Occurrence of different diseases of tomato under field condition in Raipur

KN Koshale, Priti Anant and CP Khare

DOI: https://doi.org/10.22271/chemi.2020.v8.i3w.9445

Abstract
Tomato is one of the most preferable and extensively grown vegetables in India as well as in Chhattisgarh. The tomato plant is infected with many diseases in its life but they do not occur simultaneously and their development varies with place and season. Therefore a study was undertaken in rabi season of three consecutive years (2014-15, 2015-16 and 2016-17) at Horticulture Instruction cum Research Farm, College of Agriculture, Raipur to know the prevalent diseases of tomato, their occurrence pattern and extent of infection. Five diseases viz. leaf curl, mosaic, tomato spotted wilt, early blight and collar rot were observed to infect the crop during the investigation. Under Raipur situations the first occurrence of leaf curl, collar rot, mosaic, early blight and tomato spotted wilt were recorded in November, December, December-January, January and January-February, respectively. Leaf curl and early blight were most serious diseases of the crop out of five commonly occurring diseases.

Keywords: Collar rot, early blight, leaf curl, mosaic, tomato.

1. Introduction
Tomato, Solanum lycopersicum L. belongs to family Solanaceae (Singh, 2014) is one of the most popular and extensively grown vegetables (Chaudhary et al. 2010 and Singh et al. 2015) of tropical and subtropical countries (Govindappa et al. 2013). It is a herbaceous, annual, subtropical fruiting plant (Bora et al. 2012) which is originated in Latin America and has become one of the most widely grown vegetables with ability to survive in diverse environmental conditions (Seekyewa, 2006). The name tomato probably derived from the word “Tomat” in the Nahua tonque of Mexico (Manjunatha, 2008). In England, tomato is popularly known as “love of apple” while, in India, it is commonly referred as “poor man’s Orange” (Rai and Yadav, 2005 and Mihretu and Bhalekar, 2016). Worldwide, the tomato ranks second in importance after the potato (Mihretu and Bhalekar, 2016) while it ranks third in priority after potato and onion in India (Anonymous, 2017 and Nadkarni et al., 2017) in the world, tomato is cultivated over an area of 5.7 million ha with an annual production of 211.80 million metric tonnes and productivity of 37.16 metric tonnes ha⁻¹ (Anonymous, 2016) in India, it occupies an area of about 0.80 million ha producing over 19.54 million metric tonnes with the productivity of 21.2 metric tonnes ha⁻¹ (Anonymous, 2017). Diseases are one of the important reasons of low productivity of the crop (Kakati and Nath, 2014). Tomato is known to susceptible for more than 200 diseases (Shelat et al. 2014). Among them collar rot or Sclerotium wilt; Sclerotium rolfsii (Mahato et al. 2017), damping off; Fusarium spp., Pythium spp., Rhizoctonia solani, Sclerotium rolfsii (Prasad et al. 2017), early blight; Alternaria solani (Roopa, 2012), Fusarium wilt; Fusarium oxysporum Lsp. lycopersici (Manikandan and Ragucherand, 2014), late blight (Olianya et al. 2015), Septoria leaf spot (Parker et al. 1997 and Blum, 2000), bacterial fruit canker; Clavibacter michiganensis subsp. michiganensis (Ftuyeh et al. 2010 and Sharabani et al. 2013), bacterial wilt; Ralstonia solanacearum (Ayyana and Fininsa, 2016), bud blight; Groundnut bud necrosis virus (Manjunatha et al. 2010), leaf curl; Tomato leaf curl virus (Shelat et al. 2014 and Yadav et al. 2014), tomato mosaic; Tomato mosaic virus (Alishiri et al. 2013), tomato spotted wilt; Tomato spotted wilt virus (Sevik and Arli-Sokmen, 2012) and Root knot; Meloidogyne spp (Nab et al. 2012) are major diseases of tomato (Mahato et al. 2017). But it is not necessary that all these diseases occur at the same time with great extent in one crop season, climatic conditions and location because the climatic
conditions of a particular area favours some specific pathogens and this is the important consideration for the management of disease. Therefore a study was undertaken to know the prevalent diseases of tomato, their occurrence pattern and extent of infection in Rabi under Raipur conditions.

