Pearl millet downy mildew: Prevalence and impact in farmers' fields in the Maradi Region of Niger.

Abstract:

Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is grown mainly in the arid and semi-arid regions of Africa and India. In Niger, pearl millet cultivation accounts for over 66% of the total cultivated area and constitutes 68% of total cereal production. However, its production is hampered by multiple constraints, including pearl millet downy mildew caused by *Sclerospora graminicola*. This is one of the most destructive diseases, causing losses of up to 50% in smallholder farming systems. The aim of this study is to assess the production losses caused by this disease each year in pearl millet fields in Niger. The study was carried out during the 2020 wet season, when the pearl millet was at the maturity stage. The sampling method involved randomly selecting, every ten to thirty kilometers along the national road (RN1) and secondary roads, a millet field covering an area of at least 1 hectare. Within this field, five (5) small sample plots, each comprising 12 squares, were marked out four plots at the four (4) corners of the field and a fifth plot in the center of the field. Once the plots had been marked out, data on the incidence and severity of mildew, as well as the percentage of millet ear losses due to this disease, were recorded. The incidence and severity of the disease are recorded on the 12 plots in each sub-plot; the percentage of millet ear losses is recorded on the six central plots of each sub-plot.38 smallholder fields were surveyed. With a prevalence of 100%, the incidence of the disease ranges from 6.67% to 68.33%, with an average of 32.96%, the severity of this disease ranges from 2.5% to 32.08% with an average of 15.24%, and ear losses due to this disease range from 0.89% to 39.28% with an average of 16.18%.

Keywords: Pearl millet, mildew, loss, impact, Niger

Introduction

Domesticated in West Africa over 4,000 years ago (Manning et *al*., 2011; Clotault et *al*., 2012), pearl millet [*Pennisetum glaucum* (L.) R. Br.] is grown mainly in the arid and semi-arid regions of Africa and India. The seeds are primarily used for human consumption, as fodder for livestock and in the construction of dwellings (Bashir et *al*., 2014). In Africa, pearl millet cultivation covers more than 13 million hectares and over 500 million people depend on its production for their survival (Kadidiatou, 2014). In some Sahelian countries, pearl millet accounts for over 75% of cultivated cereals (Goudia et *al*., 2016). In Niger, Africa's

second-largest pearl millet-producing country after Nigeria, cereal productionparticularly of pearl millet and sorghumsaw a significant increase in 2025 compared with previous years (MA/EL, 2025).This crop covers more than 65% of the cultivated area and accounts for over 68% of total cereal production (MA/EL, 2025). However, this production is insufficient to meet the food needs of the population due to very low yields per hectare less than 500 kg per hectare in smallholder farming (MA/EL, 2025). The low yield of pearl millet is caused not only by the gradual decline in soil fertility, the lack of fallow land and a water deficit (Zakari et *al*., 2016), but also by pressure from pests such as insects, birds and diseases (Nomaou et *al*., 2015).

Among the diseases, pearl millet downy mildew also known as pearl millet leprosy caused by a fungus called [*Sclerospora graminicola* (Sacc.) Schroet.] is the most significant disease, causing considerable damage. It is widespread in all pearl millet-producing areas of Africa and Asia, and causes yield losses of between 20 and 40% (Thakur et *al*., 2008). In some regions, crop losses due to pearl millet downy mildew can reach 50–80% (Grahame, 2014; Sudisha et *al*., 2008). The disease is characterised by the partial or total transformation of the ear into leafy growth or the complete death of the plant. Much research has been carried out on varietal resistance and control methods for pearl millet downy mildew, but few studies on the assessment of crop losses have been conducted in Niger (Karimou et *al*., 2018). This study aims to assess the impact of pearl millet downy mildew on pearl millet production in Niger. The study will be based on an assessment of pearl millet yield losses caused by *S. graminicola* attacks in smallholder farming systems in the Maradi Region.

Materials and methods

Phytosanitary surveys were carried out to assess the impact of downy mildew (*S. graminicola*) on pearl millet production in smallholder farming communities in the Maradi region of Niger. During these surveys, sampling plots were marked out in farmers' fields to estimate the incidence, severity and percentage of losses of pearl millet ears caused by the disease. The study was carried out at the millet maturity stage (physiological or full maturity).

