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Peasant perception of fungal diseases of chili pepper (*Capsicum frutescens*) and diversity of pathogens in Burkina Faso

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ACKNOWLEDGEMENTS

This research was supported by Cirad with funding from the European Union and the Ministry of Foreign Affairs of the Netherlands through the project "Safe locally produced vegetables for West Africa's consumers (SafeVeg)".

Received: 06-05-2025

Accepted: 02-12-2025

Published: 31-12-2025

ABSTRACT

Chili pepper (*Capsicum frutescens*) cultivation plays a significant socio-economic role in Burkina Faso but is severely impacted by fungal diseases. Hence, this study evaluated farmers' disease management practices and identified the primary pathogens involved. Surveys were conducted with 30 farmers across three regions. Isolates from diseased plant parts were characterized based on morphological and molecular traits, as well as in vitro inoculations on detached leaves. Results revealed that 94% were men, with 65% being illiterate a limitation affecting the adoption of new agricultural techniques. Farmers predominantly used commercial seeds, synthetic fungicides, and insecticides, alongside crop rotation and mixed fertilization. However, their knowledge of fungal diseases was limited, with difficulty distinguishing fungal infections from bacterial or viral diseases. Common symptoms included leaf yellowing, necrosis, drying, and fruit rot. Pathological analysis identified 12 fungal genera, including *Fusarium* (34%), *Colletotrichum* (14%), *Alternaria* (9%), and *Rhizoctonia* (9%). Blast analysis of consensus sequences in ITS region indicated major isolates closely related to *Alternaria porri*, *Colletotrichum capsici*, *Lasioidiplodia theobromae*, *Fusarium incarnatum*, and *Rhizoctonia solani*. All five species were pathogenic on inoculated leaves and fruits, with variations in aggressiveness, some causing extensive lesions within days. This study underscores globally recognized fungal pathogens affecting chili peppers and highlights producers' reliance on pesticides despite limited disease knowledge. Promoting sustainable, participatory management strategies is critical for improving phytosanitary control and optimizing yields.

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Keywords: Chili pepper, Fungi pathology, Farmer practices, Burkina Faso.

INTRODUCTION

Chili pepper (*Capsicum frutescens*), is a crop of significant economic and nutritional importance worldwide. It is an important cash crop for numerous farmers and is central place to traditional diets and medicine. Rich in bioactive compounds such as capsaicinoids, flavonoids, and carotenoids known for their antioxidant properties (Azlan et al., 2022; Bal et al., 2022), chili pepper also contains essential vitamins (A, C, B6, and K) and minerals like calcium, magnesium, and potassium (Chakrabarty et al., 2017; Ogunlade et al., 2013; Reddy, 2023). Furthermore, it has considerable agronomic and industrial value (Chakrabarty et al., 2017; Koffi et al., 2014). Regular consumption of chili peppers provides health benefits, including reduced risks of cardiovascular diseases, type 2 diabetes, and certain cancers (Chakrabarty et al., 2017; Yang et al., 2023). A meta-analysis revealed that its consumption could reduce mortality by 13%, cardiovascular mortality by 11% and cancer mortality by 8% (Yang et al., 2023). Additionally, it contributes to weight management by stimulating metabolism (Azlan et al., 2022).

Several studies in West Africa have highlighted the importance of chili peppers and the main factors influencing their production. These include water deficit (Ledi et al., 2020), lack of knowledge about suitable varieties (Kouassi Kouassi & Koffi-Nevry, 2012) and pressure from pathogens (Biao et al., 2019).

In Burkina Faso, chili pepper cultivation is significant agricultural activity. In 2023, national production was estimated at 8,697 tons (FAOStat, 2025), with the main production region being Hauts-Bassins, Centre-Ouest, and Boucle du Mouhoun. Most chili pepper farmers are smallholders who cultivate less than 0.25 hectares in a monoculture setting. These growers face several challenges, including limited access to agricultural inputs and financial resources and issues with pests and diseases, all of which hinder productivity (Waongo et al., 2024).

Peppers (*Capsicum* spp.) are subject to several diseases that significantly threaten their production, particularly in tropical areas,

including bacterial, viral and fungal diseases (Asare-Bediako et al., 2015; Sastry et al., 2019).

Fungal diseases are a major biotic constraint, reducing both yield and crop quality. Among these diseases, anthracnose, caused by *Colletotrichum truncatum* and *C. gloeosporioides*, manifests as sunken necrotic lesions on fruits and can result in up to 89% yield loss (Kavya et al., 2024). Seedling damping-off, caused by soil-borne fungi such as *Pythium*, *Fusarium*, and *Rhizoctonia*, affects crop establishment with losses ranging from 20% to 85% (Chen et al., 2024). Fusarium wilt, caused by *Fusarium solani*, *F. proliferatum*, *F. incarnatum*, and *F. equiseti*, can lead to losses of up to 80% and produce mycotoxins harmful to food safety (Zombre et al., 2025). These highly destructive diseases require effective management to minimize their impact on chili pepper production.

Despite their economic and agronomic significance, fungal diseases affecting chili peppers remain understudied in Burkina Faso, limiting the implementation of suitable and sustainable control strategies. Precise identification of pathogenic agents and analysis of phytosanitary management practices are crucial for developing effective and sustainable control measures. Thus, this study evaluated farmers' disease management practices and identified the primary pathogens involved and analyzing their geographical. They assessing farmers' management practices will help identify key gaps and challenges in controlling fungal diseases.

MATERIALS AND METHODS

Study area

The study was conducted in three major vegetable-growing regions of Burkina Faso. These were the Hauts-Bassins (Soumousso (11,0116931, -4,0590739), Kodené (11,133788, -4,3208769), Kiri (11,2469831, -4,2783543), Toussiana (10,8504055, -4,6345898), Leguema (11,2404352, -4,1807972)), Centre (Tanghin-Dassouri (12,2739701, -1,7206452), Saaba (12,4707326, -1,3915322), Pabré (12,5207943,

-1,6153081)) and Plateau Central (Dossin (12,5891727, -1,4146923)) regions.

