**Management of Early Blight disease of Potato caused by *Alternaria solani* through optimization of chemical fungicides**

**Abstract**

Early blight of potato is caused by *Alternaria solani* , which causes major yield losses in most of the potato growing areas in the world. For effective management of this disease early diagnosis is important, and there is a need for evaluation of suitable chemical fungicides and bio-control agents for management of early blight disease of potato to reduce the disease severity and to increased yield. Chemical control method is an effective and highly adopted approach of eliminating disease causing organism. The present study was carried out to assess the ‘Management of Early Blight disease of Potato caused by *Alternaria solani* through optimization of chemical fungicides’. Among five systemic fungicides and two bio-agents with control evaluated under field condition, 8.61 percent maximum disease reduction percent were observed in treatment at 0.15 percent concentration in treatment T3 (Carbendazim 12% + Mancozeb 63 % WP) which were significantly superior to over control and in all other four treatment of fungicides were found similar disease reduction percent with miner difference between 11.04 to 17.52 percent, and maximum 20.21 percent antagonistic activity were assessed in *Pseudomonas fluorescens* against *Alternaria solani* and all observations were mentioned in the result of the paper.

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

1. **Introduction**

 Potato (*Solanum tuberosum* L., Family: Solanaceae) is one of the most important 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, 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. The potato crop faces challenges due to attacks from various phytopathogens, which limit its productivity. 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. Traditional 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 50 to 75 per cent. Early blight of potato is an important disease 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 cfu/ml, T7 Trichoderma viridae @ 1x109 cfu/gm 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 (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= | £(Rating number x No. plant with the rating) | X 100 |
| Total number of plant x Highest rating |

1. **Result**

In the field evaluation, a total of five fungicides along with two bio-control agents and control were tested at varying concentrations for their effectiveness against *Alternaria solan.*In the evaluation of fungicides, all the tested fungicides showed significant superiority over the control in terms of disease reduction.

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

 All of eight treatment, manly five traditional fungicides and two bio-control agent were found to be a superior result that was noticeably better than the control. Among all the fungicides, minimum 7.54% disease incidence percent was recorded in T3 (Carbendazim12%+ Mancozeb 63 % WP @ 0.15 %) treatment followed by T2 (Propiconazole 25%EC @ 0.1 %) treatment and T4 (Mancozeb 75%WP @ 0.25 %) treatment which was found significantly superior over the rest of the treatment. Carbendazim12% + Mancozeb 63 % WP was very effective at its concentration and gave the good result at 0.15 % concentration. Pseudomonas fluorescence performed a good antagonistic effect against *Alternaria solani,* maximum 20.03% incidence percent was recorded followed by *Trichoderma viride* with 18.27% incidence percent.

**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 cfu/ml  | 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 cfu/gm  | 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* during 2024-25.**

All of eight treatment, manly five traditional fungicides and two bio-control agent were found to be a superior result that was noticeably better than the control. Among all the fungicides, minimum 9.68% disease incidence percent was recorded in T3 (Carbndazim12%+ Mancozeb 63 % WP @ 0.15 %) treatment followed by T2 (Propiconazole 25%EC @ 0.1 %) treatment and T4 (Mancozeb 75%WP @ 0.25 %) treatment which was found significantly superior over the rest of the treatment. Carbendazim12% + Mancozeb 63 % WP was very effective at its concentration and gave the good result at 0.15 % concentration. Pseudomonas fluorescence performed a good antagonistic effect against *Alternaria solani,* maximum 20.393% incidence percent was recorded followed by *Trichoderma viride* with 18.38% incidence percent.

**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 cfu/ml | 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 cfu/gm  | 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 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* 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 % cfu/ml | 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 % cfu/gm  | 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**

Similarly, Deshsmukh *et al.* (2020) observed cent percent inhibition of mycelial growth of *Alternaria solani* by Mancozeb 75% WP at 0.2 percent. Chapei *et al.* (2019) reported that Mancozeb 755 WP at 0.2 percent concentration inhibited 93.33 per cent of mycelial growth. Arunakumara and Satyanarayan (2018), Yadav *et al*. (2018) and Misba *et al.* (2022) reported effectiveness of Manacozeb 75% WP against *Alternaria solani* in vitro conditions. Dhaka and Chaudhary (2022) and Misba *et al*. (2022) reported effectiveness of Propiconazole and tebuconazole and Surekha S.R, *et al.*(2024) reported effectiveness of Carbendazim 12% + Mancozeb 63 % WP.

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.

**Disclaimer (Artificial intelligence)**

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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