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Efficiency of Selected Fungicides on Blast and Blight of Rice Leaves

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

The effect of pathogens on grains is closely related to the severity of the disease on plants. Similarly, infection of leaves is very important in epidemic of blast and blight. The objective of this study was to develop a treatment program suitable for different fungicides to protect the leaves of rice plants throughout the vegetative phase against blast and leaf blight by determining the required dose and the duration of protection for each fungicide.

The results showed that *Pyricularia oryzae was* drastically inhibited on the leaves of rice at 300 ppm combined dose of Carboxin + Thiram, whereas *Helminthosporium oryzae* was completely inhibited at a dose of 750 ppm with the same fungicide combination. However, this product caused a total leaf yellowing and requires repeated applications So it is not recommended. Pyrazophos has no effect on *Helminthosporium oryzae* even at very high doses. However, this product completely inhibited *Pyricularia oryzae* at a dose of 750 ppm per an experimental unit. To protect against rice leaf blast throughout the vegetative phase, the product should be applied every two weeks. On the other hand, the 750 ppm Tricyclazole totally

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inhibited the severity of *Pyricularia oryzae* on rice leaves. Whereas, a dose of 1500 ppm of the product was required to achieve the same level of protection against *Helminthosporium oryzae*. When this product was combined with Mancozeb, the *H. oryzae* was completely inhibited at 750 ppm.
Furthermore, Mancozeb inhibited both pathogens at a dose of 1000 ppm. However, when Mancozeb was applied each week to protect rice leaves until the end of the vegetative phase, a single application of Tricyclazole or a combination Tricyclazole + Mancozeb continued to protect rice leaves against *P. oryzae* and *H. oryzae* until the emergence of panicles. A treatment program with the most effective fungicides is then established taking account into the duration of rice plants protection throughout the vegetative phase against blast and leaf blight. The appropriate time for application for effective results is shown as follows:
Foliar treatment from the sixth week (from the day of planting) either by one treatment of Tricyclazole at 750 ppm against *P.oryzae* or Tricyclazole + Mancozeb at 750 ppm related to *H. oryzae*, one application of Pyrazophos at 750 ppm every 15 days against *P. oryzae*, or one application of Mancozeb at 1000 ppm every week against both pathogens.

Keywords: Rice leaves; P. oryzae; H. oryzae; treatment program; Carboxin + Thiram combination; Pyrazophos; Tricyclazole; Mancozeb; Tricyclazole + Mancozeb combination; vegetative phase.

1. INTRODUCTION

Fungal diseases, such as the blast caused by *Pyricularia oryzae* and the blight caused by *Helminthosporium oryzae* are among the most limiting factors towards rice cultivation and production in the world, including Morocco. Indeed, in this country, many studies and research have been focused on the rice foliar diseases due its importance [1-8].

As many of other fungal diseases, the control of these two fungi was conventionally established by fungicides [9-12]. Since the incidence of both pathogens on grains is associated with the severity of the disease on plants [13], the infection of leaves was very important in the epidemics of the blast and leaf blight [14]. Consequently, it is important to treat the leaves of rice against these two pathogens to reduce the quantity of aerial inoculum resulting from necrosed and sporulated lesions or to prevent the grains from being infected if there is transmission from panicles to grains in a systemic way [15,16].

The objective of this study was to determinate the required dose and duration of protection for each fungicide with the aim of developing a treatment program for various fungicides which are able to protect rice leaves from the fungal pathogens during the vegetative stages against blast and blight diseases of rice.

2. MATERIALS AND METHODS

2.1 Fungal Material

The isolates FK1 of *Pyricularia oryzae* and Hot that of *Helminthosporium oryzae*, isolated respectively from the foliar lesion of the varieties Kenz and Triumph of rice were cultivated on a grain rice flour medium for 15 days.

When the cultures colonize the whole surface of twenty Petri dishes, spores and mycelia were scraped by a metallic spatula from these fungal colonies. This suspension was put in sterile distilled water then filtered through muslin tissue in the aim to obtain suspension that contains only spores. The concentration of the obtained spore's suspension was adjusted, with distilled water containing 0.02% Tween 20 and 0.5% gelatin, to 105 spores /mL.