2. Material and Methods
A study was undertaken in Rabi season of three consecutive years (2014-15, 2015-16 and 2016-17) at Horticulture Instruction cum Research Farm, College of Agriculture, Raipur (Chhattisgarh) to know the prevalent diseases of tomato, their occurrence pattern and extent of infection. The observations on percent disease incidence and percent disease index (PDI) of each disease were recorded at fortnightly interval from ten untreated plots of tomato (cv. Pusa Ruby). Percent disease incidence was calculated by following formula suggested by Nene (1972) [29]:

\[
\text{Percent Incidence} = \frac{\text{Number of Infected plants}}{\text{Total number of plants observed}} \times 100
\]

However the disease rating was recorded for each plant of every plot by following rating scales as described in below thereafter percent disease index (PDI) was calculated for each plot by implying formulae suggested by Wheeler (1969) [47].

\[
\text{PDI} = \frac{\text{Sum of numerical disease ratings}}{\text{Number of plants observed} \times \text{maximum disease rating}} \times 100
\]

2.1 Leaf curl
Disease rating of individual plants was recorded by using a slightly modified visual scale of 0-7, where: 0 = No visible disease symptom; 1 = Top leaves curled only; 3 = Top leaves curled and slight stunting of plant or All leaves curled without stunting; 5 = All leaves curled and slight stunting of plant and 7 = Severe curling of leaves, stunting of plant and proliferation of auxiliary branches (Alegbejo, 1995 and Alegbejo and Banwo, 2006) [1, 2].

2.2 Mosaic
Disease symptoms of mosaic were rated on a scale of 0-5, where: 0 = No symptoms; 1 = Light or dark green mottling or mosaic; 2 = Light or dark green mottling or mosaic with distortion or reduction of younger leaves; 3 = Dark green areas of the mottle often appear thicker and somewhat elevated giving the leaves a blister like appearance with no stunting; 4 = Dark green areas of the mottle often appear thicker and somewhat elevated giving the leaves a blister like appearance with stunting and sometimes yellow mottling of leaves and 5 = Severe stunting of plant with leaves look fem like and sharply pointed and sometimes dark necrotic streaks in stems, petioles, leaves or fruit (Cerkaukas, 2004 and Anonymous, 2012) [15, 8].

2.3 Tomato spotted wilt
A visual disease rating of 1-5 was used, where: 1 = No visible symptoms; 2 = Mild purpling, chlorosis, and limited leaf distortion; 3 = Moderate purpling, chlorosis, and leaf distortion with some plant stunting; 4 = Severe purpling, chlorosis, leaf distortion and plant stunting; 5 = Severe purpling, chlorosis, leaf distortion and extreme stunting (Canady et al. 2001 and Sivparsad and Gubba, 2011) [14, 43].

2.4 Early blight
The percent disease index (PDI) of the early blight was recorded according to following scale of 0-9 given by Mayee and Datar, 1986 [28]. Where: 0 = No symptoms; 1 = Small circular, scattered, brown spots, covering 1 per cent or less of the leaf area; 3 = Spots enlarging, dark brown in colour covering 1 to 10 per cent of leaf area and infection on the lower most leaves of the plant; 5 = Spots enlarging, dark brown in colour covering 11 to 25 per cent of leaf area and infection on the lower most leaves of the plant; 7 = Spots dark brown in colour covering 26 to 50 per cent of leaf area and covering one third of the plant and 9 = Spots uniformly dark brown, coalescing, covering 50 per cent or more leaf area and severe infection on all leaves (Abdussamee et al. 2014) [1].

3. Results and Discussions
In field condition the occurrence of prevalent diseases were recorded for rabi seasons of three consecutive years (2014-15, 2015-16 and 2016-17). It was recorded starting from the second fortnight of November to the first fortnight of March (Table 1, 2 and 3). Five diseases viz. leaf curl, mosaic, tomato spotted wilt, early blight and collar rot appeared during the course of investigation.

