Original Research Article

Performance Assessment of Native Tomato Genotypes to Late Blight Disease under Natural Epiphytotics

Raghuveer Singh¹*, N. Tiamberen Ao², Valenta Kangjam², N. Bidyaleima Chanu³, L. Daiho² and Susanta Banik²

¹ICAR Research Complex for NEH Region, A.P. Centre, Basar-791101, Arunachal Pradesh, India
²Department of Plant Pathology, SASRD, Nagaland University, Medziphema Campus-797106, Nagaland, India
³Department of Vegetable Science, College of Horticulture & Forestry, CAU, Pasighat-791102, Arunachal Pradesh, India

*Corresponding author

A B S T R A C T

A field study conducted to evaluate the native tomato genotypes for their resistance to late blight under natural epiphytotics conditions was carried out during 2017-18 and 2018-19. Twenty native tomato genotypes were collected from different tomato growing areas of Nagaland, Manipur and Arunachal Pradesh. Characteristics of tomato genotypes revealed that most of the collected genotypes were indeterminate in nature except Pusa Ruby (semi-determinate), Arka Rakshak, F₁ hybrid (determinate) and T₂ (determinate). The late blight disease severity was assessed visually on stems, leaves and fruits of all plants of each replication following scale 0-5, when total late blight infestation had occurred in the control plot. Disease severity data revealed that least PDI was recorded in T₃ (16.81) and T₁₇ (35.99) whereas highest PDI was recorded in Arka Rakshak, with 89.72. This experimental result revealed that most of the genotypes (20 genotypes) reacted as highly susceptible, while T₃ (16.81 PDI) and T₁₇ (35.99 PDI) was found resistant and tolerant respectively. These results clearly indicate that a good source of resistance to late blight is available in the genotype T₃ (cherry tomato). The resistant genotype thus obtained through this experiment shows a potential disease resistance trait contributor for tomato breeding against late blight disease.

Key words
Resistance, Late blight, Natural epiphytotics conditions, Native tomato genotypes

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Introduction

Late blight disease of tomato caused by Phytophthora infestans (Mont.) de Bary is devastating and widespread in nature. It is an economically important disease of tomato worldwide including India (Son et al., 2008). Worldwide losses were estimated to $170
billion annually and thus the pathogen was considered as a threat to global food security (Latijnhouwers et al., 2004; Wu et al., 2012). This disease can cause total destruction of all plant parts within a week or two when weather conditions are favourable (Agrios, 1997). And also could causes up to 100 % crop losses if not controlled (HCDA, 1996). Yield losses up to 79 % from late blight damage have been reported from India (Arora et al., 2014; Chowdappa et al., 2015). P. infestans has intensified its genetic variation in recent years, comprising isolates that are highly aggressive and highly virulent. Some isolates are resistant to phenylamides fungicide even (Goodwin et al., 1996). In order to subdue this trait, it is imperative to explore and find durable resistance. Several commercial tomato cultivars commonly grown in Nagaland are highly susceptible to late blight disease and show considerable yield losses under disease conducive conditions. The present investigation was carried out in Nagaland for the first time to determine the level of resistance in native tomato genotypes against late blight and its possible utilization in breeding programs to develop late blight disease resistant cultivars.

**Materials and Methods**

**Collection of tomato genotypes**

Ripened fruits of 20 native tomato genotypes were collected from different tomato growing areas of Nagaland, Manipur and Arunachal Pradesh. Known susceptible hybrid (Arka Rakshak, F₁) and susceptible variety (Pusa Ruby) seeds were also collected from IIHR, Bangalore and local market, Dimapur, respectively.

**Field experiment**

Field experiment was conducted during the tomato growing seasons (September-January) of 2017-18 and 2018-19 at the research farm of the Department of Plant Pathology, SASRD, Nagaland University, Medziphema Campus, Nagaland. The present experiment site is located in the foothills of Nagaland and situated at 25° 45´ 45” North latitude and 93° 51´ 45” East longitudes at an elevation of 310 m above mean sea level. The site is in a sub-humid tropical with high humidity and moderate temperature (12-32 °C), having moderate to high rainfall (2000-3000 mm) and R.H. of 70-80 %.

