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EVALUATION OF NEWER FUNGICIDES IN MANAGING THE BLAST DISEASE OF RICE IN SUNDARBANS, WEST BENGAL, INDIA

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Abstract

The blast disease of rice caused by *Pyricularia oryzae*, Cav. (telemorph *Magnaporthgrisea* (Hebert) Barr.) is one of the most notorious and economically devastating diseases across rice producing countries of the world. Judicious application of fungicides is a way forward in management of blast disease of rice. Eight fungicides *viz.* Picoxystrobin 22.52% SC, Kresoxim-methyl 44.3% SC, Pyraclostrobin 10% CS, Tebuconazole 25% WG, Picoxystrobin 6.78% + Tricyclazole 20.33 % SC, Tebuconazole 50% + Trifloxystrobin 25% WG, Tricyclazole 75%WP + Zinc EDTA (12%), Tricyclazole 75% WP were evaluated in comparison to control treatment at Basantiin Sudarban region of West Bengal during Boro season of 2016-17 and Boro season of 2017-18 against blast disease of rice under natural condition. The experiment was set up with popularly grown susceptible rice variety Shatabdi (IET 4786) commonly known as Mini kit' with three replications by using RBD. Among the eight fungicides evaluated, it has been observed that Tricyclazole75%WP + Zinc EDTA (12%) was significantly superior in reducing the leaf as well as neck blast incidence followed by Picoxystrobin 6.78% + Tricyclazole 20.33% SC. Maximum percent reduction over control of leaf and neck blast (60.06%) was achieved with the application of Tricyclazole 75%WP + Zinc EDTA (12%). Picoxystrobin 6.78% + Tricyclazole 20.33 % SC came next in order (53.54%) in controlling the leaf and neck blast incidence. These chemicals can be incorporated into the integrated disease management system for sustainable production of rice.

Key words: Rice blast, fungicides, *Pyricularia oryzae*, disease occurrence, management.

Introduction

Rice, as a cereal grain, is the most widely consumed staple food for a large part of the world's human population. Rice is a main staple in more than 100 countries worldwide (Liu *et al.*, 2018). Global consumption of rice has seen a slight increase over the last several years. In the 2018/2019 crop year, about 486.62 million metric tons of rice was consumed worldwide, up from 437.18 million metric tons in the 2008/2009 crop year (Statista, 2020). It is anticipated that the rice consumption around the world will continue to grow steadily at around 1.1 percent per annum to 2025 when it is expected to reach a market volume of 570 million tones, according to a new rice market report published by market research firm Index Box. China and India will remain the world's leading rice producers. The rice production in India was 172.8 million metric tons in 2018 and is projected to register a CAGR of 2.7% during the forecast period, 2020-2025. India is the second-largest rice producer in the world after China, with more than 11% of the global production share. The rice production has increased by 3.5 times in the last 60 years (Mordor Intelligence, 2020). Major Rice producing states in India are West Bengal, Uttar Pradesh andhra Pradesh, Punjab, Tamil Nadu, Odisha and Bihar. West Bengal is the largest producer of rice in India. The total production of rice during 2017-18 was 14.97 million tones with a share of 13.26% in all India production (Prasad, 2019).

The average yield of rice in India is low as compared to China, Japan and Indonesia. Among the various factors, diseases of rice are one of the contributing factors in reducing the yield. One of the most serious and important disease of global significance found in rice crop is blast disease caused by *Pyricularia oryzae,* Cav (telemorph *Magnaporthgrisea* (Hebert) Barr.). Rice blast is responsible for yield losses of about 10% to 30% annually (Wilson *et al.*, 2009; Ashkani *et al.*, 2015; Sakulkoo *et al.*, 2018). Underfavorable environmental conditions, it can play havoc on the entire rice plants within 15 to 20 days and cause yield losses of up to 100% (Musiime *et*

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al., 2005). Thus, it poses a crucial challenge to rice production thereby threatening the global food security.

