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Incidence of Maize Streak Virus (MSV) in the Sudanian and Sudano Sahelian Zone of Burkina Faso

Mahamadou Dao[1,2], Bakary Ouattara[1], Emmanuel Kabore[1], Thierry K. Dakouo[1], Sidnooma Véronique Zongo[2,3], Drissa Sereme[1], Jacques Simpore[2,3]*

[1]Virology and Plant Biotechnology Laboratory, Institute of Environment and Agricultural Research (INERA), Ouagadougou, Burkina Faso
[2]Molecular Biology and Genetics Laboratory, University of Joseph Ki-Zerbo, Ouagadougou, Burkina Faso
[3]Pietro Annigoni Biomolecular Research Center (CERBA), Ouagadougou, Burkina Faso
Email: *simpore93@gmail.com

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Abstract

Maize streak virus (MSV, genus *Mastrevirus*) disease, which causes significant yield losses, poses a threat to maize cultivation in Burkina Faso. The objective of this work is to determine the status of streak disease in the two main maize production zones (Sudanian and Sudano-Sahelian zones) of Burkina Faso. To this end, a phytosanitary survey was conducted in maize farms during the rainy seasons from 2020 to 2024. The incidence and severity were initially determined at 4 experimental sites where 12 varieties were evaluated, and subsequently in 100 maize fields, with 50 fields per agro-ecological zone. In each field, six survey squares, each measuring 100 square meters, were established. Four of these squares were positioned at the corners, while two were placed internally. If the field contained trees, additional squares were positioned beneath a maximum of five trees in each field. The results indicate a very low incidence of the stripe, ranging from 0.47% to 1.41% across the 12 tested varieties and the 4 experimental sites. In the Sudanian zone, the incidence and severity of MSV recorded were higher (53.38% and 4.05%, respectively) compared to those observed in the Sudanese-Sahelian zone (11.61% and 2.98%, respectively). The incidence and severity of MSV recorded under the trees in the fields were also higher (52.55% and 3.98%, respectively) compared to those observed in open areas (12.41% and 3.05%, respectively). These preliminary results provide baseline information that can be utilized for the development of control strategies against the disease.

Keywords

Maize Streak Virus, Incidence, Severity, Burkina Faso

1. Introduction

Maize is one of the main cereal crops in the world. Its global annual production is estimated at 2.5 billion tons, making it a pillar of food security [1]. The size of the African maize market is estimated at USD 41.40 billion in 2024 and is expected to reach USD 57.26 billion by 2029 [2]. In Burkina Faso, maize ranks second in cultivated area and first in production [3]. It is an important crop for the country's food security and socio-economic development, which underscores its significance in the presidential initiative and the agropastoral offensive [4].

Despite this importance, its production faces biotic constraints, including viral diseases. The maize streak virus (MSV) is one of the main diseases affecting maize. In the field, yield losses of up to 100% can be recorded, depending on the variety and stage of infection of the crop [5]. The virus is transmitted by at least 6 species of leafhoppers from the genus *Cicadulina* (*Homoptera cicadulidae*) in a persistent manner [6]. MSV is capable of infecting over 80 other species in the Poaceae family [7], including wheat, sorghum, millet, and sugarcane [8]. In general, the proposed control strategies against the disease include the removal of infected plants and chemical control of the vector and have not effectively managed the emergence of the disease. The work conducted by Asare-Bediak *et al.*, Alegbejo *et al.*, and Mbong *et al.* has shown that several factors are involved in the transmission mechanism of this virus and in the epidemiology of the disease [9]-[11]. In this same vein, several authors have demonstrated the influence of agro-ecological factors on the emergence of MSV affecting maize, particularly in Nigeria [12] and in Cameroon [11].

In Burkina Faso, significant information has been generated regarding, on one hand, the biological and serological variability of the virus [13] [14] and, on the other hand, the transmission mechanisms [15]. However, knowledge about the epidemiology of this viral disease remains fragmentary and outdated. Indeed, there is insufficient recent data available on the incidence and distribution of MSV in Burkina Faso. Furthermore, the existing knowledge regarding the main transmission pathways of MSV is not enough to fully understand the epidemiology of this viral disease. In this context, the current study was initiated to contribute to providing information on the epidemiology of MSV in Burkina Faso. The objective of this study was to assess the incidence and distribution of MSV in the Sudanian and Sudan-Sahelian zones of Burkina Faso.