Two commercial susceptible cultivars of tomato, Pusa Ruby (semi-determinate type) and Arka Rakshak, F₁ (determinate type) were used in the experiment as control check.

Seeds of 22 genotypes were sown in the nursery beds (line sowing in spacing of row to row, 8 cm and seed to seed, 1 cm and depth, 1 cm) on the second week of September and transplanted into the field on the second week of October during both years.

The field experiment was laid out in a randomized block design (RBD) with three replications (Gomez and Gomez 1984). Each plot was 1.95 m x 2.0 m (raised plot) with three rows. Each row was spaced 65 cm apart. The distance from plot to plot was 50 cm and from plant to plant 50 cm. Four plants per row and 12 plants per plot were maintained. Common cultural practices were followed during the cropping period.

**Fruit yield**

The yield of ripened fruits harvested at different dates from all plants was computed and their average per plant was noted in gram.

**Disease severity**

The disease severity was assessed visually on stems, leaves and fruits of all plants of each
replication following scale 0-5 (Irzhansky and Cohen, 2006; table 1) when total late blight infestation had occurred in the control plot under natural epiphytotics conditions. The severity grades were converted into percentage disease index (PDI) for analysis (Wheeler, 1969).

\[ \text{PDI} = \left( \frac{\text{Sum of numerical rating}}{\text{No. of plant scored} \times \text{maximum score in scale}} \right) \times 100. \]

**Statistical analysis**

Analysis of variance (ANOVA) was performed using the WASP 2.0 (WebAgrilStatPackage) software. None of the data was transformed.

**Results and Discussion**

**Characterization of tomato genotypes**

Characterization of 22 tomato genotypes and their collection locations are mentioned in Table 2. Result revealed that most of the collected genotypes were indeterminate in nature except Pusa Ruby (semi-determinate), Arka Rakshak, F₁ hybrid (determinate) and T₂ (determinate).

Fruit shape of collected genotypes were oblong oval (Arka Rakshak F₁), flattish round (Pusa Ruby), small round cherry type (T₂, T₃, T₄, T₉, T₁₆, T₁₇, T₁₈, T₁₉ and T₂₀), round medium size (T₃), plum type (T₆, T₁₀, T₁₁ and T₁₄), pointed small grape type (T₇), small round (T₈, T₁₂, T₁₅), round (T₁₃) and Heirloom (T₂₁).

Various research workers collected and characterized different genotypes of tomato, genotypes with spherical, smooth fruit especially John Bear, Main Crop, Sunshine, Victory and Matchless (Bondartzeva, 1926), which were reported to possess resistance to late blight of tomato. Yimchunger et al., (2018) also recorded different shapes of cherry tomato from Nagaland. They reported that shape among the traits like round, oblong, heart shape was noticed in different genotypes. They also mentioned that variations in different shape of fruit are influenced by the genetic makeup of the genotype.

**Fruit yield**

The yield of ripened fruits harvested at different dates from all plants was computed and their average per plant was recorded in gram. The data concerning to yield of tomato genotypes is depicted in Table 3.

The data revealed that Arka Rakshak, F₁ hybrid recorded highest yield (3433.55 g plant⁻¹ and 105.65 t ha⁻¹) followed by T₅ (645.35 g plant⁻¹ and 19.85 t ha⁻¹) and T₂₁ (628.61 g plant⁻¹ and 19.34 t ha⁻¹). The lowest yield was recorded in T₁₉ with 268.15 g plant⁻¹ and 8.25 t ha⁻¹.

