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STUDY OF THE FUNGAL COMPLEX RESPONSIBLE FOR ROOT ROT OF WHEAT AND BARLEY IN THE NORTH-WEST OF MOROCCO

Safaa Qostal[1], Sanae Kribel[1], Mohamed Chliyeh[1], Samira Serghat[2], KarimaSelmaoui, Amina Ouazzani Touhami[1], Hafida Zaarati[2] Rachid Benkirane[1]and Allal Douira[1*]

[1]Laboratory of Botany Biotechnology and Plant Protection, Department of Biology, Faculty of Sciences BP. 133, Ibn Tofail University, Kenitra, Morocco.

[2]Faculté des Sciences Ben M'Sik, Université Hassan II, Casablanca, Morocco.

Abstract

Surveys carried out in wheat (hard and soft) and barley fields in April-May 2017 in northwestern Morocco revealed the presence of root rot symptoms in all prospected wheat and barley plots. The detailed examination of the plants brought back to the laboratory (wheat and barley) revealed the presence of necrotic lesions or black lesions on the roots or the collar of the plants, with a very variable extent and depending on the extent of the attack. The disease has led to the appearance of ears partially or totally shriveled with pink coloring and grain with sometimes black spots. Prospected plots are widely affected with impacts ranging from 46 to 100% and disease indices, which can reach 86% in durum and soft wheat and 75.3% in barley.

The root lesions of wheat and barley also contain a variable fungal pathogenic complex, consisting of *Bipolaris sorokiniana*, *Curvularia spicifera* (= *Helminthosporium spiciferum*) and *Fusarium* species such as *Fusarium culmorum*, *F. solani*, *F. nivale*, *F. poae*, *F. oxysporum*, *F. graminearum*, *Fusarium* sp. and *F. roseum*. The isolation percentages of these species vary between 5 and 27%. *Curvularia spicifera* was isolated for the first time in Morocco from wheat and barley roots showing rot symptoms.

The isolations also made it possible to identify other saprophytic fungal species, *Penicillium* sp., *Aspergillus* sp., *Alternaria alternata*, *Alternaria* sp. and indeterminate ones. The isolation percentages of indeterminate, other than the known species responsible for the root rot of cereals, are sometimes high and vary between 3 and 68%.

Key words : Root rot, indices, incidences, *Bipolaris sorokiniana, Curvularia spicifera, Fusarium.*

Introduction

Cereal growing is the backbone of Moroccan agriculture, occupying an annual area of 5 million hectares (Nasrellah *et al.,* 2011),more than 75% of the total Agricultural area (Tahhar, 2015; Salama *et al.,* 2016). According to Tahhar (2015), durum wheat, soft wheat and barley account for 33%, 35% and 32% of total cereals (El Mourid *et al.,* 1991; Ait El Mekki, 2006) and the majority of cereal areas (90%) are located in the Bour zones (Balaghi *et al.,* 2013), with 50% in arid and semi-arid regions (200-400 mm of rainfall) (Tahhar, 2015). The sector plays a multiple role with regard to the annual sowing of arable land, the formation of the agricultural gross domestic product, employment in rural areas and the use of industrial processing capacities (Akka Ait El Mekki, 2006).

In Morocco, wheat and barley are subject to many biotic restrictions whose effects have been well documented in previous works(El Yousfi, 1984; Jlibène, 1990; Lyamani, 1988; Toufiq, 1988; and Wahbi, 1989; El Yamani, 1992; Arifi, 1995; Zidane *et al.,* 2010) including fungal diseases which cause substantial losses in both yield and grain quality, under favorable environmental conditions for the pathogen, and when the used varieties are sensitive (Ezzahiri, 2017). The development of these diseases is favored by the practiced cultural methods: early planting date, high seedling rate per hectare, excessive or insufficient manure, intensive monoculture, debris and crop residues, and susceptible varieties (Eyal

Author for correspondence : E-mail : douiraallal.com

et al., 1987). Cryptogamic diseases attacking wheat can be classified into three groups according to the symptom they induce and the affected parts of the plant (Lacroix, 2002): telluric diseases (root fetuses, root rot and foot rot), seed-borne diseases (caries, coals and ear diseases) and foliar diseases (septoria, brown rust, tanned or helminthosporium spot, powdery mildew (King *et al.,* 1982; Eyal *et al.,* 1987; Jlibene, 1990; Ezzahiri, 2017;) that destroy leaf tissue and reduce photosynthetic efficiency (Boulif, 2011).

Root rot is part of cereal crop diseases in Morocco, especially in areas of low to moderate rainfall: arid and semi-arid zones (Parry *et al.,* 1996; Smiley *et al.,* 2005; Dyer *et al.,* 2011; Evans *et al.,* 2010). They are considered to be discrete diseases that reduce the vigor of the plants and impair the functioning of roots and snares, resulting in foot losses (Lyamani, 1988; Khabouze, 1988; Mergoum, 1991;).

Symptoms of root rot occur in older plants through infection of the underground parts (Mhamdi, 2011): root, rhizome and subterranean stem tissue (El hadj Hammiche, 2013). They are due to the presence of an inoculum in the soil, infected plant debris and contaminated seeds (Gargouri *et al.,* 2001). They are caused by a fungal complex, *Bipolaris sorokiniana* (Sacc.) Shoemaker and various species of the *Fusarium* genus (Lafraoui *et al.,* 1996; Champion, 1997; Bailey *et al.,* 2004, EL Yacoubi *et al.,* 2012, Couture, 2004;), a fungal complex that varies by region (Smiley and Patterson, 1972; Hogg *et al.,* 2007). Infection with *Fusarium* species occurs first at the roots of the collar and sub-collar of diseased plants (Malalasekera *et al.,* 1973; Cook and Papendick, 1970). Hyphae develop first in conductive tissues and then in surrounding tissues (Christensen, 1922). While, infection with *Helminthosporium sorokiniana* occurs at the young tissues of the neck, the sub-collar and at the base of the stem (Specht and Rush, 1988; Tinline, 1951). These pathogens also contaminate grain seed, particularly wheat and barley, resulting in both lowering of emergence (seedling) and lower yield (Neched, 2015).

In the field, indications revealing the root rot disease (Champion, 1997; Bailey *et al.,* 2004), are the seedling melt (Cassini, 1967; Uoti, 1976b; El Yousfi, 1984; Wahbi, 1989; Boulif, 2011), the drying out of seedlings (Tinline, 1994) and the premature, unproductive spike symptom (Wiese, 1987; Bockus *et al.,* 2010). When wheat seeds, for example, are heavily infected, there are always problems in pre- or post-emergence causing early death of seedlings (Duthie and Hall, 1987). Diseased plants always show, depending on the extent of the disease, the presence of necrotic or blackish lesions on the neck, rhizome or roots (Sturz and Bernier, 1987). In severe cases, rot spreads all over the diseased plant (Cook,1968 and 1980; Wiese, 1987). Diseased plants produce white or discolored ears containing stunted grains (Sims *et al.,* 1961).