2.2 Treatment of Rice Leaves

Rice grains of the Triumph variety, very sensitive to the pathogens *P. oryzae* and *H. oryzae* [17,18] were disinfected by soaking in 0.6% 0f sodium hypochlorite for ten minutes, then rinsed quickly with sterile distilled water. After 24 h of drying, grains were placed in Petri dishes containing sterile cotton imbibed with distilled water. After 75 h of incubation in 28°C in darkness, the seedlings were planted in pots containing disinfected soil of the forest Mamora. Then, they were watered with tap water until the required

stage for the inoculation (plant with 3 or 4 leaves).

2.2.1 Fungicides and used doses

Seven fungicides were used in this test (Tricyclazole, Carboxine + Thirame, Pyrazophos, Mancozeb, Thiabendazole, Benomyl and Methylthiophanate). Every fungicide was tested at concentrations of 300, 750, l000, l500 and 2000 ppm.

2.2.2 Plants treatment

Three lots of treatments were conducted and each treatment was performed with two repetitions of 15 pot plants:

a. Plants inoculated with the spore suspension, (l05 spores / mL), of each pathogen. They constitute the positive control (diseased).
b. Plants, treated only with water, constitute the negative control (healthy).
c. Plants treated with fungicides cited in the used fungicide part were then inoculated, 24 hours later, by the spore suspension (105 spores/mL) of the tested pathogens.

All the pot plants were placed in the laboratory for 48 hours, under black plastic covers to maintain a relative humidity of l00%, then, they were taken into greenhouse of the University. The disease severity was estimated, seven days after every inoculation with the pathogen, by using the scale of Barrault [19] for *H. oryzae* and that of Notteghem et al. [20] for *P. oryzae.* The infection coefficients were then calculated by multiplying the incidence by the severity. The reduction's percentage of the disease was deducted comparing to the controls. The most effective fungicides were used for the next experience, with the minimum dose which gave the maximum of inhibition, for each fungicide.

2.2.3 Persistence's estimation of the rice plants protection by various fungicides

Each plot containing the various treatments were treated only once at the stage of 3 to 4 leaves per plant by the most effective fungicides retained in the previous experience. For every fungicide, the minimum dose which gave the maximum of inhibition was used.

Twenty four (24) hours after various treatment applications, one of the plots was inoculated with spore suspensions at 105 spores / ml of the pathogens. The reduction's percentage of the disease was noted one week later. At this time, the second plot was inoculated with the pathogens to see if the protective effect of the tested fungicides persisted one week after treatment.

Every week, the same operation was repeated to see the effect of fungicides, after 15, 22 and 29 days. So, according to the obtained results, a program of treatment by each fungicide along the vegetative stage of the growth cycle development could be considered and developed. Controls, inoculated only with pathogens, have the same age to those treated with fungicides. After every inoculation with the pathogens, all the plants were placed, 48 hours under black plastic covers in the conditions of the laboratory. Then, they were placed in a greenhouse. In all these works, every treatment was the object of 15 repetitions.

2.3 Statistical Analysis

The result's statistical treatment was focused on the variance analysis with a single classification criterion according to (Newman and Keuls test).

3. RESULTS

3.1 Effect of Tested Fungicides on the Severity of Blast

The results in Table 1 showed that the percentage of severity of the blast on the leaves of the rice plants and consequently its infection coefficient by the various fungicides, depending on the quantity to which the latter was applied. Indeed, the disease inhibition in the presence of Carboxine + Thirame at 300 ppm was complete. In the same quantity, Tricyclazole and Pyrazophos inhibited considerably the blast. The inhibition's percentages were respectively in the order of 75 and 73.2% respectively.

Mancozebe was very effective against *P. oryzae* at the doses of 300 and 750 ppm, with inhibition's percentages which were respectively 85 and 92.3%. A dose of l000 ppm of this fungicide was necessary to reach l00% of disease's reduction. Thiabendazole, Benomyl and Methylthiophanate required to be brought at l500 ppm to inhibit completely the pathogen.

