**Evaluation of fungicides and Bio-agents against *Alternaria solani* causing Early Blight of Potato cropunder In vivo conditions.**

**Abstract**

Early blight of potato caused by *Alternaria solani* causes major yield losses in most of the potato growing areas in the world. The characteristic symptoms of the disease are dark brown to black lesions with concentric rings, which produce a target spot effect. The present investigation which was carried out to study the efficacy of different fungicides and bio-agents for management of early blight of potato crop revealed that all the five fungicides namely Tebuconazole @ 0.1 %, Propiconazole @ 0.1 % , Carbendazim 12 % + Mancozeb 63 % WP @ 0.15 % , Mancozeb 75 % WP @ 0.25 % , Copper oxychloride @ 0.30 % and two bio-agents namely *Pseudomonas* *flurescens* @ 1x109 and *Trichoderma viridae* @ 1x109 were found significantly superior over control. Almost same pattern was observed after seven to twenty one days of overall pooled first and second spray**,** all the treatments were effective in controlling disease infestation at different intervals after each application in comparison to untreated control. The highest most effective reduction per cent of disease early blight *Alternaria solani* of the potato crop was found mean 8.61 Per cent in the treatment of Carbendazim 12% + Mancozeb 63 % WP @ 0.15 %. After first and second spray the second effective treatments were Propiconazole 25%EC @ 0.1 % with mean (11.04 Per cent), followed by Mancozeb 75 % @ 0.25 with Mean (13.96 Per cent), Tebuconazole 25.9% EC0.1 % with Mean (15.91 Per cent), Copperoxychloride 50 % WP @ 0.30 % with Mean (17.52 Per cent), *Trichoderma viridae* @ 1x109 with Mean (18.32 Per cent) and *Pseudoman fluorescens* @ 1x109 with Mean (20.21 Per cent) per cent 61.04 during the year 2023-24- 2024-25.

**Key words:** Fungicides, Bio-agents, *Alternaria solani*, Management

1. **Introduction**

Potato (*Solanum tuberosum* L., Family: Solanaceae) is one of the most important renumerable solanaceous vegetable crop either for local consumption and exportation in the world. The potato ranks third in global significance as a human food crop, trailing only rice and wheat. There is evidence suggesting that it was likely introduced to India in the early 17th century, possibly by Portuguese traders or British missionaries (Pushkarnath, 1976). To be known as the “king of vegetables,” the potato holds a vital place in India’s vegetable markets. Thanks to its high dry matter and edible protein content, the potato stands out as a nutritionally superior vegetable and one of the world’s essential food crops (Bansode *et al.,* 2018). Uttar Pradesh is a leading state in potato production in India, playing a crucial role in the country’s agricultural sector. The top 10 potato-growing districts in Uttar Pradesh in the year 2022-23, with their production are Agra, Firozabad, Kannauj, Hathras, Farrukhabad, Aligarh, Badayun, Mainpuri, Barabanki, Allahabad and Barabanki 28.0, 20.8, 20.4, 19.9, 15.9, 11.0, 8.5, 7.6, 7.3, and 7.2 Lac Metric Tonnes. Despite its potential for higher production, the potato crop faces challenges due to attacks from various phytopathogens, which limit its productivity. The potato plant is susceptible to several diseases and one of the major is Early blight *Alternaria solani*, can lead to significant yield losses in potato crops. Reports indicate that average annual yield losses due to early blight range from approximately 50 per cent to 75 per cent of production (Murmu *et al.,* 2017). The organism *Alternaria solani* is air-borne, soil inhabiting and the most common disease causing pathogen of the cultivated potato in areas with heavy dew, frequent rainfall and high humidity (Agrios, 2005). However, the excessive use of the Fungicides and Bio-agents is not desirable because of its residual effects on the food chains. Hence, there is a need for continuous evaluation of Fungicides and Bio-agents against disease and safety to the non target bio-agents. Now a day’s many new emerging Fungicides and Bio- agents are available in the market with good efficacy for disease management and safety to non target organism. Potato production is currently threatened by a number of biotic and abiotic factors. Among the biotic stresses, fungal diseases like late blight *Phytophthora infestans* and early blight *Alternaria solani* were the most destructive fungal diseases, which reduces the quality, quantity and market value of potato tubers **(**Abbas *et al*., 2013**).** Among the fungal diseases, early blight is one of the most destructive disease of potato. The disease can damage both potato foliage and tubers and in turn cause yield loss up to 5 to 50 per cent. An early blight disease is prevalent across worldwide, wherever potatoes, tomatoes, peppers and egg plants are grown. Early blight is a polycyclic disease that can cause more than one disease epidemics within a single cropping season **(**Tsedaley, 2014). An early blight of potato is caused by two pathogens *viz*., *Alternaria solani* and *Alternaria alternata* but in some areas only *A. solani* is considered as the causative organism of this disease, with their spores in abundance in the atmosphere and in the soil. (Iglesias *et al*., 2007) There is always a threat when conditions become conducive for infection and thus represents a serious threat to potato production(Leiminger and Housladen 2012). Depending upon the varieties grown, weather conditions and inoculum load in the soil, this disease can causes an average annual yield loss of approximately 79 per cent of the total production of potato **(**Yadav *et al*., 2017). For effective management of this disease in early stage of crop growth, there is a need of suitable management approaches in order to reduce the disease severity with increased tuber yield. Therefore, by considering the above factors the present investigation was taken for the management of early blight of potato by using newer fungicides*.*

