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Identification of genotypes resistant to blast, bacterial leaf blight, sheath blight and tungro and efficacy of seed treating fungicides against blast disease of rice

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A total of 35 inbred and 13 hybrid varieties including susceptible checks were screened against the 4 major diseases of rice (blast, bacterial leaf blight, sheath blight and tungro) as well as experiments on management of blast were conducted in the rain-fed and irrigated rice ecosystems during 1999 to 2003. Results showed that none of the tested high yielding varieties (HYV) were resistant to blast, while the hybrids, sonarbangla1, aalock6201, KRH2, IR71101H, IR68877H and IR76901H, and inbreds BR12, BR15 and IR72 were moderately resistant in the irrigated rice ecosystem. On the other hand, all the varieties tested against bacterial leaf blight (BLB) and sheath blight (ShB) were moderately susceptible in the same ecosystem. The inbred varieties BR22, BR25, BRRI dhan31, BRRI dhan32, BRRI dhan33, BRRI dhan34, BRRI dhan38 and BRRI dhan39 demonstrated moderately resistant reactions but all the hybrids were moderately susceptible to BLB in the rain-fed ecosystem. Eight inbreds, predominantly, BR22, BR23, BRRI dhan27, BRRI dhan31, BRRI dhan32, BRRI dhan37, BRRI dhan38 and BRRI dhan40 were moderately resistant to tungro disease. Among the 3 fungicides tested in 2 different trials, adivistin and haydazim 50 WP (carbendazim) at the rate of 0.4% were more effective as seed-treating fungicides for the control of rice blast disease.

Key words: Hybrids, inbreds, screening genotypes, major rice diseases, seed-treating fungicides.

INTRODUCTION

Rice is a cereal foodstuff which forms an important part of the diet of many people worldwide, an important staple food and cash crop of Bangladesh (Sarma, 1999). Generally, the rice crop is threatened by more than 40 diseases, and that is one of the reasons for low yield of rice in the world including Bangladesh. The diseases may appear at any growth stage of the plant, attacking the seed sown, root system, foliage, stalk, leaf sheath, inflorescence and even the developing grain (Virmani and Siddiq, 1998). Certain diseases and pests are more prevalent on hybrid rice than on conventional varieties. According to Wang (1985), Rao et al. (1990) and Naidu (1992), bacterial leaf-blight (BLB), sheath blight (ShB) and rice blast, are sometimes considered important diseases at various parts of rice growing areas of the world and threaten the continuous cultivation of hybrid rice. The rice disease BLB, caused by *Xanthomonas oryzae pv. oryzae*, occurs mostly during the wet season when water overflows in rice fields in the world. In some areas of Asia, it can reduce crop yield by up to 50% (Khush and Ogawa, 1989) even up to 80% (Singh et al., 1977). The most effective approach to control BLB is using resistant varieties. The ShB, caused by *Rhizoctonia solani* J. G. Kühn AG1-1A (teleomorph: *Thanatephorus cucumeris* (A. B. Frank) Donk.) (Gangopadhyay and Chakrabarti, 1982; Ou, 1985) is a major disease of rice in many countries including Bangladesh, USA, Malaysia, affecting more than 50% of all global rice production areas (Groth et al., 1991; Marchetti and Bollich, 1991). Some rice cultivars found in various areas of thenworld, have been identified as moderately resistant to ShB;

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however no fully resistant cultivars have been found so far (Prasad and Eizenga, 2008). Rice tungro disease (RTD), caused by the co-infection of rice tungro bacilliform virus (RTBV) and rice tungro spherical virus, is one of the most destructive rice diseases in South and Southeast Asia with outbreaks affecting thousands of hectares (Dai and Beachy, 2009). The disease remains one of the major threats to sustainable rice production in many rice growing countries. The lack of resistance genes to RTBV- the causal agent of tungro-disease makes it even more difficult to manage RTD (Dahal et al., 1992). Therefore, sustainable strategies are urgently required for the management of RTD.