2. Materials and Methods

2.1. Study Area

Burkina Faso is characterized by a tropical Sudanian-Sahelian climate with alternating seasons: a long dry season from November to May and a short-wet season from June to October. The national territory is subdivided into three major climatic zones based on annual rainfall and thermal regime [16]. These zones include the Sahelian zone, the Sudano-Sahelian zone, and the Sudanian zone. The study was conducted in the Sudanian and Sudano-Sahelian zones of Burkina Faso (**Figure**

1). These two agro-climatic zones, which are the main maize production areas, differ mainly in their climatic characteristics.

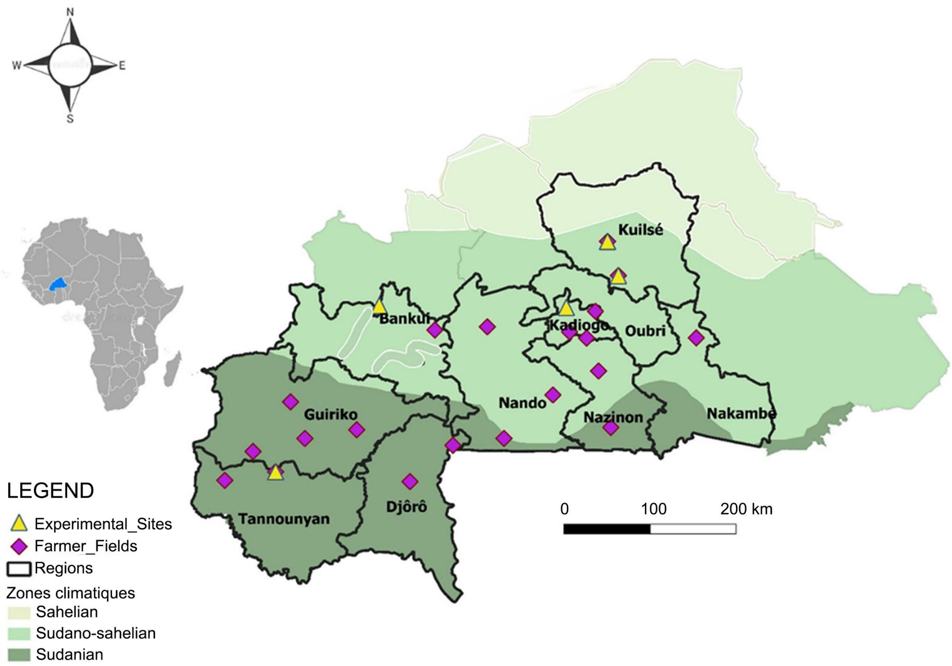


Figure 1. Map showing the locations of the study area and the sites for the experimental plots.

2.2. Plant Material

The plant material consisted of maize leaf samples showing streak symptoms. Twelve maize varieties were also used for the establishment of the experimental plots (Table 1).

Table 1. List of maize varieties used.

No.	Denomination	Genetic Nature	Breeder
1	Komsaya	Hybrid	INERA/BFA
2	Bondofa	Hybrid	INERA/BFA
3	KPJ	Composite	INERA/BFA
4	Espoir	Composite	INERA-IITA/BFA
5	Barka	Composite	INERA/BFA
6	SR21	Composite	INERA-IITA/BFA
7	Massongo	Composite	CRI/BFA
8	KEB	Composite	INERA/BFA
9	KEJ	Composite	INERA/BFA
10	FBC6	Composite	INERA/BFA
11	Wari	Composite	INERA/BFA
12	Local variety	-	-

2.3. Evaluation of Incidence and Severity in Farmer Fields

The assessment of maize streak incidence was conducted in 2023 and 2024 in farmer fields using 100-square-meter sampling squares (10 m × 10 m) each. Through visual observation within each square, the number of plants showing symptoms and the total number of plants were counted. In each field, six squares were set up, with four positioned near the corners and two placed in the center. If trees were present in the field, additional squares were placed under up to five trees in each field. The final incidence for the field was calculated by averaging the results from the different squares. For a locality, the disease incidence was calculated based on the results of five fields separated by at least 0.5 kilometers, while the incidence for an agro-climatic zone was obtained by averaging data from ten localities separated by at least 50 kilometers as described by Konaté and Traoré [13].