1. **Materials and Methods**

The experiment was conducted in the experimental field of Shri Venkateshwara University (located at NH-24, Rajabpur) Amroha, UP. The study area lies between 770 42’ East longitude and 29017’ North latitude with 237 m above mean sea level along with the treatments i.e. T1 Tebuconazole 25.9 % EC @ 0.1 % , T2 Propiconazole 25%EC @ 0.1 %, T3 Carbendazim 12% + Mancozeb 63 % WP @ 0.15 % ,T4 Mancozeb 75%WP @ 0.25 %, T5 Copper oxychloride 50 % WP @ 0.30 %, T6 *Pseudomonas fluorescens* @ 1x109 , T7 Trichoderma viridae @ 1x109 and T8 (Control) against chipsona-1 for field level evaluation, twenty-four plots were made of each about 3m × 2m having 3 replications in each treatment using Randomized Block Design (Gomez and Gomez, 1986). The spray was done at an interval of 15 days after the onset of disease in the fields. The assay was done on the basis of Disease Incidence (DI) and yield (t/ha) after first spray at 30, 40 and 50 days and second spry at 60, 70 and 80 of planting of the crop during the year 2023-24 and 2024-25. All the data were taken in eight treatments and three replicates the data recorded during investigation was subjected to statistical analysis by using the analysis of variance technique (ANOVA) for Randomized Block Design as suggested by Panse and Sukhatme (1985)**.** The data was transformed as necessary, as and when required. The standard error of the mean in each case and the critical difference only for significant cases were computed at a 5% level of statically and probability and per cent disease intensity (PDI) was calculated were calculated basis on the following formula:

|  |  |  |
| --- | --- | --- |
| PDI= | Sum of all disease rating | X 100 |
| Total number of leave x maximum grade |

1. **Result**

The mean disease incidence was homogenous and there was non-significant difference between all the treatments. A sharp decline in the disease incidence density of *Alternaria solani* was recorded at, forty five day and sixty day after application of each spray compared to control. All the treatments were performed at this stage to minimize incidence on potato crop. Each treatment was applied two times during the crop season.

* 1. **Evaluation of fungicides and bio agents against *A. solani* of the infested potato crop during 2023-24**

