Insect and Diseases Resistance in Tomato Entries

A. K. M. Quamruzzaman, Ferdouse Islam, Sharmilla Rani Mallick

Olericulture Division, Horticulture Research Center, Bangladesh Agricultural Research Institute, Gazipur, Bangladesh
Email: akmqz@gmail.com

Abstract
The study was conducted with 75 tomato entries at the farm of Olericulture Division, Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI), Gazipur, Bangladesh during the winter season of 2020-21 to evaluate insect and disease reaction. Among the various insect and diseases of tomatoes, the late blight, TYLCV, bacterial wilt infection and leaf miner, fruit borer infestation are most common in Bangladesh. The TYLCV infection was observed 0% to 27% infection, while 47 entries showed zero percent infection. The range of bacterial wilt infection was 0% to 10% and zero percent infection was observed in 62 entries. In case of leaf miner infestation and fruit borer infestation, the range was 0% to 43% and 0% to 10%, respectively. Considering tolerance to late blight, TYLCV, bacterial wilt infection and leaf miner, fruit borer infestation, fruit size, fruit shape, plant growth nature, cluster nature of fruit, type of fruit ten entries AVTO 1010, AVTO 1706, AVTO 1713, AVTO 1829, AVTO 1909, AVTO 1911, AVTO 1915, AVTO 1921, AVTO 1954 and SLA 011 were found zero percent late blight, TYLCV, bacterial wilt infection and leaf miner, fruit borer infestation. So, these ten entries can be selected for disease and insect tolerant tomato varieties development as well as developing disease and insect tolerant hybrid tomato varieties.

Keywords
Insect, Diseases, Late Blight, TYLCV, Bacterial Wilt, Leaf Miner, Fruit Borer, Infestation, Resistance, Tomato

1. Introduction
Tomato (Solanum lycopersicum) is one of the most important vegetables of Bangladesh and the world too. The tomato is an important source of antioxi-
The essential phytonutrients found in the tomato fruit are lycopene, β-carotene, α-tocopherol, polyphenols and ascorbic acid, and antioxidant activity depends on cultivar, environmental parameters, method of production and processing. The regular ingestion of an adequate amount of fresh tomatoes or processed tomato products has been inversely correlated with the development of widespread human diseases [1] [2] [3] and with an increase in plasma lipid peroxidation levels [4] [5]. This protective effect has been mainly attributed to the carotenoid constituents of the fruits, particularly lycopene and β-carotene which act as antioxidants in detoxifying free radicals [2] [6] [7] [8]. [9] reported that both fresh and processing tomatoes constitute significant amounts within produced vegetable crops.

Among the various insect and diseases of tomatoes, the late blight, TYLCV (Tomato yellow leaf curl virus), bacterial wilt infection and leaf miner, fruit borer infestation are most common in Bangladesh. The polyphagous nature of different insects, and development of insecticide resistance, provide challenges to effective management. Resistance in tomato is important for management of fruit borer. The highest levels of arthropod resistance are widely reported in wild varieties such as L. hirsutum Dunal. [10]. Attempts have been made to identify sources of resistance in L. esculentum [11] [12]. Breeding tomatoes for insect resistance is generally limited to identification of sources and mechanisms of resistance. Emphasis should be placed on development of commercial insect and disease resistant cultivars with desirable yield and market attributes [13].

Heavy use of insecticides to control these pests has resulted in the development of resistance in some pest populations [14], enhancement of the destructiveness of the leaf miner due to loss of its natural enemies [15], and may also pose environmental problems. Morphological and physical characteristics of plants are associated with attraction, feeding, and oviposition of insect pests [16]. Thus, plant phenology may influence pest populations because of factors such as maturation date, which vary according to plant cultivar. In addition, pest population development is favored by high temperatures and plant cultivars that vary in their development time may experience differing levels of pest pressure [17]. Under field conditions, temperature and relative humidity have been shown to affect populations of tomato pests such as aphids (Aphidoidea) and whiteflies (Aleyrodidae) [18].

