % and 37.99%, respectively (Fig. 3). *Lyctocoris* sp. representing 2.46% was found in onion bulb stores where *D. antiqua* was also present.

Temperature and humidity in onion bulb warehouse

The average temperature varied between 25°C and 34°C across the 4 areas during the study period (Fig. 4). No significant difference was observed in the mean temperature among the onion bulb storage warehouses (P = 0.24). The highest values (34°C) were recorded in June in Koassanga and Ziniaré, while the lowest values were observed in Poedogo (27°C) and Loumbila (28.73°C). The average relative humidity in the warehouses ranged from 50% to 90% (Fig. 5). The highest was recorded in Poedogo (90%) with a high in August, whereas the lowest occurred in Ziniaré (51.33%) in June. Overall, the relative humidity remained highest in Loumbila and Poedogo throughout the study period.

Types of loss and onion bulb storage behaviour

In all three warehouses, rotten bulbs were observed in early June, at the beginning of the storage. Except at Poedogo, where they appeared in July. The highest loss due to rotten bulbs was recorded in September at Loumbila (8.17%) and 6.5% at Koassanga (Fig. 6). In contrast, losses remained low in Poedogo and Ziniaré during the same period, at 3.83% and 3.67%, respectively.

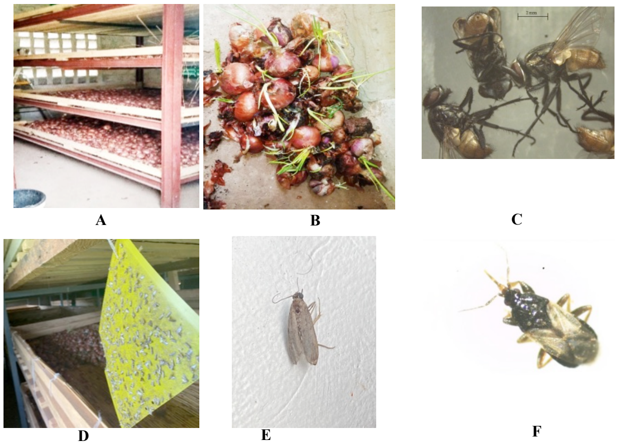

Fig. 2: Onion bulbs and insects collected: Onions placed on pallets in the warehouse (**A**); Rotten or sprouted onions (**B**); *Delia antiqua* (**C**); insects captured (**D**); *Agrotis ipsilon* (**E**); *Lyctocoris* sp. (**F**)

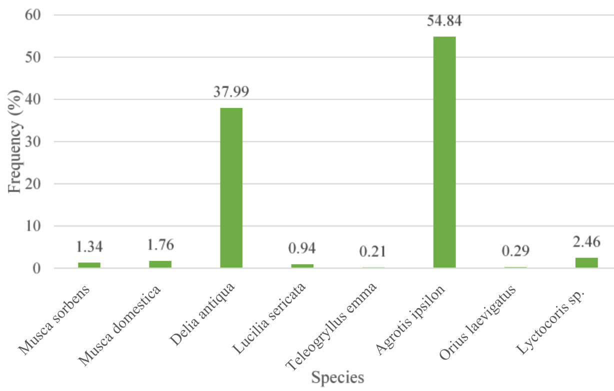

Fig. 3: Frequency of insects in storage areas

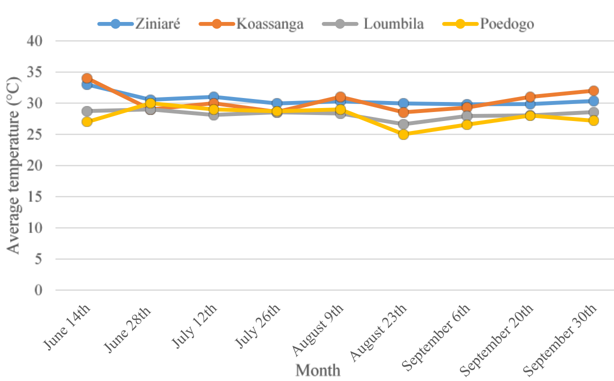

Fig. 4: Variation in the average temperature in the onion warehouses

The first germinated bulbs were observed in July in Loumbila and Ziniaré, with germination peaking in August at 5% in Loumbila (Fig. 7). In Poedogo and Koassanga, the first germinated bulbs were not observed until August, with 0.33% and 0.83%, respectively.

