



Field Evaluation of Few Novel Fungicides against Potato Late Blight Disease

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ABSTRACT

Background: Potato late blight caused by *Phytophthora infestans* (Monts.) de Bary is the most important disease in all the major potato growing areas in the world including India. The disease results total failure of the crop if proper management practices is not followed.

Methods: A field experiment with randomized block design was performed at Instructional cum Research Farm, Assam Agricultural University (AAU), Jorhat, Assam during rabi season 2021-2022 to evaluate the comparative efficacy of different fungicides viz., propamocarb, dimethomorph and azoxystrobin under different spray schedules.

Result: The study revealed that all of the fungicides were successful in controlling the late blight disease when sprayed 6 times at 8 days interval. Six sprays with propamocarb @ 0.1% at 8 days interval was significantly superior in reducing disease incidence and severity (71.21% and 65.32%, respectively) and enhanced tuber yield up to 85.82 per cent, compared to control. The treatment recorded lowest tuber infection (10.91%) and highest tuber yield (131.10 q/ha) with a maximum benefit cost ratio of 1.72:1.

Key words: Fungicides, Potato late blight disease, Spray schedule.

INTRODUCTION

Potato (*Solanum tuberosum* L.) is the most widely grown tuber crop in the world and the fourth largest crop in terms of fresh produce after rice, wheat and maize belonging to the family Solanaceae. Potato is a major food crop that is grown in more than 150 countries across the world. According to FAO estimates, in 2021, over 376 million metric tons of potatoes were produced worldwide, an increase from a production volume of 333.6 million tons in 2010. Asia alone accounts for half of the world's potato production, with China and India accounting nearly 38% of that production. India is the world's second largest potato producer after China. In India, potato occupied around 21.58 lakh hectares in 2019-20 with a total production of 51.30 million metric tonnes (Anonymous, 2020). The major potato growing states are Uttar Pradesh, West Bengal, Bihar, Gujarat, Madhya Pradesh, Punjab, Assam, Chhattisgarh, Jharkhand and Haryana. Around 10% of the nation's total potato-growing territory is spread throughout the eight north eastern states of the country, i.e. Arunachal Pradesh, Mizoram, Nagaland, Manipur, Meghalaya, Sikkim and Tripura (Yadav and Srivastava, 2014). In Assam, potato is cultivated in an area of 104.75 thousand hectares with a production of 756.22 thousand metric tonnes and average yield of 7219 kg/ha (Anonymous, 2021).

The crop is attacked by number of fungal, bacterial and viral pathogens, which reduces the marketable yield in a large measure. Amongst them, late blight caused by fungus *Phytophthora infestans* (Mont.) de Bary is considered the most important and devastating disease in different countries of the world (Fernández-Northcote *et al.*, 2000; Namanda *et al.*, 2004), with an incidence ranging from 50-100 per cent (Anonymous, 2010). It can result into total crop failure if appropriate control measures

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are not adopted. *P. infestans* is a poor saprophyte, when its hosts are not present, its populations experience drastic demographic shifts (Raza *et al.*, 2019). The disease spread quickly at a favourable temperature (15-20°C) and high relative humidity (over 80%), which was followed by persistent rain or light sprinkling for 2-3 days. When the weather is cool and wet, late blight can potentially result in a 100% crop loss by completely destroying all of the plants in a field in a matter of weeks. Over time, a number of forecasting models have been created and applied to anticipate potato late blight worldwide. For predicting the time of appearance of disease and optimizing use of fungicides without risking the crop and human health disease forecasting and warning services are essential (Singh *et al.*, 2013). The average yield losses from late blight fluctuate from year to year and range from 11% to 74% (Khalid and Grover, 2021). Every year in Assam, the disease spreads epidemically, resulting in substantial production losses of up to 90 per cent in unsprayed crops (Bhattacharya *et al.*, 1990). Moreover, potato late blight can

cause major output losses of more than 60% if sufficient chemical management techniques are not affordable (Ivanov *et al.*, 2021).

As far as late blight is concerned, fungicides forms one of the major components of disease management and has long been recommended. This management technique necessitates the selection of appropriate fungicides and the testing of their effectiveness. Several researches have shown that using fungicides to manage the disease is successful and also the use of chemicals is economical for farmers (Sharma and Saikia, 2013; Mandal *et al.*, 2018; Peerzada *et al.*, 2020; Mhatre *et al.*, 2021). However, farmers are unable to save their crops even after applying fungicides due to the unscientific application of fungicides, which includes choosing an effective fungicide and applying it at the right time, using the right method, applying the right dose and scheduling of fungicides. The present study focuses the comparative efficacy of few novel fungicides with different spray schedules in suppressing infection of potato late blight in field condition. The potato growing farmers of the region will benefit from the best management fungicide schedule techniques.

