

A New Combination Fungicide for the Management of Sheath Blight, Neck Blast, Brown Spot, False Smut and Grain Discolouration Diseases of Paddy on Farmers Field

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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

With the objective of searching suitable and practically applicable solution to the problems of low productivity due to fungal diseases in rice, this study was conducted at the farmers participatory on-farm trial on Rice var. MTU 7029 in the Sheikhpura district of Bihar during Kharif Season in the year 2012 and 2013 for the assessment of a New combination Fungicides in Integrated Disease Management (IDM) of Rice Fungal Diseases (Sheath Blight., Neck Blast, Brown Spot, False Smut & Grain Discoloration). A total of 10 farmers as replication with 0.4 ha each, under a total of 4 treatments (including farmers practice as a check) was included in the study. The spray of fungicides was done at the booting stage of rice crop followed by recording the data on severity of 5 fungal diseases and yield at the appropriate time. The mean result of 2 years indicated that the single spray of all the 3 technology options of fungicides combination significantly reduced all 5 fungal diseases along with corresponding enhancement of grain yield, net profit and BC ratio. Out of them Nativo 75 WG (Tebuconazole 50% + Trifloxystrobin 25%) @ 0.05 %, reduced all 5 fungal diseases viz. Sheath blight, Neck Blast, Brown Spot, False Smut & Grain discoloration to a minimum level of 9.4, 4.2, 6.5, 8.1 and 3.3 percent respectively along with corresponding highest grain yield (5230 kg/ha), the net return of Rs.28900/ha and B:C ratio 2.24. Both other combinations viz. Monceren 250 SC (Pencycuron 22.9% SC) @ 0.12 % +Bavistin (Carbendazim) 50WP @ 0.1% and Sheathmar (Validamycin 3% L) @ 0.25 %+ Bavistin (Carbendazim) 50WP @ 0.1 % resulted

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into significantly lower diseases level statistically at par of 12.1, 9.7, 8.5, 19.4 and 6.6 % respectively along with corresponding higher grain yield (4360 kg/ha), net return of Rs.20800/ha and B:C ratio 1.94 in comparison of 38.3, 15.5, 18.4,25.5 and 12.3 % diseases level resulting with 3720 kg/ha grain yield, Rs.15,700/ha as net profit and 1.73 as BC ratio in the Farmers practice. Hence it can be concluded that single spray of Nativo75 WG (Tebuconazole 50%+ Trifloxystrobin 25%) @ 250 gram/ha in 500 litres of water at booting stage of Rice cultivar MTU 7029 may be highly effective method to manage major fungal diseases at farmers field and to get maximum net profit.

Keywords: On-farm trial; paddy; IDM; fungal diseases; Nativo 75 WG; grain yield.

1. INTRODUCTION

Rice continues to be the most important food crop for more than half of the world's population. India is the largest rice growing country with an area of around 44 m ha with a production of more than 100 million tons [1]. It forms the major dietary energy form of food and it covers more than 9% of earth's arable land. It contributes 21% of global per capita energy and 15% of global per capita protein [2]. More than 90 % of the world's rice is grown and consumed in Asia where 60 % of the earth's populations live [3]. It is grown in almost all the states of India and plays a major role in the country's food security and provides a livelihood for about 70% of the population [4]. Sustainable rice production for food security has emerged as a challenging task especially in the background of rapidly increasing population, declining cultivable land, decreasing the availability of agricultural labour and yield losses due to abiotic and biotic stresses. Pest and diseases not only reduce crop yields but also affect the grain quality. Rice crop is attacked by a number of fungal, bacterial and viral diseases and pathogens. Among them, diseases like Sheath blight, Neck blast, Brown Spot, False Smut and grain discoloration caused by fungal pathogens are the major cause for crop damages and loss of grain yield. Scientific literature has been focusing on management of single disease by an integrated approach. No literature is available for the need of farmers for combined management of these 5 fungal diseases by single spray on their field under natural condition. Identifying the level and extent of the problem of fungal diseases in major rice-growing cultivar MTU 7029 in Sheikhpura district of Bihar a farmer's participatory on-farm trial was planned and conducted for consecutive two years in Kharif 2012 and 2013 with the objective to assess the effect of single spray at booting stage of rice crop with 3 technology options of fungicides combination viz. Nativo 75 WG (Tebuconazole 50%+Trifloxystrobin 25%) @ 0.05

%, Monceren 250 SC (Pencycuron 22.9 % SC) @ 0.12% + Bavistin (Carbendazim) 50 WP @ 0.1%, and Sheathmar (Validamycin 3% L) @ 0.25% + Bavistin (Carbendazim) 50 WP @ 0.1% on the severity (Percent Disease Intensity or Incidence) of major fungal diseases, grain yield and economics of the production.

