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## Pathogenicity study of some seed-borne fungi of onion (*Allium cepa* L.) from Burkina Faso

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### ABSTRACT

Onion production in Burkina Faso faces to several constraints including diseases. Symptoms such as seedling damping-off are currently been observed. Most of the fungi responsible for onion diseases are seed-transmitted but in Burkina Faso, little information on onion seed quality were available. In a previous study, *Aspergillus niger*, *Fusarium oxysporum* and *Fusarium solani* were found to be the main fungi present on onion seeds but their responsibility in the development of seedlings damping-off has not been established. The overall aim of this study is to evaluate *in vitro*, the effect of these fungi on onion seed germination and coleoptile growth in order to establish this responsibility. Onion seeds were inoculated with mycelium suspension of the fungi concentrated at 13.3 g/ml and incubated for 6 days under appropriate conditions. All the tested fungal isolates had an inhibitory effect on onion seed germination at rates ranging from 31 to 60%. The *Fusarium* species were the most virulent. Coleoptile length was also reduced by the fungi, leading to significant growth time-lag at rates ranging from 34 to 100%. *Aspergillus niger* was the most virulent. In conclusion, *Aspergillus niger*, *Fusarium oxysporum* and *Fusarium solani* are responsible of seedling damping-off of onion in Burkina Faso.

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**Keywords:** *Fusarium*, *Aspergillus niger*, Coleoptile length, Violet of Galmi, Prema 178,

### INTRODUCTION

The main system for cultivating onions in Burkina Faso is to produce seedlings in the nursery from dry seeds, followed by pricking them out in the field. In such a system, the use of good quality seeds is essential in order to prevent plant diseases appearing in the fields

and ensure a good crop (Diop et al., 2019). Seed health constitute an important parameter in the certification process of seed (Lepoivre, 2003). The agricultural value of a seed lot depends largely on the presence or not of pathogenic agents in the lot (Bonzi et al., 2012b; Soura et al., 2020). Seed lots can carry

many plant pathogenic agents that can directly affect their physical quality (discoloration, deformation, rots) and their agricultural value (seedling damping-off, diseases in fields) (Mathur and Kongsdal, 2003). Many studies have highlighted the central role of plant multiplication materials (seeds, cuttings, grafts) in the prevalence of plant diseases (Mathur and Kongsdal, 2003; Zida et al., 2008; Bonzi et al., 2012a). In addition to these negative effects on the productivity of the plants, the fungi carried and transmitted by the seeds mostly produce some mycotoxins (Ikeagwulonu et al., 2020) which deteriorate the nutritive quality of foods (De Marinis et al., 2019). In Burkina Faso, vegetable seeds in general, and onion seeds in particular, are mainly imported. No information about the level of seed contamination by pathogenic agents is given on the labels or other documents accompanying these imported seeds lots. In addition, the high cost of imported seed lots has led some farmers to produce and market local seeds without adequate training in seed production and seed certification. Locally produced seeds are now being increasingly used because they are cheaper, but in many cases, their germination quality is poor (Tarpaga et al., 2011). One of the major constraints to onion production in Burkina Faso is seed rot and seedling damping-off in nurseries. According to the national statistics in 2010, about 30% of onion farmers were faced with significant seedling mortality rates in nurseries (Tarpaga, 2012). Now, seedling damping-off or seed rot is observed everywhere and then has become an urgent problem to be solved. In order to learn more about the origin of seed rot, seedling damping-off and other diseases occurring in the field, an analysis of the mycoflora in onion seeds used in Burkina Faso was conducted. The results showed that fungal pathogens in the *Aspergillus* and *Fusarium* genera were predominant in both imported and locally produced seeds (Dabiré et al., 2016). Some species, such as *Aspergillus niger*, *Fusarium oxysporum* and *Fusarium solani*, were predominant in seed samples (Dabiré et al.,

2016). These fungal species have been reported to be the cause of onion diseases in many areas, being cited in many publications as the causal agents, for example, of seedling damping-off (Özer and Köycü, 2004; Dumbré et al., 2011; Ruchi, 2012). The presence of these species in onion seeds, however, cannot be the only reason for the seed rot and seedling damping-off observed. It is important to test their capacity to cause seeds rot and/or seedling damping-off in controlled conditions in order to establish scientifically that they are the causal agents of these problems. This test is particularly important because of the close link between the pathogenic capacity of many fungal species and environmental conditions (Pariaud et al., 2009). The overall aim of this study is to evaluate *in vitro*, the effect of these fungi on onion seed germination and coleoptile growth in order to establish their responsibility in the development of seedling damping-off.

## MATERIALS AND METHODS

### Fungal isolates and isolation process

A total of nine isolates were used for the study, of which three were *A. niger* isolates, three were *F. oxysporum* isolates and three were *F. solani* isolates. The isolation process took place in 2013 and 2014 in the SY-NAIE laboratory in Bobo-Dioulasso, Burkina Faso from onion seeds and infected organs (Table 1). The naturally infected organs were initially disinfected twice with ethanol for 30 sec and then with hypochlorite of sodium (1%) for 1 min. After disinfection, the organs were rinsed three times with distilled water and dried in aseptic conditions. After drying, they were transferred to Petri dishes filled with potato dextrose agar medium (PDA) and incubated at 25 °C under a light-dark cycle (12/12 h) for 7 days. The fungal colonies obtained were purified, identified morphologically and kept in tubes containing PDA and topped with paraffin oil.