Sampling involves randomly selecting, every ten (10 km) along the national road (RN1) and every 10 to 20 km on secondary roads, a pearl millet field of at least 1 ha in area, in a rural setting, at the maturity stage. The coordinates (latitude, longitude and altitude) of the field arerecorded. Within the field, five (5) sub-plots, each comprising 12 plots, are marked out using a W-shaped pattern (Louis et *al*., 2020), (Figure 1).

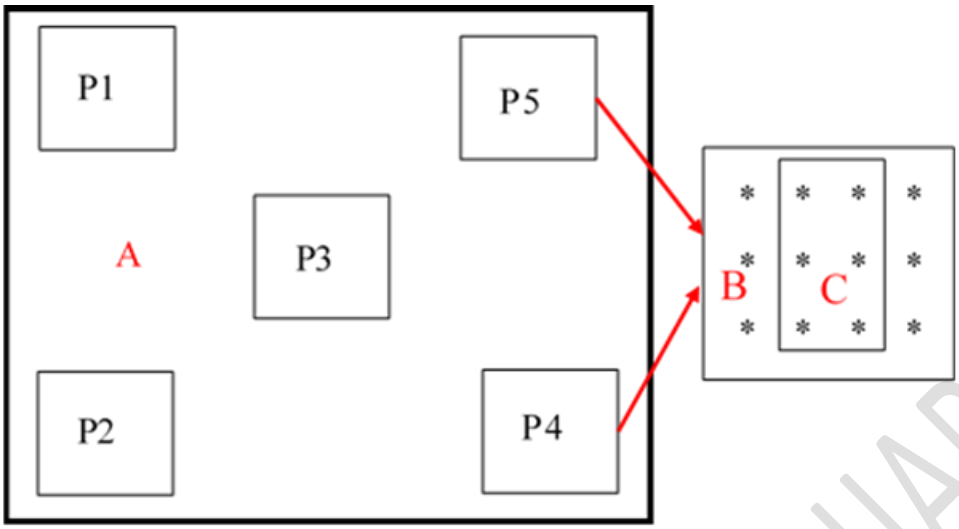

Figure 1: Diagram of a pearl millet field surveyed on a smallholder farm: (A) = millet field; P1 to P5 = test plots; (B) = test plot comprising 12 millet plants; (C) = 6-plant square for counting harvestable tillers and tillers destroyed by millet downy mildew.

In each subplot, observations on the incidence and severity of pearl millet downy mildew aremade. In addition, a percentage assessment of pearl millet ear losses was carried out on six central plots in each subplot.The incidence of pearl millet downy mildew is the percentage of plants affected by pearl millet downy mildew in a test plot. In each field, a systematic count of the total number of pearl millet plants was carried out in each plot. Among these plants, those showing symptoms of pearl millet downy mildew were counted. Using these two figures for the number of pearl millet plants, the incidence of pearl millet downy mildew was calculated using the formula below:

$$\text{Incidence (\%)} = \frac{\text{Number of plants showing symptoms of downy mildew in the plot}}{\text{Total number of plants in the plot}} \text{ x } 100$$

The severity of pearl millet downy mildew, expressed as a percentage, provides an indication of the severity of the disease outbreak in a given pearl millet field. It is rated on a severity scale ranging from 1 to 5, where 1 = no disease; 2 = a few secondary tillers affected by the disease; 3 = primary and secondary tillers affected, but less than 50% of tillers are affected; 4 = primary and secondary tillers affected, but more than 50% of tillers are affected; and finally 5 = all tillers are affected with zero yield (Figure 2).

