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STUDIES ON CHEMICAL CONTROL OF BAKANAE DISEASE (*FUSARIUM MONILIFORME*) OF RICE IN PAKISTAN

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A B S T R A C T

To evaluate the efficacy of various six seed dressing fungicides (Derosal, Daconil, Aliette, Topsin-M, Mancozeb and Precure-Combi), two concentration levels 0.15% and 0.25% of each fungicide and rice variety Bas-385 were used in all experiments. Overall performance of all fungicides in all experiments was found to be better on the average basis at 0.25% than 0.15% concentration. However, the results of all fungicides at both concentrations in all experiments were significant statistically. By using standard blotter paper technique, Daconil exhibited best results followed by Derosal and Topsin-M. Aliette and Precure-Combi showed moderate results. Least impact on germination was shown by Mancozeb.

Keywords: Fungicides, Derosal, Topsin-M, Daconi, Aliette, Mancozeb.

INTRODUCTION

Rice (*Oryza sativa* L.) belongs to family *Poaceae* (true grass) and it consumed by the large population of the world. It is leading crop in Asia and it is also an important food and cash crop of Pakistan (Khan *et al.*, 2000). Despite of all the advancement in production technologies a large portion of the produce is reduced due to diseases. There are many major and minor diseases which play a key role to reduce the rice produce. The major diseases which affect the economics of rice are blast (*Pyricularia oryzae*), bacterial leaf blight (*Xanthomonas oryzae pv oryzae*), bakanae (*Fusarium moniliforme*) and brown leaf spot (*Bipolaris boryzae*) of rice (Gill *et al*., 1999). Among these potentially important diseases bakanae disease is economically very much important. Bakanae was first noted in 1928 by Ito and Kimura in Japan. It has been reported in many rice growing countries like Australia, Bangladesh, China, Korea, India and Thailand. (Ou, 1985). In Pakistan, the pathogen was first reported in rice plants in 1988 from Punjab province (Khokhar, 1990).The disease is caused by *Fusarium moniliforme* Sheld. and the pathogen is soil-borne (Wetanabe, 1974; Nishio *et al.,* 1980) as well as seed-borne (NayeemUllah and Kafi, 1978; Saponara *et al*., 1986; Parate and Lenjewer, 1387; Sherma *et al.,* 1987; (Richardson, 1990; Ahmed and Raza, 1991). It perpetuates from season to season on host crop debris buried in soil or infected seed. Infected seeds initiate the disease in fields previously free from the pathogen. From traditional rice cultivating areas of Pakistan 10-70 percent incidence of the disease was recorded on Bas-385 in 1989 (Khokhar, 1990). The disease incidence threat is on increasing trend since no proper control measures were adopted. This resulted in a serious disease problem in the top rice growing countries (Wahid *et al*., 1991; Ma *et al*., 2008). Bakanae or foot rot of rice recently gained economic importance due to large scale cultivation of susceptible fine varieties Bas-385 and Basmati Super. The pathogen *Fusarium moniliforme* induces seedling elongation due to *Gibberellins*, foot rot or seedling rot, grain sterility and discoloration affected by the *Fusaric* acid (Iqbal, 2009).Therefore it is very much important to manage the disease. The most economical and suitable ways to combat the pathogen for long period is producing resistant or genetically

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modified varieties. But in Pakistan, still there is no work on the production of genetically modified rice crop. The other two ways to secure the rice crop from diseases are the production of resistant varieties and fungicidal seed dressing. It is found that untreated seeds were heavily infested with an overall 94.5% with disease, whereas disease incidence in treated nursery was only 5.5% (Gill and Pervez, 1992). Keeping in view the importance of fungicides for disease control, studies were undertaken on the efficacy of fungitoxicants against bakanae disease to evaluate the *in-vitro* efficacy of various seed dressing fungicides and to evaluate the efficacy of various seed dressing fungicides in controlling the disease under field conditions.