It is evident from the data that all the treatments were effective in controlling disease incidence at different intervals after each application in comparison to control. The most effective treatment was on the basis of mean data from (Table-1) recorded after first spray at 30, 40 and 50 days showed mean data that all the treatments were superior over control. The minimum disease incidence percent was observed in Carbendazim 12% + Mancozeb 63 % WP @ 0.15 % to be 7.16 per cent, the concentrations which was least effective was Propiconazole 25%EC @ 0.1 % with 9.20%. Disease incidence reduction per cent of *A. solani* are as follows, Mancozeb 75%WP @ 0.25 % (11.77), Tebuconazole 25.9 % EC @ 0.1 % (14.74), Copper oxychloride 50 % WP @ 0.30 % (16.99), *Trichoderma viridae* @ 1x109 (17.99) and *Pseudomonas fluorescens* @1x109 (19.40) respectively and after second at 60, 70 and 80 days spray the minimum disease incidence per cent was observed in Carbendazim 12% + Mancozeb 63 % WP @ 0.15 % (7.91 per cent) second most among all the concentrations the least effective treatment was Propiconazole 25%EC @ 0.1 % with 11.12 Disease incidence reduction percent of *A. solani* followed by Mancozeb 75%WP @ 0.25 % (15.11), Tebuconazole 25.9 % EC @ 0.1 % (16.78), Copper oxychloride 50 % WP @ 0.30 % (17.97), *Trichoderma viridae* @ 1x109 (18.55) and *Pseudomonas fluorescens* @ 1x109 (20.65) disease reduction per cent per ten plants compare to control respectively. On the basis of overall mean data. The disease incidence in different treatments ranged from 7.54 to 53.96 including untreated control. The minimum disease incidence per cent was observed in Carbendazim 12% + Mancozeb 63 % WP @ 0.15 % (7.54 per cent) second most among all the concentrations the least effective treatment was Propiconazole 25%EC @ 0.1 % with 10.16 Disease incidence reduction per cent of *A. solani* followed by Mancozeb 75%WP @ 0.25 % (13.44), Tebuconazole 25.9 % EC @ 0.1 % (15.77), Copper oxychloride 50 % WP @ 0.30 % (17.48), *Trichoderma viridae* @ 1x109 (18.27) and *Pseudomonas fluorescens* @ 1x109 (20.03) disease reduction per cent per ten plants compare to control, respectively.

**Table- 1: Efficacy of fungicides and bio-agents against *Alternaria solani* of the infested potato crop during 2023-24.**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatments** | **Per cent Disease Incidence (PDI) per cent/10 plants** | | | | | | | | | **Overall Mean** |
| **PDI/10 Plants** | **First Spray** | | | **Mean** | **Second Spray** | | | **Mean** |
| **1 DBT** | **30 DAT** | **40 DAT** | **50**  **DAT** | **60 DAT** | **70**  **DAT** | **80 DAT** |
| **T1** Tebuconazole 25.9 % EC @ 0.1 % | 21.32  (18.71) | 14.18 (15.36) | 14.93 (16.35) | 15.11 (14.36) | 14.74 (15.36) | 15.35 (17.24) | 16.89 (15.29) | 18.13 (18.34) | 16.79 (19.36) | 15.77 (18.58) |
| **T2** Propiconazole 25%EC @ 0.1 % | 20.93  (18.42) | 6.19 (8.32) | 9.25 (10.25) | 12.16 (13.69) | 9.20 (10.29) | 9.33 (11.36) | 11.93 (12.39) | 12.1 (13.68) | 11.12 (14.39) | 10.16 (12.69) |
| **T3**Carbendazim12%+ Mancozeb 63 % WP @ 0.15 % | 21.27  (18.71) | 5.13 (6.38) | 7.91 (8.39) | 8.44 (9.67) | 7.16 (9.38) | 6.18 (7.39) | 8.31 (9.39) | 9.24 (11.69) | 7.91 (9.68) | 7.54 (9.28) |
| **T4** Mancozeb 75%WP @ 0.25 % | 21.35  (19.05) | 8.38 (9.36) | 12.12 (13.98) | 14.81 (16.98) | 11.77 (13.98) | 14.18 (17.68) | 15.19 (18.39) | 15.96 (19.39) | 15.11 (18.39) | 13.44 (18.39) |
| **T5** Copper oxychloride 50 % WP @ 0.30 % | 21.36  (18.42) | 15.16 (19.67) | 16.13 (18.67) | 19.68 (21.38) | 16.99 (13.68) | 16.47 (19.68) | 17.5 (19.85) | 19.94 (22.35) | 17.97 (21.36) | 17.48 (19.68) |
| **T6** *Pseudomonas fluorescens* @ 1x109 | 20.755  (18.42) | 18.14 (21.65) | 18.92 (21.54) | 21.13 (22.39) | 19.40 (23.65) | 19.24 (23.51) | 20.23 (23.54) | 22.48 (24.58) | 20.65 (24.58) | 20.03 (24.59) |
| **T7** *Trichoderma viridae* @ 1x109 | 21.53  (19.05) | 15.86 (18.57) | 18.17 (20.21) | 19.93 (23.12) | 17.99 (21.35) | 17.32 (19.98) | 18.43 (19.65) | 19.9 (23.21) | 18.55 (21.54) | 18.27 (21.27) |
| **T8** (Control) | 20.23  (19.05) | 25.26 (28.64) | 37.5 (41.28) | 56.94 (59.64) | 39.90 (45.28) | 47.01 (51.24) | 63.08 (64.59) | 93.94 (95.67) | 68.01 (71.95) | 53.96 (55.57) |
| **CD at 5 %** | **NA** | **0.643** | **0.974** | **1.815** | **1.078** | **1.246** | **1.876** | **1.202** | **1.113** | **1.213** |
| **SEm±** | **0.211** | **0.213** | **0.322** | **0.600** | **0.504** | **0.412** | **0.620** | **0.398** | **0.254** | **0.362** |