In Morocco, root rot severities of 13.4 and 14.6% were recorded in Abda and Doukkala regions (Khabouze, 1988), from 4.9 to 10.6% in those of Haouz and Rhamna (Wahbi, 1989) and from 0 to 52% in the regions of Fez and Meknes (Zaid, 1983). Root rot is therefore an important constraint for Moroccan cereal producers as they lead to significant yield losses ranging from 12 to 17%, to which must be added a drop in grain quality. (El Yousfi, 1984). And so the improvement of the national production, according to these authors, goes through the implementation of a durable and efficient strategy to control this disease by suitable methods of fight, respectful of the environment and within the reach of the Moroccan farmer.

This work proposes to study the importance and severity of root rot in wheat and barley, as well as isolation and identification of fungal species associated with this disease in northwestern Morocco.

Materials and Methods

Samplings

Surveys were carried out in different localities of North West Morocco, two trips were followed: 1- Kénitra, Sidi Yahia, Sidi Slimane, Sidi Kacem and Had Kourt and 2- Kénitra, Souk Larbaa, Larache, Belksiri and Ouazzane. Six stations containing plots of hard wheat, soft wheat and barley were selected from these locations. At each of the stations and for each type of cereal (hard wheat, soft wheat and barley), a total of 100 plants were taken diagonally from each plot of 2 to 3 hectares. The collected plants were placed in white plastic bags bearing the indications of their origin (place and date of sampling) and brought back to the laboratory.

Assessment of disease severity

In the laboratory, the root part of the plants was examined visually and the disease was evaluated according to the Greany *et al.,* (1938) who distinguished six severity classes according to the types of observed symptoms: S_0, no infection; S_1, small necrotic lesions scattered in the subarray and roots; S_2, distinct necrotic lesions on the basal part of the plant, particularly in the sub-collar and roots; S_3, large necrotic lesions on the neck, the sub-collar and the roots with decreased vigor of the plant; S_4, rots of the basal part, chlorosis of the plant, often dwarfing and wilting and S_5, dead plant.

The incidence of the disease was calculated according to the following formula: I = 100 [Nm / Nt], that is the percentage of diseased plants, Nm to total number Nt of plants examined. And the index of root rot IM = 100 Σ (Ni Si)/(5 Nt), with Ni number of plants of severity class i and Si severity class i.

Isolation and identification of fungi associated with wheat foot rot

Isolation

From samples of Wheat (durum and soft) and barley showing symptoms of root rot, fragments of 1 cm in length were cut off the collar, rhizome and root. These fragments were first washed with tap water, disinfected for 10 minutes with bleach diluted to 10%, rinsed three times with sterile distilled water and dried on sterile blotting paper. They were placed in 10 mm diameter Petri dishes containing 15 ml of PSA medium. (Potato Sucrose Agar) supplemented with 0.5 mg /1 of chloramphenicol, a broad-spectrum antibiotic to eliminate growth of bacteria. The cultures were incubated for one week under a photoperiod of 16 h at 26°C.

The purification of the isolates on the PSA medium was carried out under the same culture conditions. Successive transplants from the mycelial areas developing around the fragments used for isolation, preceded by microscopic observations, led to obtain pure cultures of fungi. Conidial suspensions are also prepared from areas growing around plant fragments and spread out, according to the perpendicular streak technique, on a solid culture medium. This technique allowed isolation of single-spore colonies 24 to 48 hours after plating and transplanting them into other Petri dishes. Sometimes some conidia developed sectors are transferred one by one under the microscope using a capillary glass tubing, previously sterilized and cooled to the flame in the agar medium (15 g d'Agar-agar, 1000 mL of distilled water), then transferred using a sterilized needle to the surface of the PSA medium. Successive subcultures preceded by microscopic observations make it possible to obtain pure cultures of fungi.

Morphological identification of isolated fungal species

The percentage of isolation (infection) and / or contamination by the different fungal species is calculated according to the method of Ponchet, (1966) which defines the frequency of isolation of different fungi from 100 lesions or 100 root rot present on the plants studied according to the equation:

$$PI = (NFI / NTF) \times 100$$

Where PI is the percentage of isolation (infection) and / or contamination; NFI is the number of feet infected by a given fungal species and NTF is the total number of studied feet.

The macroscopic examination of the cultures of the fungal species was carried out on different PSA culture media (200g of potato 15g of agar agar, 20g of sucrose), PDA (Potato Dextrose Agar: Potato Dextrose Agar-Oxoid, CM 139: 40g; Agar-agar : 5g; Distilled water: 1000 mL), MEA (Malt Extract Agar: Extrait de Malt: 20g; Agar-agar: 15g; Distilled Water: 1000mL), Yeast Malt Glucose agar (Yeast extract: 4g; Malt extract: 10g; Glucose: 4g; Agar-agar: 5g; Distilled water: 1000mL), Appearance of cultures, mycelium density, color, growth, spore production.

Microscopic examination of isolated fungal species included observation under optical microscope (× 40, × 100, × 400, × 1000) of the mycelium nature, appearance of the conidiophore, form and size of conidia, presence of conservation organs, presence of chlamydospores in crops of different isolated species. The mounting liquid used is tap water or cotton blue. Fungal species were determined using the Tivoli guide (1988), the manual of Nelson *et al.,* (1983) and the determination keys of Guilman (1957), Messiaen (1968), Messiaen *et al.,* (1968), Nelson (1983), Nelson *et al.,* (1983) and Champion (1997).

Statistical Analysis

Statistical analyzes were performed by analysis of the variance by the 5% ANOVA test.

Results

Symptoms of root rot disease were noted in all surveyed wheat and barley plots. The detailed examination of the plants brought back to the laboratory (wheat and barley) revealed the presence of blackish necrotic lesions or lesions on the roots or collar of the plants, with a very variable extent and depending on the extent of the attack. The disease has led to the appearance of ears partially or totally shriveled grains with pink coloring and sometimes black spots. Different severity class of the disease were encountered table 1, they vary from one station to another. In soft wheat, at the Ouled Sellam station, the S3 (36) and S2 (33) severity classes are the most dominant monitored in S2 (27), S3 (24) and S1 (20) hard wheat and in barley S3 (24) and S4 (20) table 1. This ranking can be reversed at the Sidi Allal Tazi station. In fact, the predominant severity classes are observed in durum wheat [S3 (32) and S2 (24)] and barley [S2 (30) and S1 (24)] followed by wheat [S2 (27) and S3 (24)].