Sample collection was carried out in selected localities and analyzed at the CRE-FL (Centre Régional d'Excellence en Fruits et Legumes) laboratory (11.094237, -4.335159). These regions were chosen based on their agroecological diversity and their importance in Chili pepper production.

Survey and sampling

Farmers' knowledge of fungal diseases affecting chili peppers and their crop management practices, were assessed through a structured survey across multiple locations in the three regions. The survey was supplemented by field sampling to collect plant material exhibiting symptoms of fungal infection.

An illustrated catalog with common fungal diseases affecting chili peppers was used as a visual tool during the interviews to support the evaluation. The survey followed a random sampling methodology as described by Nikuze et al. (2020), involving individual interviews with three farmers per site. Data were collected using the KoboCollect v2024.2.4 application and subsequently exported in CSV format for analysis.

Following the farmer interviews, a field survey was conducted to collect plant material from chili pepper plots displaying symptoms of fungal infection. Sampling focused on symptomatic areas of the plants, including fruits, leaves, stems, and roots. Observed symptoms were categorized based on the type of damage and the affected plant part. To ensure geographic diversity and minimize overlap, samples were collected from two to four fields per location, with each field located at least 1 km apart. Five samples were collected per plot, yielding a total of 45 samples (15 per region).

Plant material was carefully labeled and stored in individual envelopes for subsequent identification in the mycological laboratory of the CRE-FL.

Incubation method and biological identification of fungi

Sample incubation was performed using the blotter method. Sterilized blotter discs (120°C, 30 minutes) were placed in Petri dishes (9 cm diameter). Samples, including healthy and infected plant parts, were successively disinfected with 70% alcohol (30 seconds) and 1% bleach (1 minute), then rinsed with sterile distilled water. After drying, four fragments per organ were placed on the moistened blotter paper.

The dishes were incubated under a cycle of 12 hours UV light/12 hours darkness at 25°C for 72 hours to one week. Each dish was labeled with a unique code, and dishes from the same plant received the same code. Observations began after 72 hours and continued for up to two weeks. Fungi were examined visually, under a binocular magnifier, and identified under a microscope using the identification key by Mathur and Kongsdal (2003). Detected species were recorded on the lids of the Petri dishes. Fungi isolated from symptomatic samples were purified on PDA medium. The inventory and frequency evaluation of fungal species followed the methodology described by Mathur and Kongsdal (2003).

The frequency of each observed fungal species was calculated based on the crop type and sampling locality using the following formula:

$$\text{Frequency (\%)} = (n/N) \times 100$$

where:

- n represents the total number of occurrences of an identified fungal species,
- N corresponds to the total number of observed organ fragments.

Molecular Identification of fungi

DNA extraction

DNA of ten (10) fungal isolates was extracted using the Wizard Genomic DNA Kit (Promega®) from mycelium grown on PDA medium incubated at 25°C for ten days, following the protocol described by Dianda et al. (2025).

PCR amplification and product analysis

PCR amplification was conducted in a reaction volume of 50 µL, comprising the following components: 10 µL of FirePol® Master Mix (Solis Biodyne), providing a final concentration of 1X reaction buffer, 2 mM MgCl₂, and 0.2 mM of each dNTP; 2 µL of each primer (10 µM stock), resulting in a final concentration of 0.4 µM per primer; 4 µL of template DNA; and 36 µL of sterile nuclease-free water. Two sets of primers were used: the species-specific primers Lt347-F (AACGTACCTCTGTTGCTTTGGC) (10 µM) and Lt347-R (TACTACGCTTGAGGGCTGAACA) (10 µM) for *Lasiodiplodia theobromae* identification (Xu et al., 2016) and the universal primers ITS4 TCCTCCGCTTATTGATATGC (Forward) and ITS5 GGAAGTAAAAGTCGTAACAAGG (Reverse) for amplification of the internal transcribed spacer (ITS) region (White et al., 1990). The PCR cycling conditions were optimized for each primer set. For the Lt347 primers, the protocol included an initial denaturation at 95°C for 10 minutes, followed by 30 cycles of denaturation at 94°C for 60 seconds, annealing at 60°C for 30 seconds, and extension at 72°C for 60 seconds, with a final extension at 72°C for 10 minutes. For the ITS primers, the protocol began with an initial denaturation at 94°C for 2 minutes, followed by 30 cycles of denaturation at 94°C for 30 seconds, annealing at 58°C for 30 seconds, and extension at 72°C for 30 seconds, with a final extension at 72°C for 8 minutes.

Amplified PCR products were separated via electrophoresis on a 1% (w/v) agarose gel (UltraPure™ Agarose, Invitrogen, Spain) prepared in 0.5X TAE buffer. A 100 bp DNA ladder (Solis Biodyne) was used as a molecular weight marker to estimate the size of the PCR amplicons. The sequencing was performed in both directions using the Sanger method. Successfully identified fungal isolates were subsequently inoculated onto detached chili pepper plant organs to evaluate their pathogenicity.

Pathogenicity and severity assessment

Fungal isolates studied were obtained from symptomatic plant organs. Pathogenicity was assessed on detached leaves and fruits following the method described by Latifah et al. (2018). Young, healthy samples were collected from disease-free plants (Burkina yellow pepper), disinfected, and inoculated with five isolates cultured on PDA (27 ± 1°C, photoperiod of 12 hours). Each isolate was tested five times.

Leaves and fruits were wounded at the center before applying a 5 mm disc of active mycelium. Leaves were incubated in sealed Petri dishes, while fruits were placed in airtight sterile containers. Control samples were treated with sterile PDA plugs. Incubation occurred at room temperature, and lesions were monitored over time.

Symptom severity was evaluated using the severity scale Rahman et al. (2011). The severity index (SI) was calculated using the protocol by Kranz (1988) formula:

$SI = \sum (X_i \times n_i) / (N \times Z) \times 100$ where:

- SI = Severity Index,
- X_i = Severity level i on the organ,
- n_i = Number of organs showing severity level i ,
- N = Total number of observed organs ($N = 50$),
- Z = Maximum severity level on the scale used.

