Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; 9(5): 2091-2094
Received: 27-07-2020
Accepted: 25-08-2020

**M Gusain**
Department of Plant Pathology, College of Horticulture, VCSG UUHF, Bharsar (Pauri Garhwal) Uttarakhand, India

**S Ravi**
Department of Plant Pathology, College of Horticulture, VCSG UUHF, Bharsar (Pauri Garhwal) Uttarakhand, India

**Corresponding Author:**
**S Ravi**
Department of Plant Pathology, College of Horticulture, VCSG UUHF, Bharsar (Pauri Garhwal) Uttarakhand, India

# *In vivo* assessment of fungicides and bioagents for Alternaria blight of radish (*Alternaria raphani* Groves & Skolko)

## M Gusain and S Ravi

**Abstract**

Alternaria blight is most important disease in radish caused by *Alternaria raphani* and also cause serious damage to the crop yield 46.48% and varied from year to year. *In vivo,* evaluation of six fungicides (Mancozeb, Carbendazim, Ridomil-MZ and Copper oxy chloride (CoC) with 2.5 gm/kg seed; Propiconazole and Hexaconazole with 2.5 ml); three bioagents i.e. (*B. cereus*, *P. fluorescens* and *T. harzianum* with 5 gm/kg seed) tested against *A. raphani.* Among fungicides Mancozeb was minimum PDI (5.18, 8.02 and 11.44%) and minimum PDS (9.33, 14.66 and 17.33%) at 35, 45 and 55 DAS also most effective and followed by Carbendazim, Ridomil-MZ respectively. In bioagents *T. harzianum* showed minimum PDI (12.51, 15.17 and 18.74%) and PDS (22.00, 25.33 and 29.66%) at 35, 45 and 55 DAS; also most effective. Maximum yield (kg/plot) showed by Mancozeb (7.28 kg) and followed by Carbendazim, Ridomil-MZ and minimum yield was found in *B. cereus*.

**Keywords:** Radish, Alternaria blight, *Alternaria raphani,* fungicides, bioagents, PDI, PDS and yield

## Introduction

Radish (*Raphanus sativus* L.) is an important root vegetable of tropical, subtropical and temperate regions belonging to the family Brassicaceae. Radish is originated in South East Asia. It can be cultivated under cover for early production but large scale production in field is more common in India. The major factors responsible for low production of brassicaceous vegetables in field are both biotic (fungi and bacteria) and abiotic (Temperature, water stress and nutrient deficiency etc.) factors. Biotic factors cause more loss than abiotic factors. The major diseases caused by biotic factors to brassicaceous vegetables are club root, damping off, white rust and Alternaria blight etc. Alternaria leaf blight of oilseed brassicas is known to be incited by three species namely *Alternaria brassicae* (Berk.) Sacc., *Alternaria brassicicola* (Schw.) Wiltshire., *Alternaria raphani* Groves and Skolko (Jasalavich *et al.*, 1995; Saharan and Mehta, 2002) [6, 13].

Blight in radish cause by *A. raphani* showed serious damage to the crop yield 35-38% (Kolte *et al.*, 1987) [8] and quality of the crop (Dillard and Joi, 2011) [4]. Meenu and Hundal (2004) [11] reported that seed yield losses due to Alternaria blight in radish is about (46.48%) and varied from year to year. The radish crop is severely affected by Alternaria blight caused by *Alternaria raphani* during both seed and root crop production. The Symptoms of the disease first appear on the leaves of seed stem in the form of small, yellowish, slightly raised water soaked lesions. Lesions appeared later on the stems and seed pods as necrotic spot with concentric ring (Sohaib *et al.* 2017) [16]. All foliage is full of small, circular spots and very destructive at siliqua formation stage where all floral part, pods peduncle and seeds become black (Mangala *et al.*, 2006) [9]. Alternaria is cosmopolitan in occurrence and spreads through airborne conidia and can infect several crops, including radish initiating the disease Alternaria blight. Irregular brown- to dark brown–colored spots, surrounded by concentric rings, give a “target board” effect appear on leaves. These circular spots coalesce and form large patches. Small and dark-colored spots can be seen on pods and tender twigs by Sohaib *et al.* (2017) [16]. The comparative study between the fungicides and bioagents against Alternaria leaf spot of cauliflower and concluded that the minimum PDI (%) was observed in the treatment Propiconazole@0.2% (21.30%) followed by Mancozeb @ 0.2% (23.15%), *Trichoderma harzianum* @2.0% (25.78%), *Pseudomonas fluorescens* @ 2.0% (27.04%) as compared to untreated control (28.98%) studied by Sailaja *et al.* (2017)[14]. The antifungal effects of four tomato rhizosphere *Bacillus* spp. (*B. subtilis, B. megaterium, B. pumilus* and *B. cereus*) against *A. alternata* and reported that the promising effect of the four bacteria species tested in reducing disease incidence and severity in comparison with the control and attempting to include non-toxic bio-agent in an integrated management of early blight disease Abbo *et al.* (2014) [1].