Table 1: Severity classes of root rot disease on winter wheat and barley plants in northwestern Morocco during the 2016/2017 growing season.

Station	S0	S1	S2	S3	S4	S0	S1	S2	S3	S4	S0	S1	S2	S3	S4
OuledSellam	5±0.16	20±0.6	27±0.9	24±0.8	0000	2±0.06	12±0.4	33±1.1	36±1.2	10±0.33	10±0.33	12±0.4	12±0.4	24±0.8	20±0.67
Sidi Allal Tazi	2±0.06	18±0.6	24±0.8	32±1.06	15±0.5	3±0.1	16±0.53	27±0.9	24±0.8	20±0.67	5±0.16	24±0.8	30±1	12±0.4	0000
Ouazzane	6±0.2	6±0.2	24±0.8	20±0.67	40±1.33	14±0.46	16±0.53	12±0.4	16±0.53	0000	5±0.16	32±1.06	15±0.5	16±0.53	0000
Souk Larbaa	3±0.1	10±0.33	30±1	28±0.93	25±0.83	4±0.13	12±0.4	24±0.8	36±1.2	15±0.5	4±0.13	14±0.46	27±0.9	28±0.93	15±0.5
Souk Tlat	3±0.1	14±0.46	27±0.9	36±1.2	10±0.33	7±0.23	18±0.6	21±0.7	12±0.4	20±0.66	4±0.13	16±0.53	24±0.8	24±0.8	20±0.67
Megren	2±0.06	2±0.06	24±0.8	56±1.86	20±0.66	8±0.26	12±0.4	18±0.6	24±0.8	20±0.66	2±0.06	2±0.06	12±0.4	72±2.4	25±0.83

At the Ouazzane station, the highest severity classes are found in durum wheat S4 (40), S2 (24) and barley S1 (32). However, soft wheat showed low severity classes [S1 and S3 (16)]. At the Souk Larbaa station, the most striking severity classes are observed in durum wheat [S2 (30), S3 (28) and S4 (25)] followed by wheat and barley, respectively S2 (24), S3 (36) and S2 (27), S3 (28).

The highest severity classes are noted in barley at Souk Tlat station S2 (24), S3 (24), S4 (20), followed by soft wheat [S2 (21) and S4 (20)] and durumm wheat [S2 (27) and S3 (36)]. In the Megren station, the most dominant severity classes are observed in durum wheat [S2 (24), S3 (56) and S4 (20)], barley [S3 (72) and S4 (25)] and soft wheat [S3 (24) and S4 (20)].

The S4 severity class has not been observed in barley growing at the Sidi Allal Tazi and Ouazzane stations and in durum wheat at Oulad Sellam station. Similarly, the Megren station is the most infective followed by those of Souk Tlat and Souk Larbaa. Ouazzane station remains the least infected station. Durum wheat is the most susceptible to root rot attacks, while soft wheat has been susceptible to attacks, barley is moderately susceptible.

The incidence and index of the disease varies significantly according to the stations and studied species (Table 2, Appendix 2). All stations are infected and have high of the disease incidences. They vary in durum wheat between 93.3 and 80%, respectively at the Sidi Allal Tazi and Megren stations and the Ouazzane station. They fluctuate in soft wheat between 93.3 and 53.3% respectively at the Oulad Sellam and Ouazzane stations. In barley, the incidences are lower and vary between 93 and 66.6% respectively at the Megren and Oulad Sellam stations.

The disease index varies between 20 and 86% and is highest in durum wheat at the Sidi Alla Tazi station (86%) and in soft wheat at Souk larbaa station (86%). While barley showed moderately high disease indices at all stations, they ranged from 75.3 to 20%, respectively at the Megren and Oulad Sellam stations.

The study of wheat (durum wheat and soft) roots and barley showing symptoms of decay showed the presence of approximately the same mycoflora table 3. Thus, the main identified fungal taxa in both species are: *Bipolaris sorokiniana, Curvularia spicifera*, *Fusarium solani, F. oxysporum, F.graminearum, F. roseum, Fusarium* sp., and *F. poae, Alternaria alternata, Trichoderma* sp. and *Penicillium* sp. A fungal complex of three, four, five or six of these species is isolated from the roots of the same foot (wheat or barley). In fact, three to four species considered pathogenic can be found on the roots of the same plant, cases have been observed: *Bipolaris sorokiniana is isolated either with two species of Fusarium or with Curvularia spicifera and two species of the Fusarium genus.*

Curvularia spicifera, an encountered species for the first time in Morocco on roots showing symptoms of root rot was isolated from the roots of a single foot of wheat or barley with two or three *Fusarium* species. In other cases only two or three species of the *Fusarium* genus have been isolated from root rot.

In durum wheat, the percentage of isolation of *Bipolaris sorokiniana*, the highest is 20% and was observed at the Sidi Allal Tazi station and the Souk Tlat station. This species has been encountered in four stations: Sidi Allal Tazi, Souk Larbaa, Souk Tlat and Megren, in association with different species of the *Fusarium* genus. In the Sidi Allal Tazi resort, Bipolaris sorokiniana is associated with *F. oxysporum* and *F. solani*. At the Souk Larbaa station, it was isolated in the presence of *F. graminearum, F. solani* and *F. culmorum.* At the Souk Tlat station, it is associated with *F. poae, F. nivale* and *Fusarium* sp. In the Megren station, *F. graminearum* and *F. culmorum* are among the fungal complex of *Bipolarissorokiniana*.

Table 2 : Incidence (%) and Index (%) of root rot in durum wheat, soft wheat and barley during the 2016/2017 crop year.

Station	Durum wheat		Soft wheat		Barley	
	Incidence I (%)	Disease index DI (%)	Incidence I(%)	Disease index DI (%)	Incidence I (%)	Disease index DI (%)
OuledSellam	83.3[c]	54[c]	93.3[a]	62[b]	66.6[c]	20[d]
Sidi Allal Tazi	93.3[a]	86[a]	90[a]	60[b]	83.3[b]	47.3[c]
Ouazzane	80[c]	64[b]	53.3[d]	38.6[d]	83.3[b]	45.3[c]
Souk Larbaa	90[a]	64[b]	86,6[b]	86[a]	86.6[b]	58.6[b]
Souk Tlat	86.6[b]	58.6[c]	76.6[c]	52[c]	90[a]	60[b]
Megren	93.3[a]	69.3[b]	73.3[c]	54.6[c]	93.3[a]	75.3[a]

The percentages of isolation of *Fusarium* vary between 7%, case of *Fusarium* sp. At the Ouazzane station, and 30%, case of *F. culmorum* (Megren station), *F. solani* and *F. oxysporum* (Station of Sidi Allal Tazi). At the Oulad Sellam and Ouazzane stations, the diseased roots of durum wheat plants harbor a *Fusarium* complex consisting of *F. culmorum* and *F. graminearum* (Oulad Sellam station) and *F. nivale* and *Fusarium* sp. (Ouazzane Station).