Data analysis

Collected data were entered and organized in Microsoft Office 2021 Excel spreadsheet, which was also used to generate histograms and diagrams. Symptom severity progression curves were generated using R software with the ggplot2 packages. The raw sequences obtained were analyzed using bioedit software, and the generated consensus sequences were BLAST-tested on NCBI.

RESULTS**Sociodemographic profile of producers: gender, education, experience, and age distribution**

The sociodemographic analysis of 30 chili pepper farmers (10 per region) focused on

gender, literacy, farming experience, and age distribution (Figure 1).

The sector was predominantly male, with 94% of surveyed producers being men (Figure 1A).

Literacy levels were low, with 65% of producers identified as illiterate (Figure 1B).

Over 70% of farmers had more than ten years of experience (Figure 1C), highlighting a wealth of practical knowledge.

Age distribution showed that 58.82% of producers were aged 41–50 (Figure 1D), with limited youth participation. This trend raises concerns about generational renewal, suggesting the need for strategies to attract and support young farmers in the chili pepper sector.

Seed origin, management practices and farmers' perception of fungal diseases

Most producers used commercial seeds, with some saved from previous seasons (Figure 2B). Before nursery establishment, seeds were typically treated with synthetic products to prevent infections and improve germination.

Pesticides, especially synthetic insecticides and fungicides, were widely used, while biological alternatives remained rare (Figure 2A). Crop rotation was practiced by 59% of producers to limit soil degradation and pest pressure (Figure 2C). Regarding fertilization, 52.94% of farmers combined organic manure with synthetic fertilizers (Figure 2D).

The survey highlighted a general lack of knowledge about fungal diseases. No farmer could distinguish fungal infections from bacterial or viral ones. While 15% had heard of phytopathogenic fungi, none understood their transmission (Figure 2E).

After a brief explanation, all producers recognized having observed symptoms of fungal diseases in their chili pepper fields.

Main symptoms observed on chili pepper

Field inspections revealed the presence of symptoms indicative of fungal infections affecting various plant organs. The most frequently observed manifestations included leaf yellowing accompanied by brown necrotic

lesions (Figure 3A and B), progressive drying of leaves starting from the edges (Figure 3C), and wilting of plants associated with stem browning (Figure 3D). Additionally, brown or soft rot was observed on the fruits (Figure 3E and F). These symptoms often attributed to fungal infections, significantly compromise crop growth and yield, highlighting the need for precise identification of the responsible pathogens to implement appropriate management strategies.

Frequency of symptoms

Various fungal symptoms were observed on the different localities. Generally, the most frequently encountered symptoms were leaf drying, necrosis, and yellowing (35%), which appeared to be the most common manifestations of fungal infections on chili pepper plants. The low frequency (5%) of symptoms was observed on fruit rots on chilli plants. Intermediate frequencies were recorded for wilting (15%) and plant mortality (10%) respectively.

Fungal genera identified from symptoms

A total of 12 fungal genera were identified based on microscopic observations of the symptoms observed on chili pepper plants (Figure 4). The most frequently encountered genera were *Fusarium*, *Colletotrichum*, *Alternaria*, and *Rhizoctonia* (Figure 4 A to D, respectively and Figure 5). The other genera were occasionally observed and include *Botrytis*, *Myrothecium*, *Curvularia*, *Lasiodiplodia*, *Melanospora*, *Phomopsis*, *Cercospora*, and *Corynespora* (Figure 4 E to L, respectively). *Lasiodiplodia*, *Melanospora*, and *Botrytis* were the least frequent at 2% each (Figure 5).

Frequency of identified fungal genera

Figure 5 presents the frequency of fungal genera based on the symptoms observed in production plots. The highest frequency (34%) was recorded for the genus *Fusarium*. Intermediate frequencies were recorded for *Colletotrichum* (14%), *Alternaria* (9%), and *Rhizoctonia* (9%). The lowest frequencies (2%) were observed for the

genera *Lasiodiplodia*, *Melanospora*, and *Botrytis*.

Molecular identification of fungal isolates

PCR amplification tests with specific primers detected the presence of amplicons in two isolates, at the expected size of about 350 bp. Sequence obtained with these amplicons closely matched the species *Lasiodiplodia theobromae* (Table 1). Also,

PCR tests with universal primers ITS4 and ITS5 detected amplicons in all 10 tested isolates, at the expected size of about 500 bp. However, no amplification was observed in the negative control samples (T).

Blast analysis of sequences from these amplicons revealed that Burkina Faso isolates are closely related to five species: *Fusarium incarnatum* (Gf1), *Colletotrichum capsici* (Gco1), *Alternaria porri* (PA1), *Rhizoctonia solani* (Gc1), and *Lasiodiplodia theobromae* (Pl1) (Table 1).

Pathogenic characteristics of fungal isolates

All isolates of the five fungal species demonstrated pathogenic properties *in vitro* on detached leaves and fruits. Symptoms induced

by the isolates were generally visible within two days post-inoculation (Figure 6, all “A” except on the control (plate 6)). Lesions progressed rapidly in some isolates, sometimes covering the entire surface of the leaf or fruit within seven days, giving them a rotting appearance (Figure 6 plate 2,3,4,5). Additionally, a whitish deposit, often accompanied by black spots corresponding to fungal mycelium and acervuli, was observed 7 days post-inoculation (Figure 6, all “B” except on the control (plate 6)). No symptoms were observed in the control samples (Plates 6A and B).

Severity progression of infected fungi

The progression of necrotic lesions caused by all isolates showed a steady increase during the incubation period, with varying growth rates indicating differences in aggressiveness among strains. The strains exhibited similar severity progression on fruits and leaves, except for the strain *Alternaria porri*, which did not show any symptoms until the 12th day post-infection. Symptoms only appeared between the 12th and 14th days post inoculation (Figure 7).

