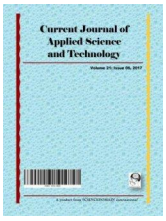

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# Occurrence and Management of Late Blight Diseases of Tomato in Terai Zone of West Bengal

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***Authors' contributions***

*This work was carried out in collaboration between all authors. Authors SH and RP designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors SH and SB guided the analyses of the study. Author MH managed the literature searches. All authors read and approved the final manuscript.*

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## ABSTRACT

**Background:** The objective of this study was to determine the influence of weather indices on disease incidence and search efficient and economically profitable management option as compared to others in field conditions against tomato late blight disease.
**Methods:** The seedlings were planted in a randomised block design. Seedlings were planted on four different dates with seven treatments and three replications to study the disease incidence and efficacy of new generation fungicides. The variety "Patharkuchi" was used for the present study. The experiment was conducted at Agricultural Farm, UBKV, West Bengal. Different weather parameters were collected from the nearest automatic weather station.
The experiment involved seven different treatments permutation for management of late blight

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disease. The fungicidal sprays were done as soon as the late blight disease was observed in the tomato field. The disease incidence was recorded in percentages of diseased plants out of total plants studied. The disease severity was assessed by PDI value in 0 to 9 scale.

**Results:** It was observed in the study, that the number of days from sowing to initiate late blight symptom on tomato was an inverse function (Y=a+bx-1) of average maximum humidity and temperature and $R^2$ values of the equation were statistically significant at 1% level of significance. Two sprayings with Ametoctradin + Dimethomorph @ 0.3%WP showed lowest disease severity of 6.14% and 83.11% reduction in disease severity over control at 90 days after planting (90DAP) which was significantly at par with the Cholorothelonil 40% w/w + Difenconazole 4% w/w SC fungicide. The data showed that fruit yield was significantly higher in Cymoxanil + mancozeb @ 0.3% treatment combinations (118.93 q/ha) compared to control (62.40q/ha).

**Conclusion:** Date of initiation of the disease positively correlated with the maximum relative humidity and negatively correlated with maximum temperature and sunshine hours. Two sprayings with Ametoctradin + Dimethomorph @ 0.3% and Cholorothelonil 40% w/w + Difenconazole 4% w/w SC fungicides could effectively manage tomato late blight disease.

*Keywords: Tomato; late blight disease; Phytophthora infestance; weather indices; fungicides.*

## 1. INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill) is an important winter vegetable crop in the state of West Bengal but after the introduction of hybrid cultivar, it is cultivated in new areas throughout the year. The State produces about 1.14 m. MT of tomatoes from an area of 0.06 m. ha. with the productivity of 20.2 t/ha. The production of tomato is concentrated in the regions of Murshidabad, Nadia, North & South 24 Parganas, Jalpaiguri and Cooch Behar [1]. This vegetable crop is also severely affected by the late blight disease (*Phytophthora infestans* Mont) is not a true fungus. This pathogen is currently classified as an Oomycete, which are members of the kingdom Chromista (Stramenopiles or Straminopiles). Oomycetes belong to one of two orders, Saprolegniales and Peronosporales. The order Peronosporales contains *Phytophthora* species and a number of other very important plant-pathogenic genera, including the genus *Pythium* [2]. Distribution of *P. infestans*, has worldwide but frequent cool, moist weather leads to severe epidemics. It is one of the most devastating diseases of tomato and potato crops worldwide in recent human history, that the pathogen caused the potato Irish famine in the 1840s. Like Potato, infected tomato plant showed symptoms of the disease on the leaves and stems and the yield loss is frequently as severe as on potato. Late blight tomato identified by, pale green to brownish-black lesions on leaves and stems that may be small at first and appear indefinite, water-soaked spots that enlarge rapidly and become necrotic. During humid weather, the leaf may be covered grayish white moldy growth on the abaxial surface and produces sporangia and sporangiophores on the surface of the infected tissue. As the disease progresses, the many lesions accumulate, the entire plant can be destroyed in only a few days after the first lesions are observed. But on tomato fruits, Late blight infections produce dark brown, firm lesions develop on green fruit which may enlarge and destroy the entire tomato fruit. Late blight lesions on tomato fruit are often followed by soft rot and disintegration as a tinny layer of white mycelium may be observed during wet weather.