MATERIALS AND METHODS

Screening of rice germplasm against bakanae disease for the source of resistance: Rice germplasm consisting of three medium grain (coarse) cultivars IR-6, KSK-133 and KS-282, and six fine grain cultivars Bas-198, Bas-2000, Bas-Pak, Bas-Super, Bas-370 and Bas-385 collected from Rice Research Institute Kala Shah Kaku was screened for resistance against Bakanae disease.

Preparation of inoculums

Source of inoculum: Previous year's preserved diseased panicles obtained from Rice Research Institute, Kala Shah Kaku (Sheikhupura) were used as the source of inoculum.

Isolation of *Fusarium moniliforme*: The infected panicles were surface sterilized with 0.1% aqueous solution of mercuric chloride, rinsed twice with distilled water, cut into small pieces and then plated on potato dextrose agar medium. The plates were incubated at 30 ^{o}C for four days. The isolated target fungus *Fusarium moniliforme* was identified according to the keys provided by Booth (1971) and Nelson *et al*. (1983).

Mass culturing: The materials used for mass culturing of *Fusarium moniliforme* were 50 x 24 cm size polypropylene bags, 1.5 cm long plastic rings (cut from 2.5 cm diam. plastic pipes), cotton plugs and wheat seeds. The wheat seeds were soaked in tap water for about 10 h and then boiled for 5-7 min. The boiled seeds were spread on a paper towel to get rid of free moisture. Then the seeds were put in polypropylene bags, about five hundred grams boiled soaked seeds per bag and the open end of each bag was passed through the plastic ring. A cotton plug was inserted tightly into the mouth of the bag passing through the small ring of PVC pipe. Wheat grains were autoclaved at 121 ^{o}C and 15 psi pressure for 20 min. for sterilization. Streptomycin and penicillin each at the rate 20 mg/bags, were added to prevent bacterial contamination. Pure mass of fungal mycelium was transferred aseptically to the mass culturing medium with the help of sterile inoculating needle. The bags were incubated at 30 ^{o}C for 15 days in alternating cycles of 12 hours darkness and 12 h of light.

Standardization of inoculum: After 15 days culture of *Fusarium moniliforme* was thoroughly meshed in water and filtered through muslin cloth to obtain the spore suspension. The concentration of the spores was measured with Haemocytometer and maintained at 1.50 × 10^{5} conidial spores ml^{-1} (Ma *et al*., 2008).

Effect of different fungicides on germination percentage of Bas-385 by using standard blotter paper technique

Seed Dressing: In this study, neat and clean Petri dishes (90 mm diam.) and plastic vessels (5 cm diameter x 7 cm height) were used. A working sample of healthy seeds of rice cultivar Bas-385 was used. Two concentration levels 0.15% and 0.25% of each fungicide Topsin-M, Aliette, Daconil, Derosal, Precure-Combi and Mancozeb were prepared for the purpose of seed dressing. Two hundred rice seeds were soaked in the each fungicidal solution separately for overnight. The excess fungicidal solution was decanted from the plastic vessels and seeds were left for few hours until touch dry. The untreated seeds were included in the study as control. The whole lot of the seeds of different treatments was sown in Petri dishes and the treatments were labeled. Fifty seeds were placed in each Petri dish, representing a replication of each treatment. Four Petri dishes were used in this method for each fungicidal treatment following standard blotter paper method (ISTA, 1985).

Germination of seedlings: Maintaining daily moisture requirements of rice seeds and observation of germination of seedlings was made on 24h basis. Final data of germination of seedlings was recorded after 14 days.