Angular transformation

DBT – Day before Treatment

DAT – Day After Treatment

**3.2. Evaluation of fungicides and bio-agents against *A. solani* of the infested potato crop during 2024-25**

It is evident from the data that all the treatments were effective in controlling disease incidence at different intervals after each application in comparison to control. The most effective treatment was on the basis of mean data from (Table-2) recorded after first spray at 30, 40 and 50 days showed mean data that all the treatments were superior over control. The minimum disease incidence per cent was with the treatments of Carbendazim 12% + Mancozeb 63 % WP @ 0.15 % (9.20 per cent) second most among all the concentrations the least effective treatment was Propiconazole 25%EC @ 0.1 % with 11.31 Disease incidence reduction per cent of *A. solani* followed by Mancozeb 75%WP @ 0.25 % (13.77), Tebuconazole 25.9 % EC @ 0.1 % (15.15), Copper oxychloride 50 % WP @ 0.30 % (17.02), *Trichoderma viridae* @ 1x109 (17.47) and *Pseudomonas fluorescens* @ 1x109 (19.32) disease reduction per cent per ten plants compare to control, respectively and after second at 60, 70 and 80 days spray. The most effective treatment was on the basis of mean data from in the present (Table-2) showed that the mean data of all the treatments were superior over the control. The minimum disease incidence per cent was observed in Carbendazim 12% + Mancozeb 63 % WP @ 0.15 % (10.16 per cent) second most among all the concentrations the least effective treatment was Propiconazole 25%EC @ 0.1 % with 12.52 Disease incidence reduction per cent of *A. solani* followed by Mancozeb 75%WP @ 0.25 % (15.21), Tebuconazole 25.9 % EC @ 0.1 % (16.96), Copper oxychloride 50 % WP @ 0.30 % (18.12), *Trichoderma viridae* @ 1x109 (19.71) and *Pseudomonas fluorescens* @ 1x109 (21.45) disease reduction per cent per ten plants compare to control, respectively. On the basis of overall mean data. The minimum disease incidence per cent was observed in Carbendazim 12% + Mancozeb 63 % WP @ 0.15% (9.68 per cent) second most among all the concentrations the least effective treatment was Propiconazole 25%EC @ 0.1 % with 11.92 Disease incidence reduction per cent of *A. solani* followed by Mancozeb 75%WP @ 0.25 % (14.49), Tebuconazole 25.9 % EC @ 0.1 % (16.06), Copper oxychloride 50 % WP @ 0.30 % (17.57), *Trichoderma viridae* @ 1x109 (18.38) and *Pseudomonas fluorescens* @ 1x109 (20.39) disease reduction per cent per ten plants compare to control, respectively.