2. MATERIALS AND METHODS

Rice fungal diseases on and after booting stage causing reduction of the yield and quality, was diagnosed as the most significant problem of farmers through benchmark survey and PRA survey of the farmers. Searching suitable technological options for solving this problem as the main biotic stress causing yield loss in main rice growing cultivar MTU 7029, this study was planned and conducted at the farmers' field in the operational area of Krishi Vigyan Kendra, Sheikhpura, Bihar as farmers participatory On-Farm Trial in Rice var. MTU 7029 during Kharif Season in the year 2012 and 2013 for the assessment of new fungicides in Integrated Disease Management (IDM) of Rice Fungal Diseases (Sheath Blight., Neck Blast, Brown Spot, False Smut & Grain Discoloration). A total of 10 farmers as replication with 0.4 ha each, under a total of 4 treatments (Farmers practice and 3 Technology Options) was included in the study as follows:

Farmer's practice: (No. spray of any fungicide)

Technology Option (T O)-1: Single spray of Nativo 75 WG (Tebuconazole 50%+Trifloxystrobin 25%) @ 250 gram/ha in 500 litres of water at booting stage (0.05%).

Technology Option (T O)-2: Single spray of Monceren250 SC (Pencycuron 22.9%SC) @ 625ml (0.12%) +Bavistin (Carbendazim) 50WP @500gram/ha (0.1%) in 500 litres of water at booting stage.

Table 1. Method adopted for the assessment of the rice fungal diseases under on-farm trial

Disease	Pathogen	Identification	Scoring	Source
Sheath blight It is a major fungal disease. The incidence and severity of the disease is increasing in intensified and hybrid rice production systems.	<i>Rhizoctonia solani</i> (Teleomorph: <i>Thanatephorus Cucumeris</i> (Frank) Donk) The pathogen is soil-borne and survives in crop debris.	Oval or ellipsoidal greenish-grey lesions, usually 1-3 cm long, on the leaf sheath, initially just above the soil or water level. Lesions on the leaves usually have irregular lesions, often with grey-white centres and brown margins as they grow older.	Scoring (at growth stage 3-6)	IRRI, [5]
			Scale Relative lesion height	
			0 No infection observed	
			1 Lesion limited to lower 20 % of the plant height	
			3 20-30 %	
			5 31-45 %	
			7 45-65 %	
9 More than 65 %				
Neck Blast It's early infection of rice panicles causes a severe reduction in grain yield.	<i>Pyricularia oryzae</i> (Teleomorph: <i>Magnaporthe oryzae</i>) The pathogen is seed borne and overwinters in infected crop debris.	Lesions on the neck are grayish brown and can cause girdling. If infection of the neck occurs before milky stage, no grain is formed, but if infection occurs later, lower weight and poor quality grains are formed. Neck and node blast can also cause whiteheads or white Panicles.	Scale No. of Infected panicles	IRRI, [5]
			0 No incidence	
			1 Less than 5 %	
			3 5-10 %	
			5 11-25%	
			7 26-50%	
			9 More than 50% node, neck or lower part of the panicle axis) Scale Number of infected panicles (node, neck or lower part of the panicle axis)	
Brown spot It is a major fungal disease of rice worldwide. It causes both quantity and quality losses.	<i>Bipolaris oryzae</i> [syn. <i>Helminthosporium oryzae</i> (Teleomorph: <i>Cochliobolus miyabeanus</i>)] The fungus is seed-borne and overwinters in infected crop debris	Lesions on the leaves are initially small, circular, and dark brown to purple-brown. Fully developed lesions are circular to oval with a light brown to grey centre, surrounded by a reddish-brown margin. Spikelets can also be infected. Infection of florets leads to incomplete or disrupted grain filling and a reduction in grain quality	Scale Infected leaf area	IRRI, [5]
			0 No incidence	
			1 Less than 1 %	
			2 1-3 %	
			3 4-5%	
			4 6-10%	
			5 11-15%	
			6 16-25%	
			7 26-50%	
			8 51-75%	
9 76-100%				

