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MANAGEMENT OF BAKANAE DISEASE OF RICE

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Abstract

Bakanae disease is widely distributed in all rice growing areas of the world. In Bangladesh, it is one of the major diseases of rice. Four methods were tested for management of this disease, of which, roguing proved ineffective in a field investigation. Among the 15 fungicides tested *in vitro,* all of them were found effective in various degrees against the pathogen of the disease. Best effective 4 were selected for seed treatment and know (50% carbendazim WP) was the most effective followed by folicur (25% Tebuconazole EC), protaf (25% Propiconazole EC) and celest extra (2.5% Fludioxonil and 2.5% Difenoconazole EC). In the field, foliar spray of folicur, knowin and protaf was found ineffective to control bakanae disease. Looking for resistant one, 46 BRRI released varieties, "Purbachi"- a Chinese variety and 40 landraces of BRRI germplasm were tested *in vitro* against the pathogen. All these varieties and landraces were susceptible to the test pathogen in various degrees. Among the released varieties lower susceptibility were found in BR 23 and BR 11. Whereas, among the varieties and landraces the lowest was found in A23. Therefore, A23 may be suitable for use in the development of varieties resistant to bakanae rice disease.

Introduction

Bakanae is widely distributed rice disease in all rice growing areas of the world caused by *Fusarium moniliforme* Sheldon (Ou 1985). In many parts of South-East Asia, it is also a very common cause for yield loss. Bakanae alone caused 15.4% yield loss in Assam (Rathaiah *et al*. 1991) and 3.7-14.7% in Thailand (Ou 1985). It was found in the field that almost all cultivated rice varieties in Bangladesh are more or less susceptible to bakanae disease and up to 10.85% grain yield loss due to the disease was estimated (Hossain *et al*. 2011).

The ultimate goal of all phytopathological studies is to control plant diseases and reduce yield losses. Uncontrolled plant diseases may result in less food and higher food price, or even food of poorer quality. Various ways can be implemented to control this disease like rouging, use of fungicides, and/or planting disease resistant varieties.

Roguing is a traditional cultural practice. In this cultural practice, conscious farmers carefully remove and destroy infected plant or plant parts from their fields to reduce inoculum 'foci'. Roguing is employed in such diseases as loose smut of wheat, loose and cover smut of maize, red rot of sugarcane, ergot of bajra and many viral diseases (Mehrotra 2000).

Various workers in different countries of the world evaluated the efficacy of various fungicides against *Fusarium moniliforme,* the causal agent of the disease, under laboratory and field conditions (Aurangzeb *et al*. 1998, Tateishi and Chida 2000 and Gumustekin and Akn 2001). All these fungicides are not available in Bangladesh. Moreover, same fungicide may exhibit different effects against different isolates of *F. moniliforme*.

The best way of disease control is to grow disease resistant varieties because it is the economic and environmentally safe method of 'crop disease management' strategies. Unfortunately, very few reports on resistance against bakanae have appeared in the literature. Considering the importance of this disease in Bangladeshi context, this research project was undertaken to generate detailed information on the management of this disease.

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Materials and Methods

Fusarium moniliforme was isolated from bakanae disease infected rice variety BR-26. The pure culture was maintained on Sucrose Nutrient Agar (SNA) slants into refrigerator for further study.

About 4 weeks after transplantation of BRRI Dhan 32, three infected rice fields were selected at Chandiara village of Chandina Upazilla of Comilla district during T. Aman season to evaluate the effect of roguing on the incidence of bakanae disease. Roguing was done once in every week for 2 months at the half portion of each field. Percent bakanae infected hills of each portion were recorded before every rouging. The final count on bakanae incidence was made one week after the final roguing.

Fifteen fungicides were selected for determination of its complete inhibition levels (ppm) against *in vitro* radial growth of *F. moniliforme* (Tables 2 and 3). By using poison food technique in PSA (Potato Sucrose Agar) medium, at first, inhibition rate of these fungicides against the test pathogen were detected at 100 ppm and then at higher (200, 500, 800 and 1000 ppm) or lower (50, 25, 10, 5 and 2 ppm) concentrations were applied to get minimum dose for complete inhibition of mycelial growth.