### Seed samples used

Two seed samples of two onion varieties were used: Prema 178, originating

from The Netherlands and currently being introduced into Burkina Faso; and Violet of Galmi, a variety that has been widely grown in the country for a long time. This variety is preferred by farmers because of its long shelf life (Tarpaga, 2012).

### **Inoculum preparation process**

Mycelia suspensions of the isolates, prepared at a concentration of 13.3 mg/ml, were used as inoculum. The preparation of the mycelia suspensions followed the procedure described by Brennan et al., (2003). Five fragments, each 10 mm in diameter, were placed in the margins of the fungal colony using appropriate and sterile tools, and then put into an Erlenmeyer flask containing 250 ml of potato dextrose broth (PDB) (fluid medium). The flask was incubated at 25 °C under a light-dark cycle (12/12 h) for 7 days under constant agitation. The fungal growth product in the flask was placed in a sterile 50 ml Falcon tube and centrifuged at 4,500 G for 15 min. It was then transferred onto the Whatman paper and slightly pressed in order to remove the fluid medium. Then, 532 mg of the fungal product was weighed in sterile conditions and put into a 50 ml Falcon tube containing 40 ml of sterile water as well as Tween 20 (0.2%) and homogenized in order to obtain the target concentration of 13.3 mg/ml.

### **Seed disinfection process**

The onion seeds were soaked in a hypochlorite of sodium (1%) solution and stirred for 5 min with a glass-rod. They were then rinsed three times under aseptic conditions with sterile water, each rinsing taking 20 min. After rinsing, the seeds were aseptically dried on absorbency paper.

### **Seed inoculation process**

Eight (8) ml of the mycelia suspension were poured onto a layer of moistened blotter paper that had been placed in a Petri Dish containing about 17 ml of PDA medium and covered with a second dry blotter paper. Then,

25 disinfected seeds were arranged equidistant from each other in two concentric circles, with one seed at the center of the Petri Dish (15-9-1) in aseptic conditions. The Petri dishes used as control treatments received 8 ml of PDB as a substitution for the mycelia suspension. The filled Petri dishes were incubated at 25°C under 12 h/12 h of alternating NUV and darkness for 6 days. A total of 10 treatments per seed sample were implemented with the nine isolates and the control in four replicates. The experimental design was a completely randomized block.

### **Evaluation and statistical analysis**

Six days after incubation, data on the number of germinated seeds and the coleoptile lengths were collected and analyzed. The fact that the seeds used as controls had not germinated completely indicated that there were other factors causing the non-germination of the onion seeds. In order to eliminate these factors in the data, the number of non-germinated seeds linked to the action of the fungal isolates tested was determined by subtracting the mean of the non-germinated seeds in the control treatments from the total number of non-germinated seeds in the Petri dishes of each treatment.

These data allowed the percentage of germination inhibition due to the fungi to be calculated, using this formula:

$$\text{INHIB}_{\text{fungi}} (\%) = 4 * (\text{NGNG}_{\text{trait}} - \text{NMGNG}_{\text{tem}}), \text{ Where:}$$

$\text{INHIB}_{\text{fungi}} (\%)$  = germination inhibition rate due to pathogen;

$\text{NGNG}_{\text{trait}}$  = number of non-germinated seeds in the treatment;

$\text{NMGNG}_{\text{tem}}$  = means of non-germinated seeds in the control treatments.

The means of the germination inhibition rates and those of the coleoptile lengths were compared using the Duncan multiple Range Test at the 5% level with IBM SPSS 22 software

**Table 1:** Characteristics and origins of the tested isolates.

Fungal species	Isolates Codes	Orgins	Variety	Provenance	Year of recovery
<i>Aspergillus niger</i>	An <sub>87-013</sub>	Bulbs	Violet de Galmi	Sourou/Di	2013
	An <sub>43-014</sub>	Seeds	Violet de Galmi	Sourou/Débé	2014
	An <sub>46-014</sub>	Bulbs	Violet de Galmi	Sourou/Di	2014
<i>Fusarium oxysporum</i>	Fo <sub>20-013</sub>	Bulbs	Violet de Galmi	Mogtédo	2013
	Fo <sub>27-013</sub>	Roots	Violet de Galmi	Solenzo	2013
	Fo <sub>33-013</sub>	Seeds	Prema 178	Korsimoro	2013
<i>Fusarium solani</i>	Fs <sub>18-013</sub>	Bulbs	Violet de Galmi	Ouahigouya	2013
	Fs <sub>45-013</sub>	roots	Violet de Galmi	Sourou/Débé	2013
	Fs <sub>46-013</sub>	Basale plate	Violet de Galmi	Goinré	2013