3.1 Leaf curl
In rabi 2014-15 and 2015-16 the first appearance of leaf curl was observed in the second fortnight of November with low percent disease incidence (4.83 and 7.30) and PDI (1.46 and 2.87). However, in rabi 2016-17 the first symptoms of leaf curl was observed in the first fortnight of November with percent disease incidence of 1.67 and PDI of 0.81. In all three rabi, the disease progressed up to the first fortnight of March with maximum percent disease incidence (87.66, 79.07 and 87.91) and PDI (64.68, 59.17 and 68.80) (Tables 1, 2 and 3). The ToLCD was present in almost all fields of Belgaum, Dharwad and Haveri districts surveyed with the disease incidence ranged from 4-100 percent in rabi and was in severe form ranging from 60 to 100 percent during summer (Reddy, 2006 and Reddy, et al. 2011) [38, 37]. Ten fields of Raipur (Chhattisgarh) were selected for the pest surveillance of tomato in Rabi 2013-14. The average incidence of leaf curl was recorded from November 2013 to March 2014 with increasing trend and average maximum disease incidence of 10.94 percent was recorded in March 2014 under field condition (Anonymous, 2013-14) [5]. Ehsanullah, (2014) [17] recorded 10.8 to 91.3 percent disease incidence in major tomato growing districts of Karnataka with highest disease incidence of 70.81 percent in Kolar and least incidence of 21.00 percent in Ramanagara district.

3.2 Mosaic
In rabi (2014-15, 2015-16 and 2016-17) the first appearance of mosaic was observed in the second fortnight of December in 2014-15 whereas in 2015-16 and 2016-17 the disease was observed in the first fortnight of January and progressed up to the first fortnight of March. Initially the occurrence of the disease started with very low percent disease incidence (0.69, 0.58 and 1.11) and PDI (0.14; 0.32 and 0.38) which increased with increase in age of the plant and reached maximum in the second fortnight of February (4.18, 2.53; 6.75, 6.68; 5.06, 4.92) (Tables 1, 2 and 3). Ten fields of Raipur (Chhattisgarh) were selected for the pest surveillance of tomato in rabi 2013-14. The average incidence of mosaic was recorded from December 2013 to March 2014 with increasing trend and average maximum disease incidence of 12.61 percent was recorded in March 2014 under field condition (Anonymous, 2013-14) [5]. Jalender, et al. (2017) [20] conducted a survey in tomato growing areas of Ranga Reddy district during kharif 2013 and in Guntur district during rabi 2013-14 and recorded natural occurrence of disease incidence which ranged from 6.9 to 15.7 among different Mandalas.
3.3 Tomato spotted wilt
In *rabi* the first symptoms of tomato spotted wilt was observed in the first fortnight of January, the first fortnight of February and the second fortnight of January in 2014-15, 2015-16 and 2016-17, respectively with 0.21, 1.53 and 0.96 percent disease incidence and 0.06, 0.94 and 0.23 PDI. The disease continued up to the first fortnight of March and maximum percent disease incidence (1.52, 2.01 and 3.01) and PDI (0.76, 1.88 and 2.41) were recorded in the second fortnight of February (Tables 1, 2 and 3).

Pattaya, (2006) [32] carried out survey and surveillance of tomato spotted wilt virus disease at fields of three locations viz. Panagar, Jabalpur and Indrana to determine the incidence of virus. A total of five thousand and sixty tomato plant samples from five varieties viz. Pusa early dwarf, JT 99, Pusa ruby, Sourabh and Abhisek were observed for tomato spotted wilt virus. Overall 18 to 34, 15 to 30 and 16 to 24 percent infection was observed in Panagar, Jabalpur and Indrana respectively in different varieties. Bözdogan and Kamberoglu, (2015) [13] conducted a survey in Center (Antalya) district of Turkey and reported 74.28 to 92.30 percent (average 78.57%) infection of tomato spotted wilt virus in tomato crop during 2007-2009.

3.4 Early blight
In *rabi* the first occurrence of early blight was recorded in the first fortnight of January and progressed up to the first fortnight of March. Initially percent incidence (0.83, 0.59 and 3.68) and PDI of the disease were very low (0.03, 0.04 and 0.15) which rapidly increased and reached maximum in the first fortnight of March in 2014-15 (71.51 and 38.42) and the second fortnight of February in 2015-16 (70.24, 34.28) and 2016-17 (81.69, 45.15) (Tables 1, 2 and 3).