Disease	Pathogen	Identification	Scoring	Source	
False smut The initial stage of the disease occurs at the early flowering stage of rice crop when the ovary is destroyed.	<i>Ustilagoidea virens</i>	Plants infected with false smut have individual rice grains transformed into a mass of spore balls (sori). These spore balls are initially orange, and then turn greenish-black when mature.	Scale	Infected florets	IRRI, [5]
			0	No incidence	
			1	Less than 1 %	
			3	1-5%	
			5	6-25%	
			7	26-50%	
9	51-100%				
Grain discolouration	Pathogen: Species of <i>Sarocladium</i> , <i>Bipolaris</i> , <i>Alternaria</i> , <i>Microdochium</i> , <i>Fusarium</i> , <i>Phoma</i> , <i>Curvularia</i> , <i>Psuedomonas</i> , etc	Darkening of glumes of spikelets, brown to black colour including rotten glumes caused by one or more pathogens. Intensity ranges from sporadic discolouration to discolouration of the whole glume.	Scale	grains with severely Discoloured glumes	IRRI, [5]
			0	No incidence	
			1	Less than 1 %	
			3	1-5%	
			5	6-25%	
			7	26-50%	
9	51-100%				

Technology Option (T O)-3: Single spray of Sheathmar (Validamycin 3% L) @ 1250 ml (.25%) +Bavistin (Carbendazim)50WP @500gram/ha (0.1%) in 500 litres of water at booting stage.

The spraying of fungicides was done at the booting stage of rice crop followed by recording the data on different diseases and grain yield at the appropriate time. The crop was grown on farmers field using standard recommended agronomic practices.

Assessment of the disease: Fungal diseases of Rice after booting stage of crop growth were assessed with the standard evaluation system of IRRI [5].

Further, scored data was converted into per cent disease index (PDI) using formula given below. The data on the yield were recorded by marking 3 x 2 m section within each plot using a wire frame as described by Seebold et al. [6] and tillers within the frame were cut and harvested to determine the yield. Subsequently, the data on disease severity and yield parameters were subjected to appropriate statistical analysis as per Snedecor and Cochran [7].

$$PDI = \frac{\text{sum of the scores}}{\text{Number of observation} \times \text{Highest Number in Rating Scale}} \times 100$$

3. RESULTS AND DISCUSSION

Analysed result of 2 years data for the effect of technology options of fungicides combination on different 5 fungal diseases has been presented in Table 2 and the effect on grain yield, net profit, Benefit: Cost (BC) Ratio in Table 3.

Sheath blight: All the three technology options of fungicide combination significantly reduced sheath blight disease out of which, Nativo 75 WG (Tebuconazole 50%+ Trifloxystrobin 25%) @ 0.05% resulted into lowest disease intensity of 9.4 % followed by Monceren 250 SC (Pencycuron 22.9%SC) @ 0.10 % +Bavistin (Carbendazim) 50WP @ 0.1% and Sheathmar (Validamycin 3% L @0.2%+ Bavistin (Carbendazim) 50WP @ 0.1 % both of which resulted into very lower disease intensity at par of 12.1 and 12.5 % in comparison of 38.3 % in Farmers practice. Roy and Saikia [8] also obtained the best control of sheath blight with