## RESULTS

### Effect of fungal isolates on seed germination

The general appearance of the Petri dishes 6 days after incubation varied, depending on the isolate used. The fungal mycelia completely covered the Petri dish or the blotter paper on which the seeds had been arranged (Figure 1). The inoculation of onion seeds with the fungi significantly reduced ( $P < 0,05$ ) the number of germinated seeds compared with the non-inoculated seeds for both tested varieties. The number of germinated seeds varied from 0 to 15 among the 25 incubated seeds, depending on variety, fungal species and isolates within a fungal species (Table 2). The percentage of seed germination inhibition varied from 31 to 60%, depending on pathogen, isolate and variety used. In general, the *F. solani* isolates produced the highest percentage of seed germination inhibition in the two tested varieties. Violet of Galmi seemed more able to resist *Fusarium* attacks than Prema 178,

whereas Prema 178 was better at resisting *Aspergillus* attacks (Table 2). Among the *F. oxysporum* isolates, Fo-27-013 was the most virulent, with germination inhibition reaching 60% for Prema 178 (no germinated seeds) and 53% for Violet of Galmi. Among the *F. solani* isolates, Fs-45-013 was the most virulent, with germination inhibition reaching 49 and 52% for Prema 178 and Violet of Galmi, respectively.

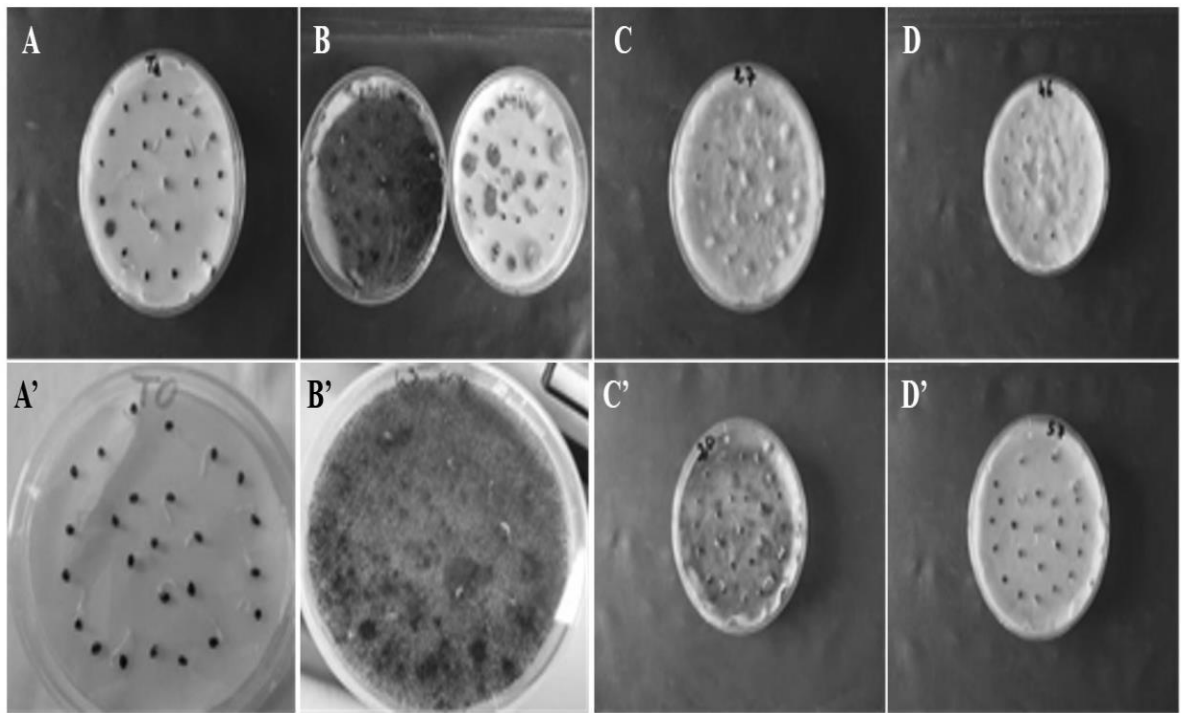
Among the *A. niger* isolates, An-43-014 was the most virulent in terms of germination inhibition, reaching 44 and 55% for Prema 178 and Violet of Galmi, respectively (Table 2). For seed germination inhibition overall, *F. solani* was the most virulent isolate (47.65%), followed by *F. oxysporum* (44.3%) and *A. niger* (42.65%). The *Fusarium* genus had a greater impact on seed germination than the *Aspergillus* genus. Overall, the germinative power of Prema 178 seeds was higher than that of Violet of Galmi.

### Effect of fungal isolates on the coleoptile length

Six days after incubation, the germinated seeds had tortuous coleoptiles with a greenish basis and pointed extremities. Non-inoculated seeds (controls) had longer coleoptiles than inoculated seeds (Figure 2).

Coleoptile length varied from 1 to 11.4 mm. Seeds of Prema 178 had longer coleoptiles than those of Violet de Galmi seeds for all the treatments, except for seeds treated with Fo-27 and Fo-33. The mean

coleoptile length of the non-inoculated seeds, considered as the reference, was 8.8 mm for Violet de Galmi and 11.4 mm for Prema 178 (Figure 3). In general, all the tested isolates negatively and significantly affected coleoptile length (Figure 3). With the exception of two *F. oxysporum* isolates, Violet de Galmi was more sensitive to the fungal actions than Prema 178. On average, the *A. niger* isolates were more virulent than the isolates of both the *Fusarium* species (Figure 3).