Based on the best inhibition capability, celest extra, folicur, knowin and protaf were selected for seed treatment. BR-22 seeds were collected randomly from infected rice field at Chandiara village to make a ‘seed lot’. From the seed lot, 15 g seeds were taken and soaked with 2% water based solution of each selected fungicide for 2 hrs followed by well rinsed and kept wet for next 22 hrs with sterile distilled water. These were designated as treated sets. Same procedure was followed for control sets where sterile distilled water was used instead of fungicide. For each set of 15 g seeds were then sown in 25 cm × 31 cm (height × dia.) earthen pots having no outlet and containing garden soil. These pots were maintained in the net house near Botany Department, Dhaka University. Number of healthy and bakanae seedlings in each pot were recorded 20 days after sowing.

For foliar spray three fungicides *viz*., folicur, knowin and protaf were selected, celest extra was excluded because its formulation was for seed treatment only. For each fungicide, three infected rice fields were selected at Chandiara village of Chandina Upazilla of Comilla district during Aus season. Each rice field was divided into two equal parts by setting up a ridge of earth in such a way so that, field water cannot mix up with each part to another. Foliar spray was done twice with 10 days interval at the half portion of each field. Number of bakanae-infected hills were counted before foliar spray and 20 days later from last foliar spray. Percent bakanae disease incidence was calculated following the method of Hossain *et al*. (2011).

Seeds of 46 BRRI released varieties, a Chinese variety - Purbachi and 40 landraces were collected from BRRI germplasm for screening against bakanae disease. One hundred dry seeds of each variety or landrace were inoculated into 8 ml suspension (5.0×10^8 conidia/ml) of the pathogen with three replications following the methods of Hossain *et al*. (2013). A known susceptible variety, BR 26, was inoculated alone with every sets of varietal screening test. Ten days after inoculation, heights of the seedlings were recorded in both the treated and control sets. Per cent increase of average seedlings height of treatment sets over control sets (Overgrowth rates) were calculated.

Results and Discussion

Effect of roguing on bakanae disease incidence is presented in the Table 1. It shows that bakanae infected hills in the portion of the plots where roguing was done and not done were 11.8

and 11.6%, respectively. As the two values were almost equal yield loss due to bakanae disease between infected plots with and without rouging might differ insignificantly.

Table 1. Roguing effect on bakanae disease incidence.

Average of per cent bakanae hills		Remarks
Roguing done	Roguing not done	
11.8 %	11.6 %	Ineffective application

Anon. (1977) reported that bakanae infected hills, from where infected tillers were rouged from time to time, produced more empty grains and yield loss was higher (16.5 and 33.75%, respectively) than that of infected tillers not rouged (8.8 and 21.25%, respectively). Thus, removal of bakanae-infected tillers was discouraged in that report. In the contrary, Hossain *et al.* (2007) reported that roguing of bakanae infected tiller at 30 days after transplantation increased yield by 2.02 - 7.5% at Comilla and Habigonj. Yield of a crop depends on many other parameters and variation on those parameters might be the reason of difference between this report and the present study.

Fifteen selected fungicides showed variation in per cent inhibition of radial growth of *Fusarium moniliforme* (Tables 2 and 3). The Table 2 shows that minimum complete inhibitory concentration (MIC) was found by knowin (5 ppm). Next to MIC were folicur and protaf (10 ppm) followed by of celest extra (50 ppm). MIC of the test pathogen was not noticed even at 1000 ppm with fuji-one, provex, rovral, thiovit and trooper (Table 3).

Table 2. Minimum complete inhibitory concentrations (≤ 100 ppm) of fungicides against the radial growth of *Fusarium moniliforme*.

Trade names with formulation of fungicides*	Per cent Inhibition of mycelial growth at different concentrations (ppm)					
	2	5	10	25	50	100
Celest extra, EC (2.5% Fludioxonil and 2.5% Difenoconazole)	-	-	-	76.21	100.00	100.00
Companion, WP (63% Mancozeb and 12 % Carbendazim)	-	-	-	-	84.26	100.00
Conza, EC (5% Hexaconazole)	-	-	-	-	89.16	100.00
Folicur, EC (25% Tebuconazole)	-	86.34	100.00	100.00	100.00	100.00
Knowin, WP (50% Carbendazim)	96.27	100.00	100.00	100.00	100.00	100.00
Protaf, EC (25% Propiconazole)	-	79.83	100.00	100.00	100.00	100.00

*Active ingredient(s) is given in parentheses; WP = Wettable powder, EC = Emulsifiable concentrate; '–': Not applicable.

