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Evaluation of fusariosis resistance in commercial onion varieties in Burkina Faso

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Abstract

Fusarium head blight is a serious fungal disease that affects various crops, including onions, in many parts of the world, including Burkina Faso. Onion varieties that have been identified as efficient in other areas may not necessarily perform well in Burkina Faso, given the particular environmental and agronomic conditions of the region. Therefore, the aim of this study was to identify onion varieties that demonstrate resistance or tolerance to *Fusarium* head blight, as well as yield high harvests, in the specific soil and climate conditions of Burkina Faso. To achieve this, seven onion varieties were evaluated during the dry season in Tabtenga, located in the commune of Loumbila. The incidence rates and the severity of *Fusarium* head blight were assessed at 35 and 75 days after transplanting. The results indicated that the varieties Noflaye, Prema 178, Rouge de Tana, and Super Yali displayed the lowest incidence of *Fusarium* head blight. However, the severity of the disease was not statistically different across all the varieties tested. Bulb yields ranged from 11.50 to 20.75 tons per hectare. This study is the first to provide data on the resistance of onion varieties to *Fusarium* head blight in the central agro-ecological zone of Burkina Faso. These findings suggest that the identified varieties may hold promise for sustainable onion production in the region. However, to confirm the results, multi-local trials should be conducted across both dry and rainy seasons.

Keywords: *Allium cepa*; Tolerant varieties; *Fusarium* head blight; Burkina Faso

1. Introduction

Onion (*Allium cepa* L.) is the most commonly produced vegetable crop in Burkina Faso [1]. As per Guissou *et al*. [2], six regions account for 80 percent of Burkina Faso's total bulb onion production, including the North (65,384 tons), Hauts-Bassins (29,968 tons), Boucle du Mouhoun (27,049 tons), Centre-West (26,725 tons), Plateau Central (22,538 tons), and Centre-Nord (21,696 tons). The onion sector provides employment to nearly 400,000 people, with 100,000 jobs held by women [3]. In 2021, the total production of fresh onions and shallots in Burkina Faso was 17859.71 tons. During the same period, the global production of these vegetables was 4562530.02 tons, with Africa contributing 1437835.75 tons [1].

Onions are a significant socio-economic crop for Burkina Faso, as they provide substantial income to producers, particularly through informal cross-border trade. The vegetable also plays a crucial role in reducing unemployment in rural areas during the dry season [2, 4, 5]. Onion cultivation in Burkina Faso faces multiple abiotic factors, such as poor water management and soil conditions that can negatively impact yields and bulb quality. Additionally, there are various phytosanitary constraints to onion production. Inventory studies have revealed that the primary fungal diseases affecting onion crops in Burkina Faso are purple spot disease caused by *Alternaria porri*, and onion basal rot or *Fusarium* head blight caused by *Fusarium oxysporum* or *F. solani* [6]. Other studies have highlighted that *Fusarium* disease due to *Fusarium sp*. can cause damage of more than 50 percent [7].

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Despite the vast land allocated for onion cultivation in various regions of Burkina Faso and the crucial role onion sales play in households' economies, farmers rely on commercial varieties from diverse sources. These varieties have been selected primarily based on their agronomic performance, organoleptic qualities, cycle, and bulb shelf life. Unfortunately, there is a dearth of information about the resistance of these varieties to existing pest problems [8]. In addition, it is important to consider the pedoclimatic parameters that affect onion cultivation. Having this information is crucial to develop effective management strategies for onion pathogens and improve productivity by identifying the varieties best adapted to the climate. This study aimed to address this knowledge gap by identifying onion varieties that are resistant or tolerant to *Fusarium* head blight and have good yields under the soil and climate conditions of Burkina Faso.

2. Material and methods

2.1. Study area

The study was carried out from October 2021 to March 2022, in the market garden area of Tabtenga, situated in the rural commune of Loumbila, Oubritenga province in the Central Plateau region (Burkina Faso). The commune of Loumbila has a Sudan-Sahelian climate, with a rainy season that alternates with a long dry season that lasts around eight to nine months [9]. Rainfall is characterized by strong interannual and spatio-temporal variability, with an average range of 600 and 800 mm, and a corresponding increase in temperature [9, 10]. The choice of of Loumbila commune as the study site was based on several factors. Firstly, the region is home to a considerable number of dams compared to other parts of the country [9]. Additionally, Loumbila has the largest area of land dedicated to onion cultivation. Finally, the commune was selected for its accessibility, which is particularly important given the current security situation in the country.