MATERIALS AND METHODS

Field experiment was carried out under well drained medium land situation during *rabi* season of 2021-2022 at ICR farm of AAU, Jorhat (26°44'N latitude and 94°10'E longitude with an elevation of 91 m above mean sea level). The mean minimum and maximum temperature during the experiment was 10°C and 24°C, respectively. The average morning and evening relative humidity recorded was 98% and 56%, respectively.

Comparative efficacy of few novel fungicides in suppressing infection of potato late blight in field condition

The variety 'Kufri Jyoti' used in the present study was obtained from the AICRP on Potato, Assam Agriculture University, Jorhat. This variety have a short life span about 90-110 days and producing oval, white with shallow eye tubers. Compare to all varieties', Kufri Jyoti is more acceptable variety because it is more susceptible to potato late blight. Three fungicides viz., propamocarb @ 0.1%, dimethomorph @ 0.1% and azoxystrobin @ 0.1% in different spray schedules were evaluated for their efficacy against potato late blight.

The pre and post planting operations were carried out for raising the crop following the standard recommended agronomic practices (Anonymous, 2015). The plot was laid out in randomized block design (RBD) with three replication and ten treatments. The individual plot size was maintained as 3m×2m. Potato tubers were planted with a spacing of 60 cm×30 cm. The fungicides were given according to the spray schedule and plots sprayed with sterile water served as control.

Assessment

The per cent disease incidence (PDI), disease severity (DS) and tuber infection index were calculated on each treatment and evaluated as follows.

Disease incidence (%) =

$$\frac{\text{No. of infected plants per plot}}{\text{Total no. of plant per plot}} \times 100$$

Disease severity index (%) =

$$\frac{\text{Total sum of numerical rating}}{\text{Total no. of observation} \times \text{maximum disease rating}} \times 100$$

Tuber infection (%) =

$$\frac{\text{No. of infected tuber harvested from plot}}{\text{Total no. of tuber harvested from plot}} \times 100$$

The disease severity index of late blight on the potato leaves was calculated following the scale suggested by Henfling (1987).

Disease severity scale of late blight of potato (Henfling, 1987).

Score	% foliage affected	Description
1	0	None or very few lesions on the leaflets
2	3	More than 0% but less than 10%
3	10	More than 10% but less than 25%
4	25	More than 25% but less than 50%
5	50	Half of the foliage destroyed
6	75	More than 50% but less than 75%
7	90	More than 75% but less than 90%
8	97	Only very few green areas leaf (much less 10%)
9	100	Foliage completely destroyed

Statistical analysis

The experimental data were analyzed by Fisher's method of analysis of variance (ANOVA) and interpretation of data was carried out in accordance with Gomez and Gomez (1984). Duncan's multiple range test (DMRT) at $p \leq 0.05$ was used to separate treatment means. DMRT is used to make all possible comparisons between means and to compare the mean of control treatment with the rest of the treatment means. To test the significance of different sources 'F' test was done and calculated 'F' values were compared with the appropriate value of 'F' at 5 per cent level of probability.

RESULTS AND DISCUSSION

Effect of different fungicidal treatment on disease incidence and severity of potato late blight

There was significant difference among the treatments in disease incidence and severity of late blight (Table 1). Among the different treatments, 6 foliar applications of propamocarb @ 0.1% at 8 days intervals (T_1) was highly effective in managing the disease with least disease

incidence (28.39%), which was statistically at par with the treatment comprising of azoxystrobin @ 0.1% (T_3) and dimethomorph @ 0.1% (T_2) with disease incidence of 30.05 and 32.32 per cent, respectively under same spray schedule. The maximum percentage of disease incidence (98.61%) was observed in control plot (T_{10}). This was followed by T_8 (4 sprays of dimethomorph @ 0.1% at 12 days intervals) and T_9 (4 sprays of azoxystrobin @ 0.1% at 12 days intervals) with disease incidence of 53.19 and 50.70 per cent, respectively. However, both the treatments were statistically at par. Similar trend was also observed with respect to disease severity where T_1 recorded minimum (31.85%) disease severity followed by T_3 (34.82%) and T_2 (35.56%), which were at par with each

other. The disease severity was found maximum (91.85%) in control plot. Maximum reduction in disease incidence (71.21%) and severity (65.32%) over control were recorded in T_1 followed by T_3 (69.52 and 62.09%) and T_2 (67.23 and 61.29%, respectively) (Fig 1). Among all the treatments, T_8 was found least effective and caused 46.06 per cent disease reduction and 36.29 per cent in reduction of disease severity over control.