***In-vitro* efficacy of various seed dressing fungicides on Bas-385 by tray method:** In this study, six fungicides Derosal, Daconil, Aliette, Topsin-M, Mancozeb and Precure-Combi were tested for their efficacy *in-vitro*. For this study sick soil was prepared. During the preparation of sick soil, formalin solution (1:320) was mixed to the soil and covered with plastic sheet for 24 hours. The soil was left uncovered for 48h for the revival

of beneficial microorganism and the inoculum of *Fusarium moniliforme* fungus was mixed in to the soil. Fungicidal solution of each fungicide was prepared with 0.15% and 0.25% concentration for seed dressing. Rice seeds of variety Bas-385 before seed dressing were artificially inoculated by dipping in the fungal spore suspension of 1.50×10^5 ml^{-1} (Ma *et al*., 2008) overnight. A total of 400 rice seeds infested with pathogen were dressed with each fungicidal solution by dipping overnight following the liquid seed treatment method. Artificially infested seeds without fungicide treatment served as control.

Excess fungicidal solution was decanted from the beakers and seeds were left for few hours until touch dry. The whole lot of the various fungicidal dressed seeds was sown in the 37 trays (30"L ×20"W) and the treatments were labeled. Each tray was containing the sick soil. Hundred seeds were placed in each tray, representing a replication of each treatment.

Germination of seedlings: Maintaining daily moisture requirements of rice seeds and observation of germination of seedlings was made on 24h basis. Data on percentage disease control was recorded twice a week (Bhalli *et al.,* 2001). Final data of germination, discoloured, elongated and stunted seedlings were recorded after 30 days.

Efficacy of various seed dressing fungicides on Bas-385 under field conditions: The efficacy of various fungicides Derosal, Deconil, Alliet, Topsin-M, Precure-combi and Mancozeb was studied on rice variety Bas-385 under field conditions. Fungicidal solution of each fungicide was prepared with 0.15% and 0.25% concentration for seed dressing. A total of 400 rice seeds were dressed with each fungicidal solution by dipping overnight following the liquid seed treatment method. These were then sown in the field in a RCB design with four replications. Untreated seeds served as control. The inoculum suspension of 1.50×10^5 conidial spores ml-1 was mixed in to the soil and sprayed on the germinated seedlings after four weeks. Observation of germination of seedlings was made on 24 h basis. Data on percentage disease control was recorded once a week (Bhalli *et al*., 2001). Final data of germination, discoloured, elongated and stunted seedlings were recorded after up to mature.

Statistical Analysis: Data collected during the experiments was analyzed through appropriate procedures (M Stat-C software) of statistics (Steel *et al.,* 1997).

RESULTS

Table 1. *In-vitro* efficacy of various fungicides on germination of Bas-385 by using standard blotter paper technique.

Fungicides	Fungicide concentration % / seed germination %				Mean	
	0.15%		0.25%			
Topsin-M	71.00	f*	82.00	bc	76.50	B
Aliette	64.50	gh	75.00	e	69.75	C
Daconil	77.00	de	85.50	ab	81.25	A
Derosal	86.00	A	69.50	f	77.75	B
Precure-Combi	62.00	hi	79.25	cd	70.63	C
Mancozeb	60.00	I	68.25	fg	64.13	D
Control	56.00	J	56.00	j	56.00	E
Mean	68.07	B	72.93	A		

* Means with same letters do not differ significantly at p 0.05 by Duncan's Multiples Range Test.
Coefficient of Variation: 3.73%, LSD value (p 0.05) = 3.753.

While the impact of fungicides on the germination of Bas-385 was studied using standard blotter paper technique, the results as shown in Table 1 revealed a significant response in terms of increase in germination percentage compared to the control. Germination was found to be better on average basis at 0.25% concentration (72.93%) than at 0.15% concentration (68.07%). Germination percentage for all the fungicides varied significantly at both of these concentrations. Daconil exhibited best results with maximum mean germination (81.25%) followed by Darosal (77.75%) and Topsin-M (76.50%). Aliette and Precure-Combi showed moderate results were found to be statistically at par. Least impact on germination was shown by Mancozeb (64.13%).

Table 2. Evaluation of the efficacy of various seed dressing fungicides on germination of Bas-385 by tray method.

