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# Foliar Spray of Fungicides at Different Concentrations in Controlling Alternaria Leaf Blight of Mustard

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**Abstract**

A field experiment was conducted to test the effect of four fungicides namely, Rovral 50 WP, Indofil M-45, Ridomil Gold and Dithane M-45 at four concentrations (0.10, 0.15, 0.20 and 0.25%) against Alternaria leaf blight of mustard. The fungicides were applied at 10 days interval, starting from onset of the disease and continued up to pod maturity. Significantly lowest disease severity of Alternaria leaf blight was observed when Rovral 50 WP was sprayed @ 0.25% concentration. This treatment significantly reduced the percentages of leaf area diseased, leaf and siliqua infection and number of spots siliqua$^{-1}$. Next to Rovral, Indofil M-45 and Ridomil Gold showed better performance. The highest seed yield was recorded from the plots treated with Rovral @ 0.25% concentration which was statistically at par with Rovral applied @ 0.20%. The result indicates that the seed yield exhibited a regular trend of significant increase with the increase in fungicidal concentration up to 0.20%.

**Keywords:** Alternaria leaf blight, Fungicides doses, Mustard.

## INTRODUCTION

Mustard (*Brassica juncea*, *B.campestris* and *B.napus*), groundnut (*Arachis hypogaea*) and sesame (*Sesamum indicum*) are the three important oilseed crops in Bangladesh. But the oilseed production in Bangladesh is largely dependent on mustard and rapeseed (Razzaque *et al*. 2002). The average yield of mustard in Bangladesh stands at 900 kg ha$^{-1}$ (Anon. 2008), which is low compared to many mustard/rapeseed growing countries of the world (1575 kg ha$^{-1}$) (Anon. 2003). Various diseases play an important role in reducing the quantity and quality of mustard/rapeseed (Ahmed and Ahmed 1994). Mustard and rapeseed suffer from 14 diseases in Bangladesh (Bakr *et al*. 2007). Alternaria blight has been recognized as the most serious and devastating disease of mustard in Bangladesh (Ahmed and Ahmed 1994). The disease causes blight of leaf, siliqua and stem (Ahmed and Ahmed 1994) and seed abnormalities (Howlider *et al*. 1991). It is endemic in Bangladesh and most of the cultivated varieties are susceptible to this disease. The disease causes yield losses of 40-70% in India (Vishwanath and Kolte 1997) and 30-

60% in Bangladesh (Ahmed and Ahmed 1994, Meah and Hossain 1988). In addition to direct yield losses, the disease adversely affects the seed quality by reducing seed size and causing seed discolouration and reduction in oil contents (Howlider *et al*. 1991). Siliqua of *Brassica* spp. is the main component of seed yield and normal filling of seed takes place if siliqua can be protected from infection (Hossain and Mian 2004). Protection of siliqua from Alternaria blight infection should, therefore, be the most important aim for higher yield of mustard.

Available literature reveals that there have been multifarious efforts to control Alternaria leaf blight of mustard. The most economical and environmentally safe method of controlling the disease is the development of resistant varieties. But, there is no information on the resistance source, although some sort of tolerance has been reported (Shah *et al*. 2005, Rajendra *et al.* 2002). Various aspects of Alternaria leaf blight disease have been investigated in home and abroad and useful information obtained. Cultivars and advanced mustard lines have been screened against the disease, but material with high degree of resistance and good agronomic type are almost lacking. In absence of good level of resistance, use of fungicides would be an alternative option to keep the disease below economic threshold level. Because fungicides had quick action, broad spectrum activity and easy availability to the growers. The present work was, therefore, undertaken with the objectives to determine the effectiveness of fungicides as foliar spray applied in different concentrations for reducing Alternaria leaf blight incidence of mustard.