In accordance with the present study, Hossain *et al.* (2007) found their *in vitro* investigation that overnight seed soaking with 0.3% (3000 ppm) knowin eliminate the pathogen from seeds (blotter method) but rovral and trooper could not. Hossain *et al.* (2007) found that companion and ridomil failed to eliminate the pathogen completely from the seeds though in the present study these two fungicides inhibit the growth completely at 100 and 500 ppm concentrations. This difference might be due to inability of the fungicides to penetration into the seed coat. Considering the above results celest extra, folicur, knowin and protaf might be used in seed treatment and foliar spray to control the test pathogen.

Bakanae disease incidence was found in various degrees at the pots seeded with celest extra, folicur, knowin and protaf treated and untreated seeds (Table 4). Among the fungicides used, knowin was found most effective (0.0%) in seed treatment followed by folicur (1.6%), protaf (1.8%) and celest extra (2.7%).

Table 3. Minimum complete inhibitory concentrations (≥ 100 ppm) of fungicides against the radial growth of *Fusarium moniliforme*.

Trade names with formulation of fungicides*	% inhibition of mycelial growth at different concentrations (ppm)				
	100	200	500	800	1000
Calixin, EC (75 % Tridemorph)	42.55	59.66	77.38	100.00	-
Dithane M45, WP (80 % Mancozeb)	48.24	61.73	74.46	100.00	-
Fuji-one, EC (40 % Isoprothiolane)	27.59	31.56	32.62	33.17	33.64
Marabou, WP (12.5 % Diniconazole)	66.89	75.61	89.11	100.00	-
Provex, WP (37.5 % Carboxin and 37.5 % Thiram)	31.29	33.52	33.84	34.16	34.36
Ridomil gold MZ, WP (64 % Mancozeb and 4% Metalaxyl)	56.19	72.34	100.00	-	-
Rovral, WP (50 % Iprodione)	38.45	39.85	40.97	41.89	42.79
Thiovit, WP (80 % Sulpher)	23.26	25.22	28.38	29.16	29.87
Trooper, WP (75 % Tricyclazole)	18.24	24.49	28.31	30.29	31.15

*Same as Table 2.

Table 4. Per cent bakanae incidence in pots seeded with and without fungicide.

Parameters	Name of fungicides				Control (Untreated)
	Celest extra	Folicur	Knowin	Protaf	
% bakanae incidence/pot	2.7	1.6	**0.0**	1.8	13.8
Efficiency gradient**:** Knowin > Folicur > Protaf > Celest extra					

In accordance with the present study, Hossain *et al.* (2007) reported that bakanae incidence was absent in the seedbeds when these were seeded with knowin treated seeds. Therefore, from the present *in vitro* and *in vivo* study, it could be concluded that knowin is an effective seed treating fungicide for controlling bakanae disease.

Effects of foliar spray of folicur, knowin and protaf for controlling bakanae disease are presented in the Table 5. The table shows that effect of folicur, knowin and protaf in foliar spray for controlling the disease was insignificant.

In another experiment performed by Hossain *et al.* (2007) found that spraying different fungicides including bavistin, knowin, (@ 3 g/litre), both have same active ingredient, on the standing crops at tillering stage were ineffective against bakanae disease. This report was in agreement with the present study.

Screening results of 47 varieties *viz.*, BR 1 to 12, BR 14 to 26, BRRI dhan 27 to 47 and Purbachi are shown in the Table 6. All these varieties were susceptible to the test pathogen in various degrees at 28 ± 3ºC. Lower OGRs (34.38 and 35.33%) were found in BR 23 and BR 11 and the highest OGR (257.68%) was found in BRRI Dhan-40. It should be mentioned that no variety was named as ‘BR 13’ by the BRRI authority because of superstitious belief. In every set of inoculation, the known susceptible variety (BR 26) showed satisfactory disease symptoms.

Screening results of 40 landraces from BRRI germplasm are presented in the Table 7. All these landraces were susceptible to the test pathogen in various degrees at 28 ± 3ºC. The lowest (4.27%) and the highest (169.63%) OGRs were found in the landrace whose accession numbers were 23 and 117, respectively. In every set of inoculation, the known susceptible variety (BR 26) showed satisfactory disease symptoms.

Table 5. Fungicidal effect in foliar spray for management of bakanae disease.

Name of fungicide	Per cent bakanae incidence at untreated (UT) and treated (T) part of field					
	Folicur		Knowin		Protaf	
	UT	T	UT	T	UT	T
Before foliar spray	8.3	8.7	11.5	10.9	9.2	8.6
After foliar spray	8.9	9.2	11.3	11.5	8.8	8.5
Comment	Ineffective application					

Table 6. Effect of spore suspension (5.0×10^{8} conidia/ml) of *Fusarium moniliforme* at 28 ± 3ºC on the growth of seedling of 47 rice varieties.