Effect of different fungicidal treatments on tuber infection of potato

The results (Table 1) also showed that the tuber infection differed significantly in different treatments. Lowest tuber infection (10.91%) was recorded in treatment comprising

Table 1: Effect of different fungicidal treatments on development of late blight and tuber infection of potato.

Treatments	Disease incidence (%)	Disease severity (%)	Tuber infection (%)
T1 6 sprays of propamocarb @ 0.1% at 8 days intervals	28.39*(32.21)**	31.85 (34.38)	10.91(19.29)
T2 6 sprays of dimethomorph @ 0.1% at 8 days intervals	32.32 (34.66)	35.56 (36.62)	12.72 (20.91)
T3 6 sprays of azoxystrobin @ 0.1 % at 8 days intervals	30.05 (33.26)	34.82 (36.18)	12.24 (20.49)
T4 5 sprays of propamocarb @ 0.1% at 10 days intervals	40.25 (39.40)	46.67 (43.11)	12.01 (20.29)
T5 5 sprays of dimethomorph @ 0.1% at 10 days intervals	42.40 (40.65)	50.37 (45.24)	17.78 (24.95)
T6 5 sprays of azoxystrobin @ 0.1 % at 10 days intervals	42.08 (40.46)	48.15 (43.96)	17.47 (24.72)
T7 4 sprays of propamocarb @ 0.1% at 12 days intervals	45.30 (42.33)	52.59 (46.51)	18.27 (25.32)
T8 4 sprays of dimethomorph @ 0.1% at 12 days intervals	53.19 (46.85)	58.52 (49.93)	20.75 (27.11)
T9 4 sprays of azoxystrobin @ 0.1 % at 12 days intervals	50.73 (45.44)	53.33 (46.94)	20.82 (27.16)
T10 Control	98.61 (85.45)	91.85 (76.27)	30.91 (33.80)
SEd ($\pm$)	4.27	4.49	3.15
CD(0.05)	8.97	9.43	6.62

*Data are mean of three replications.

**Figures in the parentheses are arc sine transformed value.

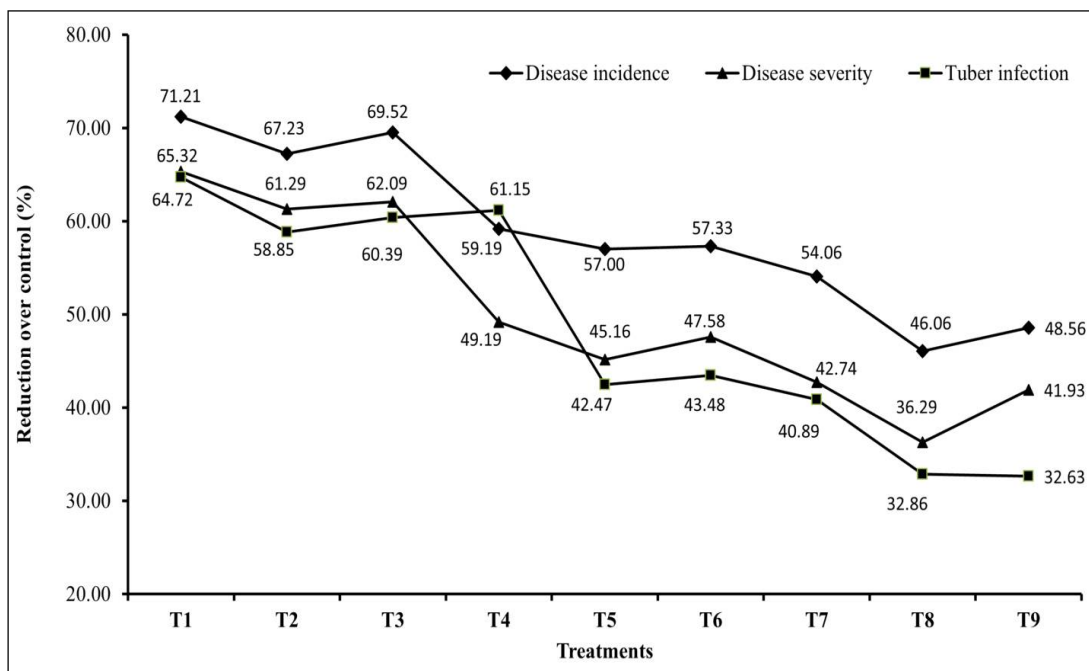


Fig 1: Effect of different fungicides on per cent reduction in disease incidence and severity of potato late blight and tuber infection over control.