## MATERIALS AND METHODS

This experiment was conducted at Regional Agricultural Research Station (RARS), BARI, Jessore, Bangladesh during the rabi season of 2006-07 and 2007-08. Foliar spray of four fungicides namely, Rovral 50WP, Indrofil M-45, Ridomil Gold and Dithane M-45 were applied each at four concentrations viz., 0.10, 0.15, 0.20 and 0.25% of the formulated product. The fungicides were sprayed three times at ten days interval beginning from initiation of infection by *Alternaria brassicae*. The suspensions of fungicides were prepared in tap water. The experiment was laid out in a RCBD with three replications. After final preparation of land, the field was divided into 3m x 3m unit plots maintaining a distance of 1m between plots and 2m between the blocks to prevent drifting of spray from plot to plot. Seeds of BARI sarisha 6 were sown on 18th and 20th November in 2006 and 2007, respectively maintaining a spacing of 30 cm between the rows. Each year the crop had received 120 kg N, 30 kg P, 60 kg K, 30 kg S, 2 kg Zn and 1 kg B per hectare. The sources of nutrients were urea, TSP, MoP, gypsum, zinc sulphate and boric acid for N, P, K, S, Zn and B respectively. Intercultural operations viz., weeding, irrigation and insecticide spray were done when required. Development of Alternaria leaf blight was assessed by recording data (% leaf infection, % leaf area diseased, % siliqua infection and number of spots siliqua$^{-1}$) 3 times during crop growth stage on the following way:

i. Percentage of leaf infection: Ten plants in a unit plot were randomly selected and tagged for all observations. Total number of leaves and number of infected leaves from the selected plants were counted and the percentages of leaf infection were determined.

ii. Percent leaf area diseased: Five leaves from each of 10 selected plants discarding the older (lower part) and younger ones (upper part) were assessed for estimating percent leaf area diseased (Meah, 1994). The whole leaf surface area was considered as 100 and the infected area was estimated thereof.

iii. Percentage of siliqua infection: Counting of total number of healthy and diseased siliquae in selected 10 plants in each plot was done to determine the percentage of siliquae infection.

iv. Spots per siliqua: Diseased spots on 20 siliquae in the main rachis from 10 cm below the top were counted on each of 10 plants to calculate the number of *Alternaria* spots per siliqua.

The crop was harvested at mature stage. Data on the yield and yield contributing characters from all plots were recorded. The data were statistically analyzed following the principle of F-statistics and the mean values were separated by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

## RESULTS

Fungicides significantly affected the percentage of leaf infection and leaf area diseased. The lowest percentage of leaf infection and leaf area diseased were found after the treatment with Rovral, which were statistically lower than other fungicides. Next to Rovral, Indofil M-45 also was effective in controlling the disease. However, the efficacy of Dithane M-45 was significantly lower as compared to Rovral, Ridomil Gold and Indofil M-45. It is evident from Table 1 that % leaf infection, % leaf area diseased, % siliqua infection and number of spots / siliqua were also reduced when Rovral @ 0.25% concentration applied during 2006-2007 and 2007-2008 crop seasons. The maximum disease and other characters were noted at

0.10% concentration (Table 1). It is evident from Table 2 that other plant characters such as number of siliquae / plant, number of seeds / siliqua, 1000-seed weight and seed yield were recorded better when treated with Rovral at the @ 0.25% concentration and poor at 0.10. The lowest percentages of leaf infection and leaf area diseased were recorded at 0.25% concentration which was statistically similar to those at 0.20% concentration but differed from other concentrations. The interaction effect of fungicides and their doses were significant in reducing percentages of leaf infection and leaf area diseased (Table 3). The lowest percentage of leaf infection was observed in the treatment $T_9$ ($F_1D_3$) where Rovral was applied @ 0.20% concentration and it was statistically similar to $T_{13}$ ($F_1D_4$ ) in the year of 2007-08. On the other hand, the lowest percent leaf area diseased was recorded in treatment $T_{13}$ ($F_1D_4$) where Rovral was applied at 0.25% concentration and it was statistically similar to Rovral applied at 0.20% concentration $T_9$ ($F_1D_4$) (Table 3).