The severity assessment was conducted simultaneously with the incidence assessment using the same sampling squares. Only plants displaying maize streak symptoms were evaluated. Similar to incidence, the final severity was determined by averaging the results from different squares within a field and the average of 5 fields for a locality. Leaf samples were collected from maize plants showing MSV symptoms and from asymptomatic plants for laboratory diagnosis to confirm symptomatic observations.

2.4. Evaluation of Incidence in Experimental Plots

Experimental trials were conducted during the rainy seasons of 2020, 2021, and 2022 with 12 varieties of maize (**Table 1**). The crops were exposed to natural inoculation in four different locations: Bérégadougou in the Tannounyan region, Kodougou in the Bankui region, and Korsimoro and Zorkoum in the Kuilsé region (**Figure 1**). Agricultural operations were carried out according to the farming practices of each locality. The incidence of MSV was evaluated per variety by counting all plants exhibiting maize streak symptoms across the entire experimental plot area. The incidence for each variety was determined by averaging the data from the four implantation sites.

2.5. Determination of Incidence and Severity

The disease incidence was determined using the formula described by Mbong *et al.* [11]:

$$I\ (\%) = PA \times 100/PT$$

where I = disease incidence; PA = number of infected plants (a plant is considered infected when it shows symptoms at the time of observation); PT = total number of plants.

The Standard Evaluation System of diseases, defined by IRRI (International Rice Research Institute, 1996), was utilized to classify the levels of attack:

-A very low incidence where the disease appears as traces, with the percentage of infected plants being less than 1%.

-A low incidence corresponds to a percentage of infected plants between 1 and

10%.

-A moderate incidence corresponds to a percentage of infected plants between 11 and 31%.

-A high incidence corresponds to a percentage of infected plants between 31 and 50%.

-A very high incidence corresponds to a percentage of infected plants exceeding 50%.

Severity, on the other hand, was assessed using the semi-quantitative scale by Bello *et al.* [17], which ranges from 1 to 5 based on the severity of symptoms:

-The plant exhibits some chlorotic spots visible upon very detailed inspection.

-The plant shows a faint but easily visible streak.

-60% of the plant displays a streak.

-75% of the plant shows a significant streak of stunting.

-More than 75% of the plant is severely affected with significant stunting.

2.6. Statistical Analysis

Data on the incidence and severity of the disease have been entered and processed using Microsoft Excel and analyzed with the XLSTAT 2016 software. ArcGIS software was used to map the inspected locations.

3. Results

3.1. MSV Incidence in the Sudanian and Sudano-Sahelian Regions

The infection rates obtained in open-air locations and shaded areas compared to their averages are presented in **Figure 2**. Shaded areas show significantly higher incidences than open areas. The average incidence observed in open areas in 2023 and 2024 is 1.14% and 1.88% in the Sudano-Sahelian zone and 21.44% and 25.16% in the Sudanian zone. Conversely, under trees, the incidence during the same periods is 21.32% and 22.07% and 81.73% and 85.19% respectively, in the Sudano-Sahelian and Sudanian zones. The infection rates obtained differ from one agro-climatic zone to another. The Sudanian zone exhibits a very high incidence (51.58% in 2023 and 55.18% in 2024) compared to the Sudano-Sahelian zone, which demonstrates a moderate incidence (11.23% in 2023 and 11.98% in 2024).