Fungicides	Germination %age at Concentration				Mean	
	0.15%		0.25%			
Topsin-M	61.00	fg*	70.25	bc	65.63	B
Aliette	55.25	hi	64.25	ef	59.75	C
Daconil	66.00	de	73.25	ab	69.63	A
Derosal	73.75	a	59.50	g	66.63	B
Precure-Combi	53.00	ig	68.00	cd	60.50	C
Mancozeb	51.25	J	58.50	gh	54.88	D
Control	47.75	k	47.75	k	45.63	E
Mean	58.28	B	62.46	A		

* Means with same letters do not differ significantly at p 0.05 by Duncan's Multiples Range Test.
Coefficient of Variation = 3.78%, LSD value (p 0.05) = 3.253.

While the effect of various fungicides on the germination of Bas-385 was studied by using the tray method, the results as shown in Table 2 revealed a significant response in terms of increase in germination percentage compared to the control. Germination was found to be better on average basis at 0.25% concentration (62.46%) than at 0.15% concentration (58.28%). Germination percentage for all the fungicides varied significantly at both of these concentrations. Least effect on germination was shown by Mancozeb (54.88%). Daconil exhibited best results with maximum mean germination (69.63%) followed by Darosal (66.63%) and Topsin-M (65.63%). Precure-Combi (60.50%) and Aliette (59.75%) showing moderate results were found to be statistically at par.

Table 3. Effect of various seed dressing fungicides on the occurrence of discoloured seedlings of Bas-385 by tray method.

Fungicides	No. of Discolored Seedlings at				Mean	
	0.15% Conc.		0.25% Conc.			
Topsin-M	13.14	de*	11.04	ef	12.09	C
Aliette	15.85	bc	13.63	c-e	14.74	B
Daconil	7.19	gh	6.14	h	6.67	E
Derosal	8.13	gh	9.65	fg	8.89	D
Precure-Combi	16.56	b	12.49	de	14.52	B
Mancozeb	17.09	b	14.99	b-d	16.04	B
Control	29.59	a	29.59	a	29.59	A
Mean	15.09	A	13.93	B		

* Means with same letters do not differ significantly at p 0.05 by Duncan's Multiples Range Test.
Coefficient of Variation = 3.78%, LSD value (p 0.05) = 2.431.

The effect of various fungicides on the occurrence of discoloured seedlings in Bas-385 was studied by using the tray method and the results as shown in Table 3 revealed a significant effect in terms of decrease in number of discoloured seedlings by the fungicides compared to the control. Significant reduction in the number of discoloured seedlings was found. On average basis the number of discolored seedlings was less at 0.25% concentration (13.93) than at 0.15% concentration (15.09). The number of discoloured seedlings for all the fungicides varied significantly at both of these concentrations. Least effect on discoloured seedling production was observed in case of Mancozeb that showed the maximum mean number (16.04) of discoloured seedlings. While in case of Daconil best results were recorded with minimum discolored seedlings (6.67) followed by Darosal (8.89) and Topsin-M (12.09). Precure-Combi (14.52) and Aliette (14.74) showing moderate results were found to be statistically at par.

Table 4. Efficacy of various seed dressing fungicides on the occurrence of elongated seedlings of Bas-385 by tray method.

Fungicides	No. of Elongated Seedlings at				Mean	
	0.15% Conc.		0.25% Conc.			
Topsin-M	6.55	cd*	5.71	De	6.13	D
Aliette	7.68	bc	6.62	Cd	7.15	CD
Daconil	3.40	F	3.06	F	3.23	E
Derosal	3.71	F	4.63	Ef	4.17	E
Precure-Combi	8.52	B	6.61	Cd	7.57	C
Mancozeb	9.26	B	8.14	Bc	8.70	B
Control	12.20	A	12.20	A	12.20	A
Mean	7.16	A	6.71	B		

* Means with same letters do not differ significantly at p 0.05 by Duncan's Multiples Range Test.
Coefficient of Variation = 3.78%, LSD value (p 0.05) = 1.536.

