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# Effect of fungicide schedules against early blight *Alternaria solani* (Ell. and Mart.) jones and grout in potato *Solanum tubrosum* L.

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**Abstract**
Early blight, caused by *Alternaria solani* (Ell. and Mart.) Jones and Grout is a serious disease of potato growing regions of Maharashtra. Several effective pesticides have been recommended against this pathogen but development of resistance of pathogenic fungi towards pesticides is a great problem that can affect significantly the efficacy of chemical fungicides. Therefore keeping in view an experiment on effect of fungicides schedules against early blight was conducted during 2018-19 and 2019-20 on potato. The experiment laid out in RBD design with four treatments and five replications. The results revealed that spray of mancozeb 75 WP @ 2.5 gm/ liter of water followed by hexaconazole 5 EC @ 0.5 ml /liter of water and then mancozeb 75 WP@ 2.5 gm/ liter of water at 10 days interval was found significantly superior in controlling the early blight of potato and also recorded significant highest yield as compared to other treatments.

**Keywords:** Potato, *Alternaria solani*, fungicide schedule, mancozeb, hexaconazole

## Introduction
Potato (*Solanum tuberosum* L.) is one of the most important staple food and cash crop belonging to the family solanaceae. The major potato producing states are Uttar Pradesh, Bihar, Gujarat Karnataka, Orissa, Andhra Pradesh, Maharashtra, Madhya Pradesh, and West Bengal. The annual production of potato in India for the year 2016-17 was 48.605 Million MT in an area of 2.179 Million ha with 22.31 MT/ha productivity. In Maharashtra major area under potato is confined in districts of Pune and Satara with area of 20800 Ha areas with 536620 MT Production during year 2016-17 [1]. The various factors limiting yield of potato include lack of high yielding varieties, inadequate supply of healthy seed tubers and high incidence of disease and pest. The intensive and extensive cultivation under the most favourable environmental conditions for potato crop production in the state failed to provide significant strides in potato yields, because of a number of production constraints. The crop is susceptible to many diseases, some of which are widespread and others are localized. The causal agents of these diseases include fungi, bacteria, viruses, phytoplasmas, viroids and nematodes. Among all these diseases early blight, caused by *Alternaria solani* (Ell. and Mart.) Jones and Grout is one of the very important, old and well known diseases of potatoes. In India it is first reported in Farukabad (U.P) in 1903. This disease has been underrated contrast to the more spectacular late blight disease. However, in many areas the average annual loss from this disease exceeds the losses from late blight. The losses due to early blight are estimated to be up to 20% in India [2] and 5 - 40% in Israel [3] and 20 to 30% in the USA [4, 5]. Yield loss estimates resulting from foliar damage incited by early blight on potato vary by location and cropping pattern. In recent years, increase in *A. solani* disease on potato foliage has been reported in various potato growing areas [6]. A high frequency of potato or tomato cropping in one field, as well as consecutive plantings of potatoes or tomatoes, are associated with an earlier appearance of initial early blight lesions[7]. Disease symptoms are characteristic dark brown to black lesions with concentric rings which initially observed on older, senescing leaves. It spreads and inflicts damage to stems, petioles and tubers in epidemic form and resulting in tuber yield reduction. As such, most commercial potato farmers rely on fungicide applications for control of *Alternaria solani*. Early blight can be controlled by efficient use of cultural practices, such as a 3–5-year crop rotation with non-host crops, site selection, and sanitation of fields, providing proper plant nutrition, avoiding water stress and planting disease-free seed [8]. Management of early blight of potato requires an integrated approach that includes rotation with non-hosts, resistant cultivars, cultural practices, and fungicides.

Therefore keeping in view the devastating nature of disease and to find safe, efficacious and environmentally friendly fungicides a detailed investigation was undertaken under field conditions to devise management programme of the disease.