of 6 sprays of propamocarb @ 0.1% at 8 days intervals (T_1) followed by 5 sprays of propamocarb @ 0.1% at 10 days intervals (T_4) (12.01%) and T_{-3} (12.24%), which were significantly at par with each other. The control plot recorded highest tuber infection (30.91%). T_1 recorded maximum (64.72%) reduction of tuber infection over control followed by T_4 (61.15%) and T_3 (60.39%). T_9 was found to be least effective resulting in lowest (32.63%) reduction of tuber infection over control (Fig 1).

Effect of different fungicidal treatment on tuber yield of potato

A significant increase in tuber yield over untreated control was recorded in all the fungicide treated plots (Table 2). Tuber yield was found to be maximum (131.10 q/ha) in T_1 followed by T_3 (129.43 q/ha) and T_2 (128.32 q/ha) and T_4

(122.21 q/ha). However, they were statistically at par with each other. The minimum tuber yield (70.55 q/ha) was recorded in control plot. Among different fungicidal treatments, the lowest yield of 109.30 q/ha was recorded in T_8 followed by T_7 (4 sprays of propamocarb @ 0.1% at 12 days intervals) and T_9 with tuber yield of 110.54 and 111.10q/ha, respectively. The benefit cost ratio (BCR) of all the treatments were worked out and the highest BCR (1.72:1) was achieved from plot sprayed with 6 subsequent sprays at 8 days intervals with 0.1% propamocarb (T_1), followed by BCR of 1.63:1 in the plot treated with 5 sprays of propamocarb @ 0.1% at 10 days intervals (T_4). The lowest BCR (1.03) was achieved in control plot. Per cent increase in yield due to application of different fungicidal treatments is apparent from the Fig 2 that the yield increased significantly over control. Higher per cent increase in yield

Table 2: Effect of different fungicidal treatments against late blight on yield of potato.

Treatments	Tuber yield (q/ha)	BC ratio
T1 6 sprays of propamocarb @ 0.1% at 8 days intervals	131.10*	1.72
T2 6 sprays of dimethomorph @ 0.1% at 8 days intervals	128.32	1.51
T3 6 sprays of azoxystrobin @ 0.1 % at 8 days intervals	129.43	1.55
T4 5 sprays of propamocarb @ 0.1% at 10 days intervals	122.21	1.63
T5 5 sprays of dimethomorph @ 0.1% at 10 days intervals	118.88	1.42
T6 5 sprays of azoxystrobin @ 0.1 % at 10 days intervals	120.54	1.47
T7 4 sprays of propamocarb @ 0.1% at 12 days intervals	110.54	1.48
T8 4 sprays of dimethomorph @ 0.1% at 12 days intervals	109.43	1.34
T9 4 sprays of azoxystrobin @ 0.1 % at 12 days intervals	111.10	1.39
T11 control	70.55	1.03
SEd ($\pm$)	7.47	
CD(0.05)	15.69	

*Data are mean of three replications.