Therefore, development and deployment of cultivars with resistance to the important insect pests of tomato are needed. However, Bangladesh Agricultural Research Institute (BARI) has released varieties that are higher yielder, but some varieties are prone to several pests and diseases. Beside this growers’ demand is good quality hybrid varieties having tolerance to different major insects and diseases. In this context, BARI needs to be developed tomato varieties possess traits of virus and wilt resistance. In 2020, The World Vegetable Centre has supplied 43 tomato advanced entries to BARI. This study was undertaken to screen tomato germplasm from AFACI supplied germplasm, advanced varieties, cultivars, and native entries for resistance against late blight, TYLCV, bacterial wilt infec-
tion and leaf miner, fruit borer infestation and for other morphological attributes in order to develop insect, diseases resistant cultivars.

2. Materials and Methods

2.1. Experimental Site

The experiment was conducted at the Olericulture Division of Horticulture Research Centre, Bangladesh Agricultural Research Institute (BARI) during 2020-21. The experimental field was at 23.9920°N Latitude and 90.4125°E Longitudes having an elevation of 8.2 m from sea level under agro-ecological zone (AEZ) 28. The average minimum and maximum temperature were 18.0°C and 29.0°C and the average relative humidity was 58.2%. The soil of the experimental field was sandy clay loam in texture having a pH range around 6.0.

Air temperatures and relative humidity of the experimental area

Average monthly minimum air temperatures, maximum air temperatures and average relative humidity during the season are shown in Table 1.

2.2. Plant Materials

Seventy-five tomato entries (WorldVeg Center: 41 nos., BARI varieties: 10 nos., local germplasm 17 nos., exotic germplasm 7 nos.) were included in the study (Table 2). The seeds were sown on the seedbed on 01 October 2020. Thirty-two days old seedlings were transplanted in the main field on 01 November, 2020.

2.3. Experimental Design and Layout

The experiment was laid out in an RCB design with three replications. The plot size was 5.0 × 1.0 m where 20 plants were planted with space of 60 × 50 cm in two rows.

2.4. Land Fertilization

The experimental area was enriched with organic fertilizer, Nitrogen, Phosphorus, Potassium, Sulphur, Zinc and Boron @ 3000, 250, 90, 125, 20, 3 and 2 kg/ha, correspondingly. One third of the organic fertilizer, 50% of Phosphorus and full of Sulphur, Zinc and Boron were incorporated for the period of last land-dwelling.

Table 1. Average monthly minimum temperature (°C), maximum temperature (°C) and relative humidity (%) recorded during winter season.

| Parameter                      | Oct 2020 | Nov 2020 | Dec 2020 | Jan 2021 | Feb 2021 | Mar 2021 | Mean  |
|--------------------------------|----------|----------|----------|----------|----------|----------|-------|
| Monthly minimum air temperature (°C) | 24       | 19       | 14       | 16       | 15       | 20       | 18.0  |
| Monthly maximum air temperature (°C) | 31       | 29       | 26       | 28       | 28       | 32       | 29.0  |
| Monthly mean relative humidity (%) | 72       | 66       | 63       | 54       | 49       | 45       | 58.2  |
preparation. Rest of organic fertilizer and Phosphorus and 1/3 of Potassium were applied as basal in pit. Entire quantity of Nitrogen and rest of Potassium were applied in four equal portions beginning from 20 days after transplanting. Rest three portions were fertilized at 20, 40 and 60 days after transplanting.

2.5. Data Recorded

Data on yield and yield attributing parameters with qualitative traits were recorded from 20 inner plants of each plot escaping border plants following World Veg guideline. Tomato fruits were started harvesting at breaker stage from 20 inner plant of each treatment. Four to six harvesting was done according to the different germplasm characters and data on late blight infection (%), TYLCV infection (%), bacterial wilt infection (%), leaf miner infestation (%), fruit borer infestation (%), fruit size, fruit shape, plant growth nature, cluster nature of fruit, type of fruit.