Table 1. Effect of the tested fungicides on reducing the severity of blast on rice leaves

Fungicide		Dose (ppm)				
		300	750	1000	1500	2000
Control	S	7	7	7	7	7
	IC	3.5	3.5	3.5	3.5	3.5
Carboxine+Thirame	S	0	0	L	L	L
	IC	0	0	L	L	L
	R (%)	100 a	100 a	L	L	L
Tricyclazole	S	2.5	0	0	0	0
	IC	78.7	0	0	0	0
	R (%)	75 d	100 a	100 a	100 a	100 a
Pyrazophos	S	2.9	0	0	0	0
	IC	84.4	0	0	0	0
	R (%)	73.2 d	100 a	100 a	100 a	100 a
Mancozebe	S	2,2	1	0	0	0
	IC	47.3	24.3	0	0	0
	R (%)	85 c	92.3 b	100 a	100 a	100 a
Thiabendazole	S	7	5.1	3.3	0	0
	IC	308.7	214.2	110.2	0	0
	R (%)	2 i	32 g	65 e	100 a	100 a
Benomyl	S	7	5.1	3.3	0	0
	IC	305.2	299.2	151.3	0	0
	R (%)	3 hi	5 h	52 f	100 a	100 a
Methyl-thiophanate	S	7	7	6.7	0	0
	IC	310.1	308	298.8	0	0
	R (%)	1.5 i	2.2 i	5.1 h	100 a	100 a

S: Severity; IC: Infection's Coefficient; R(%): Reduction's Percentage, L: Lethal dose.
Two results affected by the same letter did not differ significantly, at the 5% threshold (Newman and Keuls test)

Thiabendazole and Benomyl inhibited, significantly, the disease at l000 ppm, the percentages of inhibition were higher than 50%. At this dose, the inhibition by Methylthiophanate was practically non existant.

No damage was brought to the rice leaves after their treatment with fungicides at all the tested doses in comparison with the healthy control, With the exception of the Carboxine + Thirame combination, which was found to be toxic to the plant from 1000 ppm.

3.2 Effect of Fungicides Tested on the Severity of the Blight

The noted results in the Table 2 showed that *H. oryzae* was completely eliminated at a dose of 750 ppm in the combination Carboxine + Thirame while a dose of 300 ppm inhibited it with 90.4%.

Tricyclazole could protect totally the rice plant against *H. oryzae* only if it was applied in 1500 ppm. The total inhibition of the blight was reached by applying Mancozebe and Thiabendazole with the same doses from which we obtain a total elimination of *P. oryzae.* These doses were respectively 1000 and 1500 ppm.

Pyrazophos which was very effective against *P. oryzae*, practically had no effect on *H. oryzae* even if it was applied at the highest dose (2000 ppm). Indeed, in this dose the inhibition's percentage of the disease was only 30%.

Benomyl and Methylthiophanate applied at l500 ppm, inhibited *P. oryzae* in l00%. These products were effective in the same degree, against *H. oryzae* when they were applied at 2000 ppm.

3.3 Estimation of the Protection's Persistence of the Rice Plants by Various Fungicides

The results which appear in Tables 3 and 4 show that the association (Carboxine + Thirame) protected completely plants against *P. oryzae* and *H. oryzae* during one week. In l5th day, this protection was reduced (64.8% against *P. oryzae* and 59% against *H. oryzae*). The next week, the plants were not protected compared to control plants those showed that to have

a protection, plants had to be almost treated every week. After the application of Pyrazophos against *P. oryzae*, the protection of plants in the l5th day, was the highest (in the order of 90.1%). It seemed that to protect plants, this product had to be applied every 15 days.

Besides, Mancozebe could not protect plants against *P. oryzae* and *H. oryae* more than one week, also for Thiabendazole, applied so well against *P. oryzae* that against *H. oryzae*. In the l5th day the protective effect of these products did not persist anymore. These products had to be thus applied every week.