3.2. Incidence of MSV in Fields by Inspected Regions

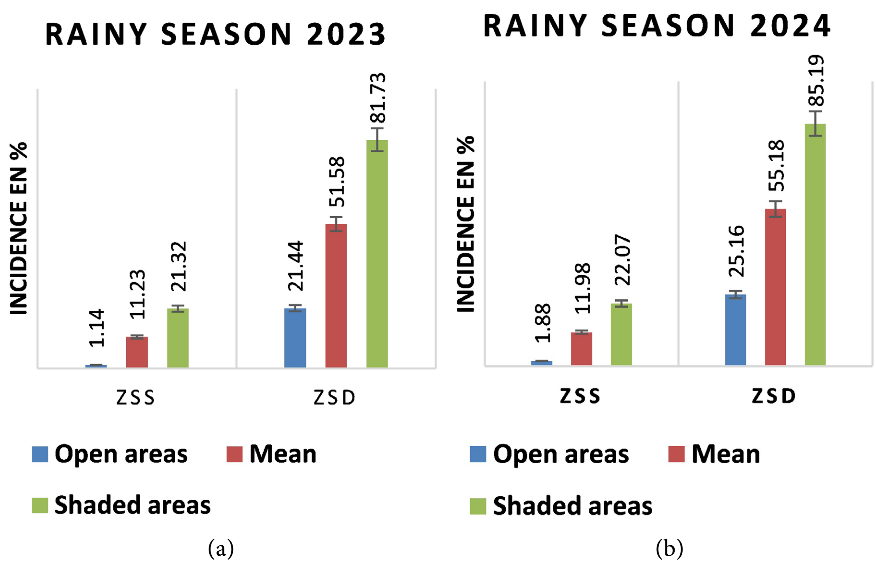
The results of the evaluation of the MSV infection rate recorded in 10 inspected regions are presented in **Table 2**. The statistical analysis (XLSTAT) of the incidence presented 6 groups of localities, while the one obtained using the IRRI incidence scale for all observations allowed to distinguish 4 levels of infestation:

-A low incidence in the Nakambé (2.35%), Kuilsé (2.95%), and Bankui (9.8%) regions;

-A moderate incidence in the Oubri (17.3%), Kadiogo (17.9%), and Nando (26.35%) regions;

-A high incidence in the Nazinon (33.8%) and Djôrô (49.8%) regions;

-A very high incidence in the Tannounyan (52.8%) and Guiriko (52.9%) regions.



Legend: ZSS = Sudano-Sahelian Zone; ZSD = Sudanian Zone.

Figure 2. Incidences recorded under trees and in clearings compared to the average of the two rainy seasons in 2023 and 2024 in the maize fields of the two agro-climatic zones.

Table 2. MSV incidence analyzed by region and based on its spatial distribution in the fields.

Regions	Incidence			
	Clearing	Under the Tree	Average by Region	Report under Tree/Clearing
Kuilsé	0.3a	5.6a	2.95a	18.67
Nakambé	0.4ab	4.3ab	2.35a	10.75
Bankui	1.3abc	18.3abc	9.8ab	14.08
Oubri	1.4abc	33.2abc	17.3ab	23.71
Kadiogo	2.4abc	33.4abc	17.9ab	13.92
Nando	11.6bc	41.1bc	26.35b	3.54
Nazinon	10.8cd	56.8cd	33.8bc	5.26
Guiriko	22.6d	83.4d	52.995cd	3.69
Djôrô	22.8d	76.8d	49.795cd	3.37
Tannounyan	20.18d	85.4d	52.79d	4.23

Legend: Values followed by the same letter in the same column are not significantly different.

3.3. Incidence of MSV in Fields across Different Localities

The analysis of data concerning the incidence of MSV indicates a significant difference (P < 0.0001) between localities (**Figure 3**). The least significant difference (LSD) test yielded 9 groups of localities, while the one obtained with the IRRI evaluation scale allowed for distinguishing 4 groups. The localities of Farakoba, Orodara, Léo, Sindou and Gaoua show a very high incidence (>50%). Banfora, Diébougou, Koumbia, Pô, and Samandeni record a strong incidence ranging from 37.5% to 49.5% in agricultural lands. Gonsé, Komsilga, Koubri, Sapouy, and Toécé demonstrate a moderate incidence between 10.8% and 23.3%, with a low incidence between 2% and 10% observed in Kaya, Koupéla, Korsimoro, Réo, and Kériba. Under the trees, all fields in the localities of the Sudanian zone exhibit a very high incidence ranging from 67.4% to 94.3%. In the clearings of the same localities, the incidences are significantly lower, ranging from 7.7% to 39.3% (**Figure 4**). In the Sudano-Sahelian zone, the lowest incidence under the trees was recorded in Koupéla (4.25%), and the highest was noted in Koubri. Meanwhile, in the clearings of the same zone, the lowest incidence was found in Kaya (0.09%), and the highest was observed in Toécé (4.99%).