carbendazim or by benomyl sprays (0.05%) both in greenhouse and field tests [9]. Swamy et al. [10] also reported that new fungicide formulations tricyclozole 400g + propiconazole 125g @ 0.25% and trifloxystrobin 25g + tebuconazole 50g @ 0.04% was on par with the standard checks hexaconazole 5% EC @ 0.2% and validamycin 3L @ 0.25%. Lore et al. [11] and Biswas, [12] also reported that Pencycuron 250 EC was very effective under Punjab and West Bengal rice growing conditions against sheath blight when sprayed at maximum tillering stage [9]. Carbendazim, benomyl, ediphenfos and kitazin have been reported to be the most effective chemicals recorded by various Indian workers [13]. Foliar sprays of fungicides such as Validamycin in Thailand, Vietnam, Malaysia, Korea and Japan and Pencycuron in Malaysia have been widely used [14]. The first spray is applied between the early internode elongation stage and the development of 2.5 to 5 cm panicle in the boot, and the second on 80-90% of emerging panicles at 10-14 days later. The best time to apply chemicals was at the jointing stage, during which time the percentage tiller infected was highly correlated with sheath blight at wax ripeness stage, percentage yield loss depended on disease index at wax ripeness [15]. Groth and Bond [16] showed that application of azoxystrobin between panicle differentiation and 50% heading stage reduced sheath blight severity and incidence, resulting in higher yield and high head rice milling yield compared with inoculated but non-sprayed plots. Field trials in 2008 and 2009 conducted by Parsons et al. [17] showed that a newly formulated mixture of azoxystrobin and propiconazole called Quilt Xcel™ was highly effective in controlling sheath blight and protecting rice yield and milling quality.

Neck Blast: All the three technology options of fungicide combination significantly reduced percent Panicle infected with neck blast disease also, among which, Nativo 75 WG (Tebuconazole 50%+Trifloxystrobin 25%) @ 0.05% resulted into lowest disease incidence of 4.2 % followed by Monceren 250 SC (Pencycuron 22.9%SC) @ 0.10 % +Bavistin (Carbendazim) 50WP @ 0.1% and Sheathmar (Validamycin 3% L) @0.2%+ Bavistin (Carbendazim) 50WP @ 0.1 % both of which resulted into significantly lower disease intensity at par of 9.7 % and 9.3 % in comparison of 15.5 % in the Farmers practice.

Table 2. Effect of a single spray of fungicides at booting stages on Rice Fungal Diseases (Sheath Blight, Neck Blast, Brown Spot, False Smut & Grain Discoloration) on Rice var.MTU-7029 in On-Farm Trial during Kharif Season of 2012 and 2013

Technology options	Sheath blight (% disease Intensity)			Neck Blast (% Panicle infected)			Brown Spot (% disease Intensity)			False Smut (% panicle infected)			Grain discoloration (% grain infected)		
	2012	2013	Mean	2012	2013	Mean	2012	2013	Mean	2012	2013	Mean	2012	2013	Mean
FP	34.4	42.2	38.3	14.8	16.2	15.5	16.4	20.4	18.4	25.2	25.8	25.5	12.6	12	12.3
T O 1	8.4	10.4	9.4	4.6	3.8	4.2	6.2	6.8	6.5	8.2	8	8.1	3.4	3.2	3.3
T O 2	12.2	12	12.1	10.6	8.8	9.7	8.4	8.6	8.5	20.4	18.4	19.4	6.8	6.4	6.6
T O 3	10.8	14.2	12.5	8.4	10.2	9.3	8.8	8.2	8.5	16	16.2	16.1	8	8.6	8.3
CD at 5%	1.02	0.68		1.60	1.88		1.24	0.46		2.01	1.49		1.11	1.02	
CV	12.04	14.44		14.27	11.66		13.09	14.32		16.24	9.8		12.54	8.61	

Table 3. Effect of a single spray of fungicides at booting stages on grain yield and economics of cultivation of Rice var.MTU-7029 in On-Farm Trial during Kharif Season of 2012 and 2013

Technology options	Yield (q/ha)			Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs./ha)	B : C ratio
	2012	2013	Mean				
Farmer's practice/Check : (No. spray)	35.6	39	37.2	21,500	37200	15,700	1.73
T O-1: Nativo 75 WG @ 0.05%	50.4	54	52.3	23,400	52300	28,900	2.24
T O-2: Monceren250 SC (Pencycuron 22.9%SC) @ 0.12% + Bavistin (Carbendazim)50WP @0.1%	42.8	44	43.6	22,800	43600	20,800	1.91
T O-3: Sheathmar (Validamycin 3% L) @ 0.25%+ Bavistin 50WP @ 0.1%	44.4	42	43.3	22,600	43300	20,700	1.92
CD at 5%	1.21	1.08					
CV	12.15	14.24					