3. Results and Discussion

The tomato entries differed significantly in all parameters studied and the results have been shown in Table 3 and Table 4. In respect of pest and disease reaction,
Table 3. Late blight, TYLCV, bacterial wilt infection and leaf miner, fruit borer infestation of 75 tomato entries.

| Entries  | Late blight infection (%) | TYLCV infection (%) | Bacterial wilt infection (%) | Leaf miner infestation (%) | Fruit borer infestation (%) |
|----------|---------------------------|---------------------|------------------------------|----------------------------|-----------------------------|
| AVTO 0301| 50                        | 13                  | 10                           | 17                         | 10                          |
| AVTO 1003| 0                         | 10                  | 0                            | 0                          | 3                           |
| AVTO 1008| 0                         | 10                  | 0                            | 0                          | 7                           |
| AVTO 1010| 0                         | 0                   | 0                            | 0                          | 0                           |
| AVTO 1219| 27                        | 27                  | 7                            | 20                         | 7                           |
| AVTO 1288| 0                         | 23                  | 0                            | 0                          | 0                           |
| AVTO 1306| 47                        | 23                  | 0                            | 27                         | 0                           |
| AVTO 1314| 27                        | 0                   | 0                            | 40                         | 0                           |
| AVTO 1315| 53                        | 0                   | 0                            | 20                         | 0                           |
| AVTO 1409| 50                        | 0                   | 0                            | 23                         | 0                           |
| AVTO 1424| 37                        | 0                   | 0                            | 43                         | 0                           |
| AVTO 1429| 0                         | 17                  | 0                            | 0                          | 0                           |
| AVTO 1464| 43                        | 20                  | 7                            | 37                         | 7                           |
| AVTO 1616| 37                        | 0                   | 0                            | 27                         | 0                           |
| AVTO 1619| 0                         | 0                   | 0                            | 0                          | 7                           |
| AVTO 1702| 27                        | 20                  | 0                            | 23                         | 7                           |
| AVTO 1705| 23                        | 0                   | 0                            | 23                         | 0                           |
| AVTO 1706| 0                         | 0                   | 0                            | 0                          | 0                           |
| AVTO 1707| 50                        | 20                  | 0                            | 40                         | 7                           |
| AVTO 1711| 0                         | 0                   | 0                            | 0                          | 3                           |
| AVTO 1712| 40                        | 0                   | 0                            | 7                          | 7                           |
| AVTO 1713| 0                         | 0                   | 0                            | 0                          | 0                           |
| AVTO 1715| 50                        | 0                   | 0                            | 23                         | 0                           |
| AVTO 1716| 43                        | 23                  | 10                           | 30                         | 0                           |
| AVTO 1717| 43                        | 0                   | 0                            | 7                          | 7                           |
| AVTO 1718| 53                        | 0                   | 0                            | 23                         | 7                           |
| AVTO 1719| 53                        | 0                   | 0                            | 40                         | 0                           |
| AVTO 1720| 47                        | 10                  | 0                            | 37                         | 7                           |
| AVTO 1828| 0                         | 17                  | 0                            | 0                          | 0                           |
| AVTO 1829| 0                         | 0                   | 0                            | 0                          | 0                           |
| AVTO 1903| 0                         | 0                   | 0                            | 0                          | 7                           |
| Code     | SLA 004 | SLA 005 | SLA 006 | SLA 007 | SLA 008 | SLA 009 | SLA 010 | SLA 011 | SLA 012 | SLA 013 | SLA 014 | SLA 015-1 | SLA 015-2 | SLA 015-3 | SLA 018 | SLA 025-1 | SLA 025-2 | SLA 025-3 | SLA 025-4 | SLA 025-5 | SLA 025-6 | SLA 025-7 | FOBHT8 | MOBHT8 |
|----------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|-----------|-----------|-----------|---------|-----------|-----------|-----------|-----------|-----------|-----------|---------|--------|
|          | 47      | 20      | 0       | 23      | 7       | 47      | 20      | 0       | 23      | 7       | 50       | 0         | 0         | 50       | 0       | 20       | 0         | 0         | 23       | 0       | 20       | 0         | 7        |
|          | 33      | 20      | 0       | 23      | 7       | 33      | 20      | 0       | 23      | 7       | 50       | 0         | 0         | 50       | 0       | 20       | 0         | 0         | 23       | 0       | 20       | 0         | 7        |
|          | 50      | 0       | 0       | 23      | 3       | 50      | 0       | 0       | 23      | 3       | 43       | 0         | 0         | 43       | 0       | 20       | 0         | 0         | 23       | 0       | 20       | 0         | 7        |
|          | 47      | 20      | 10      | 20      | 7       | 47      | 20      | 10      | 20      | 7       | 23       | 0         | 0         | 23       | 0       | 13       | 0         | 0         | 23       | 0       | 13       | 0         | 7        |
|          | 23      | 3       | 0       | 23      | 0       | 23      | 3       | 0       | 23      | 0       | 23      | 7         | 7         | 23       | 7       | 7        | 7         | 7         | 23       | 7       | 7        | 7         | 7        |
|          | 23      | 7       | 7       | 17      | 0       | 23      | 7       | 7       | 17      | 0       | 40       | 7         | 0         | 23       | 7       | 40       | 7         | 0         | 23       | 7       | 40       | 7         | 0        |
|          | 23      | 0       | 0       | 23      | 0       | 23      | 0       | 0       | 23      | 0       | 23      | 7         | 7         | 0        | 23      | 7       | 23       | 7         | 0        | 23      | 7       | 23       | 7         | 7        |
|          | 23      | 0       | 0       | 27      | 0       | 23      | 0       | 0       | 27      | 0       | 23      | 3         | 0         | 23      | 3       | 23       | 3         | 0         | 23      | 3       | 23       | 3         | 0        |
|          | 0       | 0       | 0       | 20      | 10      | 0       | 0       | 0       | 20      | 10      | 0       | 0         | 0         | 0        | 0       | 0        | 0         | 0         | 0        | 0       | 0        | 0         | 0        |
|          | 0       | 0       | 0       | 7       | 0       | 0       | 0       | 0       | 7       | 0       | 0       | 0         | 0         | 0        | 0       | 0        | 0         | 0         | 0        | 0       | 0        | 0         | 0        |
|          | 0       | 0       | 0       | 37      | 0       | 0       | 0       | 0       | 37      | 0       | 0       | 0         | 0         | 0        | 0       | 0        | 0         | 0         | 0        | 0       | 0        | 0         | 0        |
|          | 0       | 0       | 0       | 7       | 0       | 0       | 0       | 0       | 7       | 0       | 0       | 0         | 0         | 0        | 0       | 0        | 0         | 0         | 0        | 0       | 0        | 0         | 0        |
|          | 0       | 0       | 0       | 37      | 0       | 0       | 0       | 0       | 37      | 0       | 0       | 0         | 0         | 0        | 0       | 0        | 0         | 0         | 0        | 0       | 0        | 0         | 0        |
|          | 0       | 0       | 0       | 20      | 10      | 0       | 0       | 0       | 20      | 10      | 0       | 0         | 0         | 0        | 0       | 0        | 0         | 0         | 0        | 0       | 0        | 0         | 0        |
|          | 0       | 0       | 0       | 7       | 10      | 0       | 0       | 0       | 7       | 10      | 0       | 0         | 0         | 0        | 0       | 0        | 0         | 0         | 0        | 0       | 0        | 0         | 0        |
| Entries       | Fruit size | Fruit shape | Plant growth nature | Cluster nature of fruit | Type of fruit       |
|---------------|------------|-------------|---------------------|------------------------|--------------------|
| BARI Tomato-2 | 23         | 0           | 0                   | 23                     | 0                  |
| BARI Tomato-11| 0          | 0           | 0                   | 7                      | 0                  |
| BARI Tomato-14| 23         | 20          | 0                   | 7                      | 7                  |
| BARI Tomato-15| 23         | 7           | 0                   | 20                     | 7                  |
| BARI Tomato-16| 0          | 0           | 0                   | 20                     | 0                  |
| BARI Tomato-17| 37         | 0           | 0                   | 23                     | 7                  |
| BARI Tomato-18| 0          | 0           | 0                   | 20                     | 0                  |
| BARI Tomato-19| 0          | 0           | 0                   | 0                      | 7                  |
| BARI Tomato-20| 20         | 3           | 0                   | 0                      | 0                  |
| BARI Tomato 21| 0          | 0           | 0                   | 20                     | 0                  |
| **Range**     | **0 - 53** | **0 - 27**  | **0 - 10**          | **0 - 43**             | **0 - 10**         |
| **Mean**      | **20.0**   | **5.6**     | **1.3**             | **15.2**               | **2.8**            |