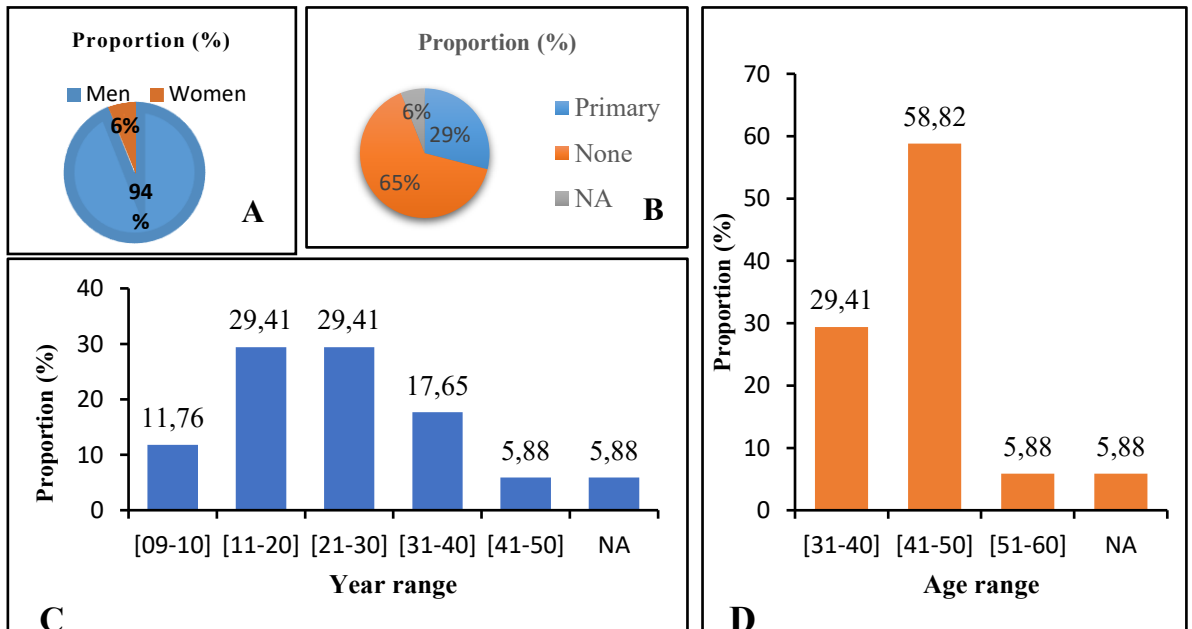


Figure 1: Socio-demographic characteristics of producers.

A: Distribution of producers by gender, B: literacy level, C: experience; D: age trance; NA: unknown age None: illiterate; M: Male; F: Female.

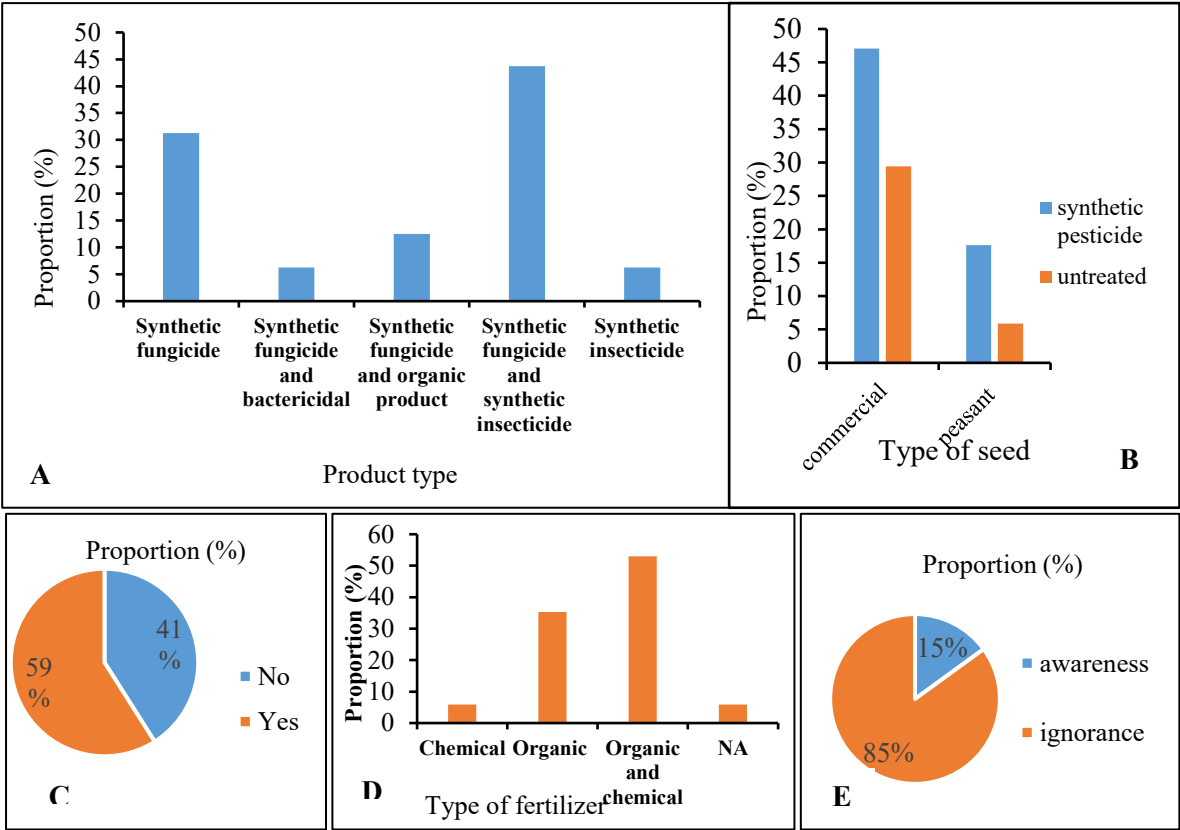


Figure 2: Overview of grower practices and phytosanitary knowledge of surveyed growers. **A:** Percentage of growers by type of pesticide used, **B:** Repartition of seed source, **C:** Crop rotation, **D:** Proportions of type of fertilizer, **E:** Distribution of producers by knowledge of fungal diseases.