In soft wheat, Bipolaris sorokiniana was isolated from diseased roots in the presence of other species of the genus *Fusarium*: F. *solani, F. oxysporum, F. graminearum, F. roseum, Fusarium* sp., and *F. poae.* The percentages of isolation of Bipolaris sorokiniana oscillate between 10% (Oulad Sellam station and Souk Larbaa saturation) and 20% (Megren station). On the other hand, the percentages of *Curvularia spicifera* isolation from the diseased soft wheat roots reached 22% at the Souk Tlat station.

Bipolaris sorokiniana was isolated from soft wheat in the Souk Larbaa station in the presence of *H. spiciferum* and *F. oxysporum. At the Megren station*, the isolated fungal complex consists of *Bipolaris sorokiniana, Fusarium oxysporum* and *F. solani*. At the Oulad Sellam station, the fungal complex is composed of *Bipolaris sorokiniana*, *Curvularia spicifera*, *Fusarium solani* and *F. oxysporum*. In the Sidi Allal Tazi resort, *Bipolaris sorokiniana* is associated with *Curvularia spicifera*, *F. oxysporum* and *F. graminearum.*

The percentages of isolation from the roots of durum wheat are variable among representatives of the *Fusarium* genus. The highest percentage of isolation (23%) was noted in *F. oxysporum* (Megren) and lowest in *Fusarium* sp. (Ouazzane Station). At the Megren, Souk Tlat and Ouazzane stations only one *Fusarium* complex has been isolated. This complex consists of *F. roseum*, *Fusarium* sp. and *F. oxysporum* at the Megren station, *F. solani* and *F. poae* at Souk Tlat station and *F. roseum*, *F. oxysporum* and *Fusarium* sp. At the Ouazzane station.

The diseased roots of barley also harbor a diverse fungal complex consisting of *Bipolaris sorokiniana*, *Curvularia spicifera*, *F. solani*, *F. nivale*, *F. poae*, F. *oxysporum, F. graminearum* and *Fusarium* sp. The percentages of isolation of *Fusarium* species, vary between 2%, case of *Fusarium* sp. At the Ouazzane station, and 22%, case of *F. oxysporum* at the Megren station. At the Megren station, the fungal complex encountered consists only of species of the *Fusarium* genus: *F. graminearum*, *F. solani* and *F. oxysporum.*

The highest percentage of isolation of *Bipolaris sorokiniana* from barley roots is 25% at the Oulad Sellam station and the lowest (10%) at the Ouazzane and Souk Tlat stations. The percentages of isolation of *Curvularia spicifera* oscillate between 2% (Ouazzane station) and 18% (Oulad Sellam station).

At the Ouled Sellam station, *Bipolaris sorokiniana*, *Curvularia spicifera* were encountered in the presence of *F. solani* and *F. graminearum*. At the Ouazzane station, these *Helminthosporium* were observed in association with *Fusarium* sp., *F. oxysporum* and *F. solani*. In the other stations investigated, *Curvularia spicifera* was not isolated from the diseased roots of barley, but *Bipolaris sorokiniana* has been encountered with a variable Fusarian complex from one station to another. At the Souk Larbaa station, *Bipolaris sorokiniana* was isolated in the presence of *F. solani* and *F. nivale* and at the Souk Tlat station, in the presence of *F. oxysporum* and *F. solani*.

At the Sidi Allal Tazi station, *Bipolaris sorokiniana* was not isolated from the diseased roots of barley and it is *Curvularia spicifera* (16%) which could form an association with *F. nivale* and *F. graminearum.* At the Ouazzane station, *H. spiciferum* is associated with *Fusarium* sp., *F. oxysporum* and *F. solani.*

A complete description of the characteristics of the different species of *Bipolaris sorokiniana*, *Curvularia spicifera*, *Fusarium* found on wheat and barley.

Table 3: Percentage Isolation (PI) and / or Infection of Different Fungal Species from Wheat Roots (Durum and Wheat) and Barley (2016/2017 Crop Year).

	Durum wheat		Soft wheat		Barley	
	Species	**PI %**	**Species**	**PI %**	**Species**	**PI %**
OuledSellam	*Fusarium culmorum*	15%	*Alternaria alternata*	30%	*Fusarium solani*	15%
	Fusarium graminearum	22%	*Aspergillus*	10%	*Fusarium graminearum*	10%
	Trichoderma sp.	8%	*Bipolaris sorokiniana*	10%	*Curvularia spicifera*	18%
	Penicillium sp.	8%	*Curvularia spicifera*	06%	*Bipolaris sorokiniana*	25%
			Fusarium solani	20%		
			Fusarium oxysporum	15%		
	Indeterminate	47%	Indeterminate	9%	Indeterminate	32%
Sidi Allal Tazi	*Fusarium solani*	30%	*Fusariumo xysporum*	20%	*Curvularia spicifera*	16%
	Fusarium oxysporum	30%	*Fusarium graminearum*	15%	*Fusarium nivale*	10%
	Bipolaris sorokiniana	20%	*Curvularia spicifera*	7%	*Aspergillus sp*	3%
	*Trichoderma*sp.	10%	*Bipolaris sorokiniana*	15%	*Alternaria alternata*	7%
	Aspergillus sp.	7%	*Trichoderma*sp.	4%	*Fusarium graminearum*	6%
	Indéterminés	3%	Indéterminés	39%	Indéterminés	58%
Ouazzane	*Alternaria alternata*	15%	*Fusarium roseum*	10%	*Fusarium*sp.	2%
	Aspergillus sp.	10%	*Fusarium* sp.	8%	*Fusariumo xysporum*	15%
	Fusarium nivale	9%	*Fusarium oxysporum*	12%	*Fusarium solani*	19%
	*Fusarium*sp.	7%	*Alternaria* sp.	2%	*Curvularia spicifera*	2%
					Bipolris sorokiniana	10%
					Aspergillus sp	10%
	Indeterminate	59%	Indeterminate	68%	Indeterminate	58%
Souk Larbaa	*Bipolaris sorokiniana*	7%	*Aspergillus*sp.	10%	*Bipolaris sorokiniana*	10%
	Fusarium graminearum	8%	*Alternaria*sp.	12%	*Fusarium solani*	15%
	Aspergillus sp.	7%	*Curvularia spicifera*	22%	*Fusarium nivale*	6%
	Trichoderma sp.	10%	*Bipolaris sorokiniana*	10%	*Aspergillus* sp.	15%
	Fusarium culmorum	16%	*Fusarium oxysporum*	25%		
	Fusarium solani	24%				
	Indeterminate	28%	Indeterminate	21%	Indeterminate	54%
Souk Tlat	*Bipolaris sorokiniana*	20%	*Alternaria alternata*	26%	*Fusarium poae*	15%
	Fusarium poae	15%	*Aspergillus* sp.	10%	*Fusarium solani*	20%
	Fusarium nivale	15%	*Fusarium solani*	9%	*Fusarium oxysporum*	16%
	Fusarium sp.	10%	*Fusarium poae*	11%	*Bipolaris sorokiniana*	20%
			Trichoderma sp.	3%		
	Indeterminate	40%	Indeterminate	41%	Indeterminate	29%
Megren	*Fusarium graminearum*	19%	*Fusarium solani*	19%	*Fusarium graminearum*	20%
	Fusarium culmorum	27%	*Fusarium oxysporum*	23%	*Fusarium oxysporum*	22%
	Aspergillus sp.	10%	*Alternaria alternata*	15%	*Fusarium solani*	15%
	Rhizopus sp.	4%	*Bipolaris sorokiniana*	20%	*Alternaria alternata*	14%
	Penicillium sp.	8%			*Rhizopus* sp.	4%
	Bipolaris sorokiniana	15%			*Penicillim* sp.	7%
	Curvularia spicifera	5%			*Aspergillus* sp.	5%
	Indeterminate	12%	Indeterminate	23%	Indeterminate	13%