In present investigation applied fungicides and bio-control agents in a compatible manner for effective and safe disease management.

## Materials and Methods

The present investigation was conducted in the Department of Plant Pathology and field experiment was conducted during *kharif* season, 2017 at Vegetable Research and Demonstration Block, College of Horticulture, VCSG UUHF, Bharsar. About 55 km away from Pauri city, situated at an altitude of 1900 meters above mean sea level. Geographical position of experimental site lies between latitude $29^0$ North and of $78^0$ East longitudes under western Himalayan zone of Uttarakhand. Seeds were sown in the field spaced at (45 cm ×10 cm). Seed of radish -Japanese white, plot size of (1.8m × 1m) number of plants/plot- forty, total experimental area ($89.46m^2$) with three replication.

**Seed treatment**: Six fungicides namely (Mancozeb, Carbendazim, Ridomil-MZ and Copper oxy chloride (CoC) with 2.5 gm/kg seed; Propiconazole and Hexaconazole with 2.5 ml; three bioagents i.e. (*Bacillus cereus, Pseudomonas fluorescens* and *Trichoderma harzianum*) with 5 gm/kg seed tested as seed treatment for their field efficacy. Based on disease intensity and disease severity against Alternaria blight of radish.

**Per cent disease intensity (PDI)** was recorded by five leaves on plants were selected randomly and rating of each leaf, done by selecting ten plants in each replicated plots, by using a (0-9) rating scale developed by (Mayee and Datar,1986) [10].

Rating scale used for recording disease intensity on leaves

| Category | Grade numerical value | Leaf area infected |
|---|---|---|
| I | 0 | Disease free |
| II | 1 | 1-10 |
| III | 3 | 11-25 |
| IV | 5 | 26-50 |
| V | 7 | 51-75 |
| VI | 9 | >75 |

$$\text{PDI} = \frac{\text{sum of all numerical rating}}{\text{No. of plants observed} \times \text{maximum grade(9)}} \times 100$$

**Per cent disease severity (PDS)**: Per cent disease severity was calculated by following formula:

$$\text{PDS} = \frac{\text{Sum of rating scale}}{\text{Total no. of leaves observed}} \times 100$$

The data had obtained under field condition and analyzed by using RCBD (randomized complete block design) with the help of OPSTAT.

## Results and Discussion

### Effect of different treatments on (PDI) at 35, 45 and 55 days after sowing (DAS)

**Per cent disease intensity (PDI) at 35 DAS:** The observations recorded in (Table 1) showed that significant differences between of all the treatments as compared over control. The performance of the treatments ranged from (5.18-17.40%). Lowest per cent of disease intensity (PDI) was observed after at 35 days in the Mancozeb (5.18%), whereas maximum was observed in control (17.40%), followed by *B. cereus* (14.10%). The Carbendazim (6.29%) and Ridomil-MZ (7.40%) found statistically at par with Mancozeb (5.18%).

**Per cent disease intensity (PDI) at 45 DAS:** The data revealed in significant variations for PDI between control and all of the treatments. It ranged from (8.02-20.59%). Lowest per cent of disease intensity was observed in the treatment Mancozeb (8.02%), maximum PDI was observed in control (20.59%), followed by *B. cereus* (17.03%). All the treatments were found significant as compared with control, whereas the Carbendazim (9.97%) statistically at par with Mancozeb (8.02%).

**Per cent disease intensity (PDI) at 55 DAS:** It is evident from the data presented significant variations for PDI between control and all of the treatments. It ranged from (11.44-24.35%). Lowest per cent of disease intensity was observed in the treatment Mancozeb i.e. (11.44%), whereas maximum was observed in control (24.35%), followed by *B. cereus* (20.10%). All the treatments were found significant as compared with control, whereas the Carbendazim (12.22%) and Ridomil-MZ (13.06%) found statistically at par with Mancozeb (11.44%). During the field trial, the per cent disease intensity of the disease was recorded at 35, 45 and 55 days after sowing (DAS). Mancozeb was found most effective and minimum (PDI) i.e. (5.18, 8.02 and 11.44%) followed by Carbendazim (6.29, 9.97 and 12.22%) at 35, 45 and 55 DAS respectively. Similar results were reported by Dabbas and Kumar (2015) [3]. Sailaja *et al.* (2017) [14] found that fungicides and bioagents against Alternaria leaf spot of cauliflower and the minimum PDI (%) was observed in Propiconazole @ 0.2% (21.30%) followed by Mancozeb @0.2% (23.15%), *T. harzianum* @2.0% (25.78%), *P. fluorescens* @ 2.0% (27.04%) as compared to control (28.98%). Khalse *et al.* (2017) [7] found that plant extracts and bio-agents were tested under field conditions for their efficacy against the Alternaria leaf spot of cabbage (*Alternaria brassicae).* Among the treatments minimum disease intensity per cent was recorded in *T. harzianum* @ 2% (29.84%) and *P. fluorescens* @ 2% (30.62%) as compared to propiconazole (treated check) @ 0.05% (25.08%) and untreated control (34.05%).