**Figure 1:** Photographs of seed germination.

AA': Non-inoculated seeds;  
BB': Seeds inoculated with *A. niger*;  
CC': Seeds inoculated with *F. oxysporum*;  
DD': Seeds inoculated with *F. solani*

**Table 2:** Number of germinated seeds and percentage of germination inhibition, according to treatments.

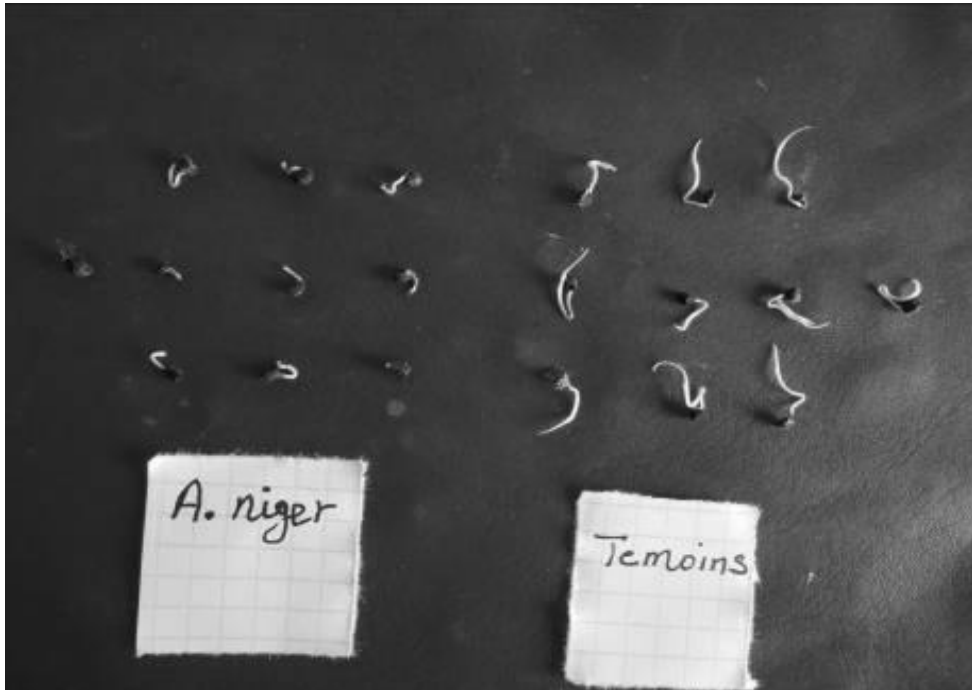
Fungal species	Treatment codes	Varieties							
		PREMA 178				VIOLET OF GALMI			
		NGS	δ	PGI	δ	NGS	δ	PGI	δ
<b>Controls</b>	<b>Cont</b>	15.0 <sup>e</sup>	±0.8	-	-	14,5 <sup>c</sup>	±3.1	-	-
	An <sub>43-014</sub>	04.0 <sup>bc</sup>	±1.2	44 <sup>bc</sup>	±4.6	00.8 <sup>a</sup>	±0.5	55 <sup>b</sup>	±02.0
<i>Aspergillus niger</i>	An <sub>46-014</sub>	02.0 <sup>ab</sup>	±1.6	52 <sup>cd</sup>	±6.5	03.0 <sup>ab</sup>	±3.4	46 <sup>ab</sup>	±13.5
	An <sub>87-014</sub>	07.3 <sup>d</sup>	±1.7	31 <sup>a</sup>	±6.8	04.5 <sup>ab</sup>	±2.9	40 <sup>ab</sup>	±11.6
<i>Fusarium oxysporum</i>	Fo <sub>20-013</sub>	06.8 <sup>cd</sup>	±2.2	33 <sup>ab</sup>	±8.9	05.5 <sup>b</sup>	±2.6	36 <sup>a</sup>	±10.6
	Fo <sub>27-013</sub>	00.0 <sup>a</sup>	±0.0	60 <sup>d</sup>	±0.0	01.3 <sup>ab</sup>	±1.3	53 <sup>b</sup>	±05.0
<i>Fusarium solani</i>	Fo <sub>33-013</sub>	04.0 <sup>bc</sup>	±2.6	44 <sup>bc</sup>	±10.3	04.5 <sup>ab</sup>	±3.7	40 <sup>ab</sup>	±14.8
	Fs <sub>18-013</sub>	04.3 <sup>bc</sup>	±2.1	43 <sup>bc</sup>	±8.3	03.8 <sup>ab</sup>	±4.1	43 <sup>ab</sup>	±16.5
<i>Fusarium solani</i>	Fs <sub>45-013</sub>	02.8 <sup>ab</sup>	±2.1	49 <sup>cd</sup>	±8.3	01.5 <sup>ab</sup>	±1.3	52 <sup>ab</sup>	±05.2
	Fs <sub>46-013</sub>	02.0 <sup>ab</sup>	±2.5	52 <sup>cd</sup>	±9.8	02.8 <sup>ab</sup>	±1.3	47 <sup>ab</sup>	±05.0
<b>F. values</b>		20.904		21.327		8.617		9.954	
<b>STAT</b>	<b>P. values</b>	0.000		0.000		0.000		0.000	
	<b>Signif.</b>	HS		HS		HS		HS	