A most notorious late blight pathogen anticipates the tomato where it is cultivated in moist, cool, rainy, and humid environments. The two most important environmental factors such as temperature and moisture are affecting late blight development. The pathogen produces spores in the conditions of a wide temperature range from 3°C to 26°C [3], the optimal conditions being 18°C-22°C, and humidity or high relative humidity of 90-100% [4]. According to Schumann and D'Arcy [5] reported that sporulation can occur from 3-26°C, but the optimum range is 18-22°C. Sporangia germinate directly via a germ tube at 21-26°C. Below 18°C, sporangia produce 6 to 8 zoospores which require water for swimming.

Due to defoliation of leaves, the main loss in yield is brought by the disease. Mostly, this disease can be managed to a great extent through the use of fungicides. Tomato late blight disease was controlled by a number of ready mixture fungicides by De and Sengupta [6]. Some researchers studied the inhibiting effect of mephenoxam and mancozeb combination [7],

carbendazim and mancozeb [8] and cupric hydroxide [9]. According to Hariki [10] compared to copper-based products, derivatives of chlorothalonil, are more effective for tomato late blight control. As per result of El-Shimy and Tomader [11], the combination of cymoxanil and famoxadone as well as the independent application of propamocarb hydrochloride, are most effectiveness for potato late blight control. The chemical substances benthiovalicarb and mancozeb are more effective in potato late blight control than mancozeb and dimethomorph [12]. It has been reported that the positive effect from the combination of dimethomorph and chlorothalonil, followed by metiram, compared to the combination of metalaxyl and chlorothalonil, followed by metiram [13]. Some worker also reported that Infinito 68.75% SC @ 1500 g/ha showed lowest late blight disease incidence in tomato [14].

Keeping this view in mind, the present study was undertaken in order to determine the effect of weather indices on disease incidence and search for efficient and economically sound new chemical against tomato late blight disease in field conditions in Terai region of West Bengal.

## 2. MATERIALS AND METHODS

The study was conducted at Agricultural Farm, Pundibari, UBKV, West Bengal (26°39` N Latitude, 89° 39`E Longitude and 50 m amsl) during 2017-18 crop season. The seedlings planted in a randomized block design. For disease incidence study four different dates (15.11.17; 01.12.17; 15.12.17; 02.01.18) planting with three replications. For evaluation of new generation fungicides, seedlings were planted on 15.12.18 with 7 treatments and 3 replications. The variety “Patharkuchi” was used for this experiment. The experiment was conducted at Agricultural Farm, UBKV, West Bengal. Weather indices (temperature, relative humidity and rainfall) were collected from the automatic weather station installed at AMFU, Cooch Behar Centre, UBKV, Pundibari, West Bengal and converted into the required format. The temperature and relative humidity data were computed on an hourly basis, whereas rainfall was computed on daily basis and these parameters were interpolated with the actual date of disease appearance (Fig. 1).

The soil at the experimental field was sandy loam to loamy in texture, acidic in reaction (pH 5.14), high in raw humus content; low in water retention capacity, low to medium in total nitrogen content with a low rate of nitrogen mineralization; low to medium in phosphorus status with high phosphorus fixation; low to medium in potash content and low in calcium and magnesium status. Micronutrients, which were deficient in this zone, were Boron, Molybdenum and Zinc. Application of micronutrients often enhances the productivity of different crops. The soil characteristics of the experimental plot were analysed with the help of Department of Soil Science, Uttar Banga Krishi Viswavidyalaya, Pundibari, Coochbehar. The treatments comprised of different management practices.T1: Cholorothelonil 40% w/w + Difenconazole 4% w/w SC; T2:Sprays of mancozeb 75WP @ 2 g/L water followed by carbendazim 50 WP @ 0.5 g/L water; T3:Sprays of Cymoxanil + mancozeb @ 0.3% at the onset of the disease; T4:Sprays of Dithiocarbamate + mancozeb @ 0.3 %; T5: Ametoctradin + Dimethomorph @ 0.3% all applied at the onset of the disease; thenT6: Difenconazole 25 EC @ 0.05% and T7: Control. Two fungicidal sprays were applied to all the plots after disease incidence at 15 days interval while control plots were sprayed with normal water and water volume of 500 litre/ha. The disease incidence was measured in percentages of infected plants out of the total plants observed:

$$\text{Percent Disease Incidene} = \frac{\text{No. of plants infected}}{\text{a Total number of plants}} \times 100$$

Whereas disease severity was calculated by Percent Disease Index (PDI) value in 0 to 9 scale [15].

$$\text{PDI} = \frac{\text{Sum of all numerical ratings of plants infected}}{\text{Total plants observed x Maximum ratings scale}} \times 100$$

## 3. RESULTS AND DISCUSSION

### 3.1 Relationship between Number of Days Required for Disease Initiation and Weather Parameters

The study was conducted in the experimental farm, Pundibari, UBKV. The seedlings of tomato were planted on four different dates (15.11.17, 01.12.17, 15.12.17 and 02.01.18) during rabi season at fifteen days intervals. Among the various fungal diseases, late blight disease was found to be the major disease occurring in tomato crop.