**Table 4.** Fruit size, fruit shape, plant growth nature, cluster nature of fruit, type of fruit characters of 75 tomato entries.
| Code     | Type          | Shape        | Category     | Cluster | Purpose                  |
|----------|---------------|--------------|--------------|---------|--------------------------|
| AVTO 1707| Medium        | Oval         | Determinate  | Cluster | Table purpose            |
| AVTO 1711| Big           | Flat round   | Determinate  | Cluster | Table purpose            |
| AVTO 1712| Medium        | Flat round   | Determinate  | Cluster | Table purpose            |
| AVTO 1713| Big           | Flat round   | Determinate  | Cluster | Table purpose            |
| AVTO 1715| Big           | Flat round   | Determinate  | Cluster | Table purpose            |
| AVTO 1716| Medium        | Flat round   | Determinate  | Cluster | Table purpose            |
| AVTO 1717| Big           | Flat round   | Determinate  | Cluster | Table purpose            |
| AVTO 1718| Big           | Flat round   | Determinate  | Cluster | Table purpose            |
| AVTO 1719| Medium        | Round        | Determinate  | Cluster | Table purpose            |
| AVTO 1720| Big           | Flat round   | Determinate  | Cluster | Table purpose            |
| AVTO 1828| Medium        | Round        | Indeterminate| Cluster | Cherry type              |
| AVTO 1829| Medium        | Oval         | Indeterminate| Cluster | (long) Cherry type       |
| AVTO 1903| Medium        | Round        | Determinate  | Cluster | Table purpose            |
| AVTO 1907| Medium        | Oval         | Determinate  | Cluster | (long) Table purpose     |
| AVTO 1909| Medium        | Oval         | Semi Determinate | Cluster | Table purpose            |
| AVTO 1910| Medium        | Round        | Semi Determinate | Cluster | Table purpose            |
| AVTO 1911| Medium        | Round        | Determinate  | Cluster | Table purpose            |
| AVTO 1913| Medium        | Oval         | Determinate  | Cluster | Table purpose            |
| AVTO 1914| Medium        | Oval         | Determinate  | Cluster | Table purpose            |
| AVTO 1915| Medium        | Oval         | Semi Determinate | Cluster | Table purpose            |
| AVTO 1919| Medium        | Round        | Determinate  | Cluster | Table purpose            |
| AVTO 1921| Medium        | Round        | Determinate  | Cluster | Table purpose            |
| AVTO 1954| Medium        | Round        | Determinate  | Cluster | Table purpose            |
| SLA 004 | Small         | Round        | Determinate  | Cluster | Cherry type              |
| SLA 005 | Small         | Round        | Indeterminate| Cluster | Cherry type              |
| SLA 006 | Small         | Round        | Indeterminate| Cluster | Cherry type              |
| SLA 007 | Medium        | Flat round   | Determinate  | Cluster | Table purpose            |
| SLA 008 | Small         | Round        | Indeterminate| Cluster | (long) Cherry type       |
| SLA 009 | Medium        | Round        | Determinate  | Cluster | Table purpose            |
| SLA 010 | Big           | Flat round   | Semi Determinate | Cluster | Table purpose            |
| SLA 011 | Small         | Round        | Indeterminate| Cluster | Cherry type              |
| SLA 012 | Small         | Round        | Indeterminate| Cluster | (long) Cherry type       |
Continued

