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Screening of Sesame (*Sesamum indicum* L.) Genotypes for Tolerance/Resistance to Biotic Constraints (Phyllody and *Macrophomina phaseolina* (Tassi) Goïd.) in Niger

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Abstract

Sesame (*Sesamum indicum* L.), an economically important crop in Niger, faces threats to its production from phyllody and *Macrophomina phaseolina*. This study evaluates the resistance of eight sesame genotypes to these two biotic constraints. The genotypes tested included mutants (ICN130, EF146, HC110), their parents (Birkan, 38-1-7), local accessions (S3, S26), and an imported variety (VI). The experiment, conducted under infested natural conditions in a randomized complete block design with four replicates, revealed significant variations in genotype resistance. For phyllody, the HC110 mutant (2.5% incidence) and the S3 accession (5%) showed high resistance, while the imported variety (VI) proved moderately susceptible (40%). For *Macrophomina phaseolina*, genotypes EF146 and VI were immune (0%), and HC110 was moderately resistant (12.5%). Local accessions S3 and the parents Birkan and 38-1-7 also showed notable resistance to both diseases. The results underline the potential of local genotypes and mutants as a source of varietal improvement for tolerance and resistance to *Macrophomina phaseolina* and phyllody. Innovative approaches such as mutagenesis could enhance sesame's resilience to these pathogens.

Keywords

Screening, *Sesamum indicum*, Phyllody, *Macrophomina phaseolina,* Niger

1. Introduction

Sesame (*Sesamum indicum* L.) is a strategic oilseed crop in Niger, valued for its economic and nutritional importance [1]. It is cultivated mainly in the regions of Maradi, Zinder, Tillabéry, and Diffa, and it represents an essential source of income for small farmers. Furthermore, it significantly contributes to food security due to its high protein content (18 - 25%) and essential fatty acids [1] [2]. However, sesame production in Niger is seriously threatened by two major diseases: phyllody, a phytoplasma disease transmitted by the leafhoppers *Orosius albicinctus* and *O. orientalis*, and charcoal rot caused by the telluric fungus *Macrophomina phaseolina* [3]. These pathogens can cause yield losses of up to 80% [4], compromising the sustainability of local farming systems. Phyllody is characterized by transforming floral organs into leaf-like structures, leading to plant sterility [5]. This disease, which is endemic in Sahelian zones, is exacerbated by climate change, which favors the proliferation of insect vectors [6].

Phytoplasmas are obligatory prokaryotic parasites that belong to the mollicutes class and are generally localized in the phloem cells of the parasitized plant. Worldwide, only two sesame varieties (PI436603 and PI256523) have been reported by [7] as resistant to Phyllody. However, these varieties were proven to be susceptible in tests carried out at the Faculty of Agronomy and Environmental Sciences of Dan Dicko Dankoulodo University in Maradi, Niger (unpublished data). At the same time, *Macrophomina phaseolina*, a telluric fungus, induces systemic desiccation of plants, particularly under the water-stressed conditions common in Niger [8]. These biotic constraints are exacerbated by the inappropriate use of exogenous varieties with low resistance, as demonstrated by recent studies [9]. Faced with these challenges, the identification of resistant genotypes is emerging as a sustainable solution. Previous work has highlighted the genetic variability of sesame in the face of these pathogens [10], but few studies have focused on local Nigerian accessions, which are nonetheless adapted to local agroclimatic constraints [11]. Research in Burkina Faso [8] and Senegal [6] highlights the importance of utilizing local genetic resources and mutants to enhance crop resilience. In this context, this study aims to screen eight sesame genotypes (irradiated mutants, local accessions, and an imported variety) for their resistance to phyllody and *Macrophomina phaseolina* under natural infestation conditions in Niger. This research is based on standardized methodologies [3] and proven evaluation criteria [4], while integrating Niger's agro-ecological specificities. The results could guide participatory breeding strategies involving local farmers, as suggested by the work of [1] on the agro-morphological characterization of local accessions.

2. Materials and Methods

2.1. Plant Material

It comprises eight (8) sesame genotypes. Of these genotypes, three (3) are mutants (ICN130, EF146, and HC110) obtained through induced mutation after irradiation with gamma rays at doses of 100, 200, 300, 400, 500, 600, 700, and 800 Gy using a cobalt source (^{60}Co) at the International Atomic Energy Agency (IAEA)

Laboratory of Agriculture and Biotechnology in Seibersdorf, Austria. Two (2) are parents (Birkan and 38-1-7) [12]. Two (2) are accessions (S3 and S26) from the national collection in Niger [1], along with an imported variety (VI) from Nigeria serving as a control. The characteristics of these genotypes are provided in **Table 1**.

Table 1. Characteristics of the sesame genotypes used in this study.

