Original Research Article

Survey for Tomato Leaf Curl Virus Disease Incidence and Severity in Different Tomato Growing Areas of Northern Karnataka, India

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A B S T R A C T

Tomato (Solanum lycopersicum L.) is one of the most widely grown vegetable crops in India. The Begomoviruses affecting tomato in India is the most devastating and is a major limiting factor in the tomato production. Tomato leaf curl virus (ToLCV) was present in almost all fields of surveyed area in northern Karnataka. Tomato leaf curl disease (ToLCD) incidence and severity during rabi 2015-2016 ranging from 5.0 to 86.6 per cent and 2.0 to 45.2 per cent respectively. The highest ToLCD incidence recorded in Haveri district (86.6 %) and severity recorded in Yadgir (45.2 %). The least ToLCD incidence (5.0%) and severity (2.0%). recorded in Dharwad district.

Keywords

Tomato (Solanum lycopersicum L.), crop

Introduction

Tomato (Solanum lycopersicum L.) is one of the most widely grown vegetable crops and is popular due to its high nutritive value, taste and versatile use.

It is a good source of vitamins (A and C) and minerals. In India, estimated area, production and productivity during 2015-16 is about 7.73 lakh hectare, 187.32lakh tonnes, 24.2 tonnes/ha, respectively.

In Karnataka it occupies an area of 0.60 lakh ha with production of 20.46lakh tonnes and productivity of 34.1 tonnes/ha (Anon, 2017).

Tomato is affected by several viral diseases. Of all the diseases reported in tomato, the tomato leaf curl virus disease is reported to be the most devastating both in terms of quantitative and qualitative yield losses. Often, the loss reaches to the extent of 100 per cent during summer throughout India (Mishra et al., 2014). Tomato leaf curl disease (ToLCD) was first reported in northern India by Vasudeva and Sam Raj (1948) and subsequently from central India (Varma, 1959) and southern India (Govindu, 1964; Sastry and Singh, 1973). Symptoms of ToLCD include leaf curling, vein clearing and stunting, which can often lead to sterility (Saikia and Muniyappa, 1989).
**Tomato leaf curl virus** causes, interveinal yellowing, vein clearing, and puckering of the leaves accompanied sometimes by rolling of the leaf margins. The older leaves become leathery and brittle. The disease induces severe stunting, bushy growth, and partial or complete sterility depending on the stage at which infection has taken place. Infected plants bear few or no fruit. The pathogen was shown to be transmitted by whiteflies but not by sap inoculation (Vasudeva and Samraj, 1948; Nariani and Vasudeva, 1963; Verma et al., 1975; Muniyappa et al., 1991).

**Tomato leaf curl virus** (ToLCV) is the name given to a group of whitefly transmitted geminivirus (family Geminiviridae, genus Begomovirus) causing leaf curl disease of tomato in many regions of India. ToLCV isolates those from northern India have two components (DNA-A and DNA-B). The ToLCV isolates from southern India (Bangalore) have a DNA-A-like monopartite genome (Muniyappa, et al., 2000). Begomoviruses are characterized by having small circular single stranded DNA genome that replicates via double stranded replication intermediates by using rolling circle (RC) mechanism (Saunders et al., 1991).

**Materials and Methods**

The roving survey was conducted during **rabi/summer 2015-2016** season to know per cent disease incidence and severity of tomato leaf curl virus disease in tomato growing areas in northern Karnataka i.e., Dharwad, Haveri, Belagavi, Bagalkot, Koppal, Raichur, Kalburgi, Yadgiri and Bidar districts. In each field, five spots were selected and counting the total number of plants present in the particular area and counting the number of diseased plants showing the characteristic symptoms of Tomato leaf curl disease. The percentage of disease incidence was assessed by using the formula mentioned below.

$$\text{Per cent disease incidence} = \frac{\text{Number of diseased plants}}{\text{Total number of plants examined}} \times 100$$