| SLA entry | Size | Shape | Determination | Cluster Type | Table Purpose |
|-----------|------|-------|---------------|--------------|--------------|
| SLA 013   | Small Round Indeterminate Cluster (long) | Cherry type |
| SLA 014   | Medium Round Determinate Cluster | Table purpose |
| SLA 015-1 | Small Round Indeterminate Cluster (long) | Cherry type |
| SLA 015-2 | Small Round Indeterminate Cluster (long) | Cherry type |
| SLA 015-3 | Small Round Indeterminate Cluster (long) | Cherry type |
| SLA 018   | Medium Round Semi Determinate Cluster | Table purpose |
| SLA 025-1 | Medium Round Semi Determinate Cluster | Table purpose |
| SLA 025-2 | Medium Round Semi Determinate Cluster | Table purpose |
| SLA 025-3 | Medium Round Semi Determinate Cluster | Table purpose |
| SLA 025-4 | Medium Round Semi Determinate Cluster | Table purpose |
| SLA 025-5 | Medium Round Semi Determinate Cluster | Table purpose |
| SLA 025-6 | Medium Round Semi Determinate Cluster | Table purpose |
| SLA 025-7 | Medium Round Semi Determinate Cluster | Table purpose |
| FOBHT8    | Medium Round Determinate Cluster | Table purpose |
| MOBHT8    | Medium Round Determinate Cluster | Table purpose |
| BARI Tomato-2 | Medium Round Determinate Cluster | Table purpose |
| BARI Tomato-11 | Small Oval Indeterminate Cluster | Cherry type |
| BARI Tomato-14 | Medium Round Determinate Cluster | Table purpose |
| BARI Tomato-15 | Medium Oval Determinate Cluster | Table purpose |
| BARI Tomato-16 | Medium Round Determinate Cluster | Table purpose |
| BARI Tomato-17 | Big Flat round Determinate Cluster | Table purpose |
| BARI Tomato-18 | Medium Round Determinate Cluster | Table purpose |
| BARI Tomato-19 | Medium Oval Determinate Cluster | Processing type |
| BARI Tomato-20 | Medium Round Indeterminate Cluster | Cherry type |
| BARI Tomato 21 | Medium Oval Semi Determinate Cluster | Table purpose |