**Table- 2: Eficacy of fungicides and bio-agents against *Alternaria solani* of the infested potato crop during 2024-25**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatments** | **Per cent Disease Incidence (PDI) per 10 plants** | | | | | | | | | **Pooled** |
| **PDI/10 Plants** | **First Spray** | | | **Mean** | **Second Spray** | | | **Mean** |
| **1 DBT** | **30 DAT** | **40 DAT** | **50 DAT** | **60 DAT** | **70**  **DAT** | **80 DAT** |
| **T1** Tebuconazole 25.9 % EC @ 0.1 % | 22.35 (23.68) | 13.18 (14.21) | 14.4 (16.28) | 17.87 (19.25) | **15.15 (17.29)** | 14.85 (13.69) | 16.39 (19.36) | 19.64 (21.36) | **16.96 (17.36)** | 16.06 (18.36) |
| **T2** Propiconazole 25%EC @ 0.1 % | 21.96 (24.39) | 9.53 (11.28) | 11.25 (14.23) | 13.15 (15.32) | **11.31 (13.65)** | 12.13 (15.36) | 12.29 (16.35) | 13.14 (12.32) | **12.52 (13.26)** | 11.92 (13.29) |
| **T3**Carbendazim12%+Mancozeb 63 % WP @ 0.15 % | 21.25 (22.63) | 7.12 (8.65) | 8.51 (10.27) | 11.97 (13.28) | **9.20 (11.29)** | 8.18 (11.39) | 9.34 (8.29) | 12.96 (14.25) | **10.16 (12.39)** | 9.68 (8.23) |
| **T4** Mancozeb 75%WP @ 0.25 % | 22.35 (24.38) | 12.79 (13.54) | 13.75 (15.32) | 14.77 (14.36) | **13.77 (12.25)** | 14.29 (16.38) | 14.39 (12.39) | 16.95 (13.29) | **15.21 (17.62)** | 14.49 (16.32) |
| **T5** Copper oxychloride 50 % WP @ 0.30 % | 21.65 (22.27) | 15.12 (16.33) | 16.85 (18.21) | 18.69 (19.62) | **17.02 (15.39)** | 16.87 (19.25) | 17.54 (19.32) | 19.95 (17.11) | **18.12 (19.13)** | 17.57 (19.39) |
| **T6** *Pseudomonas fluorescens* @ 1x109 | 21.98 (23.21) | 17.16 (18.69) | 19.67 (21.25) | 21.13 (23.21) | **19.32 (15.36)** | 19.24 (23.69) | 21.64 (17.36) | 23.47 (21.25) | **21.45 (23.25)** | 20.39 (24.39) |
| **T7** *Trichoderma viridae* @ 1x109 | 22.38 (24.25) | 15.57 (16.59) | 16.97 (18.24) | 18.93 (20.28) | **17.47 (19.35)** | 17.17 (19.25) | 19.73 (21.36) | 22.23 (19.63) | **19.71 (17.98)** | 18.38 (21.28) |
| **T8** (Control) | 23.12 (24.32) | 37.63 (39.62) | 54.63 (57.32) | 79.94 (83.42) | **57.40 (39.68)** | 56.32 (53.69) | 86.29 (63.29) | 93.91 (73.29) | **78.84 (69.28)** | 68.12 (71.29) |
| **CD at 5 %** | **NA** | **0.643** | **0.974** | **1.815** | **1.078** | **1.246** | **1.876** | **1.202** | **1.39** | **2.13** |
| **SEm±** | **0.211** | **0.213** | **0.322** | **0.600** | **0.504** | **0.412** | **0.620** | **0.398** | **0.231** | **0.269** |

Angular transformation

DBT – Day before Treatment

DAT – Day After Treatment.

**3.3. Average of two years data of fungicides and bio-agents against *Alternaria solani* at a glance during 2023-2024 & 2024-2025 cropping season.**

The overall pooled data observed that at thirteen, fourteen, fifteen of first spray and sixty, seventy and eighty days of second spray during 2023-2024 & 2024-2025, the most effective treatment were from in the present table-2 were superior over the control. The highest most effective reduction per cent of disease early blight *Alternaria solani* of the potato crop was found mean (8.61 Per cent) in the treatment Carbendazim 12% + Mancozeb 63 % WP @ 0.15 %. After first and second spray the second effective treatments were Propiconazole 25%EC @ 0.1 % with mean (11.04 Per cent), followed by Mancozeb 75 % @ 0.25 with Mean (13.96 Per cent), Tebuconazole 25.9% EC0.1 % with Mean (15.91 Per cent), Copper oxychloride 50 % WP @ 0.30 % with Mean (17.52 Per cent), *Trichoderma viridae* @ 0.1% with Mean (18.32 Per cent) and *Pseudoman fluorescens* @ 0.1% with Mean (20.21 Per cent) per cent and control also 61.04 respectively.