Rice blast, caused by *Magnaporthe oryzae* B. Couch (anamorph = *Pyricularia oryzae* Cavara) [previously known as *Magnaporthe grisea* (Hebert) Barr] (Couch and Kohn, 2002), is the most destructive seed-borne disease and widely prevalent in prospective hybrid rice growing areas (Reddy et al., 1998; Couch and Kohn, 2002). It is prevalent in tropical, subtropical and temperature regions and in the continents of Africa, America (North and South), Asia, Australia, Oceania and Europe (Ou, 1985; Shahjahan et al., 1987; Talbot, 2003). Blast may reduce rice yield significantly, particularly in the temperate flooded and tropical upland rice ecosystems (Ou, 1985). Although, blast is capable of causing very severe losses of up to 100% in artificial conditions, little information exists on the extent and intensity of actual losses in farmers' fields. This loss in rice yield should be minimized in order to help the marginal and poor farmers of developing countries like Bangladesh, India, Vietnam and Philippines. In recent years, many techniques have been developed to control the fungus however; blast disease is still a major threat to global rice production. Therefore, alternative control methods are required for the management of rice blast. Rice hybrids are considered as superior in disease and pest resistance under favorable conditions (Singh, 1998). Developing and using resistant varieties is the most practical and economical approach to control blast. However, their use has not been completely successful due to the presence of different strains (that may consist of different physiologic races of pathogen) overcoming host resistance. It has been known that some seed treatments and foliar spray of fungicides are effective for controlling the blast disease of rice (Ou, 1985; Amadioha, 2000). The present research activities were undertaken to: 1) screen the 4 major disease resistant inbred and hybrid rice varieties for the irrigated and rain-fed ecosystems under artificial inoculation conditions; and 2) search for suitable seed-treating fungicide(s) for the control of blast disease of rice.

The main hypothesis is that the varieties exhibiting resistant reactions might be used in disease endemic areas or used as parents for the development of resistant varieties. We believe that some of the fungicides at certain level would prove effective against *Magnaporthe* growth and would therefore aid in the development of chemical control systems of the organism.

MATERIALS AND METHODS

Experimental site

The experimental site is geographically situated at 23° N latitude and 91° E longitudes with an elevation of 6 m from sea level at the eastern part of Bangladesh. The soil of the experimental plot was clay loam having pH 6.0, organic carbon content was moderate at 1.13%, total nitrogen 0.08%, available P (Olsen) 9 ppm, exchangeable K (meq/100 g soil) 0.20, exchangeable Ca (meq/100 g soil) 4.5, available S 14 ppm, Zn 10 ppm and Fe was 370 ppm. The research activities were conducted in the rain-fed and irrigated rice ecosystems during 1999 to 2001 at the BRRI regional station, Comilla district.

Raising of rice seedlings

A small piece of medium low land was selected for raising seedlings for field experiments of ShB and BLB. Clean and healthy matured seeds (germination rate, >85%) were pre-germinated in a moist-plastic tray in the dark at 28°C for 24 h before sowing in seedbeds. Thirty five days old rice seedlings of the varieties were transplanted in the plots using 2 to 3 seedlings/hill in 4 m long lines. The distance between hill to hill and row to row was 20 x 20 cm. Experimental plots were fertilized with the recommended doses of 124–26–60–13–4 kg/ha N–P–K–S–Zn (BRRI, 2000).