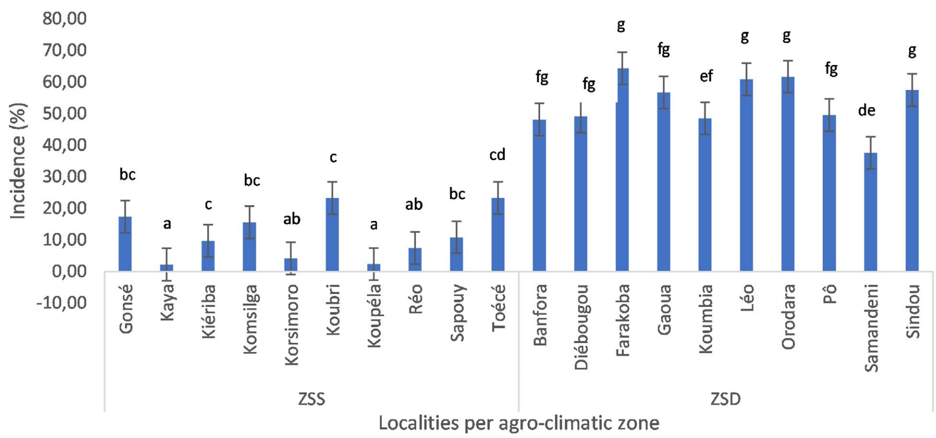


Figure 3. Average incidence over the two years (2023-2024) by localities and agro-climatic zones. The average followed by the same letter does not show significant difference.

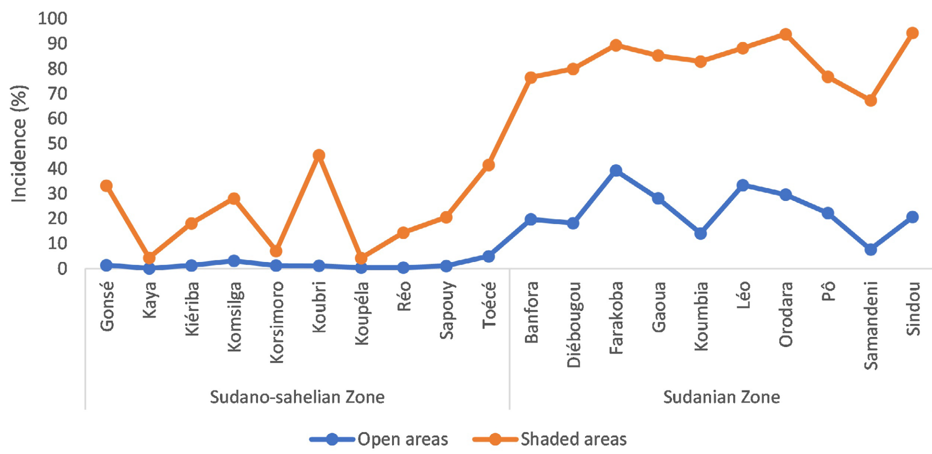


Figure 4. Incidence under trees compared to that observed in clearings.

3.4. MSV Severity

The severity of MSV in localities across various agro-ecological zones is depicted in Figure 5. Over the two study years, the disease severity did not show significant variation between agro-ecological zones. On the other hand, a significant variation was observed between the severity recorded under the trees, which is higher, and that noted in the clearings, which is lower, across all the examined locations.