Table 1. Effect of different doses of Rovral on % leaf infection, % leaf area diseased, % siliqua infection and spots siliqua$^{-1}$ of Alternaria leaf blight affected mustard.

| Doses (%) | % Leaf infection | | % Leaf area diseased | | % Siliqua infection | | Spots siliqua$^{-1}$ (no.) | |
|---|---|---|---|---|---|---|---|---|
| | 2006-07 | 2007-08 | 2006-07 | 2007-08 | 2006-07 | 2007-08 | 2006-07 | 2007-08 |
| 0.10 | 23.35a | 26.21a | 20.54a | 24.59a | 21.76a | 24.14a | 9.80a | 10.21a |
| 0.15 | 20.88b | 23.61b | 17.86b | 22.54b | 20.20b | 22.04b | 8.95b | 9.52b |
| 0.20 | 17.70c | 18.86c | 15.58c | 18.20c | 15.68c | 17.56c | 7.07c | 7.87c |
| 0.25 | 17.83c | 18.22c | 14.87c | 18.57c | 14.50d | 16.43c | 6.59d | 7.38d |
| CV (%) | 8.03 | 4.18 | 8.12 | 4.18 | 7.50 | 8.14 | 4.88 | 3.92 |

Means within a column followed by same letter(s) are not significantly different at 5% level by DMRT.

**Percentage of Siliqua Infection**

Fungicides had a significant effect on percentage of siliqua infection (Table 1). The lowest percentage of infected siliqua was found in Rovral treated plots @ 0.25% concentration in both the crop seasons. Lower concentration i.e. 0.10% produced significantly higher infection (Table 1). From the result it was observed that with the increase of concentration of fungicide the percent siliqua infection also decreased. The lowest percentage of siliqua infection was recorded at 0.25% concentration which was statistically similar to that recorded at 0.20% concentration (except 2007-08).

Interaction between fungicides and their concentrations has significant effect on percentage of siliqua infection (Table 3). The percentage of siliqua infection was statistically higher when Dithane M-45 was applied at 0.10% concentration. Rovral @ 0.20 and 0.25% concentrations ($T_9$ and $T_{13}$) performed better in reducing siliqua infection than other fungicides at same concentration. Indofil M-45 and Ridomil Gold always showed similar percentage of siliqua infection at different concentrations.

**Spots Siliqua$^{-1}$**

The numbers of spots siliqua$^{-1}$ were recorded as 6.59 and 7.38 in the year of 2006-07 and 2007-08, respectively treatment after Rovral @ 0.25% concentration, which were significantly lower than those with other concentrations used in this experiment (Table 1). The interaction effect of fungicides and their doses was significant for number of spots siliqua$^{-1}$ (Table 3). The highest number of spots siliqua$^{-1}$ was obtained under Dithane M-45 applied at 0.10% concentration $T_4$ ($F_4D_1$). Rovral @ 0.25% concentration resulted in the lowest spots siliqua$^{-1}$ which was statistically similar to those at 0.20% concentration in both the years $T_9$ ($F_1D_3$).

**Siliquae Plant$^{-1}$**

Fungicide has no significant effect in producing the number of siliquae plant$^{-1}$ (Table 2). The highest number of siliquae plant$^{-1}$ was obtained from Rovral treated plots @ 0.25% concentration and the lowest with at 0.10%. The interaction effect of fungicides and their doses on the number of siliquae plant$^{-1}$ were also found statistically non-significant (Table 4).

Table 2. Effect of different doses of Rovral on number of siliquae plant$^{-1}$, seeds siliqua$^{-1}$, 1000- seed weight and seed yield of mustard Alternaria leaf blight

| Doses (%) | Siliquae plant$^{-1}$ (no.) | | Seeds siliqua$^{-1}$ (no.) | | 1000- seed wt.(g) | | Seed yield (kg ha$^{-1}$) | |
|---|---|---|---|---|---|---|---|---|
| | 2006-07 | 2007-08 | 2006-07 | 2007-08 | 2006-07 | 2007-08 | 2006-07 | 2007-08 |
| 0.10 | 94.25a | 92.30a | 20.32b | 19.50c | 3.06c | 2.91b | 1229c | 1137c |
| 0.15 | 101.50a | 97.70a | 20.97b | 20.46b | 3.23b | 2.94b | 1330b | 1288b |
| 0.20 | 107.80a | 101.80a | 22.21a | 21.70a | 3.32a | 3.31a | 1586a | 1461a |
| 0.25 | 109.00a | 102.00a | 22.48a | 21.66a | 3.34a | 3.23a | 1622a | 1468a |
| CV (%) | 4.74 | 7.61 | 3.88 | 2.98 | 2.51 | 3.60 | 3.50 | 3.92 |

Means within a column followed by same letter(s) are not significantly different at 5% level by DMRT.