## Materials and Methods

The experiment was conducted under All India Coordinated Research Project, on Potato, National Agricultural Research Project, Ganeshkhind, Pune. The field experiment was carried out during *Rabi* season of 2018 and 2019.The experimental plot was well ploughed. Recommended doses of fertilizers (150:60:120 NPK kg/ha) and manure were applied as per standard agronomic practices. Seeds of potato variety, *Kufri Pukhraj* were used. The experiment was laid out in a Randomized Block Design (RBD) with five replications. The unit plot size was 3.0 × 2.0 $m^2$. Spacing of row to row (within plot) and tuber to tuber (within row) was 60 cm and 20 cm, respectively. Earthingup was executed at 30 days after planting. The scheduled sprays of different fungicides were evaluated for their efficacy against *A. solani*. in potato crop. The treatments were: T1: unsprayed control, T2: first spray of mancozeb 75WP (0.25%), second spray of hexaconazole 5EC (0.05%) and third spray of mancozeb 75WP (0.25%) at 10 days interval, T3: first spray of mancozeb 75WP (0.25%), second spray of difenoconazole 25% EC (0.05%) and third spray of mancozeb 75WP (0.25%) at 10 days interval T4: three sprays of chlorothalonil 75WP (0.2%) at 10 days interval. In control treatment, equal amount of plain water was sprayed. Spray was initiated as soon as the first disease intensity in traces was notices. Subsequent two sprays were given at an interval of 10 days. Care was taken during spraying, both the upper and lower surface of leaves as well as stems were well covered by fungicidal solution. Spray tank was thoroughly washed before filling fungicidal solution materials. The disease incidence was calculated by counting total number of plants per treatment/replication and among which are infected plants. The disease intensity of early blight of potato was recorded from the randomly selected 5 plants per plot based on 0-5 scale [9]. Disease intensity was monitored one day before each spray and observation on PDI (Per cent Disease Index) was recorded 7 days interval from initial appearance of disease.

The yield of potato tuber was recorded after harvesting (tones/ ha). Data on yield of potato and percentage of disease index was statistically analyzed [10].

## Results and discussion

The potato crop was planted during *Rabi* season i.e on 1st November 2018 and on 11 November 2019. The early blight disease was first appeared after 44 days of planting on 15th December, 2018 in year 2018-19 while, during 2019-20 the disease was first appeared after 42 days on 23rd December, 2019 in respective manner. The data recorded during *Rabi* 2018-19 and 2019-20 was pooled and presented in Table 1 to 3. The data recorded during experimentation revealed that there is significant difference between each treatment. All treatments recorded significantly lowest disease incidence (table 1). as compared to control. The lowest disease incidence of 25.44, 23.22 and 24.33 per cent respectively was observed during 2018-19, 2019-20 and pooled data in treatment T2 (first spray of mancozeb 75WP (0.25%), second spray of hexaconazole 5EC (0.05%) and third spray of mancozeb 75WP (0.25%) at 10 days interval) at 35 days after first appearance of disease. The per cent disease incidence increased gradually till maturity and reached its maximum i.e. 37.99, 42.11 and 40.05 per cent in control treatment respectively during 2018-19, 2019-20 and in pooled.

The observations on disease severity (table 2) was also recorded before the first spray and which was found non-significant indicating there was no significant difference between treated and untreated plots. The per cent disease severity increased gradually till maturity and reached its maximum i.e. 14.80, 20.40, 22.80 and 31.60 per cent respectively in treatment two, three, four and one during 2018-19. Similarly, during the year 2019-20 severity was 17.87, 24.53, 27.07 and 33.73 per cent respectively in treatment two, three, four and one. The pooled data on different fungicide schedule indicated that the minimum disease severity (16.33%) was observed in treatment T2 (first spray of mancozeb 75WP (0.25%), second spray of hexaconazole 5EC (0.05%) and third spray of mancozeb 75WP (0.25%) at 10 days interval) while maximum disease severity (24.93%) was recorded in treatment T3 (first spray of mancozeb 75WP (0.25%), second spray of difenoconazole 25% EC (0.05%) and third spray of mancozeb 75WP (0.25%) at 10 days interval). In control plots maximum disease severity of 32.67 per cent was noted. The results of present findings are in accordance with [11] who evaluated different systematic and nonsystematic fungicides against early blight of potato crop and reported that mancozeb and hexaconazole was found effective in reducing disease severity

The yield data of all the treatments and economics of cost benefit ratio was calculated for all the fungicides tested and which are presented in Table 3. The highest yield (16.17 tonnes/ha) was obtained in treatment T2 with cost benefit ratio of 1.56. The significantly lowest yield (11.29 t/ha) was obtained in untreated control and cost benefit ratio was 1.16.