**Table 1:** Effect of different treatments on per cent disease intensity (PDI) after at 35, 45 and 55 days after sowing (DAS)

| Treatments | Per cent disease intensity (PDI) | | |
|---|---|---|---|
| | 35 DAS | 45 DAS | 55 DAS |
| Control | 17.40 (24.63) | 20.59 (26.96) | 24.35 (29.54) |
| Mancozeb | 5.18 (13.08) | 8.02 (16.43) | 11.44 (19.74) |
| Carbendazim | 6.29 (14.50) | 9.97 (18.38) | 12.22 (20.59) |
| Ridomil -MZ | 7.40 (15.74) | 10.72 (19.10) | 13.06 (21.14) |
| Copper oxy chloride | 11.48 (19.77) | 14.64 (22.49) | 17.87 (24.99) |
| Propiconazole | 10.18 (18.59) | 13.27 (21.35) | 15.77 (23.38) |

| | | | |
|---|---|---|---|
| Hexaconazole | 9.32 (17.76) | 12.38 (20.59) | 14.86 (22.66) |
| *Bacillus cereus* | 14.10 (21.98) | 17.03 (24.34) | 20.10 (26.62) |
| *Trichoderma harzianum* | 12.51 (20.68) | 15.17 (22.91) | 18.74 (25.63) |
| *Pseudomonas fluorescens* | 13.54 (21.57) | 16.21 (23.72) | 19.33 (26.06) |
| S.E.(d) | 1.21 | 0.92 | 1.02 |
| C.D.(0.05) | 2.57 | 1.96 | 2.17 |

PDI=Per cent disease intensity
( ) = Values in parentheses are angular transformed

**Effect of different treatments for per cent disease severity (PDS) at 35, 45 and 55 days after sowing (DAS)**

**Per cent disease severity (PDS) at 35 DAS:** The data presented in (Table 2) and significant variations for per cent disease severity (PDS) between control and all of the treatments. It ranged from (9.33-32.00%). Lowest PDS was observed in the treatment Mancozeb i.e. (9.33%), whereas, maximum was observed in control (32.00%) followed by *B. cereus* i.e. (24.11%). All the treatments were found significant as compared with control, whereas the Carbendazim (11.33%) found statistically at par with Mancozeb (9.33%).

**Per cent disease severity (PDS) at 45 DAS:** The data showed that the significant variations for PDS between control and all of the treatments. It ranged from (14.66-36.00%). Lowest PDS was observed in the treatment Mancozeb (14.66%), whereas maximum was observed in control (36.00%) and followed by *B. cereus* (27.05%). All the treatments were found significant as compared with control. Whereas the Carbendazim i.e. (15.33%) and Ridomil-MZ (16.66%) found statistically at par with Mancozeb (14.66%).

**Per cent disease severity (PDS) at 55 DAS:** A perusal data in showed significant variations for PDS between control and all of the treatments. It ranged from (17.33-38.00%). The lowest per cent disease severity was observed in the Mancozeb (17.33%), whereas maximum was observed in control (38.00%) and followed by *B. cereus* (35.33%). All the treatments were found significant as compared with control except *B. cereus*, which was also found statistically at par with control (38.00%) whereas the Carbendazim (21.08%) found statistically at par with Mancozeb (17.33%). In the present investigation the per cent disease severity was recorded at 35, 45 and 55 days after sowing (DAS). Mancozeb was found most effective and also observed minimum per cent disease severity i.e. (9.33, 14.66 and 17.33%) followed by Carbendazim i.e. (11.33, 15.33 and 21.08%) at 35, 45 and 55 DAS respectively. Similar observations were reported by Tu *et al.* (2015) [18]; Waghe *et al.* (2015) [19] and Tripathi (1999) [17]. Effect of *Bacillus* spp. (*B. subtilis, B. megaterium, B. pumilus* and *B. cereus*) against early blight *(A. alternata)* and reported that the promising effect of the four bacteria species tested in reducing disease incidence and severity in comparison with the control Abbo *et al.* (2014) [1].