**Seeds Siliqua$^{-1}$**

During 2006-07 and 2007-08, significantly the highest numbers of seeds siliqua$^{-1}$ were counted as 22.48 and 21.66, respectively from the Rovral treated plots @ 0.25% concentration, which were statistically similar to 0.20% concentration. Different concentrations also have a significant effect on seeds siliqua$^{-1}$(Table 2). The interaction of fungicides and their doses was significantly effective for seeds siliqua$^{-1}$ when the crop received Rovral @ 0.20 and 0.25% concentrations (Table 4). These two treatments $T_9$ ($F_1D_3$) and $T_{13}$ ($F_1D_4$) were statistically similar to $T_{10}$ ($F_2D_3$), $T_{11}$ ($F_3D_3$) and $T_{15}$ ($F_3D_4$) in both the years.

Table 3. Interaction effect of fungicides and their doses on % leaf infection, % leaf area diseased, % siliqua infection and spots siliqua$^{-1}$ of mustard as affected by Alternaria leaf blight

| Treatments | % Leaf infection | | % Leaf area diseased | | % Siliqua infection | | Spots siliqua$^{-1}$ (no.) | |
|---|---|---|---|---|---|---|---|---|
| | 2006-07 | 2007-08 | 2006-07 | 2007-08 | 2006-07 | 2007-08 | 2006-07 | 2007-08 |
| $T_1$ | 20.50cd | 23.45de | 15.24cd | 18.64fg | 18.73de | 19.33c | 8.60ef | 9.12e |
| $T_2$ | 23.90ab | 26.19b | 21.63b | 25.53c | 21.77bc | 24.72ab | 9.90bc | 10.40bc |
| $T_3$ | 23.10abc | 26.00b | 20.82b | 24.60cd | 21.23bc | 25.25ab | 9.50cd | 10.03cd |
| $T_4$ | 25.90a | 29.20a | 24.45a | 29.57a | 25.30a | 27.25a | 11.20a | 11.30a |
| $T_5$ | 18.87de | 21.50f | 13.39d | 17.40g | 17.27ef | 17.59cde | 7.90g | 8.43f |
| $T_6$ | 21.63bcd | 24.07cd | 19.71b | 23.20de | 20.05cd | 22.70b | 9.00de | 9.63de |
| $T_7$ | 21.10bcd | 23.60b | 16.20c | 22.38e | 20.28cd | 23.03b | 8.70e | 9.23e |
| $T_8$ | 21.90bc | 25.27bc | 22.16ab | 27.17b | 23.21ab | 24.83ab | 10.20b | 10.77ab |
| $T_9$ | 13.40f | 13.56h | 10.10e | 11.40h | 10.46h | 12.09f | 5.40i | 6.43jk |
| $T_{10}$ | 17.40e | 19.60g | 14.99cd | 18.32fg | 15.55fg | 17.34cde | 6.80h | 8.00fg |
| $T_{11}$ | 17.17e | 18.80g | 15.05cd | 18.03g | 15.32fg | 17.68cde | 6.60h | 7.13hi |
| $T_{12}$ | 22.83bc | 22.40ef | 22.19ab | 25.07c | 21.39bc | 23.12b | 9.47cd | 9.90cd |
| $T_{13}$ | 16.62e | 14.65h | 9.70e | 10.99h | 9.16h | 14.94e | 5.20i | 5.97k |
| $T_{14}$ | 16.83e | 18.90g | 14.29cd | 19.83f | 14.29g | 15.81e | 6.77h | 7.63gh |
| $T_{15}$ | 16.73e | 18.60g | 14.04cd | 18.30fg | 14.23g | 15.99de | 6.40h | 6.90ij |
| $T_{16}$ | 21.13bcd | 21.80f | 21.43b | 24.90c | 20.32cd | 18.99cd | 8.00fg | 9.00e |
| CV (%) | 8.03 | 4.18 | 8.12 | 4.18 | 7.50 | 8.14 | 4.88 | 3.92 |

Means within a column followed by same letter(s) are not significantly different at 5% level by DMRT.