Tomato leaf curl disease severity was calculated by using the following formula (Wheeler, 1969).

$$\text{Percent Disease Index} = \frac{\text{Sum of all individual disease ratings}}{\text{Total No. of plants observed} \times \text{Maximum disease grade}} \times 100$$

**Results and Discussion**

A roving survey was carried out during the **rabi 2015-2016** to know the per cent disease incidence and severity of tomato leaf curl disease (ToLCD) in different tomato growing areas of northern Karnataka viz., Dharwad, Haveri, Belagavi, Bagalkot, Koppal, Raichur, Kalburgi, Yadgiri and Bidar districts. The symptoms observed during survey were yellowing, puckering of leaf, severe upward curling of leaves, reduction in leaf size, internodal length stunting and bushy appearance due to reduced internodal length with partial to complete sterility, purple pigment on the curled leaf margin. The early infected plants did not produce any fruits or bear few fruits/ small fruits (Fig. 1).

In Bagalkot district the highest incidence (39.1 %) and severity (15.6 %) of ToLCD recorded in Cholachagudda. Least incidence (12.9 %) and severity (5.0 %) recorded in Muttalgeri and Kaladgi respectively. In Belagavi district the highest incidence (64.1 %) and severity (22.2 %) of ToLCD recorded in Belavadi. Least incidence (10.0 %) and severity (4.4 %) recorded in Hirebagewadi. In Bidar district the highest incidence (66.5 %) and severity (38.6 %)
% of ToLCD recorded in Narayanpoor. Least incidence (11.1 %) and severity (4.8 %) recorded in Bagdal and Hulsoor respectively. In Dharwad district the highest incidence (81.7 %) and severity (33.3 %) of ToLCD recorded in Hebballi. Least incidence (5.0 %) and severity (2.0 %) recorded in Somapura. In Haveri district the highest incidence (86.6 %) and severity (44.1 %) of ToLCD was recorded in Byadgi. Least incidence (10.0 %) and severity (3.85 %) recorded in Hanumanamatti and Motebennur respectively. In Kalburgi district the highest incidence (83.3 %) and severity (41.6 %) of ToLCD recorded in Alurand Kukanoor respectively.

Least Incidence (5.0 %) and severity (2.8 %) recorded in Savalagi. In Koppal district the highest incidence (64.6 %) and severity (32.6 %) of ToLCD recorded in Budugumpa. Least incidence (15.0 %) and severity (4.8 %) recorded in Kushtagi. In Raichur district the highest incidence (67.0 %) and severity (40.3 %) of ToLCD recorded in Chandrabanda. Least incidence (10.0 %) and severity (3.8 %) recorded in Neermanvi. In Yadgir district the highest incidence (84.6 %) and severity (45.2 %) of ToLCD recorded in Mustur. Least incidence (17.6 %) and severity (5.0 %) recorded in Shorapur and Shahpur respectively (Table 1).

In the surveyed areas the incidence and severity of tomato leaf curl disease on tomato ranged from 5.0 to 86.6 per cent and 2.0 to 45.2 per cent respectively. Among the districts surveyed, the highest disease incidence of ToLCD on tomato recorded in Haveri district (86.6 %), followed by Yadgir (84.6 %), Kalburgi (83.3 %), Dharwad (81.7 %), Raichur (67.0 %), Bidar (66.5 %), Koppal (64.6 %), Belagavi (64.1 %) and Bagalkot district (39.1 %). Among the districts surveyed, the highest disease severity of ToLCD on tomato recorded in Yadgir (45.2 %), followed by Haveri (44.1 %), Kalburgi (41.6 %), Raichur (40.3 %), Bidar (38.6 %), Dharwad (33.3 %), Koppal (32.6 %), Belagavi (22.2 %) and Bagalkot district (15.6 %) (Table 2).