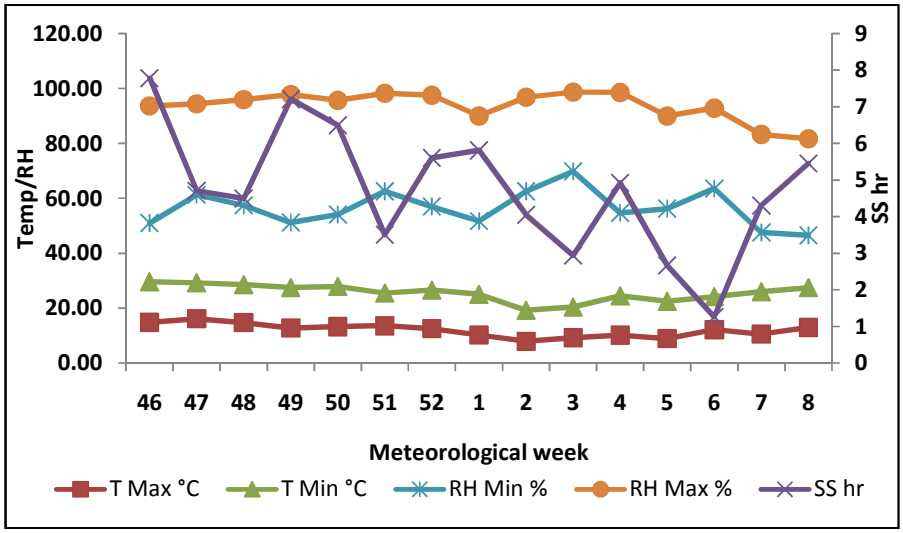


**Fig. 1. Weekly average weather parameters at experimental site during crop growth**

The crop was maintained according to the standard management practices. Five plants were selected randomly from each plot and observed regularly for disease initiation. It was observed that disease occurred within 39 days when seedlings were planted the first fortnight of November and thereafter the period for disease initiation decreased. The shortest time required twenty three days recorded for 02.010.18 sowing date.

Among the four planting dates, longest time (39 days) required for initiation of the late blight disease was 15.11.17 planting date. Thereafter the period for disease initiation decreased and shortest time required seventeen days recorded on 02.01.18 planting date.

The number of days of disease initiation positively correlated with the maximum relative humidity and negatively correlated with maximum temperature and sunshine hours. It was also observed that a number of days from planting to initiate late blight symptom on tomato was an inverse function (Y=a+bx-1) of average maximum humidity and temperature and $R^2$ values of the equation were statistically significant at 1% level of significance.