NGS: Number of germinated seeds out of 25

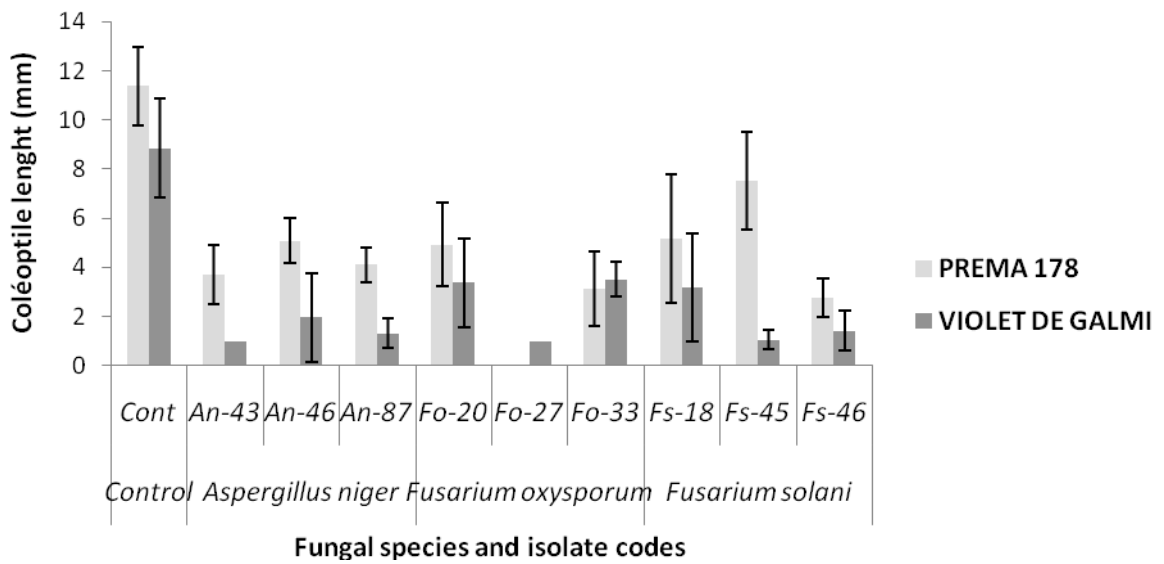
PGI: Percentage of germination inhibition (%)

Means followed by the same letter within each column are not significantly different at the 0.05 level using the Duncan range test.

HS: Highly significant



**Figure 2:** Coleoptiles of seeds inoculated with *A. niger* and coleoptiles of untreated seeds.



**Figure 3:** Coleoptile length of onion seeds 6 days after incubation (DAI), according to treatments.

## DISCUSSION

*Fusarium oxysporum* and *Fusarium solani* are widely cited as being responsible for basal rot in onion in many production areas (Smolinska and Kowalczyk, 2014; Zlata et al., 2008; Schwartz and Mohan, 2008). *Aspergillus niger* has been reported as the main causal agent of black mould in onions during bulb storage (Özer and Köycü, 2004). These fungi have also been reported to be responsible for seed rot and seedling damping-off in onion (Özer and Köycü, 2004; Taylor et al., 2013). After an analysis of the mycoflora on onion seeds used in Burkina Faso, performed at the SY-NAIE laboratory at the Polytechnic University of Bobo-Dioulasso in Burkina Faso, these three fungal species were the main ones found in onion seed samples from Burkina Faso (Dabiré et al., 2016) but their responsibility in the development of seedlings damping-off has not been established. The overall aim of this study was to evaluate *in vitro*, the effect of these fungi on onion seed germination and coleoptile growth in order to establish this responsibility. Seed inoculation with the fungal isolates showed that all the tested isolates negatively affected seed germination

and seedling development. Several authors, including Özer and Köycü (2004), Dabiré et al. (2016), have reported that *A. niger* significantly reduced seed germination and seedling damping-off in onion. *Fusarium* species are known to cause seed rot damage in tree nurseries (Zehhar et al., 2006). Dissanyake et al. (2009) reported that shallot (*Allium fistulosum*) seeds, inoculated with isolates of *F. oxysporum*, *F. solani* and *F. moniliforme*, lost their germinative power at rates ranging from 50 to 65%. A similar phenomenon was observed by Djébali et al. (2014) for wheat seeds inoculated with *F. culmorum*. The effect of *Fusarium* species on seed germination has also been reported by Zehhar et al. (2006). Özer et al. (1999) suggested that seed rot and seedling mortality caused by *A. niger* and *F. oxysporum* could be due to the abundant secretion of polygalacturonase induced by the fungi, which led rapidly to seed tissue damage and was the main cause of death. *Aspergillus niger* was the most frequent species detected in onion seeds. This fungus is ubiquitous in nature and can colonize a wide variety of substrates (Ruchi, 2012). The main source of dissemination of *A. niger* is via contaminated

seeds. It is a strong fungus and affects onion seeds so extensively that fungicide treatments are seldom efficient against it (Sinclair and Letham, 2001; Özer et al., 2009). In general, *Fusarium* species are the main cause of seed rot and seedling damping-off in many crops, but often the effects observed are the results of the actions of many fungal species (Schwartz and Mohan, 2008). *Fusarium* species abound in the soil of vegetable growing areas as chlamydospores (Schwartz and Mohan, 2008) and are the main cause of poor seedling emergence (Özer and Köycü, 2004). Their introduction into production areas is usually via seeds and agricultural tools (Schwartz and Mohan, 2008). Seeds production fields infected by basal rot produce seeds that are highly infected by *F. oxysporum* (Cramer, 2000).