Table 2. Effect of the tested fungicides on the reduction of severity of blight on rice leaves

Fungicide		Dose (ppm)				
		300	**750**	**1000**	**1500**	**2000**
Control	S	7	7	7	7	7
	IC	315	315	315	315	315
Carboxine+Thirame	S	1.20	0	L	L	L
	IC	35.8	0	L	L	L
	R (%)	90.4 c	100 a	L	L	L
Tricyclazole	S	6.5	5.1	2.9	0	0
	IC	265.2	220.3	93.4	0	0
	R (%)	29 i	41 h	75 e	100 a	100 a
Pyrazophos	S	8.1	8	7.8	7.1	6.5
	IC	363.7	354.4	343.2	298.9	261.3
	R (%)	2.6 mn	5.1 l	8.1 k	20 j	30 i
Mancozebe	S	4.7	2	0.5	0	0
	IC	181.4	72.8	4.85	0	0
	R (%)	51.4 g	80.5 d	98.7 b	100 a	100 a
Thiabendazole	S	8.3	6.2	4.1	0	0
	IC	368.5	253	151.3	0	0
	R (%)	1.3 n	32.3 i	59.6 f	100 a	100 a
Bénomyl	S	8.4	8.2	7.3	2.4	0
	IC	378	364.1	298.6	74.6	0
	R (%)	0 o	2.5 mn	20.1 j	80 d	100 a
Méthyl-thiophanate	S	8.1	7.9	7.8	6.4	0
	IC	361.3	353.9	336.2	261.1	0
	R (%)	3.3 lm	5.2 l	10 k	30 i	100 a
Tricyclazole + Mancozebe	S	1.5	0	0	0	0
	CI	39.2	0	0	0	0
	R (%)	89.5 c	100 a	100 a	100 a	100 a

S: Severity; IC: Infection's Coefficient; R(%): Reduction's Percentage, L: Lethal dose.
Two results affected by the same letter did not differ significantly, at the 5% threshold (Newman and Keuls test)

Table 3. Persistence of the fungicides effect on the reduction of blast, following a single treatment of rice plants in the 3-4 leaves stage

Fongicide	Dose (ppm)		8 days	15 days	22 days	29 days
Control	0	S	7.2	7.1	6.5	5
Carboxine+Thirame	300	S	0	2.5	6.1	5.2
		R (%)	100 a	64.8 d	6.2 f	0 h
Tricyclazole	750	S	0	0	1,2	1
		R (%)	100 a	100 a	81.5 c	80 c
Pyrazophos	750	S	0	0.7	6.3	4.9
		R (%)	100 a	90.1 b	3.1 g	2 g
Mancozebe	1000	S	0	6.7	6.6	4.9
		R (%)	100 a	5.6 f	0 h	2 g
Thiabendazole	1500	S	0	5.8	6,4	5.2
		R (%)	100 a	18.3 e	1.5 g	0 h

Two results affected by the same letter did not differ significantly, at the 5% threshold (Newman and Keuls test)

Table 4. Persistence of the fungicides effect on the reduction of blight, following a single treatment of rice plants in the 3-4 leaves stage

Fungicide	Dose (ppm)		8 days	15 days	22 days	29 days
Témoin	0	S	8	7.8	7.3	5.7
Carboxine+Thirame	300	S	0	3.2	7.2	5.5
		R (%)	100 a	59 d	1.4 h	3.5 g
Mancozeb	750	S	0	6.2	7.2	5.5
		R (%)	100 a	20.5 e	1.4 h	3.5 g
Tricyclazole+Mancozeb	1000	S	0	0	0.6	0.8
		R (%)	100 a	100 a	91.8 b	86 c
Thiabendazole	1500	S	1.5	3	7.1	5.8
		R (%)	100 a	15.4 f	0 i	0 i

S: Severity; R(%): Reduction's percentage.
Two results affected by the same letter did not differ significantly, at the 5% threshold (Newman and Keuls test)

Concerning Tricyclazole and Tricyclazole + Mancozebe, applied to the rice plants aged to 3 weeks, they continued to supply an excellent protection in these plants respectively against *P. oryzae* and *H. oryzae*, even 4 weeks after treatment. These fungicides could thus protect the plants against these two pathogens until the emergence of panicles.

4. DISCUSSION AND CONCLUSION

The results showed that *P. oryzae* was radically inhibited, on the leaves of rice plants, at a dose of 300 ppm of the association Carboxine + Thirame, while *H. oryzae* was completely inhibited only at the dose of 750 ppm of this product. However, this product provoked a total yellowing of leaves. Thus, this product was not recommended, especially as it requires repeated applications.