Prasad, (2002) [34] recorded 28.60 to 65.36 percent severity of early blight in northern districts of Karnataka during 2001. Roopa, 2012 [39] undertook a roving survey during 2011 to assess the severity of early blight of tomato in major tomato growing areas of Dhawar, Belgaum, Haveri, Gadag and Bagalkot districts. Disease severity was ranged from 17.30 to 37.25 percent, highest severity was recorded in Haveri (31.03%) and least in Dhawar (20.16%) districts. Ten fields of Raipur (Chhattisgarh) were selected for the pest surveillance of tomato in *rabi* 2013-14. The average severity of early blight was recorded from November 2013 to March 2014 with increasing trend and average maximum disease severity of 5.96 percent was recorded in March 2014 under field condition (Anonymous, 2013-14) [5].

4.1.1.5 Collar rot
In *rabi* the first appearance of collar rot was observed in the first fortnight of December with percent disease incidence of 1.04, 1.01 and 0.67 and continued up to the first fortnight of March and maximum percent disease incidence (2.25, 4.38 and 3.33) was observed in the first fortnight of January and February and the second fortnight of January in 2014-15, 2015-16 and 2016-17 (Tables 1, 2 and 3).

In field condition the incidence of collar rot was recorded 5 to 10 percent in Raipur, Chhattisgarh (Anonymous, 2013-14) [5] 10-45 percent in Himachal Pradesh (Banyal, *et al.* 2008) [10] and 7.61 to 21.79 percent in undulating red and lateritic zone of West Bengal (Mahato, *et al.* (2017) [22].

4. Conclusion
From the present investigation it can be concluded that in Raipur, five diseases viz. leaf curl, mosaic, tomato spotted wilt, early blight and collar rot were prevalent in tomato crop under field conditions. The severity pattern of the diseases was leaf curl > early blight > mosaic > collar rot > tomato spotted wilt.

| Table 1: Seasonal occurrence of prevalent diseases of tomato under field conditions (*rabi* 2014-15) |
| --- |
| Disease | Incidence and PDI | Nov | Dec | Jan | Feb | March |
| Leaf curl | Incidence | 4.83 | 19.41 | 22.17 | 25.33 | 37.18 | 63.63 | 62.53 | 87.66 |
| | PDI | 1.46 | 8.82 | 10.43 | 13.36 | 20.41 | 44.12 | 60.15 | 64.68 |
| Mosaic | Incidence | - | - | 1.75 | 0.49 | 0.76 | 0.07 | 0.03 | 0.73 |
| | PDI | - | - | 0.14 | 0.33 | 1.08 | 1.84 | 2.53 | 2.53 |
| Spotted Wilt | Incidence | - | - | 0.21 | 0.83 | 1.18 | 1.52 | 1.52 | 1.26 |
| | PDI | - | - | 0.06 | 0.28 | 0.49 | 0.76 | 0.76 | 0.76 |
| Early blight | Incidence | - | - | 0.83 | 7.48 | 22.09 | 84.24 | 71.51 | 71.51 |
| | PDI | - | - | 0.03 | 0.73 | 9.42 | 22.95 | 38.42 | 38.42 |
| Collar rot | Incidence | - | - | 1.04 | 1.05 | 2.25 | 2.25 | 2.25 | 2.25 |
| | PDI | - | - | 1.04 | 1.05 | 2.25 | 2.25 | 2.25 | 2.25 |

| Table 2: Seasonal occurrence of prevalent diseases of tomato under field conditions (*rabi* 2015-16) |
| --- |
| Disease | Incidence and PDI | Nov | Dec | Jan | Feb |
| Leaf curl | Incidence | 7.30 | 15.98 | 21.17 | 29.26 | 42.35 | 68.52 | 79.07 |
| | PDI | 2.87 | 7.44 | 11.32 | 29.26 | 28.47 | 49.39 | 58.62 |
| Mosaic | Incidence | - | - | - | 0.58 | 4.08 | 5.81 | 6.75 |
| | PDI | - | - | - | 0.32 | 3.33 | 5.48 | 6.68 |
| Spotted Wilt | Incidence | - | - | - | - | 1.53 | 2.01 | 2.01 |
| | PDI | - | - | - | - | 0.94 | 1.88 | 1.88 |
| Early blight | Incidence | - | - | 0.59 | 10.34 | 36.45 | 70.24 | 70.24 |
| | PDI | - | - | 0.04 | 1.35 | 8.49 | 32.48 | 32.48 |
| Collar rot | Incidence | - | 1.01 | 1.01 | 1.34 | 3.37 | 4.38 | 4.38 |
| | PDI | - | - | - | - | - | - | - |