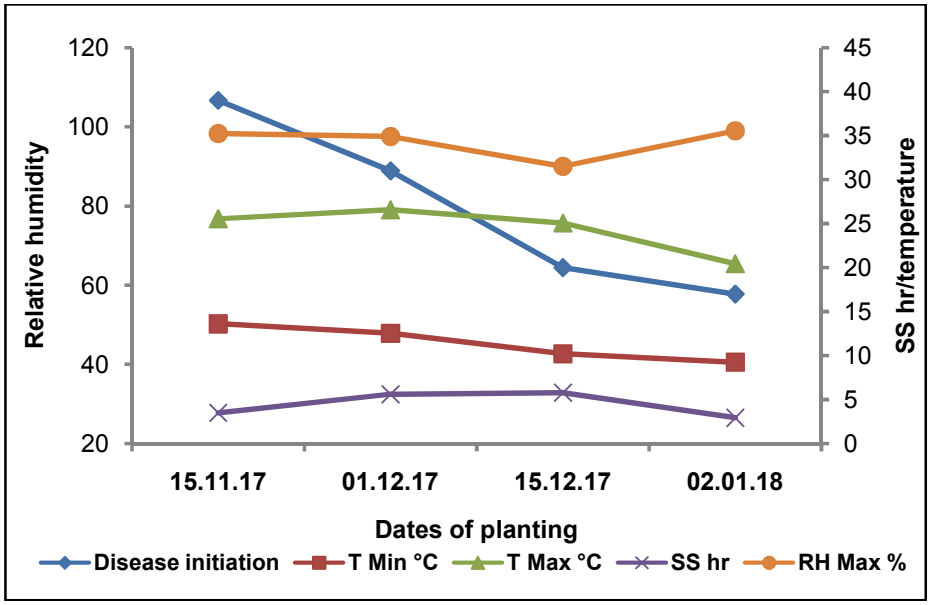


**Fig. 2. Relationship between days to disease initiation and weather parameter**

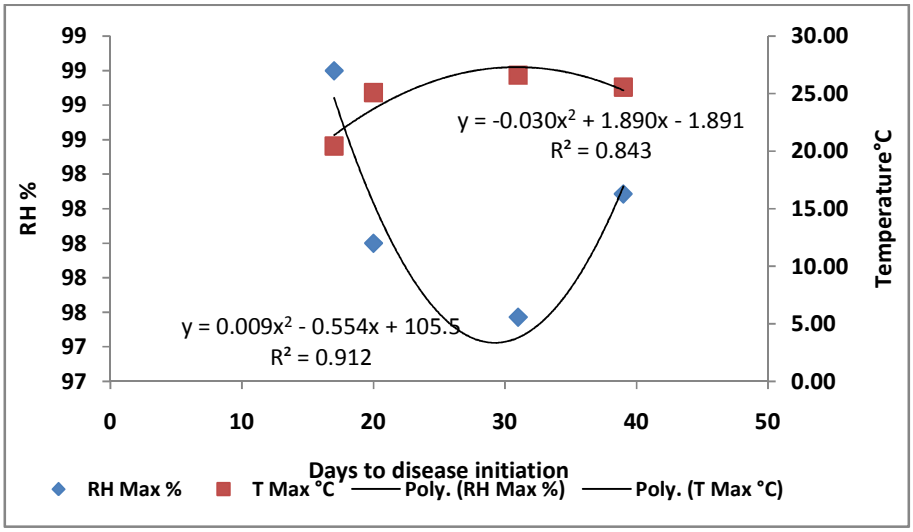


**Fig. 3. Relationship between weather parameters and days to disease initiation over combined date of planting**

### 3.2 Efficacy of Different Chemicals on Late Blight Disease of Tomato in Field Conditions

The experimental results are presented in Table 1. It is observed that the late blight disease severity in untreated plots was 36.35%. Two sprayings with Ametoctradin + Dimethomorph @ 0.3% ($T_5$) showed the lowest disease severity of 6.14% and 83.11% reduction in disease severity over control at 90 days after planting. This was significantly at par with the Cholorothelonil 40% w/w + Difenconazole 4% w/w SC ($T_1$) fungicide which recorded disease severity of 6.34 and 80.55% reduction in late blight disease severity compared to the untreated check. Moreover, in control plots the per cent increase of late blight incidence was more in comparison to treated plots.

The result showed a significant difference in disease severity (8.64%) when the Cymoxanil + Mancozeb @ 0.3% ($T_3$) fungicide was applied. The result was significantly at par with Dithiocarbamate + Mancozeb @ 0.3 % (9.55%) ($T_4$). Difenconazole 25 EC @ 0.05% ($T_6$) was not

**Table 1. Effect of various chemicals on the management late blight diseases of tomato**

| Treatment | Percent incidence of late blight disease | | | | |
|---|---|---|---|---|---|
| | Before application | 10 days after 1st application | 10 days after 2nd application | 20 days after 2nd application | % reduction over control |
| $T_1$ | 2.37 (8.96)* | 3.41 (10.64) | 4.84 (12.71) | 6.34 (14.59) | 80.55 |
| $T_2$ | 2.36 (8.75) | 5.46 (13.51) | 13.64 (21.67) | 15.15 (22.90) | 58.33 |
| $T_3$ | 2.58 (9.12) | 3.77 (11.20) | 6.73 (15.04) | 8.64 (17.09) | 76.24 |
| $T_4$ | 2.55 (9.30) | 3.83 (11.29) | 7.27 (15.64) | 9.55 (18.00) | 73.74 |
| $T_5$ | 2.96 (10.04) | 3.52 (10.82) | 4.75 (12.59) | 6.14 (14.35) | 83.11 |
| $T_6$ | 2.61 (9.15) | 6.09 (14.25) | 17.74 (24.91) | 19.31 (26.07) | 46.88 |
| $T_7$ | 2.34 (8.90) | 9.26 (17.72) | 28.12 (32.02) | 36.35 (37.08) | -- |
| SEM±0.1 | 0.091 | 0.069 | 0.062 | 0.044 | -- |
| P=0.05 | 0.280 | 0.212 | 0.192 | 0.137 | -- |