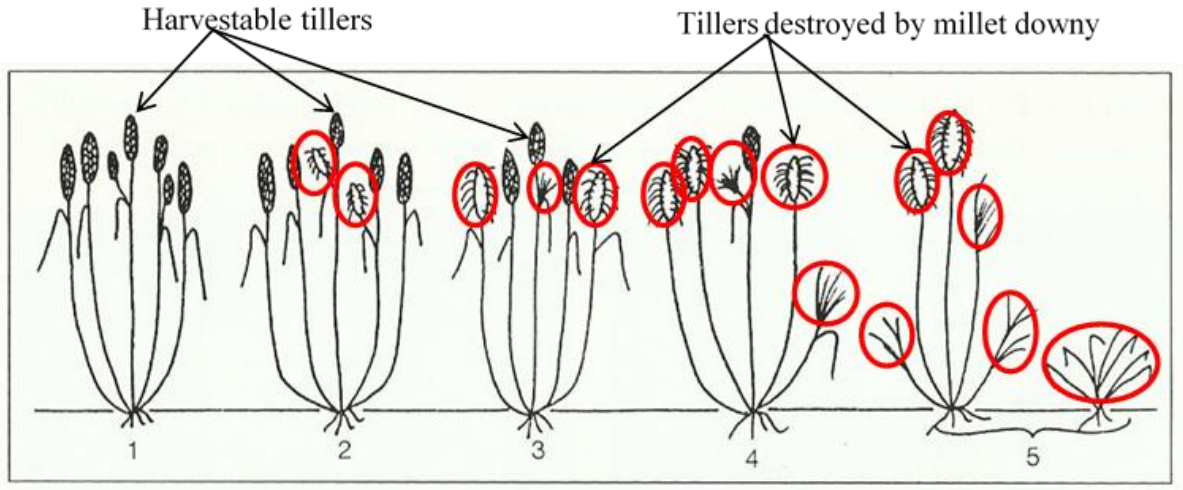

Figure 2: Diagram of the rating scale for the severity of pearl millet downy mildew (Demba, 1994)

The severity is calculated using the formula below:

$$S\ (\%) = \frac{\sum_{i=1}^{5} \mathrm{Yi(Xi-1)}}{\mathrm{N} * [\mathrm{E(Xi)-1}]} \mathrm{x}\ 100$$

S = severity
Xi = category on the scale, where i ranges from 1 to 5
Yi = number of spots corresponding to Xi
N = total number of spots in the plot
E (Xi) = range of the rating scale (5)

In each plot, a count is carried out by hill to determine the total number of harvestable tillers (those that have produced an ear) and non-harvestable tillers (those that could produce an ear if they had not been attacked by this disease). Most tiller clusters that have suffered an early attack of downy mildew (tiller clusters in category 'xi = 5') may be stunted or even die before the tillering stage. To account for these tiller clusters, the average number of tillers per cluster in a given plot is assigned to all tiller clusters in this category. The percentage of losses is calculated using the formula below:

$$\text{Ear loss}\ (\%) = \frac{\text{Number of tillers destroyed by maize downy mildew}}{\text{Total number of tillers in the plot}}\ \mathrm{x}\ 100$$

Results

Thirty-eight (38) smallholder fields were surveyed. The majority of the fields surveyed were planted with local varieties; only a few were planted with improved varieties from the National Institute for Agricultural Research of Niger (INRAN). The cropping systems used by farmers are pure pearl millet cultivation and mixed cropping, the most common combinations being pearl millet-sorghum, pearl millet-sorghum-cowpea, and pearl millet-groundnut. Table 1 presents the geographical coordinates of the surveyed village fields.