| Table 3: Seasonal occurrence of prevalent diseases of tomato under field conditions (*rabi* 2016-17) |
| --- |
| Disease | Incidence and PDI | Nov | Dec | Jan | Feb |
| Leaf curl | Incidence | 1.67 | 8.51 | 17.78 | 27.48 | 45.48 | 67.72 | 83.19 |
| | PDI | 0.81 | 4.36 | 9.90 | 16.90 | 32.24 | 51.47 | 64.37 |
| Mosaic | Incidence | - | - | - | - | 1.11 | 2.51 | 5.06 |
| | PDI | - | - | - | - | 0.38 | 1.47 | 3.85 |
| Spotted Wilt | Incidence | - | - | - | - | - | 0.96 | 2.33 |
| | PDI | - | - | - | - | - | 0.23 | 0.87 |
| Early blight | Incidence | - | - | - | - | 3.68 | 16.18 | 48.97 |
| | PDI | - | - | - | - | 0.15 | 1.92 | 14.12 |
| Collar rot | Incidence | - | 0.67 | 2.00 | 3.00 | 3.33 | 3.33 |
| | PDI | - | - | - | - | - | - |

5. References
1. Abdussamee H, Hussain Md, Ali M, Siddique MS, Jatoi SUK, Sahi ST *et al.* Genetic response of tomato germplasm against early blight and its management through fungicides. Applied Science Reports. 2014; 6(3):119-127.
2. Alegbejo M, Banwo O. Moderate resistance to *Tomato leaf curl virus* among commercial tomato cultivars in northern Nigeria. Journal of Plant Protection Research. 2006; 46(3):207-213.
3. Alegbejo MD. Screening of tomato accessions for resistance to leaf curl virus. Journal of Agricultural Technology. 1995; 3:65-68.
4. Alshirhi A, Rakshandehroo F, Zamanizadeh HR, Pulukaitis P. Prevalence of *Tobacco mosaic virus* in Iran and evolutionary analyses of the coat protein gene. The Plant Pathology Journal. 2013; 29(3):260-273.
5. Anonymous. Annual report, Indira Gandhi Krishi Vishwa Vidyalaya, Raipur (Chhattisgarh), 2013-14.
6. Anonymous. Area and production of horticultural crops-All India, 2016-17 (Third advance est.). Government of India, Ministry of Agriculture and Farmers Welfare, Department of Agriculture, Cooperation and Farmers Welfare (Horticulture Statistics Division), 2017.
7. Anonymous. FAOSTAT. http://www.fao.org/faostat/en/#data/QC. 2016.
8. Anonymous. Manual for Tomato Pest Surveillance, National Initiative on Climate Resilient Agriculture, National Centre for Integrated Pest Management (NCIPM), New Delhi, Central Institute for Dryland Agriculture, Hyderabad, Indian Institute of Horticultural Research, Bengaluru and Indian Institute of Vegetable Research, Varanasi, 2012.
9. Ayana G, Fininsa C. Effect of crop rotation on tomato bacterial wilt (Ralstonia solanacearum) and survival of the pathogen in the rhizospheres and roots of different crops in Ethiopia. International Journal of Phytopathology. 2016; 05(03):81-88.
10. Banyal DK, Mankotia V, Sugha SK. Soil characteristics and their relation to the development of tomato collar rot caused by Sclerotium rolfsii. Indian Phytopathology. 2008; 61(1):103-107.
11. Blum LEB. Reduction of incidence and severity of Septoria lycopersici leaf spot of tomato with bacteria and yeasts. Ciência Rural, Santa Maria. 2000; 30(5):761-765.
12. Bora GC, Devi J, Gogoi S, Deka A, Bhattacharyya AK, Paswan L et al. Evaluation of varieties of tomato (Lycopersicon esculentum) for resistance to leaf curl virus in North East India. Current Advances in Agricultural Sciences. 2012; 4(1):50-52.
13. Bözdogan V, Kamberoğl, MA. Incidence and distribution of Tomato spotted wilt Tospovirus (TSWV) in vegetable crops in Antalya province of Turkey. Journal of Turkish Phytopathology. 2015; 44(1-3):39-50.
14. Canady MA, Stevens MR, Barineau MS, Scott JW. Tomato Spotted Wilt Virus (TSWV) resistance in tomato derived from Lycopersicon chilense Dun. L. 1938, Euphytica. 2001; 117:19-25.
15. Cerkaukasas R. Tomato Diseases: Tomato Mosaic Virus (ToMV). Fact sheet. AVRDC- The World Vegetable Center, Shanhua; Taiwan. 2004; 04:609.
16. Chaudhary S, Gulati P, Srivastava GP, Tewari JP. Screening for natural occurrence of Tomato leaf curl virus (TLCV) in Devipatan mandal of Tarai region of Uttar Pradesh. International Journal of Plant Protection. 2010; 3(1):147-150.
17. Ehsanullah. Survey for prevalence of Tomato leaf curl virus (ToLCV) strains in Karnataka and identification of resistance source. M. Sc. Thesis, University of Agricultural Sciences GKVK, Bangalore-560065, 2014.