**Table-3: Eficacy of fungicides and bio agents against *Alternaria solani* of the infestation potato crop during 2023-24 and 2024-25 (Pooled)**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatment** | **2023-24** | | **Mean** | **2024-25** | | **Mean** | **Pooled** |
| **Ist Spray** | **IInd Spray** | **Ist Spray** | **IInd Spray** |
| **T1** Tebuconazole 25.9 % EC @ 0.1 % | 14.74 (13.25) | 16.79 (18.69) | 15.77 (17.59) | 15.15 (18.65) | 16.96 (17.39) | 16.06 (18.35) | 15.91 (18.57) |
| **T2** Propiconazole 25%EC @ 0.1 % | 9.2 (10.35) | 11.12 (10.95) | 10.16 (11.32) | 11.31 (12.35) | 12.52 (13.28) | 11.92 (12.35) | 11.04 (12.57) |
| **T3** Carbendazim 12% + Mancozeb 63 % WP @ 0.15 % | 7.16 (6.32) | 7.91 (8.35) | 7.54 (8.67) | 9.2 (11.25) | 10.16 (11.39) | 9.68 (10.28) | 8.61 (11.27) |
| **T4** Mancozeb 75%WP @ 0.25 % | 11.77 (10.39) | 15.11 (17.28) | 13.44 (12.35) | 13.77 (14.28) | 15.21 (16.39) | 14.49 (16.28) | 13.96 (16.25) |
| **T5** Copper oxychloride 50 % WP @ 0.30 % | 16.99 (17.69) | 17.97 (16.95) | 17.48 (19.87) | 17.02 (18.68) | 18.12 (19.65) | 17.57 (19.58) | 17.52 (16.28) |
| **T6** *Pseudomonas fluorescens* @ 0.1 % | 19.4 (18.98) | 20.65 (18.34) | 20.03 (19.58) | 19.32 (21.67) | 21.45 (22.65) | 20.39 (21.35) | 20.21 (21.25) |
| **T7** *Trichoderma viridae* @ 0.1 % | 17.99 (16.58) | 18.55 (19.68) | 18.27 (17.58) | 17.04 (15.98) | 19.71 (18.54) | 18.38 (19.58) | 18.32 (17.28) |
| **T8** (Control) | 39.9 (41.29) | 68.01 (63.28) | 53.96 (54.25) | 57.4 (53.29) | 78.84 (76.27) | 68.12 (71.28) | 61.04 (59.67) |

