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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 an important and most widely grown vegetable crop 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.

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 2015-16is 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 crinkling 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 of 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 number of plants showing disease symptoms and the total number of plants examined 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).

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

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
Bagalkot district									
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	Puckering, curling	WF,LM, GPB
	Niralakeri	1	Red	Mixed	Flowering	15.0	8.8	Slight curling and chlorosis of new foliage	WF, LM
						22.33	**9.51**		
Belagavi district									
Belagavi	Bailwad	2	Black	Mono	Fruiting	25.0	15.5	Puckering, 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
	Holehosuru	3	Black	Mono	Fruiting	10.6	6.6	curling, puckering, stunting	WF, AP
	Sulebhavi		Black	Mono	Fruiting	35.2	17.7	puckering, curling	WF, LM
Bylahongal	Belavadi	1	Black	Mono	Flowering	64.1	22.2	Pronounced leaf curling Yellowing,	WF,LM
	Bylahongal	2	Black	Mixed	Vegetative	15.0	5.0	Yellowing, curling	WF
	Kenganur	1.5	Black	Mono	Flowering	15.0	5.0	Yellowing of leaves, puckering, Very severe curling	WF
	Murgod	2.5	Black	Mono	Flowering	56.5	20.0	Yellowing of leaves, puckering, Very severe curling	WF, AP
Gokak	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	puckering, curling	WF
						26.1	**10.7**		
Bidar district									
Basavakalyan	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 sever 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	Puckering curling	WF, GPB
						34.6	**14.6**		
Dharwad district									
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	Puckering, sever 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
	Annigeri	1	Black	Mono	Flowering	22.2	7.0	Curling	WF, LM

	Belavatagi	0.5	Black	Mono	Flowering	14.6	4.4	Pale yellowing, curling and stuntedgrowth of plants	
Hubballi	Byahatti	0.5	Black	Mono	Flowering	16.7	4.8	Yellowing, curling	
	Chabbi	1	Red	Mono	Vegetative	18.3	3.6	curling	
	Hebsur	0.25	Black	Mixed	Fruiting	20.6	13.3	Yellowing, curling	
	Nulavi	1	Red	Mono	Flowering	5.5	2.9	Severe upward curling ofleaves	
	Varur	1	Black	Mono	Fruiting	18.6	4.8	Yellowing, curling	
						24.9	**10.1**		
Haveri district									
Byadgi	Byadgi	1	Black	Mono	Fruiting	86.6	44.1	Severe upward curling of Leaves stunting	WF LM
	Chikkabasur	1	Black	Mono	Flowering	50.00	18.3	Curling of leaves	WF LM
	Shidenur	1	Black	Mono	Flowering	17.6	11.1	Yellowing of leaves, puckering,	WF AP GPB
Haveri	Haveri	2	Red	Mono	Flowering	30.00	17.7	Slight yellowing, puckering, curling	WF LM,AP
	Kadaramandalagi	1	Black	Mono	Fruiting	28.6	10.0	Yellowing and Upward curling	WF LM AP
	Motebennur	1	Red	Mono	Flowering	25.0	3.8	Curling of leaves, puckered appearance and chlorosis	WF LM
Ranebennur	Halageri	1	Black	Mixed	Flowering	22.0	7.20	yellowing, curling,	WF
	Hanumanamatti	1	Black	Mixed	Fruiting	10.0	6.6	Yellowing, curling	WF AP
	Ranebennur	1	Black	Mono	Fruiting	66.6	33.3	Severe upward curling of Leaves stunting	WF LM,AP
						37.3	**16.9**		
Kalaburgi district									
Aland	Alur	2	Black	Mono	Fruiting	83.3	31.6	Sever curling, yellowing and stunting	WF, AP
	Dannur	0.5	Black	Mono	Fruiting	25.0	11.1	Yellowing and upward curling	WF, AP
	Kadaganchi	1	Black	Mono	Flowering	10.0	5.4	Upward curling	WF, LM
Jevargi	Jevargi	2	Black	Mono	Flowering	35.6	14.4	Sever curling and stunting	WF,LM, GPB
	Kukanoor	2	Black	Mono	Fruiting	78.6	41.6	Sever curling, stunting	WF
	Nelogi	1	Black	Mono	Fruiting	32.8	12.3	Yellowing, curling	WF, AP
	Yedrami	3	Red	Mixed	Vegetative	7.00	4.4	Light yellowing	WF
Kalaburgi	Pattana	1	Black	Mixed	Fruiting	35.6	20.0	Puckering, curling	WF
	Savalagi	0.5	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
						35.8	**16.1**		
Koppal district									
Koppal	Basapur	0.5	Black	Mono	Flowering	66.7	19.0	Yellowing and slight upward curling	WF, LM
	Bikanahalli	3	Black	Mono	Fruiting	57.5	14.1	yellowing, curling, stunting	WF, GPB
	Budugumpa	3	Black	Mono	Flowering	64.6	32.6	curling	WF
	Koppal	2.5	Black	Mono	Flowering	35.0	14.4	curling and yellowing of foliage	WF
Kushtagi	Ginigera	2	Red	Mono	Flowering	28.6	13.7	puckering curling	WF
	Gondbal	1	Red	Mixed	Flowering	25.0	7.0	yellowing curling	WF
	Kinnal	1	Black	Mono	Fruiting	50.0	25.6	Very severe curling of leaves upwards and puckering of leaves	WF, LM, AP
	Kushtagi	1	Black	Mixed	Fruiting	15.0	4.8	Upward curling	WF, LM, AP
						42.8	**16.4**		
Raichur district									