2.2. Plant material

For this study, a total of seven (07) commercial varieties of onions (Gandiol+, Noflaye, Prema 178, Rouge de Tana, Rouge Gaia, Super Yali, and Violet de Galmi,) were used as plant material. The characteristics of these varieties are detailed in Table 1. The onions were sourced from six (06) seed stores (NANKOSEM, BURKINA SEMENCES, NAFASO, PROPHYMA, BOUTAPA, EPAM.) in Ouagadougou, the capital city of Burkina Faso, during the period from August to October 2021. The selection of these varieties was based on their availability during the survey period.

2.3. Evaluation of the incidence rate of *Fusarium* head blight in the field

The experiment followed a Fischer design and comprised four (04) blocks with seven (07) individual plots of 0.5 m^2 each, resulting in a total area of 45.5 m^2. At the trial level, the disease incidence rate was determined by assessing the number of plants that displayed typical symptoms of *Fusarium* head blight in relation to the total number of plants per variety in the study area [11]:

$$DI = \frac{\sum \text{Infected plants}}{\sum \text{Observed plants}} \times 100$$

2.4. Assessment of *Fusarium* disease severity

To assess disease severity, a 0-5 rating scale was used [12]. Ten (10) plants were selected from each plot or replication, and their disease severity was rated. The disease severity index (Is) was calculated using the following formula [13, 14]:

$$Is\ (\text{in } \%) = \frac{\sum(\text{xi} \times \text{ni})}{\text{N.Z}} \times 100$$

where:

xi = severity score; **ni** = number of plants with the same severity score; **N** = total number of plants observed; **Z** = highest severity score, 5.

2.5. Evaluation of the number and average height of leaves

The number and average height of leaves were evaluated at two time points: the 35th and 75th day after transplanting (DAT). Ten (10) plants were randomly selected from each elementary plot to count the number of leaves and measure

their heights. The height measurement only involved the longest leaf of each selected plant, and it was taken using a ruler graduated in centimeters, from the base to the top of the leaf.

2.6. Bulb yield assessment

To estimate the yield of each variety, the weight of bulbs harvested from each elementary plot was measured. The yield was then calculated per hectare. A mechanical pan balance was used to weigh the harvested bulbs in kilograms (Kg).

2.7. Analysis of yield components: diameter, height, and average weight of bulbs

To determine the diameter and height of the bulbs, a foot-to-tail measurement in inches was taken for forty (40) bulbs per variety. The bulbs were randomly selected at a rate of ten (10) bulbs per elementary plot. The average weight of the bulbs was determined by measuring the 40 bulbs per variety using a precision scale. These values were used to calculate the average value of each parameter for each variety.

2.8. Statistical analysis

Raw data were processed using Microsoft Excel spreadsheet, and analysis of variance (ANOVA) was performed using XLSTAT 2016 software. The Duncan test was used for discrimination of means for each parameter evaluated at a 5% threshold.

Table 1 Characteristics of seven commercial onion varieties

Trade name	Cycle (DAT)	Commercial company	Bulb shape	Yield Potential (t/ha)	Other characteristics
Violet de Galmi	120-130	BURKINA SEMENCES	Rounded, flattened at the poles	40-45	- Resistant to root-knot nematodes; - Very early, - Very pungent taste and appreciated by consumers
Rouge de Tana	100-105	NANKOSEM	Thick dishes	***	***
Noflaye	105-110	NANKOSEM	Flattened	25-40	Bulb homogeneous in shape and size, and very good variety in conservation.
Gandiol+	110-115	NANKOSEM	Flattened globe Medium size	40-45	Homogeneous bulbs (shape, size and color) and very good aptitude for conservation.
Super Yali	95-115	PROPHYMA	Globe shaped with thin collars	***	- Good resistance to drought; - Good storage capacity - Tolerance : Mildew, purple spot, bolting and cracking
Prema178	110-120	PROPHYMA	Centered with very good uniformity in shape and size	***	Recommended for rainy season cultivation
Rouge Gaia	90-115	NANKOSEM	Spherical	***	***

DAT = Days after transplanting; *** = not detained

3. Results

3.1. *Fusarium* disease incidence rates on varieties

The incidence rates of *Fusarium* disease ranged from 0 to 5.68% at 35th DAT and from 5.68% to 32.95% at 75th DAT for the seven onion varieties evaluated (Table 2). Analysis of variance showed that there was no significant difference in the incidence rates of *Fusarium* disease among the seven onion varieties at 35th DAT. However, at 75th DAT, there was a significant difference between the incidence rates of *Fusarium* disease on the different varieties ($p = 0.013$). At 75th DAT, the highest incidence rate of *Fusarium* disease was observed in the Violet de Galmi variety (32.95%), followed by Gandiol+ with an incidence rate of 28.41%. The lowest incidence rates of *Fusarium* disease were observed in Rouge de Tana, Noflaye, Super Yali, and Prema 178 varieties with rates of 9.09%, 7.96%, 6.82%, and 5.68%, respectively.