The various cultural practices can reduce the severity of early blight, but under situations of sufficient inoculum and environmental conditions favourable for disease, complete control will not be achieved. The most effective control method is a protectant fungicide spray programme used from early in the growing season. Proper timing of initial and subsequent fungicide applications can reduce the overall number of sprays with no significant loss in yield. The results of the present investigation indicate that the sequential fungicidal treatments (T2) significantly reduced disease severity and increased yield over control. This is in accordance with the findings of [12, 11] who claimed that the best control of disease caused by *A. solani* was achieve by mancozeb at 0.2 per cent and hexaconazole 0.05 per cent at field condition. Further they reported that treatment was also the most cost effective and gave the highest yields. All these findings are in agreement with the present findings of study. Considering the findings of the present investigation, it may be concluded that sequential spraying of spray of mancozeb 75WP (0.25%), followed by hexaconazole 5EC (0.05%) and third spray of mancozeb 75WP (0.25%) at 10 days interval can be used as alternative for management of early blight of potato as the pathogen has reported fungicide resistance to common fungicides.

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**Table 1:** Diseases Incidence of early blight at different days intervals (2018-19, 2019-20 and pooled)

| Treat. | Incidence (%) days after appearance | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Before spray | | | 7th | | | 14th | | | 21st | | | 28th | | | 35th | | |
| | 2018-19 | 2019-20 | Pooled | 2018-19 | 2019-20 | Pooled | 2018-19 | 2019-20 | Pooled | 2018-19 | 2019-20 | Pooled | 2018-19 | 2019-20 | Pooled | 2018-19 | 2019-20 | Pooled |
| T1 | 6.58 (14.78) | 5.45 (13.44) | 6.01 (14.16) | 15.36 (23.05) | 11.44 (19.63) | 13.40 (21.41) | 20.80 (27.11) | 18.90 (25.68) | 19.85 (26.44) | 25.44 (30.23) | 27.24 (31.41) | 26.34 (30.83) | 32.00 (34.44) | 34.69 (36.06) | 33.35 (35.25) | 37.99 (38.03) | 42.11 (40.42) | 40.05 (39.23)* |
| T2 | 6.63 (14.84) | 5.17 (12.99) | 5.90 (14.03) | 10.61 (18.99) | 6.60 (14.83) | 8.60 (17.03) | 13.27 (21.33) | 10.61 (18.96) | 11.94 (20.20) | 18.86 (25.72) | 14.34 (22.20) | 16.60 (24.03) | 21.05 (27.29) | 19.50 (26.09) | 20.27 (26.72) | 25.44 (30.23) | 23.22 (28.75) | 24.33 (29.53) |
| T3 | 6.63 (14.84) | 4.83 (12.66) | 5.73 (13.81) | 12.38 (20.58) | 6.81 (15.05) | 9.60 (18.03) | 16.23 (23.73) | 14.20 (22.09) | 15.21 (22.94) | 20.80 (27.11) | 19.32 (26.02) | 20.06 (26.59) | 24.79 (29.83) | 25.58 (30.32) | 25.18 (30.10) | 27.51 (31.62) | 30.96 (33.78) | 29.23 (32.71) |
| T4 | 6.65 (14.77) | 5.70 (13.73) | 6.18 (14.33) | 14.60 (22.44) | 9.68 (18.07) | 12.14 (20.37) | 17.99 (25.07) | 15.40 (23.00) | 16.70 (24.07) | 23.46 (28.93) | 23.36 (28.90) | 23.41 (28.91) | 27.11 (31.35) | 28.51 (32.27) | 27.81 (31.81) | 29.95 (33.16) | 33.09 (35.10) | 31.52 (34.13) |
| SE(d) | 1.12 | 0.74 | 0.76 | 0.72 | 0.88 | 0.84 | 0.80 | 1.10 | 0.79 | 0.84 | 0.96 | 0.97 | 0.77 | 1.27 | 0.89 | 0.88 | 1.46 | 1.11 |
| C.D. @5% | N/A | NS | N/A | 1.59 | 2.71 | 1.85 | 1.76 | 3.38 | 1.75 | 1.86 | 2.95 | 2.13 | 1.69 | 3.92 | 1.97 | 1.95 | 4.49 | 2.45 |
| C.V.% | 11.91 | NS | 8.51 | 5.38 | 11.64 | 6.91 | 5.18 | 10.92 | 5.36 | 4.77 | 7.89 | 5.55 | 3.95 | 9.11 | 4.56 | 4.20 | 9.44 | 5.19 |