The disease affects all the above ground parts of rice plant, namely, leaf, node, neck of panicle, some-times leaf sheath and grain.Compared to leaf blast, neck blast causes highest yield loss since it affects the panicle directly.Using resistant variety, application of fungicides and manipulation of planting times, fertilizers and irrigationsare the most usual approaches for the management of rice blast disease (Georgopoulos and Ziogas, 1992; Moletti *et al.*, 1988; Mbodi *et al.*, 1987; Naidu and Reddy, 1989). Among several methods developed for the control of the disease (Mariappan *et al.*, 1995), a strategy that has long been viewed as a last resort for rice blast is the use of chemical fungicides to control the disease that has been widely practiced in many countries.Fungicidal control is largely practiced for blast disease in many temperate or subtropical rice growing countries, primarily in Japan, China, South Korea, Taiwan and Vietnam (Kumar *et al.*, 2014). Keeping this in view, efforts have been made to find out the efficacy of various fungicides on the management of leaf blast disease in rice.

Material and Methods

The field experiments were carried out at Hiranmaypur village of Basanti Block under Sundarban region of West Bengal during Boro season of 2016-17 and 2017-18. The study was performed under assured irrigated conditions in low land ecosystem. The highly susceptible rice variety Shatabdi (*i.e.* IET 4786, popularly known as Minikit) was grown with recommended standard agronomic practices. The seedlings of age 25 days were transplanted with spacing of 15 cm × 15 cm. In each plot (size 5m × 5m) a uniform plant stand were maintained and standard agronomic practices were followed for raising and maintenance of crop. Recommended dose of fertilizers (120:60:60 kg N:P:K/ ha) was applied. The experiment was designed using randomize block design (RBD) with nine treatments and three replications. Fungicidal formulations *viz.*, Picoxystrobin 22.52% SC (Galileo), Kresoxim methyl 44.3% SC (Ergon), Pyraclostrobin 10 % CS (Header), Tebuconazole 25% WG (Treat Power), Picoxystrobin 6.78% + Tricyclazole 20.33 % SC (Slogan), Tebuconazole 50% + Trifloxystrobin 25% WG (Nativo), Tricyclazole 75% WP + Zinc EDTA (12%), Tricyclazole 75% WP (Beam) and control were included in the treatment (Table 1). The efficacy of these fungicides was evaluated by spraying all the test chemicals with desired concentration thrice starting from 40th day after transplanting and subsequently at fortnightly interval. Ten hills were randomly selected from each plot and were tagged. Observations on the severity of disease on foliage was recorded before spray and 15 days after first and second sprayby using 0-9 scale (IRRI, 1996). The scored data was converted into percent disease index (PDI) using formula given by Wheeler, 1969:

$$\text{PDI} = \frac{\text{Sum of all scores}}{\text{Number of observation} \times \text{highest number in rating scale}} \times 100$$

Observation on the incidence of neck blast was recorded after second application of the treatments, i.e. 75 days after transplanting by selecting 10 hills from each plot. Disease incidence of neck blast was calculated by using the following formula given below:

$$\text{Incidence of neck blast (\%)} = \frac{\text{Total number of infected panicles}}{\text{Total number of panicles}} \times 100$$

The data on paddy yield wasrecorded at the time of harvest. The yield obtained from each plot was recorded separately and yield in terms of tons per hectare was calculated. Percentage of increase of yield over control was also calculated.

The disease data was subjected to statistical analysis following randomized block design as per Gomez and Gomez, (1984) and the significance of differences was tested at 5 percent level to interpret the treatment differences.

Table 1: Fungicides evaluated for management of blast disease of Rice .

Treatments	Trade name	Dose tested
T1 : Picoxystrobin 22.52% SC	Galileo	1.2 (ml/litre)
T2 : Kresoxim-methyl 44.3% SC	Ergon	1.0 (ml/litre)
T3 : Pyraclostrobin 10 % CS	Header	2.0 (ml /litre)
T4 : Tebuconazole 25% WG	Treat Power	1.5 (g/ litre)
T5 : Picoxystrobin 6.78% + Tricyclazole 20.33 % SC	Slogan	2.0 (ml /litre)
T6 : Tebuconazole 50% + Trifloxystrobin 25% WG	Nativo	0.5 (g/litre)
T7 : Tricyclazole 75%WP + Zinc EDTA (12%)	Beam + Talwar Zinc Super-14	0.6 g + 0.5 (g/litre)
T8 : Tricyclazole 75% WP	Beam	0.6 (g /litre)
T9 : Control	-	-

Results and Discussion

The data on leaf blast severity and neck blast incidence of both seasons (Boro season 2016-17 and Boro season 2018-19) were pooled and presented in table 2. Perusal of the field experiment data revealed that, there was no significant differences between treatments before application of