Inoculum preparation and cultivation of rice plants

For ShB, an isolate of *R. solani* was isolated from the susceptible variety BR11, which was collected from Gazipur district, Bangladesh. Infected samples were surfaced-sterilized by chlorox (1%) and placed on potato dextrose agar (PDA) media in the petri-dishes consisting of 39 g L^{-1} (Difco. Bacto®, Dicson and Co., MD USA). The petri-dishes were then incubated at 28°C for 48 h. For the preparation of inoculum in large scale, pathogen was grown and prepared on rice husk medium (30 g of rice husk in a 300 ml flask) for 10 days as described by Akter et al. (2003). In the case of BLB, an isolate of *X. oryzae pv oryzae pv* was collected from the susceptible variety, BRRI dhan29. Advancing lesion of the leaf tissues were cut into pieces (cal. 1.0 mm^2). Surface sterilization was done by soaking the leaf pieces in 70% ethyl alcohol followed by dipping in 5% chlorox for 1 min (Vera, 1984). The surface sterilized pieces were kept for 30 min in sterile water to release the bacterium. Finally, a full loop of the suspension was streaked on a plate of MgFe medium. Observation was made after 72 h after streaking to see the appearance of the gtalies colonies. After 5 days of incubation, the bright yellow and slimy colonies were selected. The selected colonies were re-streaked on the MgFe medium. Finally, pure single colony was selected and designated as an individual isolate. The bacterium was grown on peptone semi-synthetic agar (PSA: peptone 1.2%, sucrose 1.2%, agar 2%) slants for 48 h. After that, 100 ml of sterile water was poured in a 300 ml flask. Finally, a bacterial suspension having approx. 108 to 1010 cfu ml^{-1} of water was made (verified by a Nikon AFX-IIA microscope, Japan).

For blast, a virulent isolate of *M. oryzae* was collected from the susceptible variety, BRRI dhan29 which was grown on prune agar medium for a week. Finally, conidial suspension was prepared and adjusted to 1 x 10^5 ml^{-1} with sterilized deionized water (verified by Nikon AFX-IIA, Japan). For RTD, a virulent isolate of RTV was

Table 1. Reaction of rice blast in different varieties in nursery in the irrigated rice during 1999 to 2001*.

Variety	Disease index (DI)	Lesion area (%)	Disease reaction
Hybrids			
Sonarbangla1	4	3	MR
Loaknath503	7	28	S
Aalock6201	4	3.5	MR
Pant sankar dhan1	5	10	MS
APHR2	7	35	S
KRH2	4	2	MR
IR71101H	4	3	MR
IR69690H	6	20	MS
IR68877H	4	3	MR
IR69676H	8	61	HS
IR76901H	4	2	MR
IR69687H	5	8	MS
Inbreds			
BR12	4	2.5	MR
BR15	4	3	MR
BRRI dhan28	6	21	MS
BRRI dhan29	7	35	S
BINA5	5	7.5	MS
BINA6	6	22	MS
IR72	4	3	MR
Nizersail (S- check)	8	70	HS

*Data are average of two irrigated ecosystems. Blast scores were recorded 20 days after inoculation. MR: moderately resistant; MS: moderately susceptible; S: susceptible; and HS: highly susceptible.

collected from the susceptible variety, BR11 which was maintained and propagated by the acquisition of viruliferous green leafhoppers in glass house.