**Table 2:** Effect of different treatments on per cent disease severity (PDS) after at 35, 45 and 55 Days after sowing (DAS)

| Treatments | Per cent Disease Severity (PDS) | | |
|---|---|---|---|
| | **35 DAS** | **45 DAS** | **55 DAS** |
| Control | 32.00 (34.42) | 36.00 (36.85) | 38.00 (38.04) |
| Mancozeb | 9.33 (17.70) | 14.66 (22.46) | 17.33 (24.56) |
| Carbendazim | 11.33 (19.64) | 15.33 (23.03) | 21.08 (27.31) |
| Ridomil -MZ | 13.33 (21.36) | 16.66 (24.07) | 23.04 (28.67) |
| Copper oxy chloride | 20.66 (27.00) | 25.00 (29.98) | 27.33 (31.49) |
| Propiconazole | 19.33 (26.05) | 23.33 (28.85) | 26.00 (30.60) |
| Hexaconazole | 16.00 (23.56) | 21.53 (27.63) | 24.33 (29.54) |
| *Bacillus cereus* | 24.11 (32.34) | 27.05 (31.32) | 35.33 (36.45) |
| *Trichoderma harzianum* | 22.00 (27.90) | 25.33 (29.75) | 29.66 (32.98) |
| *Pseudomonas fluorescens* | 23.66 (29.30) | 26.66 (31.07) | 30.00 (33.16) |
| S.E.(d) | 1.72 | 1.21 | 1.91 |
| C.D.(0.05) | 3.65 | 2.57 | 4.06 |

PDS =Per cent Disease Severity
() = Values in parentheses are angular transformed

## Yield

The present investigation revealed in (Table 3) the maximum yield was found (7.28kg) when seed treated with Mancozeb and followed by Carbendazim (6.91kg), whereas the minimum yield was observed in *B. cereus* (4.85 kg) and control i.e. (4.56kg). Similarly the observations on disease incidence and germination on seed treatment in radish Islam *et al.* (2007) [5] and they also found Mancozeb was highly effective against the *A. raphani*. Dabbas and Kumar (2015) [3] and Singh *et al.*(2017)[15] also found the maximum yield in Mancozeb. Among the bioagents the maximum yield was found in *T. harzianum* (5.12 kg) similar findings was found by Singh *et al.* (2017) [15]. Adinarayana *et al.* (2018) [2] bio-fungicide (*Bacillus* var. *amyloliquefaciens* strain FZB24) on yield and control of early blight (*A. solani*) and late blight *(P. infestans)* diseases in tomato. Rai *et al.* (2014) [12] tested in field trials, the efficacy of fungicides and bioagents, as seed treatment and foliar spray against Alternaria blight disease in Indian mustard. Among the eight treatments, seed treatment combination of Metalaxyl with Carbendazim was most effective in reducing disease severity and increasing yield (35.0 and 24.0%) followed by Carbendazim (31.5 and 23.3%) and Metalaxyl (29.3 and 20.3%) alone respectively. In case of seed treatment and foliar spray of Metalaxyl with Mancozeb was found most effective in reducing disease severity and increasing yield (44.0 and 37.6%) followed by Carbendazim with Ridomil-MZ (41.2 and 33.5%), *T. harzianum* with *P. fluorescence* (28.0 and 12.0%) and *T. harzianum* with *T. harzianum* (26.9 and 14.0%) compare to control.

**Table 3:** Effect of different treatments on total yield (kg/plot)

| Treatments | Yield (Kg/plot) |
|---|---|
| Control | 4.56±0.09 |
| Mancozeb | 7.28±0.17 |
| Carbendazim | 6.91±0.18 |
| Ridomil -MZ | 6.43±0.21 |
| Copper oxy chloride | 5.23±0.19 |
| Propiconazole | 5.62±0.15 |
| Hexaconazole | 5.81±0.13 |
| *Bacillus cereus* | 4.85±0.14 |
| *Trichoderma harzianum* | 5.12±0.06 |
| *Pseudomonas fluorescens* | 4.91±0.11 |
| S.E.(d) | 0.18 |
| C.D .(0.05) | 0.39 |

## Conclusion

Alternaria blight is most important disease in radish caused by *A. raphani* and serious damage to the crop yield. Among fungicides which was minimum PDI and PDS in Mancozeb also most effective at 35, 45 and 55 DAS. In bioagents *T. harzianum* showed minimum PDI and PDS also most effective at 35, 45 and 55 DAS. Maximum yield (kg/plot) showed by Mancozeb, followed by Carbendazim, Ridomil-MZ respectively and minimum yield was found in *B. cereus.*

## Acknowledgement

The authors wish to thank Dean, College of Horticulture, Bharsar for providing a facilitate and OIC, Vegetable Research and Demonstration Block, Bharsar (Pauri Garhwal) Uttarakhand.

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