Besides, Pyrazophos has no effect on *H. oryzae* at very high doses. However, this product inhibits totally *P. oryzae* at a dose of 750 ppm. To protect the leaves of rice plant against the blast during all the vegetative phase, this product must be quite applied during two weeks.

On the other hand, Tricyclazole at 750 ppm inhibited totally the severity of *P. oryzae* on the leaves of rice. While against *H. Oryzae,* a dose of 1500 ppm of the product was required to reach the same level of protection. When this product was combined to Mancozebe, *H. oryzae* was completely inhibited at 750 ppm.

Besides, Mancozebe inhibited radically both pathogens at the dose of 1000 ppm. However, when Mancozebe had to be applied every week to protect the leaves of rice plants till the end of the vegetative phase, a single application of Tricyclazole or combination (Tricyclazole + Mancozebe) continued to protect the leaves of rice respectively against *P. oryzae* and *H. oryzae* until the emergence of panicles.

A study, carried in field, by Mbodj et al. [21] showed that in Senegal, Tricyclazole reduces the infection of the rice by P*. oryzae* in the same obtained degree by using resistant varieties. These authors tested doses 300 and 600 g / ha, which showed an inhibition considerable and better than at the dose of 150 g / ha. This product was also used to differentiate the sensibility of the varieties in the leaves blast of the panicles. Among all treatments, tested by Vinod Kumar Nirmalkar et al. [22], Tricyclazole 75% WP showed to be the best fungicides in terms of minimum disease incidence in both stages of blast (leaf and neck blast) 16.3 and 21.22%, with maximum disease reduction of about 66.61 and 43.15%,

Gouraminis [23] also reported that this systemic fungicide is specifically very active towards *P. oryzae*. The same efficiency was reported by Pandey [24] when he studied in a field experiment the efficacy of 11 foliar fungicides against leaf blast pathogen *Magnaporthe grisea* in susceptible rice variety and proved that the treatments tricyclazole at 0.6 g/l/kg, was found significantly superior in controlling the disease severity. This fungicide showed itself the most effective *in vitro* and *in vivo* against *Curvularia lunata* considered as a pathogen of rice plants [25].

Sowa et al. [26], formulated a mixture of fungicides to control the most rice fungal pathogens of which *P. oryzae* and *H. oryzae*.

Among the components of this mixture there were Tricyclazole, Mancozebe and Pyrazophos. Mustafa et al. [27] showed that Tricyclazole applied on leaves was effective on the yield. Kurahashi [28] reported that Tricyclazole was an inhibitor of the melanin‘s synthesis in the appressoria of *P. oryzae* preventing the penetration in the rice also by inhibiting the polyhydroxynaphtaline reductase. Chen Yan et al. [29] concluded in his study of the relationship between Tricyclazole and associated genes of rice resistance that the prevention of rice blast by tricyclazole is not only by inhibiting the synthesis of melanin but the results show that tricyclazole can trigger rice resistance by inducing expression of key genes in the jasmonic acid pathway.

The efficiency of chemicals as the mancozebe ; carbendazim, propiconazole and Azoxystrobin was indicated by several authors [22,30]. Indeed, Dev [31] reported that Mancozebe, inhibits *H. oryzae* but at a dose of 2 kg/ha. Besides, Percich [32] and Johnson and Percich [33] showed that this product, applied alone every seven days or after an application of Propiconazole protects the rice plants of the natural infection by *H. or*yzae and so increased the yield (38-l20%) in height fields. Besides, Kohls et al. [34] maintained control pots not affected naturally by *H. oryzae*, along the vegetative cycle of the rice, by a treatment (processing) with 2,24 kg / ha of Mancozebe.