Table 1: Geographical coordinates of the surveyed village fields

Locations	**Latitude**	**Longitude**	**Location**	**Latitude**	**Longitude**
Guidan Zaga	13°44'54.7"	7°08'03"	Birnin Dafass	13°30'15"	8°8'25,2"
Gd Alkali II	13°37'33,6"	06°33'46,4	Doubawa	13°35'42,9"	8°6'23,7"
Gonar Nayahe	13°40'37,3"	06°45'13,7"	Gounaka	13°40'17,6"	8°2'59,8"
Dan Turké	13°40'25,4"	06°37'14,9"	Tessaoua	13°44'27,6"	7°59'54,6"
Kadata	13°30'51,8"	7°39'45,9"	Elkolta Tessawa	13°44'56,0"	08°04'58,9"
Guidan Karo	13°41,1'02,1"	7°01'46,7"	Rappa	13°46'58,5"	7°56'27,3"
Dare	13°46'36,9"	7°00'20,2"	Douchi	13°49'28,6"	7°52'3"
Magami	13°24'28,3"	7°33'12"	Sabon Machi	13°53,8'08,7"	6°58'44,7"
Bagué	13°28'47.7"	7°31'9"	Jaja	13°58,8'26,7"	6°58'27,4"
Tchadoua	13°32'26,9"	7°28'11,7"	Kornaka Saboua	14°02'58,3"	7°55'49,8"
Guidan Zoudi	13°36'20,5"	7°28'59,8	Kornaka	14°07'38,7"	6°53'37,7"
Mai Janguéro	13°33'02,5"	07°28'58,8"	Guidan Meli	14°11'40,6"	6°51'14,8"
Débi	13°32'53,9"	735'40,8"	Acha Bissa	14°15'40,5"	6°48'38"
Dan Kada	13°30'51,8"	7°39'45,9"	Ajé Koriya	14°20'48,2"	6°47'8,7"
Dodo	13°29'59,7'	7°43'51,5"	RDI	13°18'07,0"	7°14'29,7"
Sabon layi	13°30'51,7"	7°50'44,5"	Dan Makao	13°21'21,6"	7°12'44,1"
Mai Farou	13°31'24,6"	7°58'02,8"	Kirya	13°25'48,3"	7°09'27,1"
Koona	13°32'11,8"	8°3'40,3"	Dan Aicha	13°40'3,6"	7°29'30,3"
Dadin Sarki	13°26'01,3"	8°09'12,9"	Sherkin Haoussa	13°49'13,1"	7°33'5,9"

The results regarding the incidence of pearl millet downy mildew, the severity of the disease, and the loss of pearl millet ears due to the disease are shown in Table 2.

Table 2: Incidence (%), severity (%) and ear loss (%) in the surveyed fields

Locations	**Incidence (%)**	**Severity (%)**	Ear loss **(%)**
Guidan Zaga	41,67	27,08	39,28
Gd Alkali II	21,67	8,75	12,78
Gonar Nayahe	46,67	17,08	15,81
Dan Turké	62,42	31,25	18,93
Kadata	36,67	19,58	30,78
Guidan Karo	18,33	7,5	9,21

Dare	33,33	15,42	19,22
Magami	21,67	10	12,83
Bagué	33,33	15	14,21
Tchadoua	33,33	14,17	12,22
Guidan Zoudi	8,33	3,75	2,27
Mai Janguéro	26,67	10	12,04
Débi	31,67	12,92	17,77
Dan Kada	18,33	7,08	9,76
Dodo	40	13,33	10
Sabon layi	40	18,75	16,24
Mai Farou	30	13,33	8,16
Koona	40	24,58	22,6
Dadin Sarki	28,33	20,42	25,79
Birnin Dafass	48,33	30,83	30,13
Doubawa	36,67	20	17,91
Gounaka	10	3,33	0,89
Tessaoua	48,33	20	18,68
Elkolta Tessawa	35	14,58	10,76
Rappa	38,33	13,33	12
Douchi	28,33	10	6,09
Sabon Machi	48,33	23,75	26,45
Jaja	23,33	9,17	8,07
Kornaka Saboua	38,33	19,17	28,25
Kornaka	40	19,17	21,93
Guidan Meli	41,67	15	11,01
Acha Bissa	38,33	13,75	13,48
Ajé Koriya	68,33	32,08	33,99
RDI	20	10	15,93
Dan Makao	21,67	11,25	17,6
Kirya	6,67	2,5	6,17
Dan Aicha	28,33	12,08	16,34
Sherkin Haoussa	20	9,17	9,22
Average	**32,96**	**15,24**	**16,18**

The incidence of the disease ranges from 6.67% in a field in Kirya in the Madarounfa department south of National Road No. 1 (RN1) to 68.33% in a field in Ajé Koriya in the Dakoro department north of RN1, with an average of 32.96%. The lowest severity of pearl millet downy mildew was observed in a field in Kirya (2.5%) and the highest severity (32.08%) in a field in Ajé Koriya, with an average of 15.24% (Table 2). The percentage of ear losses due to pearl millet downy mildew ranged from 0.89% in Gounaka in the Tessaoua department south of the national road (RN1) to 39.28% in Guidan Zaga in the Guidan Roumdji department north of the RN1, with an average of 16.18% (Table 2). Twenty-five (25) fields have a downy mildew incidence between 25% and 50%, representing 66% of the fields surveyed; 8 have an incidence of downy mildew between 10% and 25%, representing 21% of the fields surveyed; 3 fields have an incidence of downy mildew between 5% and 10%, representing 8% of the surveyed fields, and 2 fields, representing 5% of the surveyed fields, have an incidence of pearl millet downy mildew between 50% and 80% (Figure 3).