1. **Discussion**

The present investigation which was carried out to study the efficacy of different fungicides and bio-agents for management of early blight of potato crop. The present findings also get support from the observations of Surekha S. *et al*., (2024) Under in vitro evaluation fungicides, among non-systemic fungicides, mancozeb 75% WP exhibited the highest mean mycelial growth inhibition at 96.25 percent, followed by thiram 75% WP with a mean mycelial growth inhibition of 92.51 percent. Among six systemic fungicides evaluated, hexaconazole 5%, EC and tebuconazole 25.9%, EC recorded cent percent mycelial growth inhibition at all four concentrations (0.025, 0.05, 0.1, 0.15%) tested which were significantly superior Shahni Y. S. *et al*., (2023) The maximum potato yield (kg/ha) was obtained from T1 (tuber treatment with *T. harzianum* @ 8g/kg) i.e.,, 6,875 kg/ha followed by T5 (Tuber treatment with *P. fluorescens* @ 8g/kg + copper oxychloride @ 4g/l of water) (6458 kg/ha) and T4 (Tuber treatment with *T. harzianum* @ 8g/kg+ copper oxychloride@ 4g/l of water) (6250 kg/ha) which are statistically significant when compared to the control treatment (3958 kg/ha). Prasad P.S. *et al*., (2023) with mancozeb (100 %) inhibition at 1000 ppm concentrations. At field evaluation, the best treatment was found that zineb 68% + hexaconazole-4% WP fungicide with least percent disease index (PDI) of 15.11 followed by hexaconazole 5% EC (17.55%) at 65 days after planting. Kumar A. *et al*., (2023). Enlightening this issue, the efficacy of various treatments, viz., chemical fungicides (Amistar Top, Nativo, and Conta), biochar and fungal bioagent (*Trichoderma viride*) was assessed under both in vivo and in vitro conditions. Induced resistance is mediated by several regulating pathways, like salicylic acid and jasmonic acid and in situ, with MIC values ranging between 6.3–25 mg/mL. 5-Hydroxymethylfurfural was determined to be the main component of this extract (33.24%). Garlic water extract was proposed as a potential biopesticide against potato phytopathogens. Mittal Shubham *et al*., (2021) Early Blight of Potato (15%).To stop Early Blight of Potato (15%) I have used three types of fungicides Namely Mancozeb 75% WP (65.73%) at 1000 PPM Teubuconalzole 25.9% (100%) at 250PPM Azoxytrobin (47.73%) at 500 PPM. Mane M. M. *et al*., (2014) Observation for percent disease intensity was recorded at 60 and 80 days after sowing. Lowest disease intensity was recorded in mancozeb (15.07% and 18.40%, respectively) as compared to control which recorded highest disease intensity (20.91% and 33.80%, respectively). Mancozeb not only reduced disease intensity but also recorded highest yield (253.00 q/ha) as compared to control which recorded 157.83 q/ha. The bio agents *Trichoderma harzianum* and *Pseudomonas fluorescens* (seed treatment +foliar spray) were also effective in reducing the disease intensity and increasing tuber yield. Mane *et al*. (2014) The treatments comprised of seed treatment and foliar spray (once and twice) of bio agents *Trichoderma harzianum* and *Pseudomonas fluorescens* while fungicide taken up was mancozeb and control (spray of plain water). Lowest disease intensity was recorded in mancozeb (15.07% and 18.40%, respectively) as compared to control which recorded highest disease intensity (20.91% and 33.80%, respectively). Mancozeb not only reduced disease intensity but also recorded highest yield (253.00 q/ha) as compared to control which recorded 157.83 q/ha. Ganie *et.al.,*(2013a) among systemic fungi toxicant hexaconazole 5 EC was most effective and exhibited a maximum mean mycelial growth inhibition of 84.19% over check. Under in vivo conditions seed treatment with mancozeb 75WP (0.3 %) + foliar spray with hexaconazole 5 EC (0.1%) + foliar spray with datura (50%) + foliar spray with *Trichoderma harzianum* (1 × 107 spore/ml) were highly effective in controlling the disease severity as compared to control.

1. **Conclusion**

The study aimed to evaluate various control measures against early blight disease caused by *Alternaria solani* on potato plants. The findings provide valuable insights into effective strategies for managing this devastating disease in India. Overall, the comprehensive investigation provides valuable insights into the management of early blight disease in potato plants. By highlighting the efficacy of different control measures, including fungicides and biocontrol agents against *Alternaria solani* infecting potato crop *Solanum tuberosum* (L.) the study contributes to the development of effective strategies to mitigate the impact of *Alternaria solani* on potato. These findings can enhance agricultural practices and help safeguard tomato crops against this damaging disease, ultimately enhancing agricultural productivity and food security. Among all the treatments fungicides and Bio-agents at field evaluation best fungicides were found that 8.61 Per cent in the treatment of Carbendazim 12% + Mancozeb 63 % WP @ 0.15 %. The second effective treatments were Propiconazole 25%EC @ 0.1 % with mean (11.04 Per cent), followed by Mancozeb 75 % @ 0.25 with (13.96 Per cent), Tebuconazole 25.9% EC0.1 % with (15.91 Per cent), Copper oxychloride 50 % WP @ 0.30 % with (17.52 Per cent), *Trichoderma viridae* @ 1x109 with (18.32 Per cent) and *Pseudoman fluorescens* @ 1x109 with (20.21 Per cent) compare with control 61.04 per cent.