**Figures in the parenthesis are transformed angular values*

comparatively effective in reducing late blight disease exhibiting 19.31% disease severity and only 46.88% reduction in comparison to untreated control. In these case the Mancozeb showed more disease severity as compared to other fungicides tested as also find out in the present investigation [16]. Some researcher suggested that the severe late blight disease could be effectively managed with prophylactic spray of Mancozeb @ 0.25% followed by Cymoxanil+Mancozeb or dimethomorph+ mancozeb @ 0.3% at the onset of disease and one more spray of Mancozeb @ 0.25%seven days after application of systemic fungicides [17]. However, spray with Mancozeb 75% WP (0.2%) +Dimethomorph 50% WP (0.2%) at 7-10 days intervals showed less disease severity (24.55%) as compared to controlled ($T_7$) [18].

**Table 2. Effect of different fungicides and their mixture on fruit yield of tomato crop**

| Treatments | Yield (q/ha) | Increase in yield over control (T7) |
|---|---|---|
| $T_1$ | 110.00 | 76.3 |
| $T_2$ | 116.00 | 85.9 |
| $T_3$ | 118.93 | 90.6 |
| $T_4$ | 115.00 | 84.3 |
| $T_5$ | 84.77 | 35.8 |
| $T_6$ | 99.93 | 60.1 |
| $T_7$ | 62.40 | - |
| SEM±0.1 | 1.85 | - |
| P=0.05 | 5.71 | - |

Tomato fruit yield was also influenced significantly with the application of different fungicides (Table 2) during the study. Marketable yield of each treatment was calculated after several pickings3. The data showed that fruit yield was significantly higher in treated plots as compared to control (62.40q/ha) that indicating the positive effects of different treatments on increase in yield of tomato. The maximum fruit yield (118.93q/ha) was obtained in plots $T_3$, which was statistically at par with $T_2$ (116.0q/ha) and $T_4$ (115q/ha). The lowest tomato yield (84.77q/ha) was recorded in $T_5$ followed by $T_6$ (99.93q/ha). The percentage increase in marketable yield over control ranged from 35.8% ($T_5$) to 90.6% ($T_3$). The maximum percentage increase in marketable yield over control was observed in $T_3$ which is statistically at par with $T_2$ (85.9%) and $T_4$ (84.3%). Other worker also reported that spraying of a mixture of Cymoxanil 8% and Mancozeb 64%-72%WP produced higher fruit yield [14]. Our results substantiated with earlier observations of [19], who reported that the good control of tomato late blight disease with increased yield was obtained with combination products of fungicides. Similar research finding was also reported by Asit et al. [20].

## 4. CONCLUSION

The aim of the study was on the optimization of the energy sources and utilisation of pattern for change in the scenario of Tomato cultivation in the selected area of study northern district of West Bengal, India. It is observed that the late blight severity in untreated plots was 36.35%. Two sprayings with Ametoctradin + Dimethomorph @ 0.3% ($T_5$) showed lowest disease severity of 6.14% and 83.11% reduction in disease severity over control at 90 days after planting (90DAP) which was significantly at par with the Cholorothelonil 40% w/w + Difenconazole 4% w/w SC ($T_1$) fungicide applied with disease severity of 6.34 and 80.55% reduction in late blight severity compared to untreated check. Tomato fruit yield was also influenced significantly with different combinations of fungicides during the study. Marketable yield of each treatment was calculated after several pickings3. The data showed that fruit yield was significantly higher in all treated plots as compared to control plot (62.40q/ha) that indicating the positive effects of different treatments on increase in yield of tomato. The maximum fruit yield (118.93q/ha) was obtained in plots T3, which was statistically at par with T2 (116.0q/ha) and T4 (115q/ha). The percentage increase in marketable yield over control ranged from 35.8% (T5) to 90.6% (T3). For effective management of late blight disease, the fungicide should be applied on community basis i.e. at the same time all the farmers in a locality should apply a fungicide.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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