Table 2 *Fusarium* disease incidence rates at 35th and 75th DAT

Varieties	Ri Means at the 35th DAT	Ri Means at the 75th DAT
Prema 178	0,00 a	5,68 a
Super Yali	1,14 a	6,82 a
Noflaye	1,14 a	7,96 a
Rouge de Tana	1,14 a	9,09 a
Rouge Gaia	2,27 a	18,18 ab
Grandiol+	4,55 a	28,41 b
Violet de Galmi	5,68 a	32,96 b
F	0,486	3,621
Pr > F	0,811	0,013
Significant	No	Yes

Ri= Rate of incidence. In the same column, values followed by the same letter were not statistically significant according to Duncan's test.

3.2. Severity of *Fusarium* head blight on varieties

As shown in Figure 1, there was minimal *Fusarium* head blight severity across all onion varieties at 35th DAT, and no significant differences were observed between the varieties at this time point. However, at 75th DAT, the severity of the disease varied among the varieties, ranging from 3% to 12%. Despite the variation, the analysis did not reveal any significant difference between the severity of *Fusarium* head blight across the different onion varieties at 75th DAT.

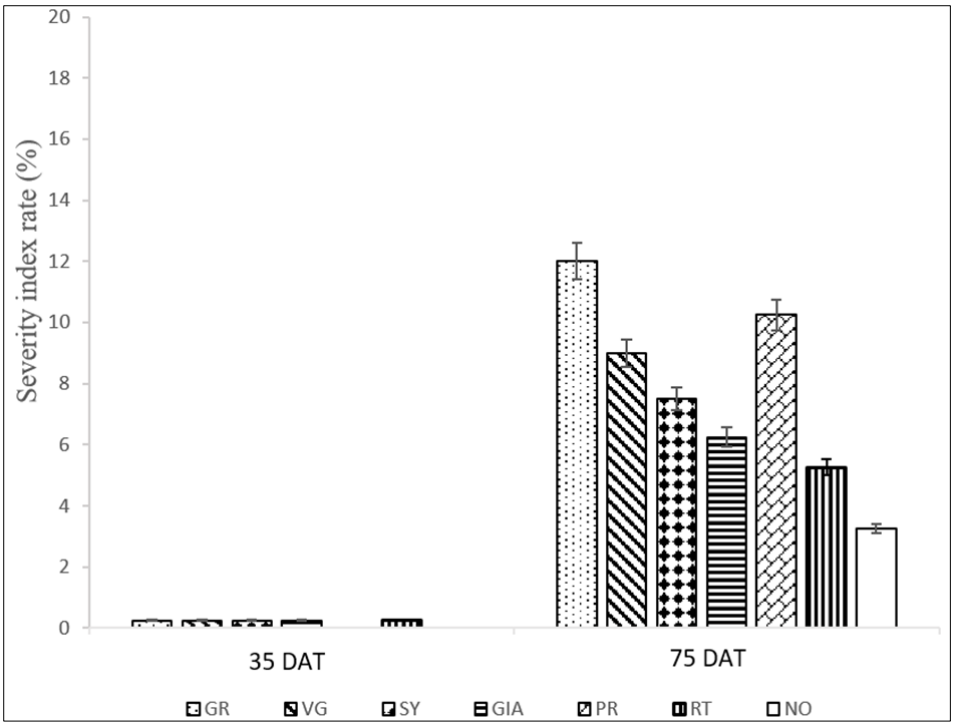


Figure 1 Severity index (Is) of *Fusarium* disease on varieties at 35th and 75th DAT

GR = Gandiol+; VG = Violet de Galmi; SY = Super Yali; GIA = Rouge Gaia; PR = Prema178; RT = Rouge de Tana; NO = Noflaye.

3.3. Number and average leaf length of varieties

Table 3 displays the mean number of leaves and mean length of leaves for each onion variety at 35th and 75th DAT. The statistical analysis of the mean number of leaves per variety showed significant differences between varieties at both 35th (p = 0.049) and 75th DAT (p = 0.010). The variety Violet de Galmi had the highest mean number of leaves at all dates, and this number was statistically the same as those obtained by the varieties Super Yali, Rouge de Tana, Rouge Gaia, and Prema178, and significantly higher than those of the varieties Noflaye and Gandiol+.