Saikia [18] has confirmed that sprays of edifenphos, thiophanate methyl and carbendazim at 0.1% effectively reducing the leaf blast by 71.3-81% and neck blast by 60-65% with a corresponding increase in yield. Prasanna Kumar et al. [19] evaluated three new QoI fungicides (Kresoxim methyl, Metaminostrobin and Trifloxystrobin) in combinations with other groups for two seasons against blast and sheath blight of rice [9]. All the QoI group fungicides were very effective in controlling leaf and neck blast and also improved the growth of the plant regarding height, test weight and yield. Ghazanfar et al. [20] evaluated several fungicides on a highly susceptible rice variety Basmati C-622 and also observed the control of disease in case of neck blast was shown by Tetrachlorophthalide 30 WP @ 3g/litre, Difenoconazole 250 EC and Tebuconazole + Trifloxystrobin @ 0.8 g/litre of water to the tune of 12.81%, 14.24% and 17.01%, respectively.

Brown Spot: Brown spot is one of the most important rice diseases in India. The disease affects the yield and milling quality of the grain but in our study area, this disease was in mild condition. All the three technology options of fungicide combination significantly reduced percent disease intensity of brown spot also, out of which, Nativo 75 WG (Tebuconazole 50%+Trifloxystrobin 25%) @ 0.04% resulted into lowest disease intensity of 6.5 % followed by Monceren 250 SC (Pencycuron 22.9%SC) @ 0.10 % +Bavistin (Carbendazim) 50WP @ 0.1% and Sheathmar (Validamycin 3% L) @0.2%+ Bavistin (Carbendazim) 50WP @ 0.1 % both of which resulted into significantly lower disease intensity at par of 8.5 % in comparison of 18.4 % in the Farmers practice. Celmer et al. [21] also found that tebuconazole, azoxystrobin and trifloxystrobin + propiconazole effectively reduced brown spot with enhanced grain yield. According to Sunder et al. [22], among six fungicides evaluated, propiconazole (2ml/l) proved most effective and reduced the brown leaf spot with a significant increase in yield.

False Smut: In our study spray of all the three technology options of fungicide combinations at booting stage of rice, significantly reduced percent panicle infected with false smut disease also, among which, Nativo 75 WG (Tebuconazole 50%+Trifloxystrobin 25%) @ 0.05% resulted into lowest disease incidence of 8.1 % followed by Monceren 250 SC (Pencycuron 22.9%SC) @ 0.10 % +Bavistin (Carbendazim) 50WP @ 0.1% and Sheathmar

(Validamycin 3% L) @0.2%+ Bavistin (Carbendazim) 50WP @ 0.1 %, both of which resulted into significantly lower disease incidence of 19.4 % and 16.1 % in comparison of 25.5 % in the Farmers practice. Singh Ram and Sunder S. [23] reported that spraying of Trifloxystrobin 25% + Tebuconazole 50% @ 0.4 g/l at booting stage caused minimum incidence/ % infected panicles (8.05%) and severity/ % infected grains (0.39 %) of False smut and maximum grain yield (5117 kg/ha) in Rice genotype CR 333-6-1 [9]. He also found that spraying the fungicides at 100% panicle emergence stage provided less disease control compared to spraying at booting and 50% panicle emergence stage. This might be attributed to the fact that infection does not occur after heading as reported by earlier researchers (Guo et al 2012). Evaluation of fungicides trifloxystrobin 25% + tebuconazole 50% and propiconazole 25 EC in vitro and in vivo condition showed 100% inhibition to the growth of fungal mycelium. Application of prochloraz + carbendazim followed by chlorothalonil had effective in controlling the false smut of rice [24]. Propiconazole 25EC (0.1 %) recorded lowest disease severity than other treatments, followed by trifloxystrobin + tebuconazole 75 WG when sprayed at booting or 50% panicle emergence [25]. Spraying of Propiconazole 25 EC and trifloxystrobin + tebuconazole 75 WG at booting stage results in higher yields [9].

Grain discolouration: In our study spray of all the three technology options of fungicide combinations at booting stage of rice, significantly reduced percent grain infected with grain discolouration disease also, among which, Nativo 75 WG (Tebuconazole 50%+Trifloxystrobin 25%) @ 0.04% resulted into lowest disease incidence of 3.3 % followed by Monceren 250 SC (Pencycuron 22.9%SC) @ 0.10 % +Bavistin (Carbendazim) 50WP @ 0.1% and Sheathmar (Validamycin 3% L) @0.2%+ Bavistin (Carbendazim) 50WP @ 0.1 %, both of which resulted into significantly lower disease incidence of 6.6 % and 8.3 % in comparison of 12.3 % in the Farmers practice.