The damage inflicted by *F. oxysporum* on seed germination and coleoptile length differed greatly. This finding accords with those reported by Taylor et al. (2013) who saw the same phenomenon when working with *F. oxysporum* isolates on onion seeds. A wide variation in aggressiveness among isolates of the same *Fusarium* species on onion seedlings was also observed by Palmero et al. (2012). The differences in aggressiveness among isolates of the same species were due to the use of different pathogenicity genes by each colony during seed attacks (Cuomo et al., 2007). Ramos et al. (2007) and De Vega-Bartol et al. (2011) reported finding a great quantity of a transcription factor called *ftf1* (*Fusarium* transcription factor 1) in the cytoplasm of extremely virulent *F. oxysporum* isolates. This factor seems to play an important role in the initiation and development of infection. The production level of some pectinolytic enzymes (Beugré et al., 2019) (involved in seed infection) could explain the differences in aggressiveness among *F. oxysporum* isolates (Özer et al., 2003). In general, *F. solani* isolates were more virulent than those of *F. oxysporum*. This difference could be explained by the location of the fungus on onion seed. Mathur and Kongsdal (2003)

reported that *Fusarium* species can infect seeds as spores on the surface or as mycelium inside the seed integument. Their effect on the seeds would then vary, depending on infection mode. Violet of Galmi tended to more sensitive to most of the fungal isolates than Prema 178. Özer et al. (2003) explained that for each variety-isolate interaction involving *F. oxysporum*, for example, the damage intensity depended on the nature and quantity of pectinolytic enzymes produced by the pathogen, on the one hand, and the nature and quantity of antifungal compounds produced by the variety, on the other. An interesting finding in our study was that farmers select Prema 178 (shown by our study to be the less sensitive variety) to produce onions during the rainy season, which is just when all the conditions that favor fungal diseases are present in Burkina Faso. If tolerance of these three fungal species can be achieved, this would enhance the possibility of producing good quality onion crops during the rainy season.

## Conclusion

In conclusion, our study found that *A. niger*, *F. oxysporum* and *F. solani* are pathogenic for onion seeds. They reduced seed germinative power at rates ranging from 31 to 60% for the Prema 178 variety and from 36 to 52% for the Violet of Galmi variety. They also significantly reduced coleoptile length, compared with non-inoculated seeds. *Fusarium* species had a greater effect on seed germination and *A. niger* had a greater effect on coleoptile growth. Prema 178 was found to be more tolerant than Violet of Galmi. Our study showed that seed rot and seedling damping-off in onion production nurseries in Burkina Faso could be due largely to the infection of seeds by *Aspergillus* and *Fusarium* species. These results suggest that efficient seed disinfection methods need to be devised and applied by farmers in order to prevent disease problems in onion nurseries, in the field and during bulb storage.



## COMPETING INTERESTS

The authors declare that they have no competing interests

## AUTHORS' CONTRIBUTIONS

TGD: Study design, conduct of essays, drafting of the manuscript. BFN: Performing statistical analyzes, critical reading of the manuscript. IS: Review of the manuscript. AL: Supervision of manipulations, critical reading of the manuscript.