Bipolaris sorokiniana (Sacc.) Shoemaker

Bipolaris sorokiniana colonies are dark green to blackish, brownish, sometimes dark in the center and clear to the periphery. Under a microscope, the mycelium is septate and greyish in color. Conidiophores are simple, partitioned, olivaceous, and paler at the top, brownish, alone or grouped (2 to 4). They are branched, irregular branching, bear many conidia (1 to 6), light brown to dark brown or olive brown, black, thick-walled, sometimes straight or curved, elliptic to ovoid, wider near the middle, with tapered base (hilum). Conidia (46-100 × 6-14 µm), multicellular, are black, dark brown, smooth, straight or slightly curved, with distinct transverse septa (3 to 10 septa). The germination of conidia is bipolar axial, bipolar perpendicular to the base, sometimes absent at the top, often 2-3 germinal tubes are observed at the basal cell level. This description is identical to that given by Rieuf and Teasca (1973) and Berber *et al*., (2008).

-Curvularia spicifera *(= Helminthosporium spiciferum* (Bainier) Nicot, syn. *Bipolaris spicifera*, Forme parfaite: *Cochliobolus spicifer*).

Curvularia spicifera has never been isolated in Morocco from the roots of wheat and barley. As a result, the description of this species is necessary. Colonies of this species show more or less rapid growth and are gray to blackish brown in color. The mycelium is septate grayish, olive brown. Conidiophores are solitary or in small groups, with cords, repeatedly geniculate, brown to black. Conidia, 2 to 4 cells, are golden-brown, olive-brown, and smooth. They are straight or cylindrical, rounded at the ends, and measure 16, 65- 26.64µm × 6.66 - 9.99 µm; some conidia may have a slight curvature. This description is identical to those given by Ellis (1971), Nelson (1983), Zillinsky (1983), Ennaffah *et al.*(1997), Drider *et al.,* (2011), Kachkouch *et al.,* (2011) and Kumar *et al.,* (2002).

Identification of *Fusarium* species is difficult because of large variations in morphological and cultural traits, such as colony morphology, pigmentation, growth rate, presence or absence of macro and/or microconidia and their form, presence or absence of chlamydospores, presence or absence of sclerotia.

Distinctive characteristics of the main species of *Fusarium* encountered on seeds (Messiaen, 1968 and Cassini, 1970).

Fusarium ***oxysporum***

Colonies of *Fusarium oxysporum* Schltdl (1824) show slow growth. The aerial mycelium is abundant and white in color. When chlamydospores are abundant, the mycelium becomes violet or blue, but becomes yellowish brown when the sporodochies are abundant. The microconidia (4.5-5.5µm×1.5-2.5 µm) are generally abundant, ellipsoid, borne by simple and short phialides or on a trendy conidiophore. They are never formed into chains, usually unicellular, ellipsoid to cylindrical, straight or curved. Macroconidia vary in size (13-20 microns × 2-3 microns), spindle-shaped, lightly curvées or arcuate, pointed at the ends. Basal cells are pedicellate, 3 (5) septa, 27 to 46 × 3 to 4.5 µm. Chlamydospores, subglobose, are terminal or intercalated on the mycelium, smooth-walled or rough-walled hyaline, and 5 to 15 µm in diameter. These descriptions are identical to those given by Meddah *et al.,* (2010), Mouden *et al.,* (2013)

Fusarium ***solani* (Mart.) Sacc. 1881.**

Fusarium solani is characterized in isolation medium by mycelium, colonies often powdery appearance and homogeneous pigmentation, even on young colonies, dark purple color. On PSA medium, *F. solani* forms fluffy or cottony colonies of white to creamy color. The growth of the colonies is slow, with a regular periphery. Microconidia, scanty, with a single ovoid cell. The macroconidia, partitioned from 3 to 5 septa, are elongated, not sufficiently curved, with very rounded ends, often in chain on the mycelium, with very characteristic double walls. Chlamydospores, spores of resistance, are in terminal or intermediate position, solitary (7.3 µm) or in pairs of 8 to 10.6 µm in length, abundant, with smooth wall. These descriptions are consistent with those of Chermette and Bussieras (1993) and Chliyeh *et al.,* (2017).