Post-harvest losses of onion bulbs

Rotten bulbs represented the most significant source of loss, accounting for 23.34%, 21.34%, 11.17% and 7.99% of the total losses in Loumbila, Koassanga, Ziniaré and Poedogo, respectively, with a significant difference (*P = 0.034*). These were followed by losses due to germinated bulbs at 7%, 2.67%, 1.5% and 0.66% in Loumbila, Ziniaré, Koassanga and Poedogo, respectively. The overall losses during the four months period of storage were 30.34%, 22.84%, 13.84% and 8.65% in Loumbila, Koassanga, Ziniaré and Poedogo, respectively showing a significant difference among sites (*P = 0.003*). The highest loss rate was observed in Loumbila (Fig. 8).

Discussion

This study is the first carried out in Burkina Faso to show the significant presence of insects associated with onion bulbs in storage. Eleven insect species belonging to 10 families and 4 orders were identified from onion bulb stored in four areas, with *A. ipsilon,* being the most dominant followed by *D. antiqua*, *Lyctocoris* sp., *M. domestica*, *M. sorbens* and *O. laevigatus*.

Regarding *A. ipsilon,* it is Lepidopteran specie commonly classified as a maize pest due to the aggressive attacks of its larvae. It was found in abundance infesting onion bulbs confirming its polyphagy status. Therefore, onion bulbs could serve as a potential host for this species. This presence could be associated to infestations, with individuals being carried into storage facilities during harvesting operations. Fernandes *et al.* (2013) reported that that neonate larva can be found beneath leaf litter on dryland field. These larvae can capable of completing their development due to their adaptability, the availability of suitable crop residues, and favourable storage conditions (Lee *et al.* 2023). Moreover, elevated temperatures and specific humidity levels can accelerate their development and enhance their survival rate (Verma *et al.* 2021).

As for *D. antiqua,* its abundance could be attributed to the infestation of onion bulbs by its eggs from production fields. Boquel (2021) showed that the female *D. antiqua* lay their eggs on the ground near the onion plant, often on the crown, leaf axils or between the bulb scales. The larvae then develop inside the bulbs, causing them to rot. This leads in the destruction of plants and seedlings during cultivation as well as bulb decay during storage. *Lyctocoris* sp. was found in association with *D. antiqua* but at low abundance. This insect is recognized as a predatory insect and a potential biological control agent, as it feeds on small Lepidoptera larvae, small white greens, aphid thrips and certain warehouse pests (Clandish 2016). Its presence could be associated with the presence of *D. antiqua* larvae and pupae. However, *Lyctocoris* sp. may also cause damage to bulbs during storage through its feeding puncture (Anukiruthika and Jayas 2025). Its presence in the storage environment could be explained by sucking the sap from the onion bulbs.