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## REFERENCES

- Beugré MM, Konan FKY, Yapo SES, Konan EK, Kouadio JY. 2019. Effet du temps de chauffage des graines de palmier à huile (*Elaeis guineensis* Jacq.) sur quelques métabolites au cours du processus de la germination. *Int. J. Biol. Chem. Sci.*, **13**(7): 3202-3213. DOI: <https://dx.doi.org/10.4314/ijbcs.v13i7.19>
- Bonzi S, Somda I, Zida PE, Sérémé P. 2012a. *In vitro* antifungal activity of various local plant extracts in the control of *Phoma sorghina* (Sacc.) Boerema and *Colletotrichum graminicola* (Ces.) Wilson, as sorghum seed mold pathogen in Burkina Faso. *Tropicultura*, **30**(2): 103-106. DOI: <http://www.tropicultura.org/text/v30n2/103>
- Bonzi S, Somda I, Zida PE, Sereme P. 2012b. Efficacy of plant extract and effect of seed soaking duration on treatment of sorghum seed naturally infected by *Colletotrichum graminicola* and *Phoma sorghina*. *Archives of Phytopathology and Plant Protection*, **45**(12): 1405-1410. DOI: <https://doi.org/10.1080/03235408.2012.674713>
- Brennan MJ, Fagan B, Van Maanen A, Cooke BM, Doohan FM. 2003. Studies on *in vitro* growth and pathogenicity of European *Fusarium* fungi. *European Journal of Plant Pathology*, **109**: 577-587. DOI: <https://doi.org/10.1023/A:1024712415326>
- Cramer CS. 2000. Breeding and genetics of *Fusarium* basal rot resistance in onion. *Euphytica*, **115**: 159-166. DOI: <https://doi.org/10.1023/A:1004071907642>
- Cuomo CA, Güldener U, Xu J, Trail F, Turgeon BG, Pietro ADi, Ouellet T. 2007. The *Fusarium graminearum* Genome reveals a link between localized polymorphism and pathogen specialization. *Rep. M. Nature*, **317**(5843): 1400-2. DOI: <https://doi.org/10.1126/science.1143708>
- Dabiré TG, Bonzi S, Somda I and Legrève A. 2016. Identification of seed-borne fungi of onion (*Allium cepa* L.) in Burkina Faso. *International Journal of Innovation and Scientific Research*, **25**(2): 562-575. DOI: <http://www.ijisr.issr-journals.org/>
- De Marinis P, Spada A, Aristil J. 2019. Evaluation des paramètres productifs et quantification d'aflatoxine de sept variétés de maïs (*Zea mays* L.) testées en Haïti. *Int. J. Biol. Chem. Sci.*, **13**(7): 3009-3022. DOI: <https://dx.doi.org/10.4314/ijbcs.v13i7.3>
- De Vega-Bartol JJ, Martin-Dominguez R, Ramos B, Garcia-Sanchez MA, Diaz-Minguez JM. 2011. New virulence groups in *Fusarium oxysporum* f. sp. *phaseoli*: the expression of the gene coding for the transcription factor FTF1 correlates with virulence. *Phytopathology*, **101**: 470-9. DOI: <https://doi.org/10.1094/PHYTO-09-10-0252>
- Desjardins AE, Manandhar G, Plattner RD, Maragos CM, Shrestha K, McCormick

- SP. 2000. Occurrence of *Fusarium* species and mycotoxins in Nepalese Maize and Wheat and the effect traditional processing method on mycotoxin levels. *J. Agric. Food Chem.* **48**: 1377–1383. DOI: <https://doi.org/10.1021/jf991022b>
- Diop P, Sylla ES, Diatte M, Labou B, Diarra K. 2019. Effect of cut seed tubers and pre-germination on potato tuber yield. *Int. J. Biol. Chem. Sci.*, **13**(7): 3157-3163. DOI: <https://dx.doi.org/10.4314/ijbcs.v13i7.15>
- Dissanayake CM, Kashima R, Tanaka S, Ito S. 2009. Pathogenic variation and molecular characterization of *Fusarium* species isolated from wilted Welsh onion in Japan. *J. Gen. Plant. Pathol.*, **75**: 37-45. DOI: <https://doi.org/10.1007/s10327-008-0135-z>
- Djébalı N, Tiyab N, Gargouri S, Hessini K. 2014. Effet d'osmo-amorçage des grains sur la germination, la croissance du blé dur à *Fusarium culmorum*. In: Journée nationale sur la valorisation des résultats de la recherche sur les grandes cultures. Tunis le 17/04/2014. Retrieved from: [http://www.iresa.agrinet.tn/images/Djebali\\_Naceur.pdf](http://www.iresa.agrinet.tn/images/Djebali_Naceur.pdf)
- Dumbré S, Guldekar D, Potdukhe RS. 2011. Survey of seed-borne fungi of onion (*Allium cepa* L.) from various locations of MAHARASHTRA. *Journal of Soils and Crops*, **21**(2): 221-224. DOI: <https://www.cabi.org/isc/FullTextPDF/2012/20123022545.pdf>
- Ikeagwulonu RC, Onyenekwe CC, Ukibe NR, IKIM CG, Ehiaghe FA, Emeje IP, Ukibe SN. 2020. Mycotoxin contamination of herbal medications on sale in Ebonyi State, Nigeria. *Int. J. Biol. Chem. Sci.*, **14**(2): 613-625, 2020. DOI: <https://dx.doi.org/10.4314/ijbcs.v14i2.24>
- Lepoivre F. 2003. Phytopathologie: Bases moléculaires et biologiques des pathosystèmes et fondements des stratégies de lutte (edition de Boeck Université). *Presses Agronomiques de Gembloux* : Belgique.
- Mathur SB, Kongsdal O. 2003. *Common Laboratory Seed Health Testing Methods for Detecting Fungi* (1<sup>st</sup> edn). Kandrup's Bogtrkkeri Publication, Denmark.
- Özer N, Chilosi G, Magro P. 1999. Polygalacturonase production by *Aspergillus niger*: Expression in onion seeds and possible involvement in virulence. *Journal of Plant Pathology*, **81**: 17–24. DOI: <https://www.jstor.org/stable/41997937>
- Özer N, Köycü ND, Chilosi G, Pizzuolob PH, Coşkuntunaa A, Magro P. 2003: Pectolyticisoenzymes by *Fusarium oxysporum* f. sp. *cepae* and antifungal compounds in onion cultivars as a response to pathogen infection. *Canadian Journal of Plant Pathology*, **25**(3): 249-257. DOI: <https://doi.org/10.1080/07060660309507077>
- Özer N, Köycü ND. 2004. Seed-borne fungal diseases of onion and their control. In *Disease Management of Fruits and Vegetables*, Mukerji KG (ed.). Academic Publishers Kluwer: Dordrecht, 281-306.
- Özer N, Koç M, Der B. 2009. The sensitivity of *Aspergillus niger* and *Fusarium oxysporum* f. sp. *Cepae* to fungistasis in onion growing soils. *Journal of Plant Pathology*, **91**: 401-410. DOI: <https://dx.doi.org/10.4454/jpp.v91i2.970>
- Pariaud B, Ravigné V, Halkett F, Goyeau H, Carlier J, Lannou C. 2009. Aggressiveness and its role in the adaptation of plant pathogens. *Plant Pathology*, **58**: 409-424. DOI: <https://doi.org/10.1111/j.1365-3059.2009.02039.x>
- Palmero D, Miguel de Cara, Nosir W, Gálvez L, Cruz A, Woodward S, González-Jaén MT, Tello JC. 2012. *Fusarium proliferatum* isolated from garlic in Spain: identification, toxigenic potential and pathogenicity on related *Allium* species. *Phytopathologia Mediterranea*, **51**(1): 207-218. DOI:10.14601/Phytopathol\_Mediterr-10341