Artificial inoculation and cultivation of rice plants

For ShB, each hill of rice plant at max. tillering stage was inoculated with 50 g inocula of 10 days old culture of *R. solani* as described by Akter et al. (2003). For, BLB, the plants were inoculated with the isolate of *X. oryzae* at max. tillering stage as described by Hossain et al. (2004). Five hybrid and 12 inbred varieties (Table 2) were transplanted in 2 different experimental plots and the plants of 1 plot were inoculated with BLB inoculums and the other plot was inoculated with ShB inoculums during 1999 to 2000 irrigated rice ecosystems. Again in rain-fed ecosystem during 2000 to 2001, 18 inbred and 4 hybrids (Table 3) were tested against BLB of rice following the aforementioned procedure. These studies were conducted in the irrigated ecosystem during 1999 to 2000. For blast, seeds of the different varieties were directly sown in 1 m long rows with approx. 100 plants. Tested varieties were replicated 3 times. Nizersail was used as susceptible variety. Twenty days old plants, with 3 or 4 fully expanded leaves, were inoculated by spraying (by hand sprayer) aqueous spore suspension at the rate of 1×10^5 spore ml^{-1} onto the rice leaves (Filippi and Prahbu, 2001). Inoculated nursery beds were irrigated (by sprinkler) in the evening and covered overnight with a plastic sheet to maintain high relative humidity. A total of 12 hybrids and 8 inbreds (Table 1) were tested against blast under artificial inoculums pressure in the irrigated rice ecosystem during 1999 to 2001. In the case of tungro, 50 seeds of each variety were seeded randomly or in rows either in tray or pot. Seven to 10 days after sowing, seedlings in excess of 30 were removed. No fertilizer was used during nursery evaluation. Initially, leafhoppers were left to feed on 45 to 60 days old infected plants (exhibiting tungro symptoms) for 2 to 3 days. The seedlings in tray were then exposed to viruliferous leafhoppers for 1 day on rate of at least 3 viruliferous green leafhoppers per seedlings. The green leafhoppers on the seedlings were disturbed for several times to ensure even distribution. Four weeks after inoculation, the seedlings were scored based on visual observation of the symptoms. A healthy check was used as a reference to measure height. Experiments were conducted in rain-fed ecosystem during 2000 to 2001 with 18 inbred and 4 hybrid varieties.

Efficacy of 3 fungicides, acmecop 50 WP (copper oxychloride), adivistin 50 WP (carbendazim) and haydazim 50 WP (carbendazim) were tested for the control of blast disease of rice during 2001 to 2003. Infected seeds were treated at the rate of 0.4, 0.3 and 0.2% of each seed-treating fungicide. Seeds were collected from the previously blast infected field and the severity of panicle blast was evaluated with disease index (DI) 7 described by IRRI (1996) and fungal frequency was 25 to 30%. Two control treatments, control (healthy) and control (diseased), were maintained for comparison. 35 days old rice seedlings of BRRI dhan29 were transplanted at 25 x 15 cm spacing in 3 x 3 m unit plot.

Experimental design and statistical analysis

The experiments were laid out in a randomized complete block design (RCBD) with 4 replicates for each treatment. For screening,

Table 2. Disease infestation of bacterial leaf and sheath blight in transplanted field after artificial inoculation in the irrigated rice during 1999 to 2000*.

Variety	Bacterial leaf blight			Sheath blight		
	Disease index (DI)	Lesion area (%)	Disease reaction	Disease index (DI)	RLH (%)	Disease reaction
Hybrids						
Sonarbangla1	5	20	MS	5	40	MS
Loaknath503	5	25	MS	5	38	MS
Aalock6201	7	40	S	7	60	S
IR69690H	7	45	S	5	45	MS
IR68877H	7	48	S	5	42	MS
Inbreds						
Anamika	7	50	S	7	65	S
BR1	5	22	MS	5	42	MS
BR6	5	25	MS	5	40	MS
BR7	5	20	MS	5	45	MS
BR8	5	24	MS	5	44	MS
BR14	5	21	MS	5	43	MS
BR16	5	23	MS	5	42	MS
BR18	5	25	MS	5	45	MS
BR19	5	20	MS	5	41	MS
BRRI dhan28	7	50	S	5	40	MS
BRRI dhan36	5	24	MS	5	43	MS
BRRI dhan29 (S- check)	5	24	MS	7	63	S

*Data are average of two irrigated rice ecosystems. MS: moderately susceptible; S: susceptible; and RLH: relative lesion height.

data on disease index (DI), lesion area (%), incidence (%), plant height reduction (%) and disease reaction of blast, BLB, ShB and tungro were recorded. For the management of blast disease, the incidence (%) of leaf, node and panicle blast, DI and yield were recorded. All the DI scales and disease reactions were obtained by following a standard evaluation system (IRRI, 1996), where the index values were: 0 to 1 = HR (highly resistant), 2 = R (resistant), 3 = MR (moderately resistant), 4 to 6 = MS (moderately susceptible), 7 = S (susceptible) and 8 to 9 = HR (highly susceptible). Statistical analyses were performed by analysis of variance (ANOVA) followed by protected Fisher's least-significance difference (LSD) test at the p = 0.05 level of probability (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Screening of disease resistance genotypes