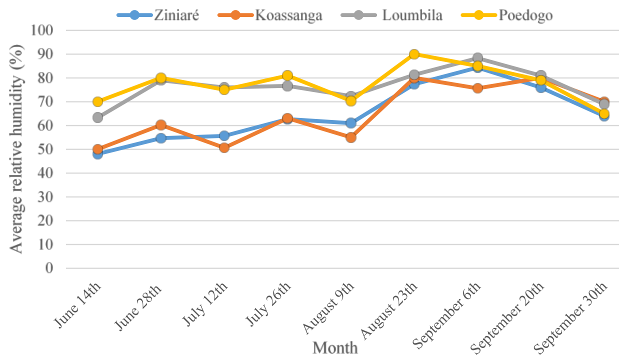

Fig. 5: Variation in the average relative humidity in the onion warehouses

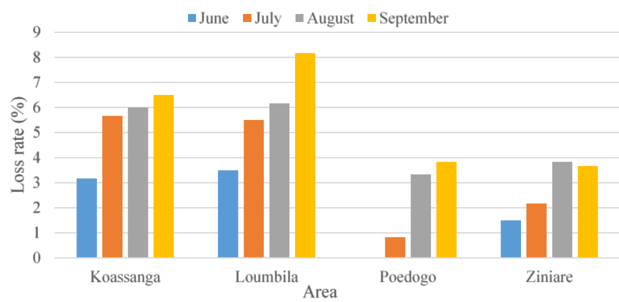

Fig. 6: Onion bulb rot loss rate in the warehouses

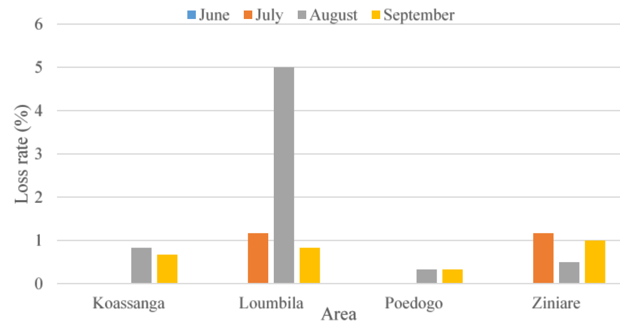

Fig. 7: Onion bulb sprouting loss rate in the warehouses

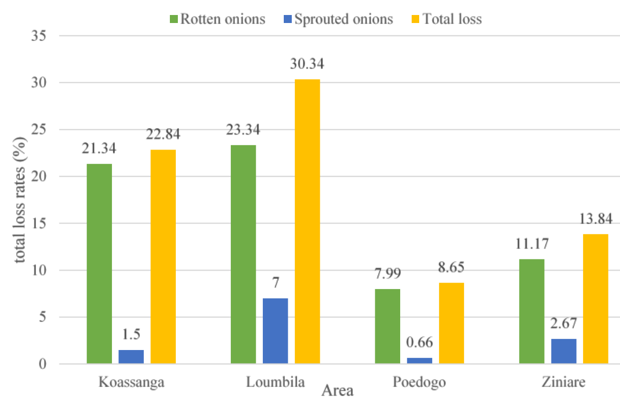

Fig. 8: Post-harvest loss rate of onion bulbs in warehouses

The relatively low temperatures and high relative humidity recorded in the warehouses may be due to the construction materials. The warehouses were built using cut laterite blocks, which, as shown by Cazor *et al.* (2015), provide more suitable thermal conditions for onion storage. The storage warehouses were also equipped with ventilation systems. According to Andriamparanony and Lesoa (2011), significant aeration during the rainy season can raise the relative humidity inside the warehouse through the significant entry of air loaded with water vapour.

The emergence of bulb rot symptoms in June, immediately after storage, may be due to the presence of fungal and bacteriological agents from the harvest fields. Fondio *et al.* (2001) also observed the appearance of rotting symptoms at the start of storage.

The first germinated bulbs appeared in July in all stores, and this germination increased until September. This could be due to the dormant state of the bulbs just after the harvests and the favourable conditions engendered germination (Serrar 2017). Indeed, relative humidity is a condition for the germination of onion bulbs. A relative humidity of over 70%, coupled with temperatures varying between 23 and 27°C, favours bulb germination in storage (Serrar 2017).

High loss rates were observed in stores infested with *A. ipsilon* and *D. antiqua*, likely due to the damage caused by these insect pests. Their presence therefore constitutes a new challenge for onion preservation. Claudine *et al*. (2013) have also shown that nitrogen fertilization increases yield, reduces dry matter content but increases rotting and early sprouting, limiting the suitability of onions for post-harvest storage. *Agrotis ipsilon* therefore reduces yields by increasing the susceptibility of onion bulbs to post-harvest pathogens. In contrast, *D. antiqua* larvae cause internal damage and quality deterioration in onion bulbs, rendering them unsuitable for export. Field monitoring using pheromone traps and the applications of *Bacillus thuringiensis* based bio-pesticides are recommended against *A. Ipsilon* (Ismail 2021; Jin *et al.* 2023). However, proper drying, sorting, removal of infested bulbs, and adequate ventilation prior to storage are essential for effective management of *D. antiqua* (Moretti *et al.* 2021; Filgueiras *et al.* 2023).

Conclusion

Onion production remains economically crucial in the Central Plateau region. However, it is confronted with abiotic and biotic constraints, especially those from insect pests. The abundance of *A. ipsilon* and *D. antiqua* is major concern for onion storage. Inappropriate storage practices can result in considerable losses for growers. Bulb rot was the primary cause of loss, followed by sprouting bulbs across all 4 observations sites. This study contributes a better understanding of the insects associated with this crop; the most important vegetable crop produced in Burkina Faso. Therefore, effective control strategies need to be developed.

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Author Contributions

Rahim ROMBA: Visualization, Investigation, Formal analysis, Data curation, Writing-original draft, Methodology and Conceptualization. Samuel Fogné DRABO: Investigation. Anselme Zézouma DAO: Investigation. Anselme KABRE: Investigation. Souleymane DAMIBA: Investigation. Olivier GNANKINE: Writing – original draft, Visualization, Supervision, Data curation and Conceptualization.

Conflicts of Interest

All authors declare no conflict of interest.

Data Availability

Data presented in this study will be available at the corresponding author's fair request.

Ethics Approval

Not applicable to this work.

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