Table 2: Evaluation of fungicides on disease severity of leaf blast and neck blast incidence during Boro season 2016-17 and 2017-18

Treatments	Dose	PDI fo leaf blast			Percent disease reduction over control	PDI of neck blast Pooled mean (15 days after 3rd spray)	Percent disease reduction over control
		Pooled mean (before spay spray)	Pooled mean (15 days after 1st spray)	Pooled mean (15 days after 2nd spray)			
T1 : Picoxystrobin 22.52% SC	1.2 ml/l	20.94(27.23)*	30.39(33.45)	32.40 (34.70)	47.28	10.27(18.69)	60.81
T2 : Kresoxim-methyl 44.3% SC	1.0 ml/l	20.32(26.80)	33.82(35.56)	36.23 (37.01)	41.06	12.64(20.82)	51.77
T3 : Pyraclostrobin 10 % CS	2.0 ml /l	20.36(26.82)	31.06(33.87)	33.83 (35.57)	44.95	11.07(19.43)	57.75
T4 : Tebuconazole 25% WG	1.5 g/ l	19.27(26.04)	34.84(36.17)	37.30 (37.64)	39.31	13.02(21.14)	50.34
T5 : Picoxystrobin 6.78% + Tricyclazole 20.33 % SC	2.0 ml /l	20.34(26.81)	26.86(31.22)	28.56 (32.30)	53.54	8.15(16.59)	68.89
T6 : Tebuconazole 50% + Trifloxystrobin 25% WG	0.5 g/l	20.59(26.98)	33.12(35.13)	35.15 (36.36)	42.80	11.83(20.11)	54.85
T7 : Tricyclazole 75%WP + Zinc EDTA (12%)	0.6 g + 0.5 g/l	20.67(27.04)	23.30(28.86)	24.55 (29.70)	60.06	6.55(14.82)	75.01
T8 : Tricyclazole 75% WP	0.6 g /l	20.10(26.64)	29.37(32.81)	31.27 (34.00)	49.12	9.62(18.06)	63.30
T9 : Control	-	20.23(26.73)	42.28(40.56)	61.46 (51.63)	0.00	26.21(30.79)	-
SEm(±)		0.39	0.38	0.49		0.34	
C.D. (p=0.05)		1.14	1.09	1.40		0.98	
C.V. (%)		4.68	3.75	4.36		5.29	

*Figures in the parentheses represent arcsine transformed values,
PDI=percent disease index for leaf blast and percent disease incidence for neck blast.

fungicides and the leaf blast severity ranged between 20.94-19.27%. At 15 days after first spray, all the treatments gave significant control of leaf blast disease in paddy compared to untreated control. Application of Tricyclazole 75%WP + Zinc EDTA (12%) recorded least leaf blast severity (23.30%) followed by Picoxystrobin 6.78% + Tricyclazole 20.33% SC (26.86%) and Tricyclazole 75% WP (29.37%) during both the seasons. The efficacy of Picoxystrobin 6.78% + Tricyclazole 20.33% SC was found to be at par with Tricyclazole 75% WP. Non-significant difference was found between the treatments Picoxystrobin 22.52% and Pyraclostrobin 10% CS (30.39 and 31.06%, respectively) and these treatments were found to be significantly superior to Tebuconazole 50% + Trifloxystrobin 25% WG andKresoxim methyl 44.3% SC. Least efficacy was recorded with treatment Tebuconazole 25% WG (34.84%). Similar trend was observed at 15 days after second spray. When all the different fungicidal treatments were compared with respect to percent disease reduction over control, it has been found that Tricyclazole 75%WP + Zinc EDTA (12%) was the most efficient and gave 60.06% control. The order of efficacy after this treatment are T5>T7>T1>T3>T6>T2>T4 (53.54>49.12>47.28> 44.95>42.80>41.06>39.31%).