Devadurga	Hemanal	2	Red	Mixed	Fruiting	38.0	22.2	yellowing, curling, stunting	WF, LM
	Hirebudur	2	Red	Mono	Flowering	45.0	22.2	Very severe curling of leaves upwards and puckering of leaves	WF, LM, AP
Manvi	Gorkal	2	Red	Mono	Flowering	25.5	20	Yellowing and Upward curling	WF, LM
	Kallur	2	Black	Mono	Fruiting	63.3	31.1	Sever curling, stunting	WF, LM
	Neermanvi	1	Red	Mono	Flowering	10.0	3.8	Yellowing, slight curling	WF, LM
Raichur	Chandrabanda	2	Red	Mono	Flowering	67.0	40.3	Very severe curling of leaves upwards and puckering of leaves	WF, LM
	Shakthinagar	1	Black	Mono	Fruiting	66.6	17.7	yellowing, curling, stunting	WF, GPB
	UAS Campus	4	Black	Mixed	Flowering	20.0	13.3	Curling of leaves, puckered appearance and chlorosis	WF, AP
Sindhanur	Kalmangi	1	Black	Mono	Fruiting	48.0	22.2	Slight yellowing, puckering, curling	WF, LM,
	Roudakunda	3	Black	Mono	Fruiting	45.0	12.00	Light yellowing, curling	WF
	Salagunda	1	Black	Mono	Fruiting	35.0	17.7	Yellowing, curling	WF, GPB
	Sindhanur	2	Black	Mono	Fruiting	20.0	11.1	Upward curling	WF, LM
						40.28	**19.46**		
Yadgir district									
Shahpur	Bheemarayangudi	1	Black	Mixed	Fruiting	32.8	20.2	yellowing, puckering, curling	WF,GPB
	Goji	0.5	Black	Mono	Fruiting	19.3	10.7	Puckering Curling	WF,LM
	Gundhalli	1.5	Black	Mixed	Flowering	55.0	37.7	Sever curling and stunting	WF, AP, GPB
	Khanapur	2	Red	Mono	Flowering	50.0	33.3	Very severe curling of leaves upwards and puckering of leaves	WF,
	Shahpur	3	Black	Mixed	Flowering	35.0	5.0	Slight yellowing, puckering, curling	WF, GPB
Shorapur	Shorapur	1	Black	Mono	Flowering	17.6	11.1	Yellowing curling	WF
	Gonal	1	Black	Mixed	Flowering	30.0	6.6	Yellowing and curling	WF, LM
Yadgir	Jinker	0.5	Black	Mixed	Fruiting	42.9	13.7	Yellowing curling	WF, GPB
	Koulur	1	Black	Mono	Fruiting	71.6	32.1	Very severe curling of leaves, stunting	WF, LM
	Mustur	0.5	Black	Mixed	Vegetative	84.6	45.2	Sever upward curling, stunting	WF, LM, AP
	Malhar	1	Black	Mono	Fruiting	56.8	20.0	Curling, stunting	WF, LM
	Nagadadinni	0.5	Black	Mono	Vegetative	26.6	11.1	Puckering, curling, stunting	WF LM
						43.51	**20.55**		

Table.2 Tomato leaf curl disease incidence -district wise

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.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	I	S	I	S	I	S
37.2	16.0	25.4	12.3	36.4	16.2	27.9	12.2	26.0	12.3	29.1	12.9	40.9	17.8

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 leaves and slight curling, growth, flowering and yield not greately 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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