Regarding the mean length of leaves, it ranged from 31.25 cm to 37.5 cm at 35th DAT and from 40.25 cm to 44.75 cm at 75th DAT for each variety. However, the statistical analysis showed that there was no significant difference in the mean length of leaves among the different varieties at both 35th and 75th DAT.

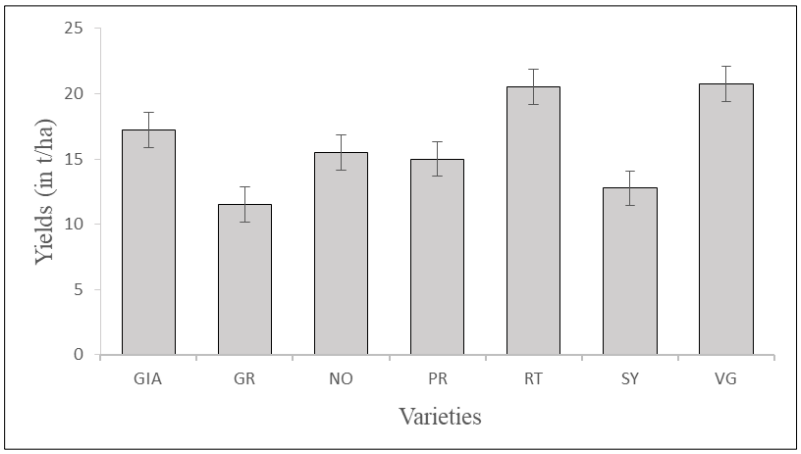
Table 3 Number and average length of leaves of varieties at 35th and 75th DAT

Varieties	NrbF 35 DAT	NrbF 75 DAT	LMF 35 DAT	LMF 75 DAT
Violet de Galmi	8,25 ac	9,00 bc	37,500 a	44,75 a
Rouge Gaia	8,00 bc	8,25 bc	32,250 a	41,00 a
Prema 178	7,25 abc	8,00 abc	33,000 a	42,50 a
Rouge de Tana	7,75 abc	8,00 abc	31,500 a	43,25 a
Grandiol+	6,75 a	7,25 ab	33,000 a	41,50 a
Super Yali	7,25 abc	8,00 abc	31,250 a	40,25 a
Noflaye	7,00 ab	7,00 a	31,250 a	41,25 a
Pr > F	0,049	0,010	0,555	0,616
Significant	Oui	Oui	Non	Non

NrbF = number of leaves; LMF = average leaf length. In the same column, values followed by the same letter were not statistically significant according to Duncan's test.

3.4. Bulb Yields of Varieties

Figure 2 displays the average bulb yields of the seven onion varieties evaluated. The analysis of variance did not reveal any significant differences between the average yields of the varieties. The average yield per hectare ranged from 11.50 t/ha to 20.75 t/ha across the varieties.



GIA= Rouge Gaia; GR= Gandiol+; NO= Noflaye; PR= Prema178; RT= Rouge de Tana; SY= Super Yali; VG= Violet de Galmi

Figure 2 Onion bulbs of yields of different varieties

3.5. Variety yield components

Table 4 presents the average values of bulb weight, diameter, and height for each onion variety. Analysis of variance showed no significant differences between the mean bulb diameters of the different varieties, which ranged from 47.64 mm to 61.62 mm. In contrast, a highly significant difference ($p = 0.002$) was found among the varieties for average bulb height, with Rouge de Tana recording the highest average height of 58.38 mm. This value was statistically equivalent to the average height of bulbs from the varieties Violet de Galmi, Rouge Gaia, and Prema178, while the lowest average height was observed for Noflaye at 47.26 mm. Average bulb weight did not show any significant differences according to analysis of variance, ranging from 67.3 g to 103.31 g across the different varieties.

Table 4 Characteristics of the bulbs of the seven varieties tested in Tabtenga

Varieties	Weight MB (en g)	DiaMB (en mm)	HmB (en mm)
Rouge de Tana	103,31 b	56,54 ab	58,38 d
Violet de Galmi	84,86 ab	61,62 b	57,30 cd
Rouge Gaia	71,29 ab	58,44 ab	53,23 bcd
Prema 178	69,30 ab	54,63 ab	55,90 cd
Noflaye	83,03 ab	48,91 a	47,26 a
Super Yali	67,30 ab	50,19 ab	50,25 ab
Grandiol+	59,88 a	47,64 a	52,22 abc
Pr > F	0,245	0,083	0,002
Significant	Non	Non	Oui

WeightMB = average bulb weight; DiaMB = average bulb diameter; HmB = average bulb height. In the same column, values followed by the same letter were not statistically significant according to Duncan's test.