These results are in conformity with the findings of Swaroop and Suryanarayana (2005), Ahmed et al., (2007), Doreswamy et al., (2011), Dar and Sharma (2011) and Narolia et al., (2012). Bhati, (2017) also evaluated tomato genotypes for growth, yield and quality traits under foothills condition of Nagaland. It is evident from this study that there was significant difference in yield attributes among various genotypes.

It was revealed from this study that yield per hectare profoundly affected by the genotypes. Maximum yield was recorded in genotype of TODVAR-8 (46.62 t ha⁻¹) followed by TODVAR-1 (33.14 t ha⁻¹). The minimum yield was recorded by genotype H-86 (12.41 t ha⁻¹).
### Table 1: Rating scale (0-5) for the assessment of late blight disease severity in tomato

| Rating | PDI  | Description                                                                 | Reaction          |
|--------|------|------------------------------------------------------------------------------|-------------------|
| 0      | 0    | No visible symptoms apparent.                                                | Immune            |
| 1      | 0.01-10 | A few minute lesions to about 10% of the total leaf area is blighted and usually confined to the 2 bottom leaves. | Highly resistant  |
| 2      | 10.01-25 | Leaves on about 25% of the total plant area are infected.                    | Resistant         |
| 3      | 25.01-40 | Leaves on about 50% of the total plant area are infected.                    | Tolerant          |
| 4      | 41.01-60 | Leaves on about 75% of the total plant area are infected.                    | Susceptible       |
| 5      | > 60.01 | Leaves on whole plant are blighted and plant is dead.                        | Highly Susceptible|

### Table 2: Characterization of tomato genotypes and their collection location

| Genotypes Code | Type                          | Fruit type     | Growth habits | Collected from                                      | District    | State    |
|----------------|-------------------------------|----------------|---------------|-----------------------------------------------------|-------------|----------|
| T₀             | Arka Rakshak, F₁ hybrid       | Oblong oval    | Determinate   | IIHR                                                | Bangalore   | Karnataka|
| T₁             | Tomato cv. Pusa Ruby          | Flattish round | Semi-determinate | Local market                                     | Dimapur     | Nagaland |
| T₂             | Cherry tomato                 | Small round    | Determinate   | Horticulture farm, SASRD, Medziphema                | Dimapur     | Nagaland |
| T₃             | Cherry tomato                 | Small round    | Indeterminate | Near C.V. Raman Hostel, SASRD, Medziphema           | Dimapur     | Nagaland |
| T₄             | Cherry tomato                 | Small round    | Indeterminate | Daily vegetable market, Kohima town                 | Kohima      | Nagaland |
| T₅             | Tomato round medium size      |                | Indeterminate | Daily vegetable market, Risethsi                    | Kiphre      | Nagaland |
| T₆             | Tomato Plum type              |                | Indeterminate | Daily vegetable market, Merema                     | Kohima      | Nagaland |
| T₇             | Tomato Pointed small Grape type |                | Indeterminate | Daily vegetable market, Phekerkriema                | Kohima      | Nagaland |
| T₈             | Tomato Small round            |                | Indeterminate | Daily vegetable market, Merema                     | Kohima      | Nagaland |
| T₉             | Cherry tomato                 | Small round    | Indeterminate | Daily vegetable market, Tsiesema                    | Kohima      | Nagaland |
| T₁₀            | Tomato Plum type              |                | Indeterminate | Daily vegetable market, Wokha town                 | Wokha       | Nagaland |
|   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|
| T11 | Tomato | Plum type | Indeterminate | Daily vegetable market, Pfunsero | Phek | Nagaland |
| T12 | Tomato | Small round | Indeterminate | Daily vegetable market, Wokha town | Wokha | Nagaland |
| T13 | Tomato | Round | Indeterminate | Daily vegetable market, Pfunsero | Phek | Nagaland |
| T14 | Tomato | Plum type | Indeterminate | Daily vegetable market, Kohima town | Kohima | Nagaland |
| T15 | Tomato | Small round | Indeterminate | Daily vegetable market, Kohima town | Kohima | Nagaland |
| T16 | Cherry tomato | Small round | Indeterminate | Daily vegetable market, Kohima town | Kohima | Nagaland |
| T17 | Cherry tomato | Small round | Indeterminate | Daily vegetable market, D’ sector, Itanagar | Papum Pare | Arunachal Pradesh |
| T18 | Cherry tomato | Small round | Indeterminate | Daily vegetable market, Keishamthong | Imphal West | Manipur |
| T19 | Cherry tomato | Small round | Indeterminate | Daily vegetable market, Moa gate | Senapati | Manipur |
| T20 | Cherry tomato | Small round | Indeterminate | Daily vegetable market, Pisum Oinam Leikai | Imphal West | Manipur |
| T21 | Tomato | Heirloom | Indeterminate | Daily vegetable market, Risethsi | Kiphre | Nagaland |
**Table 3** Late blight disease severity, disease reaction and fruit yield of tomato genotypes under natural epiphytotics conditions