In the term of this study, a program of treatment **+**(processing) by the most effective fungicides has to be established while taking into account their rice plants protection’s duration during all the vegetative phase against the blast and the blight. This calendar was distributed as follows:

Foliar treatment from the sixth week either by:

- A single treatment by Tricyclazole in 750 ppm against *P. oryzae* or Tricyclazole + Mancozebe at 750 ppm towards *H. oryzae*;
- An application every 15 days by Pyrazophos in 750 ppm against *P. oryzae*;
- An application every week by Mancozeb at 1000 ppm against *P. oryzae* and *H. oryzae.*

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Ennaffah B. Etude des *Helminthosporium* du riz: Pouvoir pathogène, interactions compétitives, contamination et mesures de lutte chimique. Thèse de doctorat national. Université Ibn Tofail Kénitra. 1999;105.
2. Hassikou K. Contribution à l’étude de *Curvularia lunata*, agent de la curvulariose du riz au Maroc. Application de quelques moyens de lute chimique et biologique. Thése de doctorat national, Université Ibn Tofail; Faculté des Sciences de Kénitra. 2000;187.
3. Tajani M. Etude de quelques contraintes de la riziculture marocaine; Cas de la pyriculariose due à *Magnaporthe grisea*: Impact et moyens de lute. Thèse de Doctorat d’état. Université Ibn Tofail Kénitra. 2000;131.
4. Tajani M, Benkirane R, Douira A, et El Haloui N. Impact des maladies foliaires sur les composantes de rendement du riz (*Oryza sativa*) au Maroc. Actes Inst. Agron. Vet. (Maroc). 2001;21(2):83-86.
5. Serghat S. Mouria A. Ouazzani Touhami A. et Douira A. *In vivo* effect of some fungicides on the developpment of *Pyricularia grisea* and *Helminthosporium oryzae*. Phytopathol. Mediterr. 2002;41: 235-246.
6. Serghat S. Ouazzani Touhami A. et Douira A. Pathogénie *d’Helminthosporium oryzae* vis-à-vis de quelques graminées cultivées au Maroc. Cah. Rech. Université Hassan II, série A (Sciences et techniques). 2005a; 6:1-11.
7. Serghat S, Mradmi K, Ouazzani Touhami A. et Douira A. Rice leaf pathogenic fungi on weat, oat, *Echinochloa phyllopogon* and *Phragmites australis*. Phytopathol. Mediterr. 2005b;44:44-49.
8. Bahous M, Ouazzani Touhami A. Et Douira A. Survie de quelques pathogènes fongiques sur les feuilles de riz conservées au laboratoire. Bulletin de l’Institut Scientifique, Rabat, section Sciences de la Vie. 2008;n°30:13-18.
9. Lawrence E. Datnoff, Kenneth W. Seebold, Fernondo J. Et Corraa V. The use of silicone for integrated disease management: Reducing fungicide applications and enhancing host plant resistance. Studies In Plant Disease Science. 2001;8:171-184.
10. Bahous M. Contribution à l’étude de l’écologie de différents champignons sur

les feuilles de riz (*Oryzae sativa* L.). Mesures de lutte chimique par l'azoxystrobine. Thèse de Doctorat National, Université Ibn Tofaïl, Faculté des Sciences, Kénitra, Maroc. 2006;158.