*Figures in parenthesis are arc sign transformed values

**Table 2:** Diseases Intensity of early blight at different days intervals (2018-19, 2019-20 and pooled)

| Treat. | Intensity (%) days after appearance | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Before spray | | | 7th | | | 14th | | | 21st | | | 28th | | | 35th | | |
| | 2018-19 | 2019-20 | Pooled | 2018-19 | 2019-20 | Pooled | 2018-19 | 2019-20 | Pooled | 2018-19 | 2019-20 | Pooled | 2018-19 | 2019-20 | Pooled | 2018-19 | 2019-20 | Pooled |
| T1 | 4.40 (11.91) | 3.47 (10.67) | 3.93 (11.32) | 11.20 (19.53) | 8.27 (16.58) | 9.73 (18.15) | 17.60 (24.78) | 15.87 (23.31) | 16.73 (24.12) | 22.40 (28.21) | 21.33 (27.41) | 21.87 (27.84) | 28.80 (32.44) | 27.07 (31.20) | 27.93 (31.85) | 31.60 (34.18) | 33.73 (35.40) | 32.67 (34.81)* |
| T2 | 5.20 (13.12) | 3.33 (10.38) | 4.27 (11.87) | 6.40 (14.55) | 5.20 (13.14) | 5.80 (13.90) | 9.20 (17.63) | 7.73 (16.11) | 8.47 (16.91) | 10.00 (18.39) | 10.13 (18.50) | 10.07 (18.46) | 13.20 (21.28) | 14.40 (22.26) | 13.80 (21.79) | 14.80 (22.61) | 17.87 (24.89) | 16.33 (23.80) |
| T3 | 4.80 (12.59) | 3.20 (10.24) | 3.99 (11.51) | 8.40 (16.82) | 5.47 (13.48) | 6.93 (15.26) | 11.60 (19.89) | 10.67 (19.02) | 11.13 (19.47) | 13.20 (21.28) | 14.27 (22.14) | 13.73 (21.72) | 16.40 (23.86) | 19.20 (25.98) | 17.80 (24.94) | 20.40 (26.83) | 24.53 (29.67) | 22.47 (28.27) |
| T4 | 5.20 (13.04) | 3.33 (10.50) | 4.27 (11.87) | 8.40 (16.82) | 7.60 (15.93) | 8.00 (16.40) | 14.00 (21.94) | 12.27 (20.48) | 13.13 (21.23) | 16.80 (24.18) | 18.13 (25.20) | 17.47 (24.69) | 20.80 (27.12) | 22.13 (28.05) | 21.46 (27.58) | 22.80 (28.47) | 27.07 (31.33) | 24.93 (29.94) |
| SE(d) | 1.28 | 0.66 | 0.80 | 0.74 | 0.84 | 0.53 | 0.77 | 1.04 | 0.62 | 0.63 | 0.97 | 0.82 | 0.68 | 1.18 | 0.97 | 0.70 | 1.48 | 1.18 |
| C.D.@ 5% | N/A | NS | N/A | 1.62 | 2.58 | 1.16 | 1.70 | 3.19 | 1.37 | 1.40 | 2.99 | 1.80 | 1.50 | 3.63 | 2.13 | 1.54 | 4.58 | 2.59 |
| C.V.% | 16.04 | NS | 10.87 | 6.89 | 12.65 | 5.22 | 5.78 | 11.74 | 4.83 | 4.36 | 9.31 | 5.58 | 4.10 | 9.80 | 5.77 | 3.93 | 10.95 | 6.37 |

*Figures in parenthesis are arc sign transformed values

**Table 3:** Yield and economics of different treatments (2018-19, 2019-20 and pooled)

| Treatment | Yield (t/ha) | | | Total cost of cultivation (Rs/ha) | Gross return (Rs/ha) | Net return (Rs/ha) | B:C Ratio |
|---|---|---|---|---|---|---|---|
| Treatment | 2018-19 | 2019-20 | Pooled | | | | |
| T1 | 11.23 | 11.36 | 11.29 | 99375.45 | 115722.50 | 16347.05 | 1.16 |
| T2 | 15.76 | 16.57 | 16.17 | 106423.74 | 165742.50 | 59318.76 | **1.56** |
| T3 | 14.04 | 14.48 | 14.26 | 103632.98 | 146165.00 | 42532.02 | 1.41 |
| T4 | 13.09 | 13.29 | 13.19 | 104163.27 | 135197.50 | 31034.23 | 1.30 |
| SE(d) | 1.11 | 0.55 | 0.75 | | | | |
| C.D. | 2.45 | 1.70 | 1.66 | | | | |
| C.V. | 13.01 | 9.86 | 8.67 | | | | |

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