Genotypes	Type	Cycle time (days)	Weight of 1000 grains (g)	Color of integuments
ICN 130	Mutant	82	3.67	
EF 146	Mutant	86	3.28	
HC 110	Mutant	88	3.16	
Birkan	Parent	90	4.07	Yellow/light brown
38-1-7	Parent	95	3.03	Cream
V I	Variety	-	-	White
S3	Accession	86	2.94	Beige
S26	Accession	86	4.00	Beige

2.2. Experimental Site

The trial was conducted under natural conditions at the experimental station of the Faculty of Agronomy, Abdou Moumouni University, Niamey, on land naturally infested with *Macrophomina phaseolina*. The land is flat with a slight slope, and the soil is sandy in texture. The previous crop was maize. Rainfall was relatively good on the experimental site, with a cumulative total of 790.8 mm over 35 days.

2.3. Experimental Set-Up

The experiment was conducted in a completely randomized Fisher block design with four (4) replicates. Each replication comprised eight (8) elementary plots, for a total of 32 elementary plots. Each elementary plot consists of four (4) lines, 5 m long, spaced 60 cm apart, with a line spacing of 30 cm. Plots are spaced 1.5 m apart within each block and 2 m apart between blocks.

2.4. Crop Management and Observations

In this experiment, all recommended sesame-growing practices were followed to obtain good yields, with the exception that no chemical treatments were applied to combat the aforementioned diseases. A superficial scraping of the soil, followed by harrowing, was carried out before sowing to create a good seedbed. Sowing occurred on 18/07/2024 using a daba, to a depth of 1 cm. A spacing of 30 cm between bunches and 60 cm between rows was maintained, resulting in a density of 65,000 bunches per hectare. NPK fertilizer was applied in micro-doses at the time of sowing. Culling was conducted in two stages: first to three (3) plants, and then to one (1) plant when the latter became vigorous. The incidence of both diseases was recorded during the reproductive phase (near physiological maturity) by counting the number of diseased plants. For phyllody, this was primarily at the flowering stage. Scoring was based on the visual symptoms of these two diseases: phyllody (**Figure 1**) and *Macrophomina phaseolina* (**Figure 2**). Disease incidence (%) was calculated using the following formula, and reactions were classified into the categories shown in **Table 1** [13].

$$\text{Disease incidence} = \frac{\text{Number of plants infested}}{\text{Number of plants observed}} \times 100$$

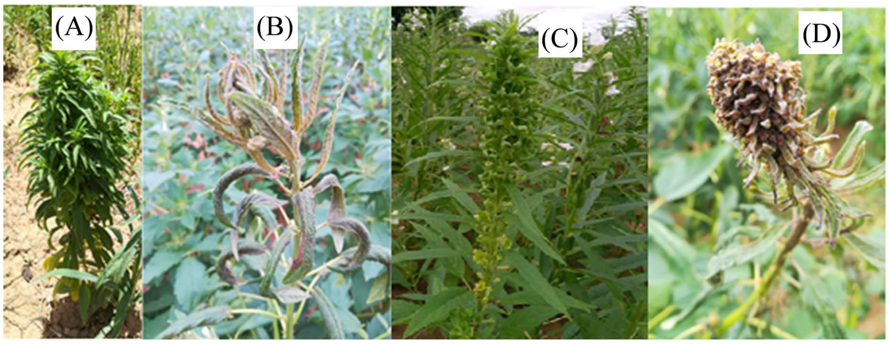

Figure 1. Symptoms of phyllody in sesame genotypes: (A) Proliferation of axillary buds due to inhibition of the terminal bud (witches' broom) with disordered leaf development, (B) depigmentation of foliage, and (C) twisted leaves closely spaced along the stem. However, the leaves on the lower part of the infected plant showed no visible symptoms. (D) Floral virescence and dark exudates appear on the floral parts of the foliage.

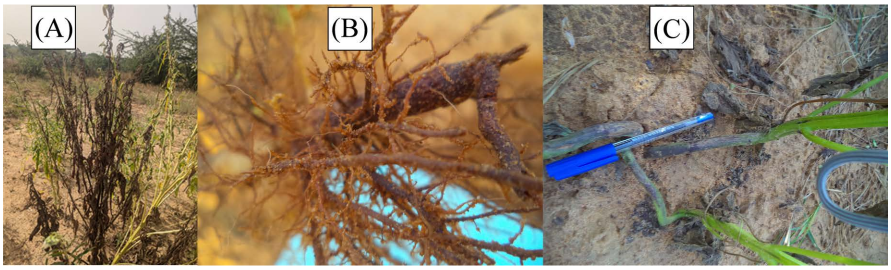

Figure 2. Symptoms of *Macrophomina phaseolina* in sesame genotypes evaluated: (A) infected sesame plant showing symptoms of rot and drying throughout the plant, (B) root of a sesame plant displaying typical symptoms of *Macrophomina phaseolina*, (C) symptoms of *Macrophomina phaseolina*, causing black spots on the basal part of the stem that gradually spread throughout the stem.