4. Discussion

In the Tabtenga locality of Burkina Faso's Central Plateau region, the susceptibility of seven commercial onion varieties (Gandiol+, Noflaye, Prema 178, Rouge Gaia, Rouge de Tana, Super Yali, Violet de Galmi) to *Fusarium* head blight and

their yield parameters were assessed. It has been previously reported that *Fusarium* head blight affects onion production in various locations throughout Burkina Faso [6, 15]. The present study showed that the varieties Noflaye, Rouge de Tana, Prema 178 and Super Yali exhibited significantly lower incidences of *Fusarium* head blight compared to Gandiol+ and Violet de Galmi. However, in terms of severity, all varieties showed similar behavior towards *Fusarium* head blight in the study area, with relatively low severity rates. These results contradict the findings of Dabiré [16] who reported high severity rates of up to 79.5% and low incidence rates of 10.33% in the Débè, Gouran, and Di sites of Sourou Province, Burkina Faso. The differences in results could be attributed to the climatic variations between the study areas. Dabiré [16] conducted their research in a Sudano-Sahelian climate area with an average annual rainfall ranging from 714.4 mm to 825.35 mm and an average temperature of 28.43°C, characterized by alternating rainy and dry seasons. In contrast, the study area enjoyed a Sudan-Sahelian type of climate with an eight-month-long dry season and an average annual rainfall of 600 to 800 mm. The variations in incidence and severity rates could also be due to the different varieties evaluated in each study. Dabiré [16] assessed the resistance of eleven onion varieties against *Fusarium oxysporum* and *F. solani*, most of which were local varieties.

Noflaye and Rouge de Tana were found to have the lowest severity rates (3.25% and 5.25%, respectively) in the present study. These findings align with those of Dabiré [16], who reported that the Noflaye variety had a 0% incidence rate and severity rate at the study sites of Débè, Gouran, and Di. Conversely, Violet de Galmi and Gandiol+ had the highest incidence rates of *Fusarium* head blight in this study. According to FAO [17], Violet de Galmi is a susceptible variety to *Fusarium* head blight. Therefore, Noflaye, Rouge de Tana, Prema 178, and Super Yali varieties would be resistant or tolerant to *Fusarium* disease. The latter varieties may have resistance genes to the pathogen in their nuclear or cytoplasmic genome [18, 19].

During the period from the 35th to the 75th day after planting, significant differences in growth parameters, such as the number of leaves and leaf length, were observed among the different onion varieties. However, at harvest, the average yields obtained among the same varieties did not show significant differences, despite ranging from 11.50 t/ha to 20.75 t/ha. These results indicate that the yields obtained were below the potential yields of the varieties. In contrast, Dabiré's study [16], showed that Noflaye and Gandiol+ varieties had acceptable average yields based on the yield range indicated, although the yields varied depending on the site. These findings suggest that the climatic conditions in Burkina Faso differ across agro-ecological zones, and these conditions can influence the expression of the agronomic potential of onion varieties.

The average bulb diameter and weight of the Prema 178 and Violet de Galmi varieties were higher than those reported by Garané et *al.* [20], while those of Noflaye and Grandiol+ were lower than those reported by Dabiré [16]. These discrepancies may be attributed to differences in the cultivation period or season [20], as well as the influence of soil factors and cultivation techniques.

5. Conclusion

The screening of seven commercial onion varieties for resistance or tolerance to *Fusarium* head blight revealed that these varieties exhibited different levels of susceptibility to the disease, with Violet de Galmi and Gandiol+ being the most susceptible. On the other hand, Noflaye, Rouge de Tana, Prema 178 and Super Yali showed resistance or tolerance to the disease. Despite the differences in susceptibility, the yields of all varieties were statistically similar. These findings provided insight into how different onion varieties perform in terms of susceptibility to *Fusarium* head blight and their overall agronomic performance in a specific location within the agro-ecological zone of central Burkina Faso. However, multi-location trials are needed to further evaluate and recommend onion varieties for the region.

Compliance with ethical standards

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Disclosure of conflict of interest

Authors have declared that no conflict of interests exists.

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