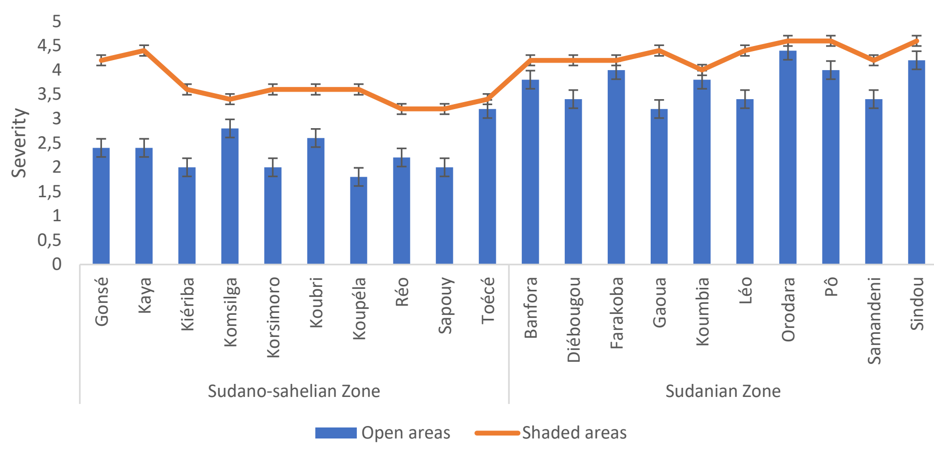


Figure 5. Severity of MSV in the various localities of the two agro-ecological zones.

3.5. Incidence in Experimental Plots

The data analyzed by variety show that all twelve tested varieties developed symptoms, with generally very low incidences (Figure 6). The infection rates are relatively higher for the varieties KEB (1.41%) and KEJ (1.09%). The remaining varieties recorded infection rates lower than 1%.

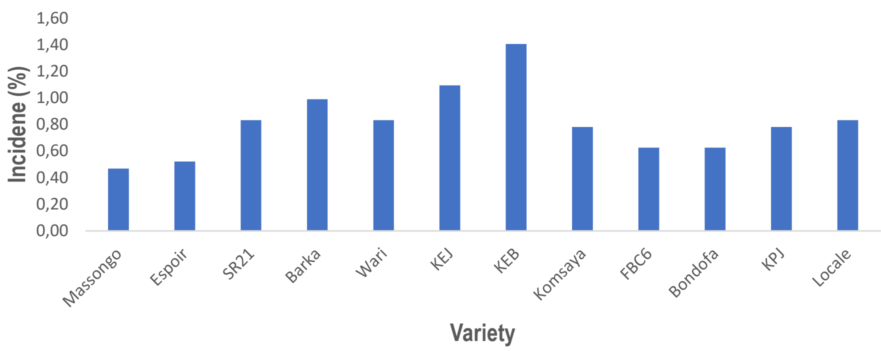


Figure 6. Mean incidence per tested variety in real-world settings.

4. Discussion

The temporal development of vector-transmitted viral diseases constitutes a multifaceted and dynamic process. It is marked by a multitude of actions, reactions, and interactions among the pathogen, vector populations, host plants, and the abiotic elements of the environment. In the specific case of maize streak virus (MSV), the subject of our study, the results demonstrate that the disease exhibits an uneven distribution across the Burkinabe territory due to distinctive variations among the country's three agro-climatic zones.

The Sudanian zone exhibits a significantly higher incidence and severity of streak than the Sudano-Sahelian zone. These findings are consistent with those reported by Konaté and Traoré [13], who observed a gradual decrease in the incidence and severity of MSV when transitioning from the Sudanian zone to the Sudano-Sahelian and Sahelian zones. Quantitative variations in vegetation cover across different agro-climatic zones could provide explanations for the observed spatial distribution of MSV. Indeed, the Sudanian zone is characterized by a more abundant grass flora compared to the Sudano-Sahelian zone. It is the most wooded and harbors the highest number of reservoir hosts compared to the Sudano-Sahelian zone, which is more sparsely populated with trees and shrubs (savannah). The incidence and severity of streak evolve depending on the development of the vector insect (cicadulina), which in turn relies on the abundance of reservoirs and host grasses. These statements are partly in line with those of Alegbejo *et al.* and Magenya *et al.*, who state that the population size of leafhoppers is mainly determined by the abundance of host grasses [12] [18]. Additionally, Seydou *et al.* counted approximately 3 infected plants per square meter (m^2) in the Guinean northern zone, around 1 plant per m^2 in the Sudanian savannah zone, and less than 1 plant per m^2 in the Sahelian zone [15].