Sl. no.	Name of variety	OGR (%)*	Sl. no.	Name of variety	OGR (%)	Sr. no.	Name of variety	OGR (%)
01	BR 1	86.54	17	BR 18	56.04	33	BRRI Dhan 34	120.04
02	BR 2	119.21	18	BR 19	102.12	34	BRRI Dhan 35	114.43
03	BR 3	80.79	19	BR 20	93.86	35	BRRI Dhan 36	143.46
04	BR 4	92.34	20	BR 21	105.55	36	BRRI Dhan 37	73.53
05	BR 5	98.18	21	BR 22	60.72	37	BRRI Dhan 38	71.33
06	BR 6	90.74	22	BR 23	34.38	38	BRRI Dhan 39	78.16
07	BR 7	104.61	23	BR 24	140.87	39	BRRI Dhan 40	257.68
08	BR 8	203.38	24	BR 25	141.54	40	BRRI Dhan 41	91.91
09	BR 9	165.62	25	BR 26	137.57	41	BRRI Dhan 42	97.75
10	BR 10	143.43	26	BRRI Dhan 27	85.48	42	BRRI Dhan 43	78.27
11	BR 11	35.33	27	BRRI Dhan 28	102.16	43	BRRI Dhan 44	202.24
12	BR 12	127.44	28	BRRI Dhan 29	102.09	44	BRRI Dhan 45	120.51
13	BR 14	94.97	29	BRRI Dhan 30	210.48	45	BRRI Dhan 46	188.50
14	BR 15	88.60	30	BRRI Dhan 31	93.92	46	BRRI Dhan 47	109.92
15	BR 16	103.53	31	BRRI Dhan 32	203.16	47	Purbachi	183.36
16	BR 17	119.75	32	BRRI Dhan 33	142.70			

* Overgrowth rate.

Thirty varieties and lines were screened for resistance to bakanae by Anon. (1977). Among the test varieties and lines, 16 were found resistant including Dulhabhog (BR 5). In the contrary, 98.18 % OGR was found in BR 5 in the present study. Haque *et al.* (1979) were screened 21 varieties and lines following laboratory method. None of the test materials was resistant to the disease. In their study, OGR of six BRRI released varieties *viz.* BR 1, BR 3, BR 6, BR 7, BR 8 and BR 9 were 148.1, 36.2, 83, 67.4, 6.9 and 15.2%, respectively. The results differed considerably with the present study except BR 6. The reason might be due to the difference in methodology and pathogenic strain.

Among the tested 87 varieties and landraces, comparatively higher susceptibility was found in the BRRI varieties than in the landraces (Tables 6 and 7). It was reported that most farmers used BRRI released varieties (Hossain *et al*. 2011). Virulent pathogen with a plentiful amount of susceptible host exists in our country. There is a possibility that the disease may reach to epidemic level in near future if a favourable environment exists in the country. One landrace from BRRI germplasm (accession number 23) showed insignificant susceptibility (OGR = 4.27%) to the pathogen and will, therefore, be suitable for use in the development of varieties resistant to bakanae rice disease.

Table 7. Effect of spore suspension (5.0 × 10^8 conidia/ml) of *Fusarium moniliforme* at 28 ± 3ºC on the growth of seedling of 40 landraces.

Sl. no.	Landrace*	OGR (%)**	Sl. no.	Landrace	OGR (%)	Sl. no.	Landrace	OGR (%)
01	A03	63.54	15	A46	65.47	28	A110	128.13
02	A07	9.57	16	A47	88.35	29	A113	119.91
03	A14	18.42	17	A49	112.55	30	A115	168.91
04	A16	55.89	18	A50	68.84	31	A117	169.63
05	A22	79.55	19	A54	94.40	32	A122	126.71
06	**A23**	**4.27**	20	A63	105.55	33	A131	137.45
07	A24	113.01	21	A64	88.56	34	A132	119.45
08	A30	80.49	22	A65	72.25	35	A632	35.10
09	A31	24.08	23	A66	108.81	36	A639	36.22
10	A32	39.83	24	A68	117.46	37	A640	27.06
11	A34	69.94	25	A94	128.08	38	A712	61.40
12	A40	19.95	26	A95	69.36	39	A766	59.54
13	A42	92.61	27	A97	152.44	40	A791	37.44
14	A43	72.84						

* A = Accession number. ** Overgrowth rate.

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