Fig.1 Tomato leaf curl disease infected tomato plant
## Table 1: Survey for incidence and severity of tomato leaf curl disease in tomato during 2015-2016

| Taluk      | Village                  | Area (ha) | Type of soil | Cropping system | Crop stage | Incidence (%) | Severity (%) | Symptoms                                                                 | Insects |
|------------|--------------------------|-----------|--------------|-----------------|------------|---------------|--------------|--------------------------------------------------------------------------|---------|
| Badami     | Badami                   | 1         | Red          | Mixed           | Flowering  | 15.0          | 6.6          | Curling of leaves, puckered appearance and chlorosis                      | WF, LM  |
|            | Cholachagud              | 1         | Red          | Mixed           | Vegetative | 39.10         | 15.6         | Severe upward curling of leaves                                          | LM, AP  |
|            | Mutalgeri                | 0.5       | Red          | Mono            | Vegetative | 12.9          | 11.1         | Slight yellowing, puckering, curling                                      | WF, LM  |
| Bagalkot   | Bagalkot                 | 0.5       | Black        | Mono            | Flowering  | 30.0          | 10.0         | Curling of leaves, puckered appearance and chlorosis                      | WF, LM  |
|            | Kaladagi                 | 1         | Red          | Mixed           | Fruiting   | 22.0          | 5.0          | Pucking, curling                                                         | WF,LM, GPB |
|            | Niralakeri               | 1         | Red          | Mixed           | Flowering  | 15.0          | 8.8          | Slight curling and chlorosis of new foliage                               | WF, LM  |
| Belagavi    | Bailwad                  | 2         | Black        | Mono            | Fruiting   | 25.0          | 15.5         | Pucking, curling and crinkling of leaves                                  | WF, LM, AP |
|            | Hirebagewadi             | 1         | Black        | Mono            | Fruiting   | 10.0          | 4.4          | Curling of leaves, puckered appearance and chlorosis                      | WF, GPB |
|            | Holehosururu             | 3         | Black        | Mono            | Fruiting   | 10.6          | 6.6          | curling, puckering, stunting                                              | WF, AP  |
|            | Sulebhati                | 2         | Black        | Mono            | Fruiting   | 35.2          | 17.7         | Pucking, curling                                                         | WF, LM  |
| Bylahongal | Belavadi                 | 1         | Black        | Mono            | Flowering  | 64.1          | 22.2         | Pronounced leaf curling                                                  | WF,LM |
|            | Bylahongal               | 2         | Black        | Mixed           | Vegetative | 15.0          | 5.0          | Yellowing, curling                                                       | WF      |
|            | Kenganur                 | 2         | Black        | Mono            | Flowering  | 15.0          | 5.0          | Yellowing of leaves, puckering, Very severe curling                      | WF      |
|            | Margod                   | 2.5       | Black        | Mono            | Flowering  | 56.5          | 20.0         | Yellowing of leaves, puckering, Very severe curling                      | WF, AP  |
|              | Ankalagi                 | 2         | Black        | Mixed           | Fruiting   | 13.7          | 7.7          | upward curling of leaves                                                 | WF      |
|              | Banachinamaradi          | 0.5       | Black        | Mixed           | Fruiting   | 16.3          | 6.6          | curling                                                                 | WF      |
|              | Nesargi                  | 1         | Black        | Mixed           | Flowering  | 16.00         | 7.3          | Pucking, curling                                                        | WF      |
| Bidar       | Bet balkunda             | 1         | Black        | Mixed           | Fruiting   | 40.0          | 10.0         | yellowing puckering                                                      | WF      |
|              | Hulsoor                  | 1         | Red          | Mono            | Flowering  | 12.9          | 4.8          | yellowing                                                                | WF      |
|              | Narayanpur               | 0.5       | Black        | Mono            | Fruiting   | 66.5          | 38.6         | Very severe curling, stunting                                             | WF, LM, GPB |
| Bidar       | Bagdal                   | 0.5       | Red          | Mono            | Flowering  | 11.1          | 7.7          | yellowing puckering                                                      | WF      |
|              | Bidar                    | 0.5       | Red          | Mono            | Flowering  | 56.2          | 21.2         | yellowing                                                                | WF      |
|              | Kamthana                 | 0.5       | Red          | Mixed           | Fruiting   | 21.4          | 5.7          | Pucking, curling                                                         | WF, GPB |
| Dharwad     | Garag                    | 1.5       | Black        | Mono            | Fruiting   | 17.6          | 8.8          | curling of leaves, reduced plant growth and few fruits                   | WF, LM, GPB |
|              | Hebballi                 | 0.5       | Black        | Mono            | Fruiting   | 81.7          | 33.3         | Pucking, severe curling, stunting                                        | LM, WF  |
|              | Narendra                 | 1         | Black        | Mono            | Flowering  | 25.5          | 11.1         | Light yellowing along the leaf margins and mild vein clearing            | WF, LM and AP |
|              | Somapura                 | 1         | Black        | Mono            | Flowering  | 5.0           | 2.0          | Light yellowing along the leaf margins and mild vein clearing            | WF      |
|              | UAS, Campus              | 1         | Black        | Mono            | Flowering  | 19.6          | 14.4         | Severe upward curling of leaves                                          | WF, LM, GPB |
|              | Amaragol                 | 1         | Black        | Mono            | Fruiting   | 58.1          | 31.1         | Severe upward curling of leaves                                          | WF, GPB |
|              | Amigery                  | 1         | Black        | Mono            | Flowering  | 22.2          | 7.0          | Curling                                                                  | WF, LM  |