The neck blast incidence was recorded 15 days after third spray and data of both experimental years (Boro season of 2016-17 and 2017-18) were pooled and subjected to analysis of variance and presented in table 2. The result revealed that application of Tricyclazole 75% WP + Zinc EDTA (12%) recorded least neck blast incidence (6.55%) and gave 75.01% reduction of the disease over control. This was followed by treatment Picoxystrobin 6.78% + Tricyclazole 20.33% SC (8.15%) and Tricyclazole 75% WP (9.62%) which did not differ significantly. Non-significantdifference was observed between the treatments Picoxystrobin 22.52% (10.27%) and Pyraclostrobin 10% CS (11.07%) and were significantlysuperior to the treatments Tebuconazole 50% + Trifloxystrobin 25% WG (11.83%) and Kresoxim methyl 44.3% SC (12.64%). Least efficacy was recorded with treatment Tebuconazole 25% WG (13.02%). When all the different fungicidal treatments were compared with respect to percent disease reduction over control with respect to neck blast incidence, it has been found that Tricyclazole 75%WP + Zinc EDTA (12%) was the most efficient (75.01%). The order of efficacy after this treatment are T5>T7>T1>T3>T6>T2>T4 (68.89>63.30> 60.81>57.75>54.85>51.77>50.34%).

The two years (Boro season 2016-17 and Boro season 2017-18) pooled yield data are presented in table 3. Perusal of the data in this table reveals that in unsprayed control plot the yield was 3.42 t/ha which was significantly lower as compared to treated plots. The highest yield was achieved with Tricyclazole 75%WP + Zinc EDTA (12%) (5.36 t/ha) followed by Picoxystrobin 6.78% +

Table 3: Effect of different treatments on the grain yield of rice during Boro season 2016-17 and 2017-18.

Treatments	Dose	Pooled Yield (t/ha)	% yield increase over control
T1 : Picoxystrobin 22.52% SC	1.0 ml/l	5.13	50.34
T2 : Kresoxim-methyl 44.3% SC	2.0 ml /l	4.91	43.90
T3 : Pyraclostrobin 10 % CS	1.5 g/ l	5.06	48.06
T4 : Tebuconazole 25% WG	2.0 ml /l	4.83	41.46
T5 : Picoxystrobin 6.78% + Tricyclazole 20.33 % SC	0.5 g/l	5.30	55.05
T6 : Tebuconazole 50% + Trifloxystrobin 25% WG	0.6 g + 0.5 g/l	4.99	46.18
T7 : Tricyclazole 75%WP + Zinc EDTA (12%)	0.6 g /l	5.36	56.84
T8 : Tricyclazole 75% WP	1.0 ml/l	5.23	53.07
T9 : Control	-	3.42	-
SEm(±)		0.24	
C.D. (p=0.05)		0.56	
C.V.(%)		3.95	

Tricyclazole 20.33% (5.30 t/ha), Tricyclazole 75% WP (5.23 t/ha), Picoxystrobin 22.52% SC (5.13 t/ha), Pyraclostrobin 10% CS (5.06 t/ha), Tebuconazole 50% + Trifloxystrobin 25% WG (4.99 t/ha), Kresoxim-methyl 44.3% SC (4.91 t/ha) and Tebuconazole 25% WG (4.83 t/ha). It may be noted that PDI was least in Tricyclazole 75 %WP + Zinc EDTA (12%) and Picoxystrobin 6.78% + Tricyclazole 20.33% SC sprayed plots which also gave maximum grain yield. When observations were recorded on percentage yield increase over control Tricyclazole 75% WP + Zinc EDTA gave 56.84% higher yield compared to remaining treatments.