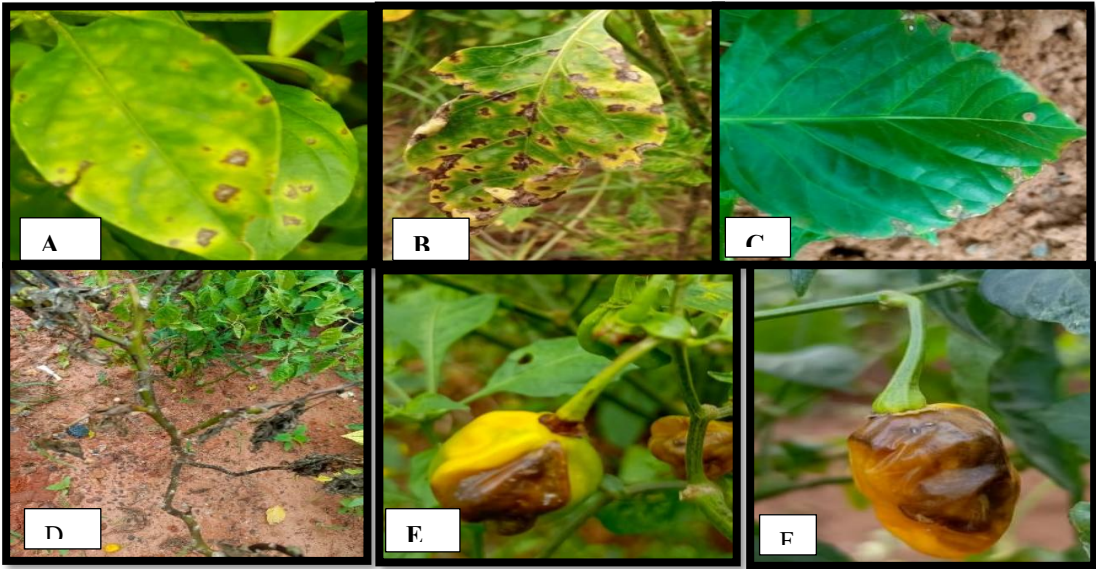


Figure 3: Main symptoms observed in chili pepper. **A and B:** leaf yellowing and necrotic lesions, **C:** Progressive drying of leaves starting from the edges, **D:** wilting of plants and stem browning, **E and F:** brown or soft rot on the fruits .

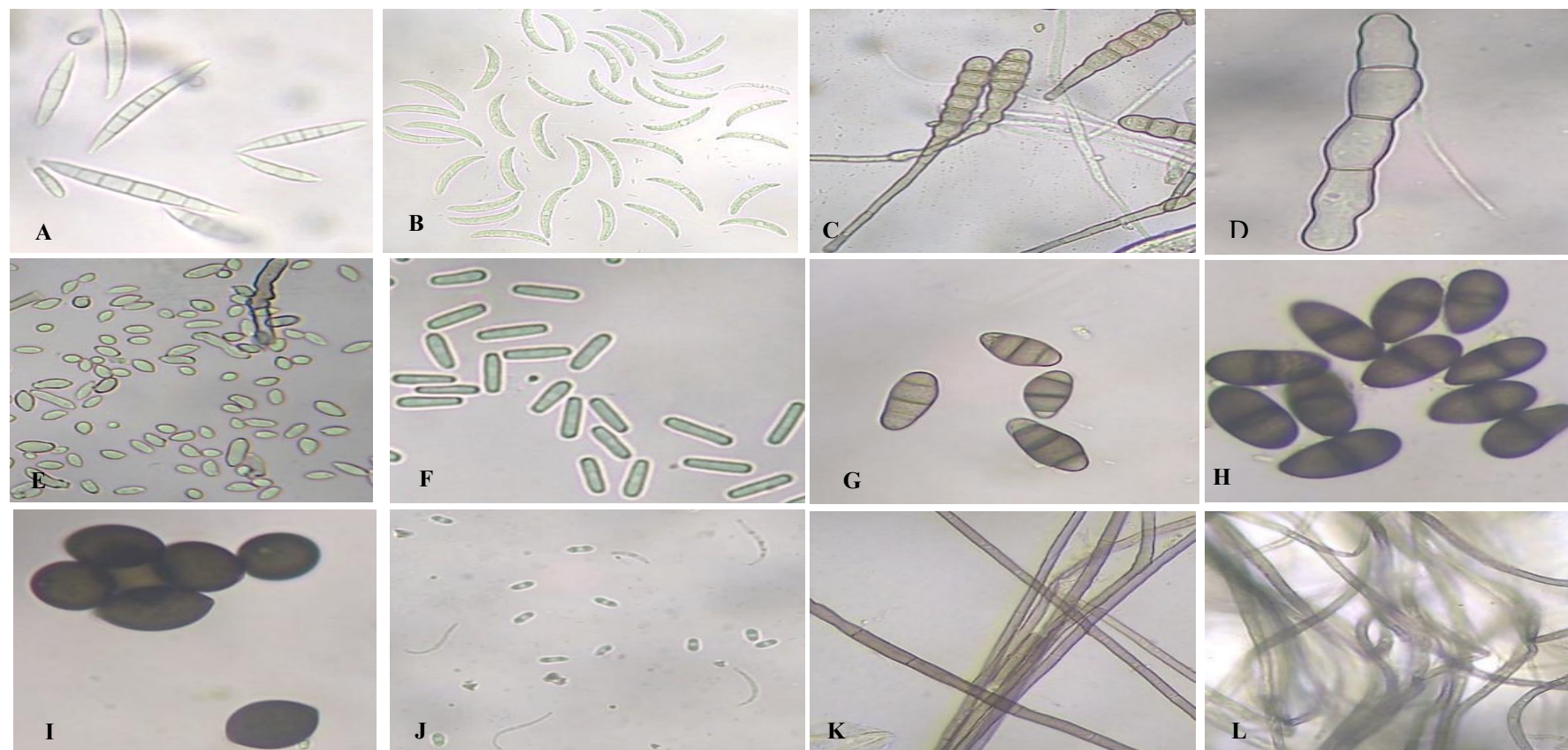


Figure 4: Less frequent fungi genera.