- Ramos B, Alves-Santos FM, Garcia-Sanchez MA, Martin Rodrigues N, Eslava AP, Diaz-Minguez JM. 2007. The gene coding for a new transcription factor (FTF1) of *Fusarium oxysporum* is only expressed during infection of common bean. *Fungal Genetics and Biology*, **44**: 864–876. DOI: <https://doi.org/10.1016/j.fgb.2007.03.003>
- Ruchi S. 2012. Pathogenicity of *Aspergillus niger* in plants. *Cibtech Journal of Microbiology*, **1**(1): 47-51. DOI: <http://www.cibtech.org/cjm.htm>
- Schwartz HF, Mohan KS. 2008. Basal rot of onion. In *Compendium of Onion and Garlic Diseases* (2nd edn), Schwartz FH, Mohan Krishna S (eds). APS Press: Minnesota; 12-14.
- Sinclair PJ, Letham DB. 2001. Incidence and sites of visible infection of *Aspergillus niger* on bulbs of two onion (*Allium cepa*) cultivars. *Aust. Plant Pathol.*, **25**: 8–11. DOI: <https://doi.org/10.1071/AP96002>
- Smolinska U, Kowalczyk W. 2014. The impact of the Brassicaceae plant materials added to the soil on the population of *Fusarium solani* (Mart.) and *Fusarium oxysporum* Schlecht. *Journal of Horticultural Research*, **22**(1): 123-129. DOI: <https://doi.org/10.2478/johr-2014-0015>
- Soura HB, Gnancadja-André SL, Zandjanakou-Tachin M, Gandonou C, Baba-Moussa FAK. 2020. Etude de l'effet de *Cercospora oryzae* Miyake sur la qualite des grains du riz et le developpement de la ternissure. *Int. J. Biol. Chem. Sci.*, **14**(2): 440-451. DOI: <https://dx.doi.org/10.4314/ijbcs.v14i2.11>
- Tarpaga, VW, Rouamba A, Tamini Z. 2011. Effects of the production season and the size of onion bulbs (*Allium cepa* L.) on their storage life at room temperature and humidity in Burkina Faso. *Agric. Biol. J.N. Am.*, **2**(7): 1072-1078. DOI: 10.5251/abjna.2011.2.7.1072.1078
- Tarpaga WV. 2012. Contribution à l'étude de la montaison prématurée des variétés tropicales d'oignon (*Allium cepa* L.): Cas du Violet de Galmi cultivé au Nord du Burkina Faso. Thèse de Doctorat de l'Université de Ouagadougou, Ouagadougou, Burkina Faso, p.118.
- Taylor A, Vagany V, Barbara DJ, Thomas B, Pink DAC, Clarkson JP. 2013. Identification of differential resistance to six *Fusarium oxysporum* f. sp. *cepae* isolates in commercial onion cultivars through the development of a rapid seedling assay. *Plant Pathology*, **62**(1): 103-111. DOI: <https://doi.org/10.1111/j.1365-3059.2012.02624.x>
- Zehhar G, Ouazzani Touhami A, Badoc A, Douira A. 2006. Effet des *Fusarium* des eaux de rizière sur la germination et la croissance des plantules de riz. *Bull. Soc. Pharm. Bordeaux*, **145**: 7-18.
- Zida PE, Séremé P, Leth V, Sankara P. 2008. Effect of aqueous extracts of *Acacia gourmaensis* A. Chev and *Eclipta alba* (L.) Hassk. on seed health, seedling vigour and grain yield of sorghum and pearl millet. *Asian Journal of Plant Pathology*, **2**(1): 40-47. DOI: <https://dx.doi.org/10.3923/ajppaj.2008.40.47>
- Zlata D, Jelena T, Stevan N, Jelica M, Mijana A, Svjetlana R. 2008. *Fusarium* rot of onion and possible use of bioproduct. *Proc. Na. Sci.*, **114**: 135-148. DOI: <http://dx.doi.org/10.2298/ZMSPN0814135K>