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| District | Cluster | Village | Leaf Color | Leaf Color Type | Stage | Disease Symptom | WP, GPB, LM, AP |
|----------|---------|---------|------------|----------------|-------|----------------|----------------|
| Kalaburgi | Aland | Alur | Black | Mono | Fruiting | 83.3 | 31.6 | Sever curling, yellowing and stunting | WF, AP |
| Jevargi | Jevargi | Jevargi | Black | Mono | Fruiting | 35.6 | 14.4 | Sever curling and stunting | WF, LM, GPB |
| | | Kankanur | Black | Mono | Fruiting | 78.6 | 41.6 | Sever curling, stunting | WF |
| | | Nelogi | Black | Mono | Fruiting | 32.8 | 12.3 | Yellowing, curling | WF, AP |
| | | Yedrangi | Red | Mixed | Vegetative | 7.00 | 4.4 | Light yellowing | WF |
| Kalaburgi | Pattana | 1 | Black | Mixed | Fruiting | 35.6 | 20.0 | Puckering, curling | WF |
| | | Savalagi | Red | Mono | Vegetative | 5.5 | 2.8 | Light yellowing | WF, |
| | UAS Campus | 1 | Black | Mono | Fruiting | 45.5 | 17.7 | Yellowing and slight upward curling | WF, LM |
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| Sl. No. | District                          | Per cent disease incidence       | Per cent disease severity       |
|--------|----------------------------------|----------------------------------|---------------------------------|
|        |                                  | Minimum | Maximum | Average | Minimum | Maximum | Average |
| 1      | Bagalkot                         | 12.9    | 39.1    | 22.3    | 5.0     | 15.6    | 9.5     |
| 2      | Belagavi                         | 10.0    | 64.1    | 26.1    | 4.4     | 22.2    | 10.7    |
| 3      | Bidar                            | 11.1    | 66.5    | 34.6    | 4.8     | 38.6    | 14.6    |
| 4      | Dharwad                          | 5.0     | 81.7    | 24.9    | 2.0     | 33.3    | 10.8    |
| 5      | Haveri                           | 10.0    | 86.6    | 37.3    | 3.85    | 44.1    | 16.9    |
| 6      | Kalburgi                         | 5.5     | 83.3    | 35.8    | 2.8     | 41.6    | 16.1    |
| 7      | Koppal                           | 15.0    | 64.6    | 42.8    | 4.8     | 32.6    | 16.4    |
| 8      | Raichur                          | 10.0    | 67.0    | 40.2    | 3.8     | 40.3    | 19.4    |
| 9      | Yadgir                           | 17.6    | 84.6    | 43.5    | 5.0     | 45.2    | 20.5    |