Data regarding the effect of various fungicides on the occurrence of elongated seedlings in Bas-385 using the tray method are given in the Table 4. The results revealed a significant effect in terms of decrease in number of elongated seedlings by the fungicides compared to the control. On average basis the number of elongated seedlings was less at 0.25% concentration (6.71) than at 0.15% concentration (7.16). The number of elongated seedlings for all the fungicides varied significantly at both of these concentrations. Least effect on the reduction of number of elongated seedlings was observed in case of Mancozeb that showed the maximum mean number (8.70) of elongated seedlings. Daconil and Derosal exhibiting best results with minimum number of elongated seedlings (3.23 and 4.17) were found to be statistically at par. Topsin-M (6.13), Precure-Combi (7.57) and Aliette (7.15) showed moderate results.

Table 5. Efficacy of various fungicides on the occurrence of stunted seedlings of Bas-385 by tray method.

Fungicides	No. of Stunted Seedlings at				Mean	
	0.15% Conc.		0.25% Conc.			
Topsin-M	7.80	fg*	7.53	fg	7.67	D
Aliette	19.49	c	17.49	c	18.49	B
Daconil	10.58	ef	8.57	fg	9.58	D
Derosal	7.12	g	8.00	fg	7.56	D
Precure-Combi	14.66	d	12.15	de	13.40	C
Mancozeb	14.66	d	13.24	de	13.95	C
Control	26.08	a	26.08	a	26.08	A
Mean	13.84	A	13.30	B		

* Means with same letters do not differ significantly at p 0.05 by Duncan's Multiples Range Test.
Coefficient of Variation = 3.78%, LSD value (p 0.05) = 2.799.

Data regarding the effect of various fungicides on the occurrence of stunted seedlings in Bas-385 using the tray method are given in the Table 5.

The results revealed a significant effect in terms of decrease in number of stunted seedlings by the fungicides compared to the control. On average basis the number of stunted seedlings was less at 0.25% concentration (6.71) than at 0.15% concentration (7.16). The number of stunted seedlings for all the fungicides varied significantly at both of these concentrations. Least effect on the reduction of number of stunted seedlings was observed in case of Aliette that showed the maximum mean number (18.49) of stunted seedlings. Derosal and Topsin-M exhibiting best results with minimum number of stunted seedlings (7.56 and 7.67) were found to be statistically at par. Daconil (9.58), Precure-Combi (13.40) and Mancozeb (13.95) showed moderate results.

Table 6. Efficacy of various fungicides on germination of Bas-385 under field conditions.

Fungicides	Germination %age at Concentration				Mean	
	0.15%		0.25%			
Topsin-M	50.50	f*	65.00	ab	57.75	B
Aliette	45.25	G	59.25	d	52.25	C
Daconil	54.00	E	65.25	a	60.63	A
Derosal	60.75	cd	55.25	a	58.00	B
Precure-Combi	43.00	gh	63.00	bc	53.00	C
Mancozeb	42.00	hi	54.25	e	48.13	D
Control	39.75	I	39.75	i	39.75	E
Mean	47.86	B	57.68	A		

* Means with same letters do not differ significantly at p 0.05 by Duncan's Multiples Range Test.
Coefficient of Variation = 2.82%, LSD value (p 0.05) = 3.027.

While the effect of various fungicides on the germination of Bas-385 was studied in the field conditions, the results as shown in Table 6 revealed a significant response in terms of increase in germination percentage compared to the control. Germination was found to be better on average basis at 0.25% concentration (57.68%) than at 0.15% concentration (47.86%). Germination percentage for all the fungicides varied significantly at both of these concentrations. Least effect on germination was shown by Mancozeb (48.13%). Daconil exhibited best results with maximum mean germination (60.63%) followed by Darosal (58.00%) and Topsin-M (57.75%). Precure-Combi (53.00%) and Aliette (52.25%) showing moderate results were found to be statistically at par.

Table 7. Efficacy of various seed dressing fungicides on the occurrence of discoloured seedlings of Bas-385 under field conditions.