Hunjan et al. [26] also found Trifloxystrobin 25% + tebuconazole 50% as highly effective in managing sheath blight, brown spot and grain discolouration of rice.

Rice grain discolouration is a disease complex caused by many pathogens. Nativo 75% WG was able to check grain discolouration to a moderate extent. The grain discolouration

ranged between 13.2% and 18.2% at the test doses of Nativo 75 WG (200, 150 and 100 g/ha) as compared to 29.4% in untreated control [27].

Azher Mustafa and Muhammad Mohsan [28] reported that among the twelve treatment including a control for the management of grain discolouration, Nativo 75 WG outclassed all the chemicals in reducing discoloured panicle by 49.59% as compared to control 67.40%. And hence improving the paddy yield.

Grain Yield and Economics of cultivation:

Besides the effect on significant reduction of five fungal diseases in rice, application of all the three technology options of fungicide combinations at booting stage of rice, also significantly enhanced the grain yield, net profit and B:C Ratio in both years of study. Nativo 75 WG (Tebuconazole 50%+Trifloxystrobin 25%) @ 0.05% resulted into highest mean grain yield of 5230 kg/ha, net profit of Rs 28,900 / ha with B:C Ratio as 2.24. Other two options as Monceren 250 SC (Pencycuron 22.9%SC) @ 0.10 % +Bavistin (Carbendazim) 50WP @ 0.1% and Sheathmar (Validamycin 3% L) @0.2%+ Bavistin (Carbendazim) 50WP @ 0.1 %, resulted at par yield of 4360 and 4330 kg/ha, net profit of 20,800 and B:C Ratio as 1.92, in comparison with that of 3720 kg/ha, Rs.15700 and 1.73 respectively in the Farmers practice.

Saikia [18] has confirmed that sprays of edifenphos, thiophanate methyl and carbendazim at 0.1% effectively reducing the leaf blast by 71.3-81% and neck blast by 60-65% with a corresponding increase in yield.

Groth and Bond [16] showed that application of azoxystrobin between panicle differentiation and 50% heading stage reduced sheath blight severity and incidence, resulting in higher yield.

Celmer et al. [21] also found that tebuconazole, azoxystrobin and trifloxystrobin + propiconazole effectively reduced brown spot with enhanced grain yield.

Hunjan et al. 2011 also reported Trifloxystrobin 25% + tebuconazole 50% as highly effective in managing sheath blight, brown spot and grain discolouration of rice along with higher yield. Higher grain yield with effective control of false smut and grain discolouration of rice was found with use of Trifloxystrobin 25% + tebuconazole 50% also by Raji et al. [25]. Azher Mustafa and Muhammad Mohsan [28] reported that among the twelve treatment including control for the

management of grain discolouration, Nativo 75 WP outclassed all the chemicals in reducing discoloured panicle by 49.59% as compared to control 67.40%.and hence improving the paddy grain yield.

4. CONCLUSION

Under farmer field condition with standard agronomic practices single spray of all the technology options of fungicides combinations like Nativo 75 WG (Tebuconazole 50% + Trifloxystrobin 25%) @ 0.05 %; Monceren (Pencycuron 22.9% SC) @ 0.12 % +Bavistin (Carbendazim) 50WP @ 0.1% and Sheathmar (Validamycin 3% L) @0.25 %+ Bavistin (Carbendazim) 50WP @ 0.1 % at booting stage can significantly reduce the extent of damage caused by all 5 fungal diseases viz. Sheath blight, Neck Blast, Brown Spot, False Smut & Grain discolouration along with corresponding higher grain yield, net return and B:C ratio in comparison to the Farmers practice. However, a single spray of Nativo75 WG (Tebuconazole 50%+Trifloxystrobin 25%) @ 0.05% in susceptible Rice cultivar like MTU 7029 may result into minimum diseases level with maximum yield, net profit and Benefit-Cost Ratio.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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