A: *Fusarium* sp.; **B:** *Colletotrichum* sp.; **C:** *Alternaria* sp.; **D:** *Rhizoctonia* sp.; **E:** *Botritis*; **F:** *Myrothecium*; **G:** *Curvularia*; **H:** *Lasiodiplodia*; **I:** *Melanospora*; **J:** *Phomopsis*; **K:** *Cercospora* et **L:** *Corynespora*.

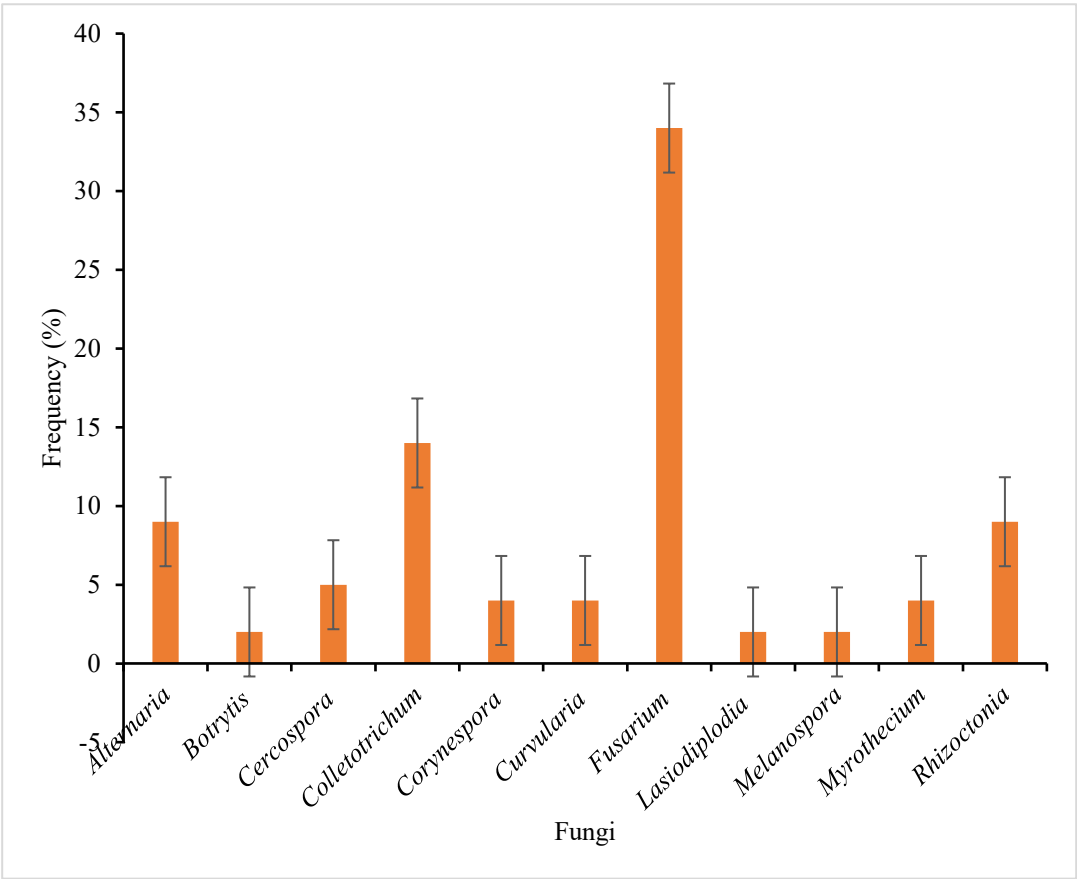


Figure 5: Frequency of fungi genera identified on chili pepper.

Table 1: Blast of consensus sequences from isolates of different species.

Isolate code	Provenance	Corresponding species on Genbank	Sequence length (pb)	Genbank accession number	Similarity rate (%)
PA1	Saaba	Alternaria porri	555	JF422724.1	99
Gco1	Kiri	Colletotrichum capsici	538	KJ174419.1	99
Pl1	Soumouosso	Lasiodiplodia theobromae	524	KM357551.1	99
Gf1	Loumbila	Fusarium incarnatum	501	MW521146.1	98
Gc1	Soumouosso	Rhizoctonia solani	449	MN190634.1	99