| Genotypes                      | Disease severity at 124 DAS (PDI) | Disease reaction | Fruit yield (g plant⁻¹) | Calculated Fruit yield (t ha⁻¹) |
|--------------------------------|----------------------------------|------------------|--------------------------|---------------------------------|
|                                | 2017-18  | 2018-19  | Pooled | 2017-18  | 2018-19  | Pooled | 2017-18  | 2018-19  | Pooled |
| T₀ Arka Rakshak F₁ (Control)   | 92.22    | 87.22    | 89.72   | HS       | 3450.44  | 3416.67  | 3433.55  | 106.17   | 105.13  | 105.65  |
| T₁ Pusa Ruby (Control)         | 84.44    | 90.00    | 87.22   | HS       | 275.56   | 271.33   | 273.44   | 08.48    | 08.35   | 08.41   |
| T₂                             | 88.88    | 78.89    | 83.88   | HS       | 327.50   | 276.67   | 302.08   | 10.08    | 08.51   | 09.29   |
| T₃                             | 22.65    | 10.98    | 16.81   | R        | 329.50   | 256.00   | 292.75   | 10.14    | 07.88   | 09.01   |
| T₄                             | 47.01    | 79.18    | 63.09   | HS       | 286.67   | 311.67   | 299.17   | 08.82    | 09.59   | 09.20   |
| T₅                             | 53.87    | 83.94    | 68.90   | HS       | 634.03   | 656.67   | 645.35   | 19.51    | 20.20   | 19.85   |
| T₆                             | 55.44    | 87.96    | 71.70   | HS       | 418.73   | 393.33   | 406.03   | 12.88    | 12.10   | 12.49   |
| T₇                             | 62.75    | 86.48    | 74.61   | HS       | 504.63   | 423.33   | 463.98   | 15.53    | 13.02   | 14.27   |
| T₈                             | 58.63    | 68.00    | 63.31   | HS       | 541.41   | 446.67   | 494.04   | 16.66    | 13.74   | 15.20   |
| T₉                             | 50.73    | 78.57    | 64.65   | HS       | 371.69   | 343.33   | 357.51   | 11.44    | 10.56   | 11.00   |
| T₁₀                            | 67.97    | 79.76    | 73.86   | HS       | 514.78   | 463.33   | 489.05   | 15.84    | 14.26   | 15.05   |
| T₁₁                            | 73.96    | 81.11    | 77.53   | HS       | 340.75   | 355.33   | 348.04   | 10.48    | 10.93   | 10.70   |
| T₁₂                            | 76.39    | 86.46    | 81.42   | HS       | 462.86   | 408.67   | 435.76   | 14.24    | 12.57   | 13.40   |
| T₁₃                            | 67.39    | 80.22    | 73.80   | HS       | 339.41   | 285.67   | 312.54   | 10.44    | 08.79   | 09.61   |
| T₁₄                            | 60.00    | 87.53    | 73.76   | HS       | 300.67   | 291.33   | 296.00   | 09.25    | 08.96   | 09.10   |
| T₁₅                            | 66.07    | 76.94    | 71.50   | HS       | 331.81   | 306.67   | 319.24   | 10.21    | 09.43   | 09.82   |
| T₁₆                            | 53.52    | 79.35    | 66.43   | HS       | 334.61   | 266.67   | 300.64   | 10.29    | 08.20   | 09.24   |
| T₁₇                            | 38.33    | 33.65    | 35.99   | T        | 238.85   | 325.33   | 282.09   | 07.35    | 10.01   | 08.68   |
| T₁₈                            | 59.61    | 78.34    | 68.97   | HS       | 254.82   | 293.33   | 274.07   | 07.84    | 09.02   | 08.43   |
| T₁₉                            | 53.70    | 78.70    | 66.20   | HS       | 282.97   | 253.33   | 268.15   | 08.71    | 07.79   | 08.25   |
| T₂₀                            | 51.59    | 81.11    | 66.35   | HS       | 284.02   | 283.33   | 283.67   | 08.74    | 08.72   | 08.73   |
| T₂₁                            | 71.67    | 81.20    | 76.43   | HS       | 693.89   | 563.33   | 628.61   | 21.35    | 17.33   | 19.34   |
| SEM±                           | 4.06     | 3.30     | 2.52    | -        | 57.25    | 38.44    | 36.03    | 1.76     | 1.19    | 1.11    |
| C.V. (%)                        | 11.41    | 7.50     | 6.33    | -        | 18.49    | 13.05    | 12.25    | 18.94    | 13.35   | 12.26   |
| CD (P=0.05)                     | 11.59    | 9.42     | 7.19    | -        | 163.40   | 109.70   | 102.83   | 5.03     | 3.41    | 3.17    |