Fusarium ***graminearum***

F. graminearum colonies are usually red to purple, sometimes becoming vinous brown. Mycelium differentiates only macroconidia, microconidia are absent. The macroconidia, hyaline, are fusiform, curved, septate, terminal cell, pointed, weakly elongated and strongly curved near the tip. Macroconidia measure between 3 and 6 µm and have three to seven septa. Chlamydospores are rare, intercalated or terminal, globose, hyaline to pale brown. The basal cell of macroconidia is elongate, tapered and slightly curved. This description is consistent with that described by Messiaen *et al*., (1996)

Fusarium ***culmorum***

The colonies of *F. culmorum* are yellow or pink then ocher to red-brown. Growth is rapid on PSA media and aerial mycelium is loose. Phialides, formed on aerial mycelium or grouped in sporodochia, are short and broad. Macroconidia, generally between 4 and 8 µm, are fusiform, curved, and septate, with short apical cells and pointed, pedicellate at the base, with three to five clearly differentiated septa. Microconidia are absent. Chlamydospores are intermediate or terminal, subglobose, brownish, smooth or warty. This description is identical to that given by Nelson *et al.,* (1983).

Fusarium ***poae***

On PDA media, *F. poae* colonies are whitish, pinkish, with dense aerial mycelium. Older colonies are brownish reddish as the culture ages. The reverse of the colonies is whitish or reddish yellow. The fungus develops short clusters of branched and unbranched monophialides (5-18 μm). Microconidia are abundant, globose or ovate to pear-shaped, 0-1 septate, 5-10 × 5-8 μm. Macroconidia are rare, typically sickle-shaped, 2-5 septate, 18-38 × 3.5-7 μm and have a foot-shaped basal cell.

Fusarium ***nivale***

Fusarium nivale has yellowish-white colonies. The aerial mycelium is scanty, sometimes short. Microconidia are absent. The macroconidia, hyaline, are present, small, curved, sickle-shaped, thinned at both ends, and not clearly pedicelled at the base. The apical cell is more pointed than the basal cell. Macroconidia have 1 to 3 septa and measure 8.32 - 13.32 μm × 1.66 - 4.99 μm.

Fusarium ***roseum*** **(Link) Snyd and Hansen**

Fusarium roseum exhibits colonies characterized by white mycelium, sometimes very loose. Sporodochia are pink in color, giving the colony a pinkish color over time. Les microconidies sont absentes. Macroconidia (17-20 μm × 2-3μm) are short, with angular ends. Abundant chlamydospores in some isolates, this description is identical to that noted by Tivoli (1988).

Alternaria alternata**(Fr.) Keissl., 1912**

The colonies of *Alternaria alternata* (Fr.) Keissl 1912 are black to brown, sometimes black olive. Conidiophores are solitary or forming small groups, single or branched, droits ou flexibles, souvent géniculés, de couleur olivâtre à brun doré. Les conidies se forment en longueur, souvent branchées en chaîne, ovoïdes ou elliptiques, de couleur pâle à brun doré, lisses ou verruqueuses, mesurant 24-38 × 7- 14 μm avec 1 à 8 cloisons transversales, généralement longitudinales ou obliques. Cette description est identique à celle donnée par Berber *et al.,* (2008).

Discussion and Conclusion

Wheat root rot disease is present in all areas surveyed in the northwestern region of Morocco. The incidences, calculated for durum wheat, soft wheat and barley, varying between 93.3% and 80%, 93.3% and 53.3% and 93% and 66.6% respectively. These impacts are as important as those recorded in previous surveys in the same region (Lafraoui, 1997; El Yacoubi *et al.,* 2012) or in other parts of Morocco (Zaid, 1983; El Yousfi, 1984).

Disease indices, which can reach 86% in durum wheat and soft wheat and 75.3% in barley at some of the surveyed sites, are much higher than those recorded in the same region (10 to 56%) in 2012, in durum wheat (Yacoubi *et al.,* 2012), and 7.2 and 10.8% in the west central region (Lyamani, 1988). According to Yacoubi *et al.,* (2012), the high incidence and index of root rot are related to climatic conditions. The frequency of each species depends on the conditions of humidity and temperature favorable to its development (Anahosur 1992). According to Cook (1981), Paulitz *et al.,* (2002) and Smiley *et al.,* (1972 et 2005), the infection is favored by moisture conditions shortly after sowing and the severity of the disease increases and yield reductions become significant when the infected plants are under water stress, favored by stress associated with hot, dry soil, and / or high temperatures at the end of growth.

The pathogenic fungal complex responsible for root rot is variable and several species can be isolated from the roots of a single foot of wheat or barley. *Bipolaris sorokiniana,* for example, has been encountered with one or two *Fusarium* species. To this association, sometimes added *H. spiciferum,* species encountered for the first time in Morocco at the roots of wheat or barley showing the symptoms of rot. Sometimes H. spiciferum is isolated with only *Fusarium* species. In other cases, two or three *Fusarium* species are isolated from the same plant. Smiley *et al.*, (2005a) reported that fungal complex pathogens responsible for root rot may appear in isolation, but they often exist in the same fields and even inside individual plants. This complex is dominated by various pathogens according to the different growing areas (Paulitz *et al.,* 2002). According to Wiese (1987), and Tinline (1994) and Piccinni (2000), the *Bipolaris sorokiniana- Fusarium* complex dominates in arid or semi-arid zones. In other studies, root rot is caused by *Bipolaris sorokiniana* (Rush, 1990), *F. culmorum* and sometimes with *F. avenaceum* (Sturz and Bernier, 1987), *F. graminearum* (Uoti, 1976b) and *F. crookxellense* (Wiese, 1987).

Among the species of the fungal complex isolated from the diseased roots of wheat or barley growing in the prospected stations, *Bipolaris sorokiniana*, *H. spiciferum* and *Fusarium* species such as *Fusarium culmorum* and *F. solani*, *F. nivale*, *F. poae*, *F.oxysporum*, *F. graminearum*, *Fusarium* sp. and *F. roseum.* Lafraoui (1997) noted, between 1993 and 1995, that infection rates of wheat and barley roots by *H. sativum* in northwestern Morocco are frequently higher than those induced by *Fusarium culmorum, F.graminearum* and *F. avenaceum*. El Yacoubi *et al.* reported in 2012 that the most frequently isolated fungi from wheat plots in northwestern Morocco are *Cochliobolus sativus*, *Fusarium culmorum*, *F. graminearum*, *F. oxysporum*, *F.moniliforme*, *F. solani* and *F. equiseti.* Lyamani, in 1988 noted that the fungi most associated with the symptoms of root rot in Morocco were *Helminthosporium sativum*, *Fusarium equiseti*, *F. culmorum*, *F. oxysporum* and *F. solani*.

Root rot can also be induced by telluric fungi, bacteria, nematodes, or viruses, but most studies of these diseases have focused on *Bipolaris sorokiniana,* and *Fusarium* species such as *Fusarium culmorum* and *Fusarium pseudograminearum* (Papendick and Cook, 1973; Baye, 1984; El Yousfi, 1984; Conner and Atkinson, 1989; Houmairi, 1993; Ezzahiri, 2017).