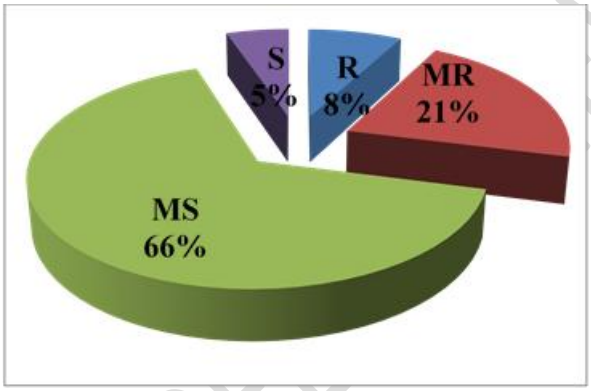

Figure 3: Response of genotypes found in the surveyed fields to attack by millet downy mildew
NB: (R) = resistant; (S) = susceptible; (MR) = moderately resistant; (MS) = moderately susceptible.

Discussion

Pearl millet [*Pennisetum glaucum* (L.) R. Br.] plays a vital role in the daily survival of the Sahelian population in general, and particularly that of Niger and its livestock. However, the cultivation of this cereal is hampered by biotic and abiotic stresses. With climate change, variations in the virulence of the fungal, bacterial and viral microorganisms responsible for the main pearl millet diseases can be observed, depending on the intensity and distribution of rainfall in space and time. Due to a lack of information on the main diseases of pearl millet, and particularly pearl millet downy mildew (Halilou, 2024) in Niger, this study was undertaken. The study showed that the disease is present in all the fields surveyed, with varying levels of infestation.These findings confirm those of Issa et *al*., (2021), who reported

the presence of pearl millet downy mildew in all pearl millet-producing fields in Niger. In this study, conducted in 2015 across the five pearl millet-producing regions of Niger, the incidence of pearl millet downy mildew ranged from 0.6% to 31.8%, with a national average of 11.12%. This study also confirms that of Pande et *al*., (1997), who reported a variability in the incidence of pearl millet downy mildew ranging from 1% to over 50% in smallholder farming systems in Niger. During the present study, the incidence of the disease was low (≤ 10%) in 8% of the surveyed fields. However, in 66% of the surveyed fields, the incidence of pearl millet downy mildew ranged between 25 and 50%; similarly, in 5% of the surveyed fields, the incidence of pearl millet downy mildew was over 50% (62.42% in the locality of Dan Turké and 68.33% in that of Ajé Koriya). The variation in disease incidence observed from the north (Ajé Koriya) to the south (Kirya) in this region can be explained by climatic conditions (humidity and temperature), as the south receives more rainfall than the north. These results are similar to those of Sharma et *al.,* (2011), who noted that out of 97 fields surveyed on farms in the districts of Uttar Pradesh, India, pearl millet downy mildew was present in 86 fields, or 89% of the surveyed fields, with an incidence ranging from 2% to 100%.

Conclusion

This study complements other research carried out in Niger on pearl millet downy mildew and provides pearl millet scientists, funding bodies and the government with a guide to the incidence of pearl millet downy mildew in the Maradi region, as well as the 'hotspots' (fields and locations with an incidence of over 50%) where this disease can be assessed to identify sources of resistance. The study revealed that pearl millet downy mildew is present in all smallholder fields in the Maradi region, with infection rates varying from one locality to another and from north to south.

Acknowledgements

The authors would like to thank all the farmers in the Maradi region whose fields were surveyed for their cooperation in ensuring the success of this study.

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