HR = Highly resistant, R = Resistant, T = Tolerant, S = Susceptible and HS = Highly susceptible.
Fig.1 Late blight disease reaction of tomato genotypes, $T_0$ (Arka Rakshak F$_1$, highly susceptible) and $T_3$ (Cherry tomato, resistance)

Fig.2 Late blight disease severity (Pooled PDI) of tomato genotypes under natural epiphytotics conditions

**Disease severity**

In all, 22 genotypes were screened against the late blight disease under natural epiphytotic conditions in field and disease reaction was recorded at 124 DAS and presented in table 3. The data of disease severity revealed that least PDI was recorded in $T_3$ (16.81) and $T_{17}$ (35.99) whereas highest PDI was recorded in Arka Rakshak, F$_1$ control with 89.72 (Fig. 2).
This experimental result revealed that most of the genotypes (20 genotypes) reacted as highly susceptible, while $T_3$ (16.81 PDI) and $T_{17}$ (35.99 PDI) was found resistant and tolerant respectively under natural epiphytotics conditions. These results clearly indicate that a good source of resistance to late blight is available in the genotype $T_3$ (Fig. 1). The resistant genotype thus obtained through this experiment shows a potential disease resistance trait contributor for tomato breeding against late blight disease.

This is in line with the findings of Islam et al., (2001) who evaluated 15 advanced lines of tomato against late blight under natural epiphytotics conditions. The highest late blight severity was found in V-215 and V-52 and the lowest in V-378. Two lines were found resistant (V-259 and V-426), two moderately resistant (V-385 and V-187), two tolerant (V-422 and V-282), four moderately susceptible (V-378, V-138, V-258 and BARI-10), three were susceptible (V-330, V-201 and Manik) and two highly susceptible (V-52 and V-215), but none were found highly resistant. Khalid et al., (2012) also evaluated 82 tomato genotypes against late blight using whole plant assays. None of the test genotypes were immune or highly resistant. The overall screening results indicate that TMS-2 is a good source of resistance and it can be useful for the development of tomato hybrid cultivars resistant to late blight.

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