Other authors (Paulitz *et al*., 2002 ; Cook, 2010 ; Hogg *et al.,* 2007 et 2010) have reported that root rot is mainly caused by *Fusarium culmorum*, *F. pseudograminearum*, *F. graminearum*, *F. avenaceum, F. acuminatum, F. equiseti* et *Microdochium nivale* (= *F. nivale*). In contrast, the other *Fusarium* species contributed by the authors are less virulent and less abundant (Cook, 2010). In Europe, the main species responsible for root rot of cereals are *F. graminearum, F. culmorum, F. avenaceum, F. poae* and *M. nivale* (Bottalico and Perrone, 2002; Ioos *et al.,* 2004; Parry *et al.,* 1996).

In Tunisia, Boughalleb *et al.* (2006) identified and classified, in addition to Microdochium nivale, five *Fusarium* species from wheat collar samples in order of magnitude of damage: *F. culmorum, F. graminearum, F. avenaceum, F. solani* et *F. equiseti*. In Morocco, Lyamani (1988) reported that *F. culmorum* and *H. sativum* are pathogenic on wheat and that *Fusarium equiseti* is most common in soils followed by F. solani and *F. oxysporum*. D'après Strausbaugh *et al.* (2004),the main agents responsible for root rot are *Fusarium culmorum* and *Bipolaris sorokiniana.* In a study in China on wheat root rot, four groups of pathogens were identified: *Cochliobolus sativus* (41 isolates), *Fusarium* spp. (33), *Microdochium nivale* (24) and *Epicoccum nigrum* (12); pathogenicity assessed by greenhouse inoculation appeared to be greater for C. sativus, followed by *Fusarium* spp. (Li *et al.,* 2011).

Other authors (Burgess *et al.,* 2001, Paulitz *et al.,* 2002, Smiley *et al*., 2005) reported that the fungal complex responsible for wheat root rot in arid areas is *Bipolarissorokiniana*, *F. culmorum*, and *F. pseudograminearum*. These species are considered the most pathogenic and the most economically damaging. In the prospected stations of North West Morocco, the percentage isolation of *Bipolaris sorokiniana* from the roots of wheat and barley plants sometimes exceeds that of *Fusarium* species.

Lafraoui (1997) reported that *Bipolaris sorokiniana* is a pathogen highly associated with root rot of wheat and barley, the infection rate of plants in northwestern Morocco is quite important. Similarly, Fedel-Moen and Harris (1987) reported that the infection rate of wheat and barley plants by this pathogen can reach 40%. Umechuruba (1986) and Wiese (1987) noted that *B. sorokiniana* is known for its formidable aggressiveness in inducing root rot in wheat and barley. Tinline (1986) noted that this fungus is the first invader of the rhizomes of wheat and barley plants even before *F. culmorum* and / *F. acuminatum*.

The composition of the fungal complex responsible for root rot is variable. Some authors (Xu & Nicholson, 2009) have reported that several species can be found together, region-wide, of the parcel and also on the same foot (roots or ear of a single plant), where they form the fungal complex. Similarly, according to Oerke *et al.* (2006), the severity, incidence and prevalence of each species vary according to geographical location, climatic variations of years and cultural practices adopted.

Bipolaris sorokiniana is the causal agent of common rot, leaf spot disease, damping-off, ear blight and black spot of cereals(Kumar, 2002; Asad *et al.,* 2009). According to Rémi (1997), this fungus is transmitted by seeds and the attacked species are wheat, oats, barley and forage grasses. It is considered the most formidable for grasses, especially barley, its gravity comes from the ability of this fungus to adapt to different climatic conditions (Sjoberg *et al*., 2007). Indeed, it is able to survive in the colder regions of the world and grow well in hot, humid weather (Kumar *et al.,* 2002). It has been reported in several countries, such as China (Chang and Wu, 1998), Brazil (Mehta *et al*., 1985), India, Pakistan, southeastern Australia, and parts of Europe. (Kwasna, 1995).

B. sorokiniana or *Helminthosporium sativum* has a diverse host range. It has been cited in Morocco as a pathogen of cereals (Rieuf and Teaska, 1973; Lyamani, 1988; Wahbi, 1988; El Yousfi, 1984; Mergoum, 1991; El Yakoubi *et al.,* 2012; El Wazziki *et al.,* 2015). It is also considered as a foliar pathogen of rice (Ouazzani Touhami *et al.,* 2000; Bahous *et al.,* 2008; Imrani *et al.,* 2014) and Sorghum (Berber *et al.,* 2008). and isolated foliar lesions of oats, *Echinochloa phyllopogon*, *Phragmites australis* (Serghat *et al.,* 2005), of *Echinochloa crus-galli (*Lamrani *et al.,* 2012), and foliar lesions of plane trees (Yamni *et al.,* 2002).

Fusarium culmorum is the most widespread and pathogenic species among the other *Fusarium species* associated with crown rot of wheat and barley (El Yousfi, 1984; Cromey *et al.,* 2006; Paulitz *et al.,* 2002). It is considered with other *Fusarium* species, mainly *F. graminearum* and *F. avenaceum*, as agents responsible for *Fusarium* foot rot, cereal crop disease. According to £acicowa and Piêta and Kiecana *et al*., the virulence of *F. culmorum* against cereals is higher at high temperatures. The study conducted by Wiwart *et al.,* 2008; reported that the effect of F. *culmorum* may be at the early stage of wheat seedling development.

Other authors (Gargouri *et al.,* 2001; Backhouse *et al.,* 2004; Chekali *et al.,* 2011) reported that *F. culmorum* is the main agent that induces dry root and crown rot. These rots constitute a serious constraint in the majority of the world's cereal regions (Cook, 1980),

In Morocco, *F. culmorum* was reported in almost 25% of the fields (Lyamani, 1988), and its aggressiveness is a function of the fertilization adopted in the plots of wheat or barley and the climatic conditions. Indeed, according to Davis *et al.,* (2009), *F. culmorum* becomes more aggressive under conditions of excess nitrogen and drought.

Bipolaris sorokiniana and *F. culmorum* are responsible for seedling melting, root necrosis and appearance of whiteheads (El Yousfi, 1984; Wahbi, 1989; Bockus *et al.,* 2010 ;). According to Duveiller *et al*., (2007), these two agents induce different root rot biologically and epidemiologically.