Results revealed that out of 12 tested hybrids, 6 hybrids, sonarbangla1, aalock6201, KRH2, IR71101H, IR68877H and IR76901H showed moderately resistant reactions, while loaknath503 and APHR2 were susceptible to blast in the irrigated rice. On the other hand, 3 HYV varieties (BR12, BR15 and IR72) were moderately resistant to blast, whereas BRRI dhan28 was moderately susceptible and BRRI dhan29 was susceptible (Table 1). BRRI dhan29 is highly susceptible to blast as described by BRRI (2000). Despite the breakdown of major gene resistance, some varieties had shown moderate resistance in our sub-tropical irrigated environment. Although Bonman and Mackill. (1988) reported the durable resistance to rice blast that is attributed to partial or quantitative resistance was observed in IR36 in the irrigated tropical areas. In other studies, 2 high-yielding hybrid rice varieties, shanyou 63 and shanyou 22, and 2 high quality traditional rice varieties, huangkenuo and zigu, were used for the experiments of rice blast control using genetic diversity by Yunnan Agricultural University, China (Zhu et al., 2003; Liu et al., 2003). In the irrigated rice during 1999 to 2000, all the tested hybrid and inbred varieties were moderately susceptible to susceptible against BLB and ShB (Table 2). No immune variety against ShB was found elsewhere (Webster and Gunnell, 1992). In the rain-fed ecosystem during 2000 to 2001, none of the varieties was resistant to BLB. Among the inbreds, BR22, BR25, BRRI dhan31, BRRI dhan32, BRRI dhan33, BRRI dhan34, BRRI dhan38 and BRRI dhan39 were moderately resistant to BLB. These cultivars showed certain degree of resistance at max. tillering stage of the crop. This indicated that they possess the adult plant resistance character. The results corroborated the findings of Zhang and Mew (1989).

On the other hand, BR5, BR11 and BINA sail were susceptible to BLB. All the 4 tested hybrids were moderately susceptible (Table 3). In the case of tungro screening, it was observed that almost all the varieties

Table 3. Screening of inbred and hybrid rice varieties against bacterial leaf blight in the rain-fed rice during 2000 to 2001*.

Variety	Disease index	Lesion area (%)	Disease reaction
Inbreds			
BR5	7	45	S
BR10	5	20	MS
BR22	3	10	MR
BR23	5	20	MS
BR25	3	12	MR
BRRI dhan27	5	22	MS
BRRI dhan30	5	20	MS
BRRI dhan31	3	12	MR
BRRI dhan32	3	9	MR
BRRI dhan33	3	11	MR
BRRI dhan34	3	10	MR
BRRI dhan37	5	20	MS
BRRI dhan38	3	12	MR
BRRI dhan39	3	11	MR
BINAsail	7	40	S
Nizersail	5	21	MS
Pajam	5	23	MS
BR11 (S-check)	7	40	S
Hybrids			
IR69690H	5	20	MS
IR68877H	5	25	MS
IR67161H	5	24	MS
Sonarbangla1	5	21	MS

*Data are average of two rain-fed ecosystems. MR: moderately resistant; MS: moderately susceptible; and S: susceptible.