18. F해야h R, von Diedemann A, Koopmann B, Abu-Ghorrah M, Rudolph K. Occurrence of Clavibacter michiganensis subsp. michiganensis, the causal agent of bacterial canker of tomato, in Syria. Phytopathologia Mediterraneae. 2010; 49:172-178.
19. Govindappa MR, Bhemanna M, Hosmani A, Ghante VN. Bio-eficacy of newer insecticides against tomato leaf curl virus disease and its vector whitfly (Bemisia tabaci) in tomato. International Journal of Applied Biology and Pharmaceutical Technology. 2013; 4(3):226-231.
20. Jalender P, Bhat BN, Anitha K, Vijayalakshmi K. Survey for the Incidence of Cucumber Mosaic virus in Tomato Growing Areas of Telangana and Andhra Pradesh. International Journal of Pure and Applied Bioscience. 2017; 5(4):2058-2063.
21. Kakati N, Nath PD. Sustainable management of tomato leaf curl virus disease and its vector, Bemisia tabaci through integration of physical barrier with biopesticides. International Journal of Innovative Research and Development. 2014; 3(2):132-140.
22. Mahato A, Biswas MK, Patra S. Prevalence of collar rot of tomato caused by Sclerotium rolfsii (Sacc.) under the red and lateritic zone of West Bengal, India. International Journal of Current Microbiology and Applied Sciences. 2017; 6(11):3231-3236.
23. Manikandan R, Raguchander T. Prevalence of tomato wilt disease incited by soil borne pathogen Fusarium oxysporum f.sp. lycopersici (Sacc.) in Tamil Nadu. International Journal of Tropical Agriculture. 2014; 32(1-2):279-283.
24. Manjunatha L, Patil MS, Thimmegowda PR, Mahantesh S. Survey for incidence of bud blight disease of tomato in parts of Karnataka. Journal of Plant Disease Sciences. 2010; 5(1):102-104.
25. Manjunatha L. Studies on bud blight disease of tomato caused by groundnut bud necrosis virus, M. Sc (Ag.) Thesis, University of Agricultural Sciences, Dharwad (India), 2008.
26. Mihretu FG, Bhalekar MN. Evaluation of tomato genotypes for yield potential. Vegetable Science. 2016; 43(1):96-100.
27. Nadkarni SR, Jayalekshmy VG, Umamaheshwaran K, Harikrishnan PJ. Evaluation of Tomato and Allied Species for Tomato leaf curl virus (Tolcv) Resistance (Solanum lycopersicum L.). International Journal of Pure and Applied Bioscience. 2017; 5(3):271-277.
28. Naz I, Palomares-Rius JE, Blok V, Saifulah SA, Ahmed M. Prevalence, incidence and molecular identification of root-knot nematodes of tomato in Pakistan. African Journal of Biotechnology. 2012; 11(100):16546-16556.
29. Nene YL. A survey of viral diseases of pulse crops in Uttar Pradesh. G.B. Pant Univ. Agric. Technol. Panntag Research Bulletin. 1972; 4:911.
30. Olaya OM, Larkin RP, Honeycutt CW. Incidence of Phytophthora infestans (Mont.) de Bary on potato and tomato in Maine, 2006-2010. Journal of Plant Protection Research. 2015; 55(1):58-68.
31. Parker SK, Nutter FW Jr, Gleason ML. Directional spread of Septoria leaf spot in tomato rows. Plant Dis. 1997; 81:272-276.
32. Pattaiya ML. Studies on survey and surveillance of tomato spotted wilt virus in Jabalpur. M. Sc. (Ag.), Thesis, Jawaharlal Nehru Krishi Vidyalaya, Jabalpur (Madhya Pradesh), India, 2006.
33. Prasad MR, Sagar BV, Devi GU, Rao SRK. In vitro evaluation of fungicides and biocontrol agents against damping off disease caused by Sclerotium rolfsii on Tomato. International Journal of Pure and Applied Bioscience. 2017; 5(4):1247-1257.
34. Prasad Y. Studies on variability, pre and post-harvest management of early blight of tomato. M. Sc. (Agri.) Thesis, University of Agricultural Sciences, Dharwad, India, 2002.
35. Rai N, Yadav DS. Advances in Vegetable Production. Researchco Book Centre, New Delhi, 2005, 481.
36. Reddy AB, Patil MS, Rajasekaram T. Effect of Tomato leaf curl virus infection on plant growth and yield in
37. Reddy AB, Patti MS, Reddy KM, Venkataravanappa V. Detection and diagnosis of Tomato leaf curl virus infecting tomato in Northern Karnataka. African Journal of Agricultural Research. 2011; 6(5):1051-1057.