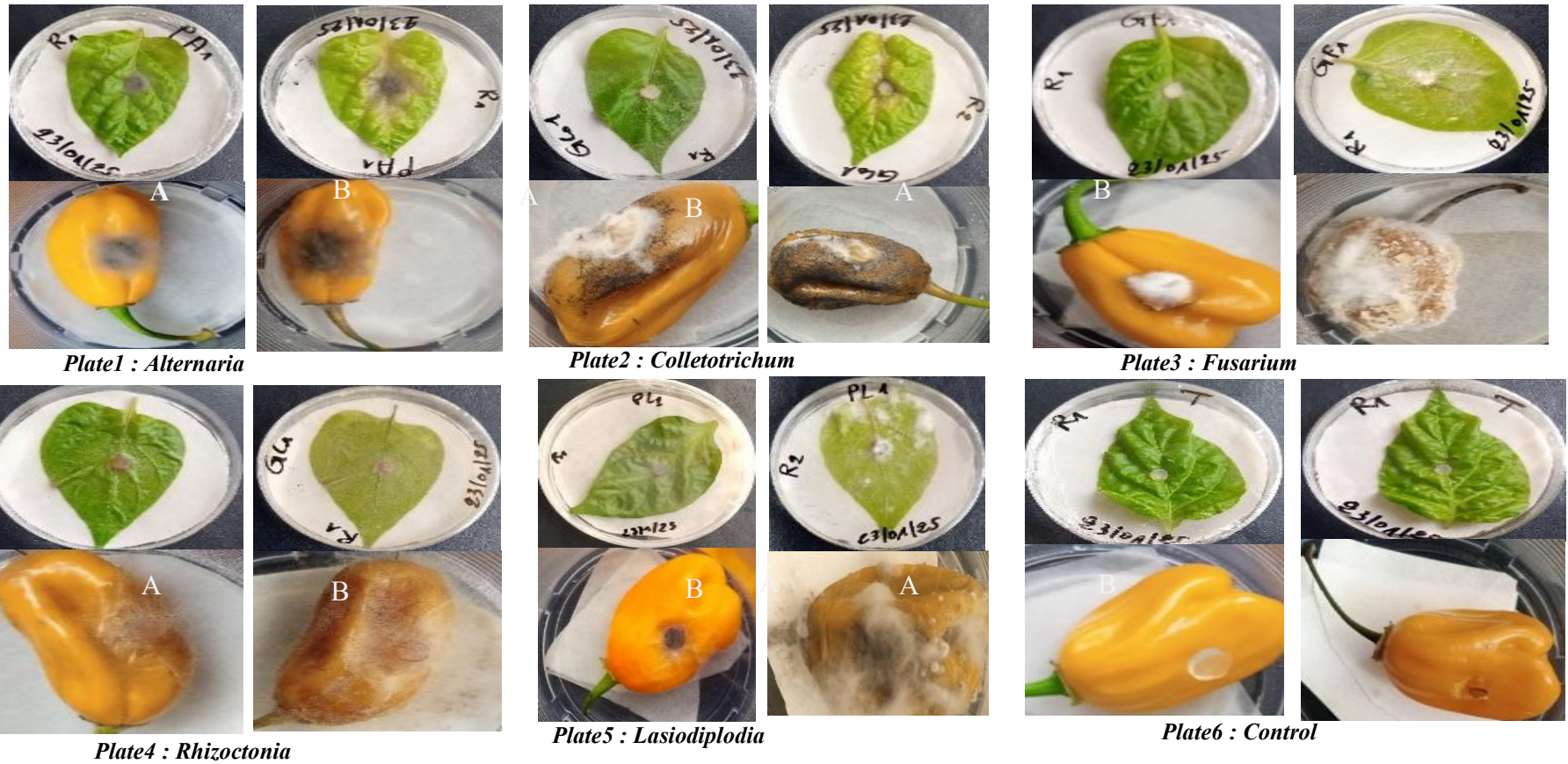


Figure 6: Pathogenicity of fungal isolates on chili pepper leaves and fruits
A: symptoms observed 2 days post-inoculation; B: symptoms observed 7 days post-inoculation