It has been shown that Tricyclazole belongs to melanin biosynthesis inhibitor (MBI) group of fungicide and prevent melanin biosynthesis in appressoria of *Pyricularia oryzae* and penetration of rice plants *via* appressoria by inhibiting polyhydroxynapthaline reductase (Kumar *et al*., 2013). Ten fungicides were evaluated for management of rice blast by Ganesh *et al.,* (2012) and found that the per cent disease index was significantly less (15.56) in tricyclazole sprayed plots followed by kitazine (17.63) and ediphenphos (18.03). The findings are in line with Pandey, (2016) who reported that among the 11 fungicides evaluated, Tricyclazole @ 0.6 g/l, was found significantly superior in controlling the leaf blast disease severity and thereby increasing the number of tillers/plant, number of spikelet/panicle, panicle length, grain yield and 100 seed weight. Among the twenty-two fungicides evaluated by Govindraju *et al.,* (2016), Tricyclazole was found to be the best fungicide in controlling the blast disease and increasing yield. Further, the role of micronutrient in plant defense are predominantly documented for Mn, Cu, Fe and Zn (Graham and Webb, 1991; Dordas, 2008; Fones and Preston, 2013). Zinc is one of the important essential micronutrients for plants. The problem seems to be more acute for rice. Zinc plays an important role in different plant metabolism processes like development of cell wall, respiration, photosynthesis, enzyme activity, auxin and protein synthesis and other bio-chemical functions etc. amongst all the micronutrients Zn deficiency continues to be one of the key factors in determining the crop production in India and other countries of the World. ZnO NPs (Zinc oxide nano particles) were reported to be suitable for the control of rice blast disease. Spraying of ZnO NPs with the concentrations of 0.2% and 0.5%, 5 days before inoculation with a spore suspension of *P. grisea* was effective in controlling rice blast disease (Kalboush *et al.*, 2016). Among the fungicides evaluated, spraying of Picoxystrobin 7.5%+Tricyclazole 22.5% w/v 30SC @ 300g a.i./ha gave effective control of leaf and neck blast of paddy with highest grain yield and recorded highest C:B ratio compared to rest of the fungicidal treatments in both Rabi seasons of 2010-11 and 2011-12 (Mahesh *et al.*, 2016).

The findings are in line with Devaraju *et al.,* (2013) who studied the efficacy of different fungicidal sprays viz., carbendazim, mancozeb and tricyclazole at three growth stages viz., 50 percent flowering, milk/dough stage and physiological maturity for control of blast disease (*Pyricularia grisea*) in rice and observed that tricyclazole significantly increased number of tillers/hill (8.63) and productive tillers/hill (8), number of filled spiklets/panicle (58) in compared to different treatment combinations.

Conclusion

Blast is one of the important and devastating diseases of rice that cause moderate to severe losses in every year throughout the rice growing tracts of the world. Application of suitable ecofriendly management strategies are very much important to combat with the disease. In the present investigation, application of Tricyclazole 75% WP + Zinc EDTA (12%) revealed best followed by Picoxystrobin 6.78% + Tricyclazole 20.33% SC in reducing both leaf and neck blast incidence. These treatments can be recommended to the farming community for sustainable management of the disease.

References

Ashkani, S.,M.R. Yusop, M. Shabanimofrad, A.R. Harun, M. Sahebi and M.A. Latif (2015). Genetic Analysis of Resistance to Rice Blast: A Study on the Inheritance of Resistance to the Blast Disease Pathogen in an F3 Population of Rice. *Journal of Phytopathology,* **163(4):** 300-309.

Devaraju, P.J., N.K.S. Nagaraju and Shashidhara (2013). Efficacy of fungicides for the management of blast disease in rice seed production. *Oryza,* **50(3):** 268-272.

Dordas, C. (2008). Role of nutrients in controlling plant diseases in sustainable agriculture. A review. *Agronomy for Sustainable Development,* **28:** 33-46. doi: 10.1051/agro: 2007051.

Fones, H.N. and G.M. Preston (2013). The impact of transition metals on bacterial plant disease. *FEMS Microbiology Reviews,* **37:** 495-519. doi: 10.1111/1574-6976.12004.

Ganesh Naik, R., B. Gangadhara Naik, T. Basavaraja Naik and R. Krishna Naika (2012). Fungicidal management of leaf blast disease in rice. *Global Journal of Bio-Science and Biotechnology*, **1(1):** 18-21.

Georgopoulos, S.G. and B.N. Ziogas (1992). Principles and methods for control of plant diseases. *Athens*, 236.

Gomez, K.A. and A.A. Gomez (1984). Statistical procedures for agricultural research with emphasis on rice (1-268). Los Banos, Philippines: International Rice Research Institute.

Govindraju, C., S. Mamatha and Y.M. Somasekhara (2016). Field Evaluation Of Fungicides Against Blast (*Pyricularia grisea*) Disease of Paddy. *International Journal of Agricultural Science and Research (IJASR),* **6(2):** 165-170.

Graham, D.R. and M.J. Webb (1991). Micronutrients and disease resistance and tolerance in plants. In: J. J., Cox, F. R., Shuman, L. M., Welch, R. M. 2nd eds., *Micronutrients in agriculture* (329-370). Madison, Wisconsin, USA: Soil Science Society of America Inc.

IRRI (1996). Standard evaluation system for Rice (4th eds.) Manila, Phillipine: International Rice Research Institute.