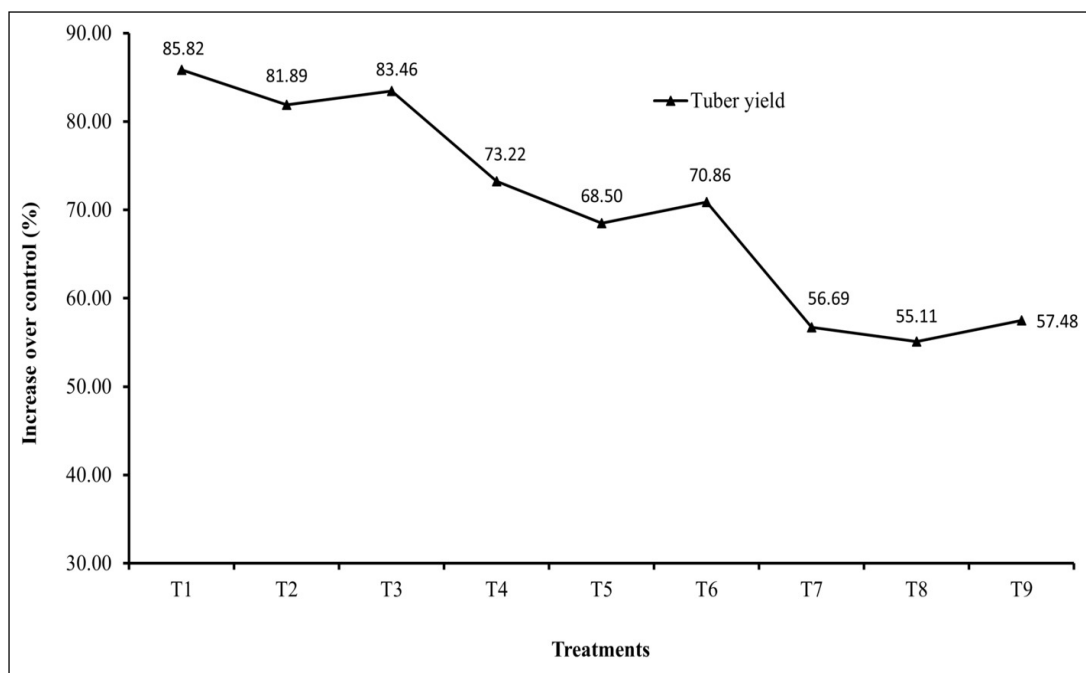


Fig 2: Effect of different fungicides on per cent increase in yield of potato over control.

(85.82%) was recorded T_1 , followed T_3 (83.46%) and T_2 (81.89%). T_8 recorded the lowest per cent increase in yield (55.11%) followed by T_7 (56.69%).

In the present investigation 3 different fungicides viz., propamocarb, dimethomorph and azoxystrobin @ 0.1% in different spray schedule were evaluated against late blight of potato. The results indicated that 6 sprays of Propamocarb at 8 days intervals was most effective with a significant reduction of disease incidence and severity (71.21 and 65.32%, respectively) and increased tuber yield up to 85.82 per cent over control followed by azoxystrobin and dimethomorph under same spray schedule. The results are in accordance with the report of Sayak *et al.* (2022) who reported that propamocarb was most effective against late blight. They further concluded that application of this preparation helped to reduce the spread of the diseases by 2.0 times, the development of diseases by 2.9 times and increase the yield by 1.4 times compared to control (without fungicides application). Similarly, Tafforeau *et al.* (2006) also reported that propamocarb has a good environmental profile and outstanding control of late blight. They also reported that the fungicide is suitable for use in integrated pest management systems in potato crop. The inhibiting ability of the propamocarb may be due to the prevention of the production of fungal cell walls by interfering with the synthesis of phospholipids and fatty acids.

The effect of propamocarb on efficient control of late blight have also been reported by various workers (Thind *et al.*, 2009; Muchiri *et al.*, 2009; Braun *et al.*, 2014; Ren *et al.*, 2018). Johnson *et al.* (2000) established that two applications of propamocarb hydrochloride plus chlorothalonil were required to restrict lesion expansion and inhibit sporulation. Size and number of lesions and sporulation on leaflets were reduced when propamocarb hydrochloride plus chlorothalonil was applied up to 48 h after inoculation.

The decrease of tuber infection by the pathogen is the most crucial part of managing late blight because the asexual populations of *P. infestans* remain as dormant mycelium on infected tubers, which are a key source of primary inoculums for the next season (Andriveau, 1996; Andrew and Caldiz, 2005). In present investigation, the highest reduction in tuber infection over control was recorded in the treatment with 6 sprays of propamocarb at 8 days intervals. This might be attributed to maximum reduction of foliar infection of late blight in potato plants since, potato tubers in soil usually get infected by the spores washed out from blighted foliage. Flier *et al.* (2003) mentioned significant association between late blight in the foliage and tuber infection. Sedlák *et al.* (2022) revealed that the application of propamocarb reduced the amount of tubers infected by late blight by an average of 72% when compared to the control. Long persistence with anti-sporulant properties of the propamocarb resulted in the high yields as well as excellent protection from tuber blight. Srivastava *et al.* (2015) observed highest improvement in potato yield due to spraying of fungicides on Kufri Jyoti (22.0%) over the non spray. They reported that fungicides'

spraying is crucial to increase the profitability of farming community for north eastern hill region.

CONCLUSION

The study was implemented to evaluate the few fungicides in their different spray schedule against potato late blight disease. The result clearly demonstrated that the high incidence of late blight disease can be effectively managed through six foliar sprays with propamocarb fungicide @ 0.1% at 8 days intervals starting from 1st appearance of the disease.

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Conflict of interest

All authors declare that they have no conflict of interest.

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