It was revealed that all the entries showed different levels of resistance or susceptibility against late blight infection (%), TYLCV infection (%), bacterial wilt infection (%), leaf miner infestation (%), fruit borer infestation (%) (Table 3).

In case of late blight infection, the range of infection was 0% to 53% at later stage of growing condition. The zero percent infection was observed in 34 entries, while 50% - 53% infection was observed in 10 entries. The TYLCV infection was an important disease for the tomato cultivation and it was observed 0% to 27% infection, while 47 entries showed 0% and 11 entries showed 20% - 27% infection. Bacterial wilt infection was very negligible among the entries in
the study, where the range was 0% to 10% and zero percent infection was observed in 63 entries. Since the season was winter season, that is why the bacterial wilt infection was low.

In case of leaf miner, 0% to 43% infestation was observed among the entries. Zero percent infestation was observed in 26 entries, while more than 25% infestation was observed on 16 entries. The most devastating insect was fruit borer in this study, while the infestation range was 0% to 10%. The zero percent infestation was observed in 43 entries, while 10% infestation was observed in 3 entries.

In terms of fruit size, fruit shape, plant growth nature, cluster nature of fruit, type of fruit characters of the tomato entries, there was a wide variation was observed (Table 4). Three sizes of fruits were observed viz., big (8 entries), medium (55 entries) and small (12 entries), while round type was observed in 47 entries, oval was in 16 entries and flat round was in 12 entries. Three types of plant were observed viz., determinate (46 entries), semi-determinate (14 entries), indeterminate (15 entries). Though all the fruits were beard cluster orientation but medium cluster was in 67 entries, while long type cluster was in 8 entries. Maximum tomato fruits were table purpose (58 entries), while cherry type was produced in 16 entries and one was processing type.

4. Conclusion

The TYLCV infection was observed 0% to 27% infection, while 47 entries showed zero percent infection. The range of bacterial wilt infection was 0% to 10% and zero percent infection was observed in 62 entries. In case of leaf miner infestation and fruit borer infestation the range was 0% to 43% and 0% to 10%, respectively. Considering tolerance to late blight, TYLCV, bacterial wilt infection and leaf miner, fruit borer infestation, fruit size, fruit shape, plant growth nature, cluster nature of fruit, type of fruit ten entries AVTO 1010, AVTO 1706, AVTO 1713, AVTO 1829, AVTO 1909, AVTO 1911, AVTO 1915, AVTO 1921, AVTO 1954 and SLA 011 were found zero percent late blight, TYLCV, bacterial wilt infection and leaf miner, fruit borer infestation. So, these ten entries can be selected for disease and insect tolerant tomato varieties development as well as developing disease and insect tolerant hybrid tomato varieties.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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