were infected with tungro virus. None of the variety got score more than 7. Among the inbreds, BR10 and BR11 were susceptible to tungro. In contrast, BR5, BR22, BR23, BRRI dhan27 and BRRI dhan31, BRRI dhan32, BRRI dhan37 and BRRI dhan38 were moderately resistant to tungro. Among the hybrids, IR69690H was susceptible to tungro, while IR67161H and sonarbangla1 were moderately susceptible to tungro. Only the hybrid, IR68877H was moderately resistant to tungro. Among the inbreds, percentage of hill infection was higher in BR10, BR11, BRRI dhan30, BRRI dhan33, BRRI dhan39, BINAsail, nizersail and pajam (Table 4). The variety BR11 is highly susceptible to BLB and tungro, while BRRI dhan31 and BRRI dhan32 are moderately resistant to tungro according to BRRI (2004). For tungro virus, several near isogenic lines (NILs) carrying resistance genes from diverse donors of traditional varieties (for example utri merah, TKM6) and wild rice (O. rufipogon) have been produced (Azzam and Chancellor, 2002).

Evaluation of fungicides against rice blast disease

The small brown eye-shaped (pinhead) blast symptoms caused by *M. oryzae* was observed on the lower leaf portion of all the rice plants, irrespective of the treatments. However, the spread of the disease incidence and the symptom development were rapid in the control plants compared to other treatments. In comparisons with the control (diseased), all the seed-treating fungicides significantly decreased the incidence of leaf, node and panicle blast in trial 1. DI for leaf blast was also reduced due to the application of 3 doses (0.4, 0.3 and 0.2%) of seed-treating fungicides compared to the control (diseased). In the case of panicle blast, all the fungicides irrespective of doses did not significantly reduce DI compared to the control (diseased) (Table 5). Similar results were also found in the case of trial 2. Considering the results of both trials, adivistin and haydazim 50 WP at the rate of 0.4% were more effective as seed-treating fungicide for the control of blast disease. Our results are in agreement with Disthaporn (1994) and Shahjahan (1994) who reported that seed-treating fungicides, carbendazim or thiophenate methyl-thiram minimized the inoculums level of blast caused by *M. oryzae*. Controlling this disease is considered to be very important in the present situation because this disease is the most prevalent and serious limiting factor for the successful

Table 4. Screening of inbred and hybrid rice varieties against rice tungro virus in the rain-fed rice during 2000 to 2001*.

Variety	Hill infection (%)	Disease index (DI)	Plant height reduction (%)	Disease reaction
Inbreds				
BR5	40	3	8	MR
BR10	70	7	42	S
BR22	9	3	8	MR
BR23	10	3	9	MR
BR25	20	5	22	MS
BRRI dhan27	20	3	7	MR
BRRI dhan30	50	5	25	MS
BRRI dhan31	10	3	9	MR
BRRI dhan32	20	3	10	MR
BRRI dhan33	50	5	25	MS
BRRI dhan34	20	5	20	MS
BRRI dhan37	30	3	10	MR
BRRI dhan38	30	3	9	MR
BRRI dhan39	60	6	28	MS
BINAsail	50	5	25	MS
Nizersail	60	6	20	MS
Pajam	70	5	23	MS
BR11 (S- check)	70	7	45	S
Hybrids				
IR69690H	80	7	40	S
IR68877H	60	3	8	MR
IR67161H	60	5	25	MS
Sonarbangla1	70	5	20	MS

*Data are average of two rain-fed ecosystems. MR: moderately resistant; MS: moderately susceptible; and S: susceptible.

cultivation of rice worldwide. Several authors reported that plant grain yield is corresponding to the disease incidence (Zarafi et al., 2004; Anaso, 1996). The data on rice blast and yield levels are presented in Table 5. In trial 1, the control (diseased) plots were also showed low level of incidence of rice blast and the yield level was 5.00 ha^{-1}. In trial 2, the application of 3 fungicides with the 3 doses significantly reduced the yield of rice compared to the control (diseased). Among the 3 different chemicals, application of adivistin and haydazim 50 WP at the rate of 0.4% were found to be effective in controlling the disease with higher yield (5.22 to 5.24 t ha^{-1}) as compared to the control (diseased) (4.70 t ha^{-1}).