$F_1$=Rovral 50 WP, $F_2$= Ridomil Gold, $F_3$ = Indofil M-45, $F_4$ = Dithane M-45
$D_1$ = 0.10%, $D_2$ = 0.15%, $D_3$ = 0.20%, $D_4$ = 0.25%.
$T_1=F_1D_1$, $T_2=F_2D_1$, $T_3=F_3D_1$, $T_4=F_4D_1$, $T_5=F_1D_2$, $T_6=F_2D_2$, $T_7=F_3D_2$, $T_8=F_4D_2$, $T_9=F_1D_3$, $T_{10}=F_2D_3$, $T_{11}=F_3D_3$, $T_{12}=F_4D_3$, $T_{13}=F_1D_4$, $T_{14}=F_2D_4$, $T_{15}=F_3D_4$, $T_{16}=F_4D_4$

## 1000-seed Weight

In respect of concentrations, significantly higher 1000-seed weights were measured as 3.34 and 3.23 g, respectively in Rovral treated plots @ 0.25% concentration during the years 2006-07 and 2007-08 (Table 2). Different concentrations of fungicide significantly affected the 1000-seed weight (Table 2). The interaction effects of fungicides and their doses showed significant effect on 1000-seed weight. The highest 1000-seed weight was obtained from $T_{13}$ ($F_1D_4$) treatment where Rovral was sprayed at 0.25% concentration and it was statistically similar to that of $T_9$ ($F_1D_3$) but superior to all other treatment combinations (Table 4).

Table 4. Interaction effect of fungicides and their doses on number of siliqua plant$^{-1}$, seeds siliqua$^{-1}$, 1000- seed weight and seed yield of mustard as affected by Alternaria leaf blight

| Treatments | Siliquae plant$^{-1}$ (no.) | | Seeds siliqua$^{-1}$ (no.) | | 1000- seed weight (g) | | Seed yield (kg ha$^{-1}$) | |
|---|---|---|---|---|---|---|---|---|
| | 2006-07 | 2007-08 | 2006-07 | 2007-08 | 2006-07 | 2007-08 | 2006-07 | 2007-08 |
| $T_1$ | 96.00a | 96.00a | 20.53cde | 19.60ef | 3.20cd | 2.93bcd | 1290def | 1197de |
| $T_2$ | 95.00a | 93.00a | 20.40cde | 19.40ef | 3.03ef | 2.91bcd | 1210fg | 1121ef |
| $T_3$ | 94.00a | 91.00a | 20.29cde | 19.60ef | 3.02f | 2.79cd | 1220efg | 1129ef |
| $T_4$ | 92.00a | 89.00a | 19.82e | 19.30ef | 2.97f | 2.67d | 1195g | 1099f |
| $T_5$ | 104.00a | 99.00a | 21.70bc | 21.05cd | 3.48b | 3.12bc | 1408c | 1391b |
| $T_6$ | 102.00a | 97.00a | 21.47bcd | 20.35def | 3.18cde | 3.02bcd | 1320cd | 1297c |
| $T_7$ | 102.00a | 98.00a | 20.53cde | 20.53de | 3.20cd | 3.03bcd | 1311de | 1283cd |
| $T_8$ | 98.00a | 97.00a | 20.17cde | 19.90ef | 3.05def | 2.90bcd | 1280d-g | 1180ef |
| $T_9$ | 110.00a | 103.00a | 23.77a | 22.81a | 3.68a | 3.57a | 1740a | 1624a |
| $T_{10}$ | 108.00a | 101.00a | 22.60ab | 21.80abc | 3.21c | 3.21b | 1603b | 1471b |
| $T_{11}$ | 107.00a | 103.00a | 22.67ab | 21.89abc | 3.22c | 3.22b | 1593b | 1452b |
| $T_{12}$ | 106.00a | 100.00a | 20.05de | 20.30def | 3.18cde | 3.05bcd | 1407c | 1298c |
| $T_{13}$ | 111.00a | 103.00a | 24.07a | 22.25a | 3.69a | 3.58a | 1748a | 1632a |
| $T_{14}$ | 109.00a | 102.00a | 22.63ab | 21.35bcd | 3.22c | 3.22b | 1603b | 1461b |
| $T_{15}$ | 109.00a | 102.00a | 22.66ab | 21.86abc | 3.23c | 3.22b | 1609b | 1478b |
| $T_{16}$ | 107.00a | 101.00a | 20.54cde | 21.16bcd | 3.20cd | 3.07bc | 1527b | 1301c |
| CV (%) | 7.74 | 7.61 | 3.88 | 2.98 | 2.51 | 3.36 | 3.50 | 3.92 |

Means within a column followed by same letter(s) are not significantly different at 5% level by DMRT.