2.5. Statistical Analysis of Data

The quantitative data collected were first subjected to descriptive analysis to determine incidence frequencies by genotype. An analysis of variance was then carried out to highlight any significant differences between the sesame genotypes studied in relation to stress. Prior to this analysis, the Shapiro-Wilk test was performed to check the normality of the data. These analyses were carried out using R software version 4.1.1.

3. Results

3.1. Degree of Sensitivity of Sesame Genotypes

The results of this study show very significant variations in the resistance of the evaluated sesame genotypes to phyllody (F value = 18.51; P value = 0.000) and to *Macrophomina phaseolina* (F value = 4; P value = 0.000). The eight genotypes evaluated showed varying degrees of susceptibility to the two diseases (**Figure 3**). The least sensitive genotypes to phyllody were the HC110 mutant (1 affected plant) and the S3 accession (2 affected plants). On the other hand, regarding Macrophomina, the EF146 mutant and the control variety (VI, an imported variety) were the least susceptible (zero affected plants). The control variety was the most sensitive to phyllody.

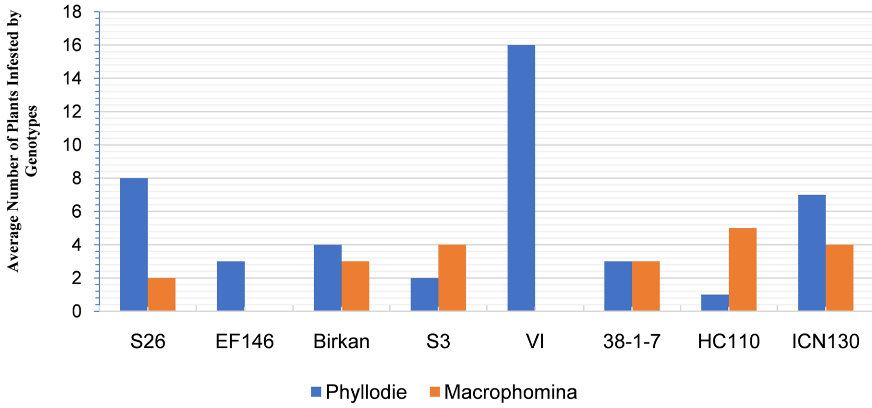

Figure 3. Sensitivity of Sesame Genotypes to Phyllody and *Macrophomina Phaseolina*.

3.2. Impact of the Two Diseases on Sesame Genotypes

For all genotypes, the incidence of phyllody disease ranged from 2.5% to 40%. The control variety (imported variety VI) and accession S26 recorded incidences of phyllody disease of 40% and 20%, respectively. The control variety (imported variety VI) had the highest incidence of phyllody (40%), while the lowest was observed in the HC110 mutant (2.5%). The overall mean incidence of phyllody was 13.75%. Genotypes EF146, Birkan, S3, 38-1-7, and HC110 proved resistant to phyllody disease as shown in **Table 2**. Genotypes S26 and ICN130 were moderately resistant to phyllody disease, while none of the genotypes were immune. The incidence of anthrax disease due to *Macrophomina phaseolina* ranged from 0% to 12.5%, with an overall mean of 6.56%. Genotype HC110 showed the highest incidence of charcoal rot (12.5%), while the lowest incidence (0%) was observed in genotypes EF146 and the control variety (imported variety VI). Genotypes IC130, Birkan, S3, 38-1-7, and S26 proved resistant to anthrax, making them potential sources of resistance for breeders in their breeding programs. Only one genotype was found to be moderately resistant to anthrax: HC110. Immunity was observed in the EF146 genotypes and the control variety (imported variety VI) (**Table 3**).

Table 2. Sesame genotype screening scale for the two diseases.

Reaction to disease	Disease incidence (%)
Immune (I)	0
Resistant (R)	1 - 10
Moderately resistant (MR)	11 - 20
Moderately susceptible (MS)	21 - 40
Susceptible (S)	41 - 40
Highly sensitive (HS)	>60

Table 3. Incidence of phyllody and Macrophomina diseases (%) in different sesame genotypes.