11. Suzuki F, Yamaguchi J, Koba A, Nakajima T, Arai M. Changes in fungicide resistance frequency and population structure of *Pyricularia oryzae* after discontinuance of MBI-D fungicides. Plant Disease. 2010; 94(3):329-334.
12. Kunova A, Pizzatti C, Bonaldi M, Cortesi P. Sensitivity of non exposed and exposed populations of *Magnaporthe oryzae* from rice to tricyclazole and Azoxystrobin 512 Plant Disease. 2014;98(4).
13. Nyvall RF, Percich JA, Porter RA, Et Brontner JA. Comparison of fungal Brown spot severity to incidence of seedborne *Bipolaris oryzae* and *Bipolaris sorokiniana* and infected floral sites on cultivated wild rice. Plant Dis. 1995;79:249-250.
14. Long DH, Corell JC, Lee FN, Te Beest DO. Rice blast epidemics initieted by infested rice grain on the soil surface. Plant Disease. 2001;85(6):612-616.
15. Manandhar HK, Jorgensen HJL, Smedegaard-Peterson V, Mathar SB. Seedborne infection of rice by *Pyricularia oryzae* and its transmission to seedlings. Plant Dis. 1998a;82:1093-1099.
16. Manandhar HK, Jorgensen HJL, Smedegaard-Peterson V, Mathar SB. Suppression of rice blast by preinoculation with avirulent *Pyricularia oryzae* and the non rice pathogen *Bipolaris sorokin*iana. Phytopathology. 1998b;88:735-739.
17. Ennaffah B, Ouazzani Touhami A. et Douira A. Pathogenic capacity of *Helminthosporium spiciferum*: foliar parasite of rice in Morocco. J. Phytopathol. 1999;147:377-379.
18. Ouazzani Touhami A, Ennaffah B, El Yachioui M. et Douira A. Pathogénie comparée de 4 espéces *d'Helminthosporium* obtenues à partir des plantes malades du riz au Maroc. J. Phytopathol. 2000;148:221-226.
19. Barrault G. L'helminthosporiose de l'orge causée par *Drechslera teres*. Thèse de Doctorat d'Etat. Institut National Polytechnique de Toulouse, France ; 1989.
20. Notteghem JL, Anriatompo GM, Chatel M, Dechanet R. Technique utilisée pour la selection de variété de riz possédant la résistance horizontale à la pyriculariose. Ann. Phytopathol. 1980;12:199-226.
21. Mbodj Y, Gaye S, Diaw S. The role of Tricyclazole in rice protection against blast and cultivar improvement. Parasitica. 1987;43(4):187-198.
22. Vinod Kumar Nirmalkar, Prasant P Said, Dushyant Kumar Kaushik. Efficacy of fungicides and bio-agents against *Pyricularia grisea* in paddy and yield gap analysis thought frontline demonstration. Int. J. Curr. Microbiol. App. Sci. 2017;6(4): 2338-2346.
23. Gouraminis GD. The present status of rice diseases and their control on northen Greece. Cahiers Options Méditerranéennes. 1996;15:97-100.
24. Pandey S. Effect of fungicides on leaf blast and grain yield of rice in Kymore region of Madhya Pradesh in India. Bangladesh J. Bot. 2016;45(2):353-359.
25. Hassikou R, Hassikou K, Ouazzani Touhami A, Douira A. Effect *in vitro* et *in vivo* de quelques fongicides sur *Curvularia lunata*. Revue marocaine des sciences agronomiques et vétérinaires. 2002;22: N°4.
26. Sowa C, Dohmen GP, Obermann M. Riediger N, Klappach K, Schmit M, Stierl R. Formulation for paddy rice fields. N° de la publication: US 20140193772A1; 2014.
27. Mustafa A, Yassin SI, Mahmood S, HAnnan A, Akhtar M. Field evaluation of new fungicides against rice (*Oryza sativa*) diseases. Pakistan Journal of Phytopathology. 2013;25(n2):141-145.
28. Kurahashi Y. Melanin biosynthesis inhibitors (MBIs) for control of rice blast. Pesticide Outlook; 2001.

    DOI. 10 1039 / b1008060
29. Chen Yan, Zhao Jun Long, Mao Gen Lin, Wang CongYing, Lin Fei, Xu Han Hong, Zhu Xiao Yuan. Tricyclazole induced expression of genes associated with rice resistance. Journal of South China Agricultural University. 2016;37(N°1):35-40.
30. Dolar Pak, Ming Pei You, Vincent Lanoiselet, Martin J. Barbetti. Azoxystrobin and propiconazole offer significant potential for rice blast (*Pyricularia oryzae*) management in Australia. European

Journal of Plant Pathology. 2017;148(2): 247–259.
31. Dev VPS. Chemical control of helminthosporiose of rice. International Rice Research Newsletter. 1980;5(4):17-18.
32. Percich JA. Comparison of propiconazole rates for control of fungal brown spot of wild rice. Plant Dis. 1989;73:588-589.
33. Johnson DR, Percich JA. Wild rice domestication, fungal brown spot disease, and the future of commercial production in Minnesota. Plant Dis. 1992;1193-1198.
34. Kohls CL, Percich JA, Et Huot CM. Wild rice yield losses associated with growth stage specific fungal Brown Spot Epidemics. Plant Dis. 1987;71:419-422.

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