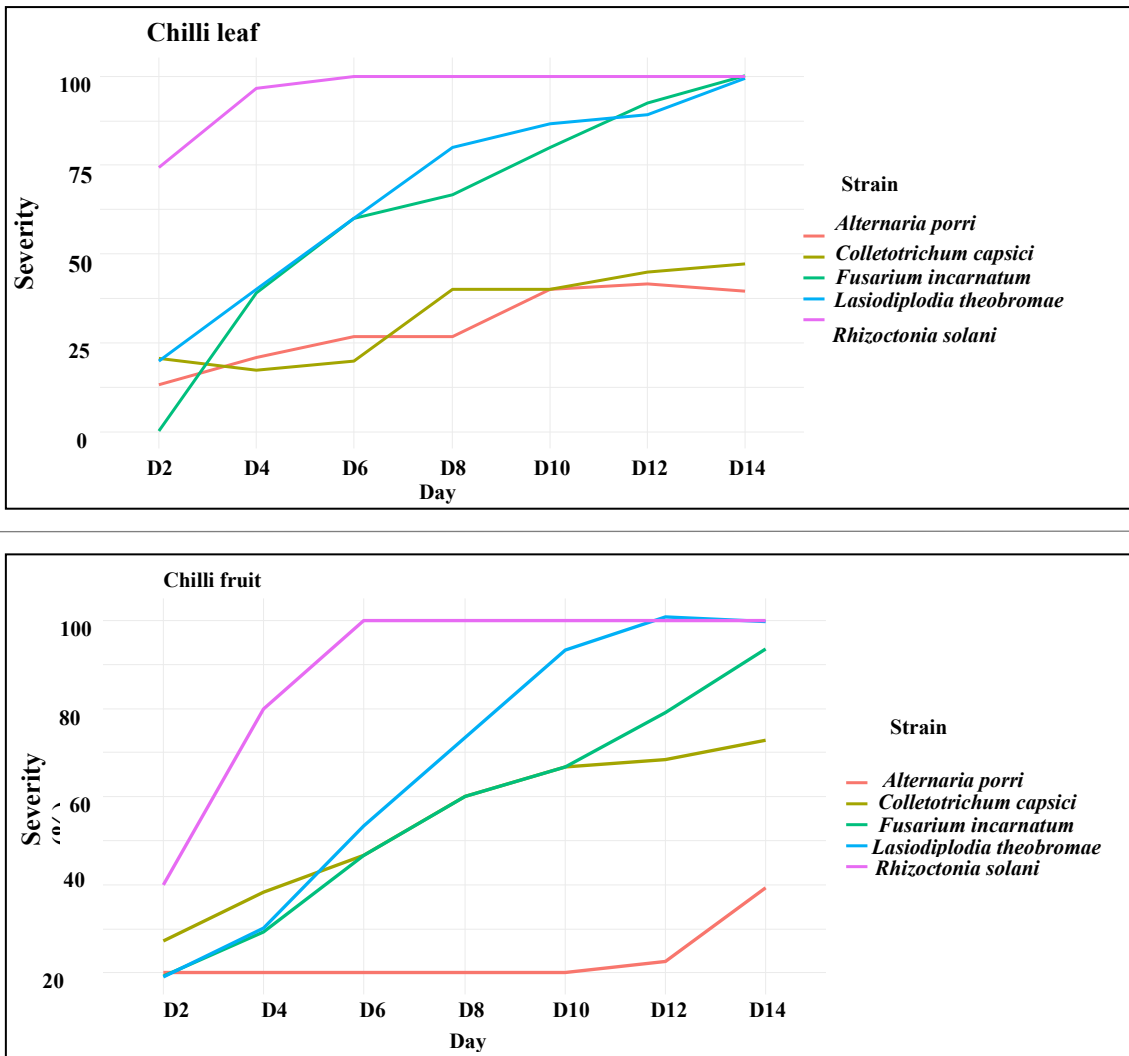


Figure 7: Evolution of the severity of fungal disease symptoms on leaves and fruit.

DISCUSSION

The production of chili peppers in Burkina Faso is affected by various constraints, including limited access to resources, an ageing farming population and widespread fungal diseases that significantly reduce yields. In this context, the results of this study highlight several key aspects regarding agricultural practices and the management of fungal diseases among chili pepper producers in Burkina Faso. First, the predominance of male producers (94%) and the high average age (58.82% aged between 41 and 50 years)

indicate demographic stability but also reveal a lack of generational renewal in the sector. This situation may hinder the adoption of new agricultural practices, particularly those requiring technical training, such as fungal disease management (Waongo et al., 2024).

The low literacy level among producers (65% illiterate) represents a major limiting factor for the adoption of modern agricultural practices. This lack of education may impede access to technical information on disease management and the implementation of ecological methods to combat pathogens. The

use of local languages for training of farmers and knowledge sharing could help for improvement of their skills. Additionally, digitalization would be an opportunity for the youths to support farmers and reduce the observed knowledge gaps.

The widespread use of commercial seeds, often treated with chemical products, illustrates the influence of conventional practices in crop management, although this may pose risks to soil and plant health in the long term (Bosland and Votava, 2012; Koffi et al., 2014).

The heavy reliance on synthetic pesticides, particularly fungicides and insecticides, take precedence over biological solutions. While these products can yield quick results, they may lead to pathogen resistance and adversely affect soil biodiversity. This underscores the need to train producers on more sustainable and ecological alternatives, such as biological fungicides or integrated pest management (IPM) strategies (Chen et al., 2024; Sawant et al., 2023).

Another key aspect of this study is the general lack of knowledge about fungal diseases, which hampers effective management. The inability to distinguish fungal diseases from bacterial or viral infections, coupled with a lack of understanding about the transmission mechanisms of phytopathogenic fungi, highlights an urgent need for education and awareness. The late recognition of fungal symptoms in fields, even after a brief presentation, demonstrates a lack of practical field training (Kavya et al., 2024; Rony et al., 2024).

The symptoms observed in this study, including leaf yellowing, necrosis, drying, and fruit rot, are characteristic of fungal infections. The diversity of symptoms affecting different plant organs suggests that multiple pathogens, including *Fusarium*, *Colletotrichum*, *Alternaria*, and *Rhizoctonia*, are responsible for the observed damage. These pathogens

demonstrated *in vitro* pathogenic properties, with rapid symptom progression, emphasizing the importance of developing swift and effective management strategies to minimize yield losses (Sawant et al., 2023; Zombre et al., 2025). The progression of lesions caused by fungal isolates showed varying growth rates, reflecting differences in aggressiveness among strains. Some strains were more virulent, while *Alternaria porri*, which manifested symptoms later, could also pose a high risk under certain environmental conditions. This phenomenon may have significant implications for managing infections in chili pepper fields (Azlan et al., 2022; Chakrabarty et al., 2017).

Although Burkinabe producers possess considerable experience in chili pepper cultivation, several challenges remain, including limited knowledge of fungal diseases and the intensive use of chemical products. It is crucial to strengthen the capacities of producers through training and promote more sustainable agricultural practices tailored to local realities to reduce the impact of fungal diseases and improve yields (Bal et al., 2022; Yang et al., 2023).

Conclusion

This study highlights the challenges faced by chili pepper producers in Burkina Faso regarding fungal disease management and the implementation of sustainable agricultural practices. Although producers have significant experience in vegetable farming, critical issues persist, including low literacy levels, lack of knowledge about fungal diseases and heavy reliance on chemical products. The widespread use of synthetic pesticides, while common, raises concerns about sustainability, pathogen resistance, and environmental degradation. The diversity of identified pathogens and the variable aggressiveness of strains underscore the need for more precise and proactive infection management. To improve the situation, it is essential to develop training programs tailored to producers and agricultural

extensionists, focusing on the recognition of fungal disease symptoms and the adoption of more ecological and integrated control practices. Promoting biological solutions and integrated pest management strategies could provide more sustainable alternatives to chemical treatments. Additionally, raising awareness among producers about the importance of diversifying agricultural practices could minimize disease risks and enhance crop resilience to future challenges.

COMPETING INTERESTS

The authors declare that they have no competing interests.

AUTHORS' CONTRIBUTIONS

This work was carried out collaboratively by the authors. ZOD drafted the protocol and the initial manuscript. MMY managed the data, performed the analyses and edited the manuscript. MS performed the statistical analysis and proofread the manuscript. DAS, AO, WVT, TCZ, FB, OT, RSO and IW read and approved the final version of the manuscript.

ACKNOWLEDGEMENTS

This research was conducted as part of the "Safe locally produced vegetables for West Africa's consumers (SafeVeg)" project (ID-4000003936), which forms part of the DeSIRA programme. This project is implemented by the World Vegetable Center, CIRAD and Wageningen University (WUR), as well as national partners: the National Institute for Agricultural Research of Benin (INRAB), the Institute for Environment and Agricultural Research (INERA) in Burkina Faso, and the Institute for Rural Economics (IER) in Mali.

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