Fungicides	No. of Discoloured Seedlings at				Mean	
	0.15% Conc.		0.25% Conc.			
Topsin-M	15.86	c*	11.93	de	13.89	C
Aliette	19.36	b	14.77	cd	17.06	B
Daconil	8.79	fg	6.70	g	7.74	E
Derosal	9.85	ef	10.42	ef	10.14	D
Precure-Combi	20.39	b	13.50	cd	16.94	B
Mancozeb	20.84	b	16.14	c	18.49	B
Control	32.90	a	32.90	a	32.90	A
Mean	18.29	A	15.12	B		

* Means with same letters do not differ significantly at p 0.05 by Duncan's Multiples Range Test.
Coefficient of Variation = 2.82%, LSD value (p 0.05) = 2.840.

The effect of various fungicides on the occurrence of discoloured seedlings in Bas-385 was studied in the field conditions and the results as shown in Table 7 revealed a significant effect in terms of decrease in number of discoloured seedlings by the fungicides compared to the control. Significant reduction in the number of discoloured seedlings was found. On average basis the number of discolored seedlings was less at 0.25% concentration (15.12) than at 0.15% concentration (18.29). The number of discoloured seedlings for all the fungicides varied significantly at both of these concentrations. Least effect on discoloured seedlings production was observed in case of Mancozeb that showed the maximum mean number (18.49) of discoloured seedlings. While in case of Daconil best results were recorded with minimum discolored seedlings (7.74) followed by Derosal (10.14) and Topsin-M (13.89). Precure-Combi (16.94) and Aliette (17.06) showing moderate results were found to be statistically at par.

Table 8. Efficacy of various seed dressing fungicides on the occurrence of elongated seedlings of Bas-385 under field conditions.

Fungicides	No. of Elongated Seedlings at				Mean	
	0.15% Conc.		0.25% Conc.			
Topsin-M	7.92	d-f*	6.17	Fg	7.04	D
Aliette	9.39	cd	7.17	Ef	8.28	C
Daconil	4.16	H	3.36	H	3.76	E
Derosal	4.52	gh	4.96	gh	4.74	E
Precure-Combi	10.52	bc	7.14	Ef	8.83	BC
Mancozeb	11.35	B	8.76	c-e	10.06	B
Control	13.34	A	13.34	A	13.34	A
Mean	8.74	A	7.27	B		

* Means with same letters do not differ significantly at p 0.05 by Duncan's Multiples Range Test.
Coefficient of Variation = 2.82%, LSD value (p 0.05) = 1.756.

Data regarding the effect of various fungicides on the occurrence of elongated seedlings in Bas-385 was recorded in the field conditions are given in the Table 8. The results revealed a significant effect in terms of decrease in number of elongated seedlings by the fungicides compared to the control. On average basis the number of elongated seedlings was less at 0.25% concentration (7.27) than at 0.15% concentration (8.74). The number of elongated seedlings for all the fungicides varied significantly at both of these concentrations. Least effect on the reduction of number of elongated seedlings was observed in case of Mancozeb that showed the maximum mean number (10.06) of elongated seedlings. Daconil and Derosal exhibiting best results with minimum number of elongated seedlings (3.76 and 4.74) were found to be statistically at par. Topsin-M (7.03), Aliette (8.28) and Precure-Combi (8.83) showed moderate results.

Table 9. Efficacy of various fungicides on the occurrence of stunted seedlings of Bas-385 under field conditions.

Fungicides	No. of Stunted Seedlings at				Mean	
	0.15% Conc.		0.25% Conc.			
Topsin-M	9.41	e*	8.14	e	8.77	E
Aliette	23.80	B	19.02	c	21.41	B
Daconil	13.03	D	9.25	e	11.14	D
Derosal	8.67	E	8.58	e	8.62	E
Precure-Combi	18.04	C	13.14	d	15.59	C
Mancozeb	17.86	C	14.30	d	16.08	C
Control	28.53	A	28.53	a	28.53	A
Mean	16.86	A	14.42	B		

* Means with same letters do not differ significantly at p 0.05 by Duncan's Multiples Range Test.