**Table 2.** Tomato leaf curl disease incidence - district wise
Table.3 Average incidence and severity of ToLCD according to soil type, cropping system and crop stage

| Soil type | Cropping System | Crop stage |
|-----------|-----------------|------------|
| Black     | Red             | Mono       | Mixed   | Vegetative | Flowering | Fruiting |
| I         | S               | I          | S       | I          | S         | I        | S |
| 37.2      | 16.0            | 25.4       | 12.3    | 36.4       | 16.2      | 27.9     | 12.2 |
| I – Incidence | S – Severity |

The disease severity was scored using 0-4 scale as described by Muniyappa et al., (1991)

| Scale | Symptoms                                                                 |
|-------|--------------------------------------------------------------------------|
| 0     | No symptom                                                               |
| 1     | Light yellowing along the leaf margins and mild vein clearing            |
| 2     | Yellowing of leaf and slight curling, growth, flowering and yield not greatly affected. |
| 3     | Pronounced leaf curling, yellowing, stunting and reduced fruiting.       |
| 4     | Very severe curling, puckering, stunting and reduction in leaf size and no fruit formation. |

Average incidence and severity of ToLCD according to soil type, in black soil 37.2 per cent and 16.0 per cent, in red soil 25.4 per cent and 12.3 per cent respectively. According to cropping system average incidence and severity of ToLCD in mono cropping was 36.4 per cent and 16.2 Per cent, in mixed Cropping 27.9 per cent and 12.2 per cent respectively. According to crop stage average incidence and severity of ToLCD in vegetative stage was 26.0 per cent and 12.3 per cent, in flowering stage was 29.1 per cent and 12.9 per cent and fruiting stage was 40.9 per cent and 17.8 per cent respectively (Table 3).

Tomato leaf curl disease is an important major constraint in the cultivation of the tomato crop. The disease is highly destructive in many states of the Indian subcontinent including Karnataka state. Survey was under taken to assess the incidence and severity of tomato leaf curl disease in certain major tomato growing districts of northern Karnataka. The results revealed that the per cent incidence and severity varied from location to location. However, the tomato leaf curl disease and the vector whitefly were found in almost all the tomato fields surveyed. Occurrence of tomato leaf curl disease is ranging from 5.0 to 86.6 per cent incidence and 2.0 to 45.2 per cent severity.

Among the districts, Haveri district recorded the highest 86.6 per cent incidence of the disease followed by Yadgir district which recorded the disease incidence of 84.6 per cent and Bagalkot district recorded the least incidence of 39.1 per cent. The highest disease severity of ToLCD on tomato was recorded in Yadgir (45.2 %), followed by Haveri (44.1 %) least severity of ToLCD was in Bagalkot district (15.6 %).

The reasons for the differences in the incidence and severity of disease in areas surveyed might be due to the variation in the source of inoculum, vector population, climatic conditions and the area. The probable causes for high incidence of disease in Haveri and Dharwad districts are extensive cultivation of tomato crop and the prevalence of whitefly vector in these districts, whereas high incidence in Yadgir and Kalburgi districts could be due to high vector population because of high temperature which favors whitefly multiplication. The another probable reason for high incidence of the disease in state is due to cultivation of mono-cropping over a larger area, introduction of B. biotype, B tabaci has also been considered to be one of the major factors for the disease to assume epidemic proportion. Similar observations were recorded by Saikia and Muniyappa (1989), Reddy et al., (2011) and Ehsanullah (2014).
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