Kalboush, Z.A., A.A. Hassan and W.E. Gabr (2016). Control of rice blast and brown spot diseases by synthesized zinc oxide nanoparticles. *Egyptian Journal of Biological Pest Control,* **26(4):** 713-720.

Kumar, P.M.K. and A.L. Veerabhadraswamy (2014). Appraise a combination of fungicides against blast and sheath blight diseases of paddy (*Oryza sativa* L.). *Journal of Experimental Biology and Agricultural Sciences,* **2(1):** 49-57.

Kumar, P.M.K., D.K. Sidde Gowda, M. Rishikant, N. Kiran Kumar, K.T. Pandurange Gowda and K. Vishwanath (2013). Impact of fungicides on rice production in India. In: Fungicides - showcases of integrated plant disease management from around the world (77-98). DOI: 10.5772/ 51009.

Liu, K., J. Zheng and F. Chen (2018). Effects of washing, soaking and domestic cooking on cadmium, arsenic and lead bioaccessibilities in rice. *Journal of the Science of Food and Agriculture*, **98(10):** 3829-3835.doi: 10.1002/jsfa.8897.

Mahesh, M., S. Gururaj, D.K. Hadimani, D. Basavaraja and A.S. Channabasavanna (2016). Bio-efficacy of new fungicide (Picoxystrobin 7.5%+Tricyclazole 22.5% w/v) 30SC for the management of paddy blast caused by *Pyricularia oryzae*. *Environment and Ecology,* **34(2A):** 767-772.

Mariappan, V., E. Rajeswari and A. Kamalakannan (1995). Management of rice blast, *Pyricularia oryzae* by using neem (*Azadirachta indica*) and other plant products. In: V. Mariappan Ed., *Neem for the Management of Crop Diseases* (3-10). New Delhi, India: Associated Publishing Co.

Mbodi, Y., S. Gaye and S. Diaw (1987). The role of tricyclazole in rice protection against blast and cultivar improvement. *Parasitica,* **43:** 187-198.

Moletti, M., M.L. Giudici, E. Nipoti and B. Villa (1988). Prove di lotta chimica contro ill brusone del riso in Italia. *Informatore Fitopatologico,* **38(3):** 41-48.

Mordor Intelligence (2020). India Rice Market - Growth and Trends, Forecast To (2020 - 2025). Retrieved from https:// www.mordorintelligence.com/industry-reports/india-rice-market.

Musiime, O., M.M. Tenywa, M.J.G. Majaliwa, A. Lufafa, D. Nanfumba, John. Wasige, P.L. Woomer and M. Kyondha (2005). Constraints to rice production in Bugiri district. *African Crop Science conference proceed*ings, **7:** 1495-1499.

Naidu, V. D. and G.V. Reddy (1989). Control of blast (BI) in main field and nursery with some new fungicides. *Review of Plant Pathology,* **69:** 209.

Pandey, S. (2016). Effect of fungicides on leaf blast and grain yield of rice in Kymore region of Madhya Pradesh in India. *Bangladesh Journal of Botany,* **45(2):** 353-359.

Prasad, K. (2019). Pocket Book of Agricultural Statistics 2018. New Delhi: Directorate of Economics & Statistics, Government of India Ministry of Agriculture & Farmers Welfare Department of Agriculture, Cooperation & Farmers Welfare.

Sakulkoo,W., M. Osés-Ruiz, E. Oliveira Garcia, D.M. Soanes, G.R. Littlejohn, C. Hacker, A. Correia, B. Valent and N.J. Talbot (2018). A single fungal MAP kinase controls plant cell-to-cell invasion by the rice blast fungus. *Science*, **359(6382):** 1399-1403.DOI: 10.1126/science.aaq0892.

Statistica (2020). Total rice consumption worldwide from 2008/ 2009 to 2019/2020 (in 1,000 metric tons). Retrieved from https://www.statista.com/statistics/255977/total-global-rice-consumption.

Wheeler, B.E.J. (1969). An Introduction to Plant Disease (301). London: John Wiley Sons Ltd.

Wilson, R.A. and N.J. Talbot (2009). Under pressure: Investigating the biology of plant infection by *Magnaporthe oryzae*. *Nature Reviews Microbiology,* **7:** 185-195. Doi: https://doi.org/10.1038/nrmicro2032.