Coefficient of Variation = 2.82%, LSD value (p 0.05) = 3.077.

Data regarding the effect of various fungicides on the occurrence of stunted seedlings in Bas-385 was recording in the field conditions are given in the Table 9. The results revealed a significant effect in terms of decrease in number of stunted seedlings by the fungicides compared to the control. On average basis the number of stunted seedlings was less at 0.25% concentration (14.42) than at 0.15% concentration (16.86). The number of stunted seedlings for all the fungicides varied significantly at both of these concentrations. Least effect on the reduction of number of stunted seedlings was observed in case of Aliette that showed the maximum mean number (21.41) of stunted seedlings. Derosal and Topsin-M exhibiting best results with minimum number of stunted seedlings (8.62 and 8.77) were found to be statistically at par. Daconil

(11.14), Precure-Combi (15.59) and Mancozeb (16.08) showed moderate results.

DISCUSSION

***In-vitro* efficacy of various seed dressing fungicides against *Fusarium moniliforme*:** The rice suffers from many seed-borne diseases, which cause reduction in germination at initial stage directing to poor crop stand and at adult stage resulting in both qualitative and quantitative loss in grain yield. *Fusarium moniliforme* is seed-borne pathogen and can cause reduction in germination and attack mature plants and developing seeds (Khan *et al*., 1990). All the fungicides have great impact on the germination of seeds by suppressing the seed borne pathogen and enhance the overall germination percentage. Thus impact of seed dressed fungicides on the germination of Bas-385 was studied using standard blotter paper technique, the results revealed a significant response in terms of increase in germination percentage compared to the control. Bas-385 was used because it was susceptible variety for seed borne pathogen *Fusarium moniliforme*. Germination was found to be better on average basis at 0.25% concentration (72.93%) than at 0.15% concentration (68.07%). Germination percentage for all the fungicides varied significantly at both of these concentrations. By increasing the fungicide concentration the efficacy of germination enhanced. All the fungicides increase germination over control (Gill *et al*., 1999). Efficacy of fungicides increased with the increase in concentration in accordance with Bhali *et al*. (2001) and Gill *et al*. (1999). Daconil exhibited best results with maximum mean germination (81.25%) followed by Derosal (77.75%) and Topsin-M (76.50%). The results were in accordance with those of Bhalli *et al*. (2001). Aliette and Precure-Combi showing moderate results were found to be statistically at par. Least impact on germination was shown by Mancozeb (64.13%). Similar studies were carried out by Ilyas (1997) who used fifteen different fungicides, Topsin-M, Benlate, Score-250, Topas-100, Rizolax, Panoram, Sandofan, Liromanzeb, Daconil, Aliette, Folicur, Thiabendazole, Apron-35, Nemispore and spotless. Benlate, Daconil, and Folicur significantly improved germination at 0.25% concentration. Aliette and Topas-100 proved to be phytotoxic while Spotless and Thiabendazole were ineffective in improving the seed germination over untreated control. During the evaluation of efficacy of six different fungicides in-vitro by tray method, the results of each fungicide were statistically significant in all parameters. The parameters were seed germination, dicolouration, elongation and stunting of seedlings. In germination percentage, dicolouration and elongation of seedlings Daconil showed best results followed by Derosal and Topsin-M and least impact was observed in case of Mancozeb. Precure-Combi and Aliette showed moderate results. But in stunting of seedlings Derosal exhibited best results and least impacts were studied in case of Aliette. Precur-Combi and Mancozeb showed moderate results. Similar studies were attained by Ilyas (1997) by using various fungicides, Benlate, Derosal, Healthied, Ridomil, Score, Topas and Topsin-M. They treated the artificially infested seeds by slurry method at 1, 2, 3 and 4 g/kg of seed. Derosal was the most effective one followed by Benlate, Topsin-M, and Healthied. The results were also in accordance with those of Sarkar (1986) and Yasuda (1986).

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