Arseniuk *et al*., (1999) reported that *Fusarium graminearum* is the principal agent responsible for Fusaeium head blight (FHB), but about 20 species belonging to the *Fusarium* genus may be involved in the complex causing this disease. Other authors (Christensen and Stakman, 1922; De Tempe, 1964) reported that *F. graminearum* and *Bipolaris sorokiniana* are the two fungi responsible for seedling death. This disease is often observed in cold and wet soils. Similarly, according to Leplat (2012), there is a close relationship between *Fusarium* head blight and damping off, not only because of the presence of the same causative agent, *F. graminearum*, but also because of the transmission of the latter by the wind or splashing rain. *F. graminearum* is also able to invade other host plants with intense virulence, including cereals such as corn, wheat, barley, oats and rye. (Chongo *et al.,* 2001), that is why it is recommended not to rotate crops between them.

F. graminearum is also a species capable of causing considerable damage in rice fields (Ou, 1985), including Moroccan rice paddies (Benkirane, 1995), when the environmental conditions are favorable, for example in case of extreme humidity (Boudoudou, 2003). Isolates of this species were particularly phytopathogenic and *in vitro* altered the early stages of seedling development of 5 varieties of rice grown in Morocco from seeds inoculated with these isolates (Boudoudou *et al.,* 2009).

Rice seeds infected with *F. graminearum* are white, yellow or reddish, or more or less covered with yellow or pink spots (Agarwal *et al.,* 1994). More the fungi are installed, the more the grains are colored red or pink. Altered grains can harbor masses of conidia and, in the case where germination is still possible, they give diseased seedlings. In wheat and barley, white ears are the result of infection with *F. graminearum* (Houmairi, 1993; Cerkauskas, 2002) found in caryopses. Seed treatment with Rhodane 2.3% at a dose of 500 g/100l was recommended for control of *F. graminearum* (Mironeko, 1960).

Fusarium roseum is among the fungal species isolated from the roots of wheat and barley in northwestern Morocco. Zaid (1983) reported that 80.57% of the fields surveyed in 1982-83 in the Fez-Meknes region were attacked by root rot with rates ranging from 0 to 15.75% white heads/m^2 and *Fusariumroseum* and *Helminthosporium sativum* are the two pathogens isolated from the collars and stems of diseased plants. Similarly, the isolation rate of *F. roseum* from soil and seed samples was important. Arifi (1995) noted that soil appears to be much more important than seed as a source of inoculum. According to Boulif (2011), root rot and root rot caused by *Fusarium roseum* and *Bipolaris sorokiniana* dominate in Morocco. In fact, these two natural soil inhabitants whose inoculum increases with the monoculture of wheat combine to attack the wheat whenever this crop is subjected to water stress (drought).

Microdochium nivale (formerly known as *Fusarium nivale*) is one of the fungi that infects grains and adult seedlings of cereals. Gindrat and Frei (2004) they isolated *M. nivale* and *F. culmorum* from the lesions at the base of the stems. It is the main pathogen responsible for seedlings disease, which causes shoot death and stem thinning (Cook, 1981). Loos (2002) reported that fusariosis of small seed cereals (wheat, barley, etc.) is caused mainly by four species, *M. nivale* and *F. culmorum*, among others. According to other authors (Gosman *et al.,* 2004; Brennan *et al.,* 2005), *F. nivale* and *F. poae* are the least aggressive species compared to other species of the fungal complex of cereals.

F. Snowfall is also considered a pathogenic species of wild grasses rice, which implies that permanent weeding is a positive cure for *Fusarium*. Boudoudou *et al.,* (2009) reported that *Fusarium*, including *F. nivale*, can be a problem during the early stages of rice seedling development and therefore it is important to monitor their evolution especially when using susceptible varieties.

The fungal complex encountered also contains *Curvularia spicifera*, isolated for the first time in Morocco from the roots of wheat and barley showing the symptoms of rot. This species has been isolated from the roots of wheat or barley with B. sorokiniana and *Fusarium* species and in other cases with only representatives of the *Fusarium* genus. According to Zillinsky (1883), *Curvularia spicifera* (syn. *Helminthosporium spiciferum* or *Bipolaris spicifera*) is considered to be a low virulent pathogen that causes wheat crown rot, but has been reported to be capable of causing mottling on soft and hard wheat in northern India and Pakistan and barley in Mexico (Zillinsky, 1883). According to this author, this pathogen induces foliar symptoms that assume the appearance of irregularly colored, dull grayish-brown mottling, spread over the entire length and width of the leaf blade. The ability of *Curvularia spicifera* to induce root rot in wheat and barley plants is not known and it is important to study the pathogenicity of isolates of this species to certain varieties of wheat and barley by inoculating either seed or soil.

Curvularia spicifera is responsible for Cynodon stem and Zoysia stem rot(Smiley *et al.,* 1972). Forsberg (1985) reported that this parasite causes foliar lesions on the date palm as well as on the ornamental palm. It was also isolated from the ground and from the seeds of some herbs (Han *et al*., 2003).

In Morocco, *Curvularia spicifera* was isolated from rice seeds (Benkirane, 1995) and foliar lesions of rice plants (Ennaffah *et al.,* 1997 ; Ouazzani Touhami *et al.,* 2000), d'*Hibiscus rosa-sinensis* (Meddah *et al.,* 2006), *Citrullus lanatus* (El Mhadri *et al.,* 2009), *Punica granatum* (Kadri *et al*. (2011), *Erythrina caffra* (Kachkouch *et al.,* (2011), *Ficus retusa nitida* (Drider *et al.,* 2011), *Musa accuminata* (Meddah *et al.,* 2010). All these authors noted that this pathogen was able to induce sporulating foliar lesions on these different plant species after their inoculation and is also responsible for the tarnishing of rice grains (Gnancadja-André *et al*., 2005).

It appears from this work that several fungal species may be involved in the complex causing root rot in wheat and barley. It is difficult to know what part each fungal species has to alter the roots of these cereals; the data in the literature remain variable and are functions of geographical areas and ecological factors. The study of the pathogenicity of each species or of certain associations consisting of two, three or more will probably specify the share of each pathogen in the development of root rot.

In this sense, a study by Bahous *et al*., (2003) showed the existence of interactions between six foliar rice parasites, *Pyricularia oryzae, Helminthosporium oryzae, Helminthosporium sativum, Helminthosporium spiciferum, Helminthosporium australiensis et Curvularia lunata*, isolés sometimes lesions of the same rice plants. These competitive interactions were quantified by the ability of each species to induce leaf lesions and the production of conidia at these lesions. A significant increase in the inoculum of a parasite should have an impact on the disease cycle caused by other species (Bahous, 2008).

Root rot in wheat and barley poses a threat to Moroccan cereal production, yield losses are significant and can be very important during drought episodes and during the growth phase (Zillensky, 1983). Emphasis must be placed on the monitoring of cereal regions in order to put in place effective control strategies.

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