High levels of humidity appear to contribute to the development of leafhoppers. In all 100 inspected fields, the incidence and severity observed under the trees are higher than those recorded in the clearings. Since humidity is generally higher in shady areas than in open areas, the higher incidence of MSV in the shade is likely linked to these high humidity levels. These results are consistent with those of Dabrowski [19], who concluded that humidity can be a limiting factor for the complete development of the insect. Similarly, Bosque-Pérez *et al.*, Alegbejo *et al.*, and Magenya *et al.* [12] [18] [20] argue that the experimental breeding conditions for the vector used by several authors involve high levels of relative humidity.

Trees serve as ecological niches, providing shelter and protection for leafhoppers against inclement weather, especially heavy rains and strong winds. It was revealed that fields with a high density of trees have higher incidences. Trees clearly play an attractive role for leafhoppers. These findings align with those of Asanzi *et al.* [21], who confirm that biotic factors (host plants) and abiotic factors (humidity, temperature) have been reported to influence the movement and feeding behavior of leafhoppers.

Localities located in the southern part of the country (Sudanian zone) show higher incidences compared to localities in the Sudano-Sahelian zone. These disparities in streak incidence are linked to the agro-climatic characteristics of each locality. In Burkina Faso, the rainfall pattern is unimodal, with the first rains typically arriving in April-May in the South and gradually spreading to the northern part of the country. During these initial weeks of rainfall, wild herbaceous flora gradually establishes, thereby attracting leafhoppers sheltered in the reservoir host plant. This first generation of leafhoppers develops rapidly and then migrates to infest nearby maize fields. Additionally, in localities located in the South, the rainy season is longer (six months) and gradually decreases as one moves towards the North of the country. This situation influences the rapid regeneration of host grasses, which in turn favors the development of leafhoppers and the spread of the disease. These statements align with those of Asanzi [22], who states that the size of the vector population is mainly determined by the amount of host grasses available for egg-laying and nymph development, and the growth of host grasses depends on rainfall. During a study on the epidemiology of MSV, Konaté and Traoré [13] reported that at the end of the rainy season, humidity gradually decreases to values below 30%. Only a small proportion of insects survive, and the size of this residual population influences the availability of the vector at the beginning and throughout the new rainy season. This phenomenon ultimately impacts the incidence of the disease.

In the experimental plots, all 12 varieties of maize exposed to natural MSV infection developed streak symptoms with a very low incidence ranging from 0.47% to 1.41% across all study sites. These preliminary results could be attributed to the low pressure of the MSV vector insect in these experimental plots, which are located in fully open areas. Such an assessment did not confidently lead to the selection of resistant or tolerant varieties to MSV. Under these circumstances, evaluating the material in a semi-controlled environment becomes necessary.

5. Conclusion

This study demonstrates that the incidence and severity of maize streak virus disease vary depending on the localities and agro-ecological zones of Burkina Faso. The results revealed a very high incidence in the Sudanian zone and a moderate incidence in the Sudano-Sahelian zone. The disease incidence is higher in fields with significant shading compared to fields with fewer trees. The 10 inspected regions were classified into 4 groups based on the level of incidence. The regions of Bankui, Kuilsé, and Nakambé have a low incidence, Kadiogo, Oubri, and Nando have a moderate level, Nazinon and Djôrô have a high incidence, and Tannounyan and Guiriko show a very high incidence. This variation in infection rates is linked to the climatic characteristics of each locality and zone, which significantly influence the diverse development of MSV host plants. This, combined with the abundant presence of vectors, the cultivation of MSV-sensitive cultivars, and favorable environmental conditions (early and irregular rains, suitable humidity and temperature), is the root cause of MSV epidemics. A study on the molecular characterization of the virus would be necessary and could contribute to the development of control strategies.

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Conflicts of Interest

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

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