Genotypes	Phyllody disease		*Macrophomina phaseolina*	
	Disease incidence (%)	Disease reaction	Disease incidence (%)	Disease reaction
S26	20.00	MR	05.00	***R***
EF146	07.50	R	00.00	***I***
Birkan	10.00	R	07.50	***R***
S3	05.00	R	10.00	***R***
VI	40.00	MS	00.00	***I***
38-1-7	07.50	R	07.50	***R***
HC110	02.50	R	12.50	***MR***
ICN130	17.50	MR	10.00	***R***

I *= Immunity,* ***R*** *= Resistance,* ***MR*** *= Moderately resistant,* ***MS*** *= Moderately sensitive,* ***S*** *= Sensitive,* ***HS*** *= Highly sensitive.*

4. Discussion

The results of this study highlight significant variations in the resistance of the evaluated sesame genotypes to phyllody and *Macrophomina phaseolina*. These results align with several previous studies cited in the references while providing new perspectives for sesame varietal improvement in Niger. The HC110 mutant and the S3 accession showed remarkable resistance to phyllody, with incidences of 2.5% and 5%, respectively. These results corroborate the observations of [14] and [15], who identified phyllody-resistant genotypes under similar conditions. However, unlike some studies such as [16], which reported immune genotypes, no genotype in our study reached this level of resistance. The existence of several leafhopper species may make absolute resistance difficult to achieve. The imported variety (VI) proved moderately susceptible (40%), underlining the unsuitability of exogenous varieties, as suggested by [17] and [3]. These results confirm the importance of exploiting local genetic resources, as proposed by [18], for sustainable resistance. The performance of the HC110 mutant (2.5% incidence) and the S3 accession (5%) confirms the findings of [19], who identified resistant genotypes under epidemic conditions in India. However, unlike their study, where some genotypes showed complete immunity, our results indicate relative resistance, suggesting a possible genotype-environment interaction, as highlighted by [14]. The susceptibility of the imported variety (40%) concurs with [20]'s findings on the importance of adapting germplasm to local conditions. Genotypes EF146 and VI showed immunity (0%) to *Macrophomina phaseolina*, while HC110 was moderately resistant (12.5%). These results are comparable to those of [21] and [22], who identified immune or resistant genotypes in their studies. However, work such as that by [23] and [24] has shown that resistance to *Macrophomina phaseolina* can vary according to environmental conditions, which could explain the differences observed. This variety was developed in Nigeria, where climatic conditions are similar to those in Niger. The reasons for its immunity to *Macrophomina phaseolina* are not yet known. Quantitative genetic studies have revealed major QTLs associated with resistance (LG5, Linkage Group 5, and LG9) [25]. These regions contain candidate genes such as peroxidases, which enhance root lignification, and ABC transporters that assist in the efflux of fungal toxins. The absence of highly susceptible genotypes in our study contrasts with the observations of [26], where some genotypes showed high sensitivity. This could be attributed to the rigorous selection of local and mutant genotypes used in our trial. Local genotypes (S3, Birkan, 38-1-7) and irradiated mutants (EF146, HC110) showed promising potential for varietal improvement, confirming the findings of [27] and [28]. The effectiveness of mutagenesis in inducing disease resistance, as suggested by our results, is also supported by [29]. However, the study reveals that resistance to one disease does not necessarily guarantee resistance to another, highlighting the need for an integrated approach, as proposed by [30]. Sesame has intrinsic resistance mechanisms (phytoalexins and phloem/root reinforcement) that could be amplified through genetic selection. The integration of *Macrophomina phaseolina* resistance QTLs and phytoplasma target genes offers a promising avenue for developing multi-resistant varieties. The results of this study open up avenues for sustainable breeding programs, notably by combining the resistant genotypes identified. However, further studies are needed to assess the stability of these resistances under different agroclimatic conditions, as suggested by [31] and [32]. Moreover, the integration of innovative methods, such as biotechnology, could enhance breeding efforts, as shown by [33]. This study identifies valuable sources of resistance for sesame in Niger while highlighting the importance of multidisciplinary approaches to tackle biotic challenges in a changing Sahelian context.

5. Conclusion

This study highlights the potential of local genotypes and irradiated mutants of sesame to enhance resilience to major biotic constraints in Niger, notably phyllody and *Macrophomina phaseolina*. Results show that the HC110 mutant (2.5% incidence) and the local S3 accession (5%) display high resistance to phyllody, while the EF146 genotypes and imported variety VI are immune to *Macropho-*

mina phaseolina. However, the moderate sensitivity of imported variety VI to phyllody (40%) underlines the unsuitability of exogenous varieties for local conditions. The performance of local genotypes (S3, Birkan, 38-1-7) and mutants (HC110, EF146) confirms the importance of exploiting indigenous genetic resources and innovative approaches, such as mutagenesis, for varietal improvement. These genotypes are promising sources for sustainable breeding programs, combining disease resistance and adaptation to Sahelian climatic stresses. Nevertheless, further studies are needed to assess the stability of these resistances under various agroclimatic conditions and to explore the underlying genetic mechanisms. Involving farmers in participatory breeding strategies, as well as integrating biotechnologies, could accelerate the development of resilient varieties, thus contributing to the food and economic security of sesame producers in Niger.

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Conflicts of Interest

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

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