$F_1$=Rovral 50 WP, $F_2$= Ridomil Gold, $F_3$ = Indofil M-45, $F_4$ = Dithane M-45
$D_1$ = 0.10%, $D_2$ = 0.15%, $D_3$ = 0.20%, $D_4$ = 0.25%.
$T_1=F_1D_1$, $T_2=F_2D_1$, $T_3=F_3D_1$, $T_4=F_4D_1$, $T_5=F_1D_2$, $T_6=F_2D_2$, $T_7=F_3D_2$, $T_8=F_4D_2$, $T_9=F_1D_3$, $T_{10}=F_2D_3$, $T_{11}=F_3D_3$, $T_{12}=F_4D_3$, $T_{13}=F_1D_4$, $T_{14}=F_2D_4$, $T_{15}=F_3D_4$, $T_{16}=F_4D_4$

## Seed Yield

Fungicides had a significant effect on the seed yield of mustard. The highest seed yields of 1622 and 1468 kg $ha^{-1}$ were obtained (during 2006-07 and 2007-08, respectively) from Rovral treated plots @ 0.25% concentration (Table 2). It is evident from Table 2 that concentrations had significant effect on seed yields. Different concentrations of fungicides significantly affected the seed yield (Table 4). The lowest seed yields (1229 and 1137 kg $ha^{-1}$, respectively) were obtained from lower concentration (0.10%) during 2006-07 and 2007-08. From this result it was observed that the seed yield exhibited a regular trend of significant increased with the increase in fungicidal concentrations up to 0.20% in both the years. The interaction effect of fungicides and their doses showed significant influence on the seed yield (Table 4). The treatment $T_{13}$ ($F_1D_4$) recorded the highest seed yield when Rovral was sprayed @ 0.25% concentration and it was statistically similar to 0.20% concentration of the same fungicide. Dithane M-45 @ 0.10% concentration noted the lowest seed yield T4 (F4D1). The seed yield ranged from 1099 to 1740 kg $ha^{-1}$.

## DISCUSSION

The results of the present study indicated that spray with Rovral @ 0.25% concentration was effective for reducing the severity of Alternaria blight and increased seed yield of mustard. The treatment caused significant reduction of % leaf area diseased, leaf and siliqua infection and spots $siliqua^{-1}$. Next to Rovral, Indofil M-45 and Ridomil Gold showed superior performance. The effectiveness of Rovral to control Alternaria leaf blight of mustard was also demonstrated by Pandya *et al.* (2000), Meah *et al*. (1999) and Mondal *et al.* (1999). The efficacy of Rovral against *Alternaria* species (*A. porri*, *A. brassicicola*, *A. Alternata*, *A. brassicae* and *A. mali*) was also reported by other workers (Ayub *et al.* 1996, Datar 1996, Ashok and Kumara 1999, Filajdic and Sutton 2002, Rahman *et al*. 2005). In the present study, Rovral was applied in the field @ 0.10, 0.15, 0.20 and 0.25%. Most of the reports indicated that the dosage 0.20% was the most effective (Kumara 1996, Meah and Hossain 1988). However, lower dose of Rovral (@ 0.10%) has also been found effective in controlling Alternaria blight of mustard (Meah *et al*. 1992, Meah and Hossain 1989, Humpherson and Madude 1983). Meah *et al*. (1992) observed that foliar application of Rovral, Dithane M-45, Duter and Topsin were effective against Alternaria blight of mustard but Rovral proved most effective. Rahman *et al*. (2005) observed that Rovral was the most effective fungicide to control *A. alternata* of chili. Ryan *et al.* (1984) found that Ridomil was an effective fungicide against *A. brassicae* of mustard. Chattopadhyay and Bhunia (2003) reported that Rovral @ 0.20% was the best treatment to control the *Alternaria* severity of mustard and increase seed yield and 1000-seed weight significantly.

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