Various investigations supported the results that higher yield is due to control efficiency of the respective chemicals (Lore et al., 2005; Biswas, 2002). In their studies, they reported that many yield attributes and grain yield were significantly increased by spraying the aliphatic compounds, SPM5C-1 and SPM5cC-2 at 500 µg ml-1 against rice blast and dithane M-45, mancozeb, triazole, iprodione against ShB. Yield reduction of different crops, even when their vegetative organs are infected by the pathogen, has been reported by Ou (1985) and Prabavathy et al. (2006). Thus, it appears that the yield loss is related with the cause of increased individual leaf blast, node blast and panicle blast per plant, which might be attributed to the severity of the disease. Our results are in agreement with their studies. We therefore, conclude that judicious application of proper chemical(s) at a right time is very critical to control the blast disease of rice and simultaneously support the plant growth.

CONCLUDING REMARKS

On the basis of obtained results, we conclude that some of the resistant materials found in this study could be used in hybridization programs for varietal improvement against the BLB, blast and tungro diseases of rice. Fungicides, adivistin 50 WP and haydazim 50 WP at the rate of 0.4% could be used as seed-treating fungicides for the control of rice blast pathogen of *M. oryzae*. Therefore, potential use of these seed-treating fungicides

Table 5. Efficacy of three seed-treating fungicides for the control of rice blast disease in the irrigated ecosystem during 2002 to 2003*.

Fungicides	Dose (%)	Leaf blast infected area (%)	DI for leaf blast	Node blast incidence (%)	Panicle blast incidence (%)	DI for panicle blast	Yield (t/ha)
Trial 1 (2001 to 2002)							
Acmecop 50 WP	0.4	12.09c	3.2c	6.42bc	7.30c	3.0a	5.10a
	0.3	12.02bc	3.3c	6.35bc	7.54c	3.0a	5.11a
	0.2	15.40bc	3.4c	7.45b	8.20bc	3.0a	5.09a
Adivistin 50 WP	0.4	9.45c	3.0c	5.05c	5.32d	2.8a	5.19a
	0.3	12.08bc	3.4bc	6.40bc	7.50c	3.0a	5.16a
	0.2	14.50b	4.0b	7.40b	10.10b	3.0a	5.01a
Haydazim 50 WP	0.4	9.34c	3.0c	5.10c	5.16d	2.7a	5.20a
	0.3	12.10bc	3.5bc	7.30b	7.20c	3.0a	5.18a
	0.2	15.00b	4.0b	7.55b	8.25bc	3.0a	5.12a
Control (healthy)	-	2.00d	1.6d	1.50d	2.40e	1.0b	5.23a
Control (diseased)	-	21.00a	4.8a	9.20a	12.30a	3.1a	5.00a
Trial 2 (2002 to 2003)							
Acmecop 50 WP	0.4	11.71c	3.0c	7.72c	7.80c	3.0a	5.14a
	0.3	11.81c	3.0c	8.03c	8.77bc	3.0a	5.12a
	0.2	14.17b	3.1c	9.50b	11.90b	3.2a	5.11a
Adivistin 50 WP	0.4	7.85d	2.7c	6.30d	6.25d	2.8a	5.24a
	0.3	11.90c	3.0c	8.90b	7.83c	3.0a	5.17a
	0.2	13.970b	4.0b	9.30b	11.10b	3.2a	5.10a
Haydazim 50 WP	0.4	7.90d	2.8c	6.20d	6.12d	2.9a	5.22a
	0.3	11.79c	3.0c	9.05b	7.71c	3.2a	5.18a
	0.2	14.20b	4.1b	9.10b	11.20b	3.2a	5.13a
Control (healthy)	-	1.00d	2.5c	1.05d	1.50e	1.0b	5.27a
Control (diseased)	-	25.00a	4.9a	12.20a	15.40a	3.3a	4.70b

*Data are average of two irrigated ecosystems. Column means bearing common small letter(s) are not different significantly at the $p = 0.05$ by LSD. DI: disease index.

for disease management should be focused on future research.

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