1. **References**
2. Abbas, M. F., Naz, F. and Irshad, G. (2013). Important fungal diseases of potato and their management-A brief review, Mycopathology, 11(1), 45-50.
3. Agrios GN. (2005). Plant Pathology, 5th edition. Academic Press, USA. 635 p.
4. Amsaraj et al., (2020).Hence these fungicides can be recommended to the farmers for the effective management of early blight disease on commercial cultivation of potato.
5. Chaurasia, A.K., Chaurasia S., Chaurasia S. and Chaurasia S. (2013). Studies on the development of fruit rot of tomato caused by Alternaria solani (Ellis & Mart.) Jones & Grout. Int. J. Pharma. Life Sci., 4(6), 215-221.
6. Chaursiya dhary, A. K., Yadavb, J., Guptac, A. K., & Guptad, K. (2017). Integrated disease management of early blight (Alternaria solani) of potato. Trop. Agrobiodivers, 2, 77- 81.
7. Faostat (2024) website at . To find specific data, select “Production,” then “,” and finally, click on “crops primary” in the Item section for a complete list of crops.
8. Ganie, S. A., Ghani, M. Y., Anjum, Q., Qazi, N., Rehman, S. and Dar, W. A. (2013a).Integrated management of early blight of potato under Kashmir valley conditions. African Journal of Agricultural Research, 8(32):4318-4325.
9. Gomez, K. A. and Gomez, A. A. 1986. Statistical procedures for agriculture research. 2nd edition, John Wiley and Sons. pp. 680.
10. Iglesias, I., Rodriguez-rajo, F. J. and Martinez, J. (2007). Evaluation of the different Alternaria prediction models on potato crop in a Limia (NW of Spain). Aerobiologia, 23, 27-34.
11. Kumar, A., Rana, T., Goutam, E., Prakash, S., & Koshariya, A. K. (2023). Evidences of induced resistance in tomato against Alternaria solani: An investigation. Trends in Horticulture, 6(2), 2677.
12. Leiminger, J. H. and Housladen, H. (2012). Early blight control in potato using disease- orientated threshold values. Plant Diseases, 96, 124-130.
13. Mane, M.M., Lal, A., Ghair, Q.N.Z. and Simon, S. (2014). Efficacy of certain bio agents and fungicides against early blight of potato (Solanum tuberosumL.). International Journal of Plant Protection7(2):433-436
14. Meena A., A. K. B. Mohapatra, C. Parhi, A. Nanda, D. Priyadarshi, D. Meena, G. Biswal, A. Mishra and Tushar Ranjan Mohanty (2022) Incidence and Intensity of Early Blight in Potato under Different Dates of Planting International Journal of Environment and Climate Change Volume 12, Issue 12, Page 1665-1679.
15. Meena, A., Mohapatra, A. K. B., Parhi, C., Nanda, A., Priyadarshi, D., Meena, D. & Ranjan Mohanty, T. (2022). Incidence and Intensity of Early Blight in Potato under Different Dates of Planting. International Journal of Environment and Climate Change, 12(12), 1665-1679.
16. Mittal Shubham, Ganga Prasad, P. K. S. Chauhan, Moti lal and R. B. Sharma (2021) In vitro Evaluation of fungicides Early Blight of Potato (Solanum tuberosumL.) caused by Alternaria solani [Ellis Jones and Grout], International Journal of Current Microbiology and Applied Sciences ISSN: 2319-7706.
17. Murmu S, Dey S and Chakraborty A. (2017) Efficacy of different fungicides for management of early blight disease of potato. Journal of Applied and Natural Science, 9(1): 280–85.
18. Panse, V.G. and Sukhatme, P.V. (1985) Statistical Methods for Agricultural Workers. Indian Council of Agricultural Research Publication, 87-89.
19. Prasad P.S., Manjamma D, Sadanand K. Mushrif, Anjaneya Reddy B., H. Amarananjundeswara, Manjunath Hubballi and Mohan Kumar S., (2023), Management of Early Blight of Potato by using Newer fungicides Biological Forum–An International Journal 15(12): 236-24.
20. Pushkarnath (1976) Potato in subtropics. Orient Longman, New Delhi, pp.289. Shahni, Y. S., Banik, S., Pongener, N., Neog, P., & Singh, A. P. (2023). Effects of biocontrol agents on early blight disease of potato in field. : 375-380.
21. Surekha, S., kulkarni, V. R., rao, M., & Shashidhar, T. (2024). Evaluation of different fungicides against Alternaria solani causing early blight disease of potato under in vitro conditions. Journal of Farm Sciences, 37(01), 20-24.
22. Tsedaley, B. (2014). Review on early blight (Alternaria spp.) of potato disease and its management options, Journal of Biology Agriculture Healthcare, 4(27).
23. Yadav, V. K., Kumar, V. and Arghya Mani (2017). Evaluation of fungicides, bio-control agents and plant extracts against early blight of potato caused by Alternaria solani, International Journal of Chemical Studies, 6(1), 1227-1230.