38. Reddy AB. Molecular Characterization, Epidemiology and Management of Tomato leaf curl virus (ToLCV) in Northern Karnataka. Ph. D. Thesis, University of Agricultural Sciences, Dharwad, 2006.

39. Roopa RS. Epidemiology and management of early blight of tomato caused by Alternaria solani (Ellis and Martin) Jones and Grout. M. Sc. (Ag.) Thesis, University of Agricultural Sciences, Dharwad, India, 2012.

40. Sevik MA, Arli-Sokmen M. Estimation of the effect of Tomato spotted wilt virus (TSWV) infection on some yield components of tomato. Phytoparasitica. 2012; 40:87-93.

41. Sharabani G, Shtienberg D, Borenstein M, Shulhani R, Lofthouse M, Sofer M et al. Effects of plant age on disease development and virulence of Clavibacter michiganensis subsp. michiganensis on tomato. Plant Pathology. 2013; 62:1114-1122.

42. Shelat M, Murari S, Sharma MC, Subramanian RB, Jummanah J, Jarullah B et al. Prevalence and distribution of Tomato leaf curl virus in major agroclimatic zones of Gujarat. Advances in Bioscience and Biotechnology. 2014; 5:1-3.

43. Singh K. Evaluation of tomato genotypes and its reaction against tolcv causing leaf curl disease in tomato (Solanum lycopersicon L.). Journal of Experimental Biology and Agricultural Sciences. 2014; 2(1S):120-125.

44. Singh RK, Rai N, Singh M, Singh R, Kumar P. Effect of climate change on Tomato leaf curl virus (ToLCV) disease in tomatoes. Indian Journal of Agricultural Sciences. 2015; 85(2):142-144.

45. Sivparsad B, Gubba A. Evaluation of tomato (Lycopersicon esculentum Mill.) plants with natural and transgenic resistance against Tomato spotted wilt virus (TSWV) isolates occurring in the Republic of South Africa (RSA). African Journal of Agricultural Research. 2011; 6(13):3013-3020.

46. Ssekyewa C. Incidence, Distribution and Characteristics of Major Tomato Leaf Curl and Mosaic Virus Diseases in Uganda. Ph. D. Thesis, Faculty of Bioscience Engineering, Ghent University, Ghent, Belgium, 2006.

47. Wheeler BEJ. An Introduction to Plant Diseases. John Wiley and Sons Limited, London. 1969, 301.

48. Yadav K, Sadhankumar PG, Nirmaladevi S, Mathew SK, George TE, Krishnan S et al. Vegetable Science. 2014; 41(1):63-65.