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Management of leaf curl virus disease of tomato (*Solanum lycopersicon* L.)

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Abstract

Tomato leaf curl disease caused by Tomato Leaf Curl Virus (ToLCV) and transmitted by the whitefly vector *Bemisia tabaci* is a devastating disease of tomato. In this experiment, the *in vivo* efficacy of chemical insecticides, botanical oils, and bioagents (alone and integrated with chitosan) were evaluated for the integrated management of ToLCV and its vector under field conditions. The results showed that, Thiamethoxam @ 25% WG was most effective with least disease incidence (1.33%) and significantly highest disease reduction (93.18%), followed by Imidacloprid 17.8 SL @ 0.1% (2.67% and 88.63%), *Pseudomonas fluorescens* + Chitosan (5.33% and 79.55%), and *Beauveria bassiana* + Chitosan (6.67% and 75.00%) after the second spray compared to the untreated control (36.00%). Correspondingly, treatment with Thiamethoxam @ 25% WG recorded the maximum fruit yield (84.44 q/ha) and the most profitable Incremental Cost-Benefit Ratio (1:23.76), followed by Imidacloprid 17.8 SL @ 0.1% (76.67 q/ha, 1:19.92), *Pseudomonas fluorescens* + Chitosan (70.00 q/ha, 1:15.28), and *Beauveria bassiana* + Chitosan (65.56 q/ha, 1:12.58). Botanical oils such as Neem oil and Karanj oil recorded the lowest disease suppression and yield enhancements but remained economically profitable and statistically superior to the control.

Keywords: Tomato Leaf Curl Virus, *Bemisia tabaci*, integrated management, Thiamethoxam, *Pseudomonas fluorescens*, Chitosan

1. Introduction

The tomato (*Solanum lycopersicon* L.) is a highly significant commercial vegetable crop globally and in India, ranking second only to the potato in total production (Anonymous, 2025) ^[1]. Its flexibility, yield high potential and outstanding nutritional profile which includes vital antioxidants like lycopene, vitamin C and vitamin A make it highly prized (Sain and Chadha, 2012; Govindappa *et al.*, 2013; Shelat *et al.*, 2014). Tomato output is significantly hampered by a number of biotic stresses, especially viral infections, despite its extensive cultivation and economic significance (Saikia & Muniyappa, 1989).

The most serious and damaging viral infection affecting tomatoes in India is known to be the tomato leaf curl virus (ToLCV) (Chakraborty, 2008; Jyothsna *et al.*, 2013; Ranjan *et al.*, 2013). This single-stranded DNA virus, which is a member of the *Geminiviridae* family, causes crippling symptoms such upward leaf curling, severe plant stunting, yellowing and blossom abortion. As a result, crop output is drastically reduced (Gafni, 2003; Crescenzi *et al.*, 2004; Pandey *et al.*, 2009). The whitefly, or *Bemisia tabaci*, is a highly effective insect vector that spreads the disease (Muniyappa and Veeresh, 1984; Uchibori *et al.*, 2013).

Managing viral infections spread by insects is a major concern since whiteflies are small, highly mobile, and challenging to keep out of agricultural regions (Mason *et al.*, 2000). Furthermore, because resistance is a complicated genetic trait, total genetic resistance in tomato cultivars has not yet been attained (Maruthi *et al.*, 2003; Singh, 2014). As a result, an integrated pest management (IPM) strategy that makes use of cultural, physical, biological, and chemical techniques is necessary for effective control (Kakati and Nath, 2014; Legg *et al.*, 2014; Loebenstein and Katis, 2014).

2. Materials and Methods

2.1 Seed Materials and Insecticides

Pure and viable tomato variety "Aryaman" seeds were gathered from the local market in Latur for the current study. The following insecticides were sprayed on tomatoes at the acceptable concentrations to prevent whiteflies. The necessary insecticides for the experiment were bought at the local market in Latur.

2.2 Botanicals

In order to successfully manage whiteflies in tomatoes and related crops, the following botanical extracts were applied in the suggested dosages in the current study. The College of Agriculture, Latur Farm, and a local market in Latur provided the botanicals needed to carry out the experiment. The following botanicals were used to control whiteflies in tomatoes and allied crops at the prescribed dosages.

2.3 Bioagents

In the current study, the bioagents were used in the recommended dosages to effectively control whiteflies in tomatoes and related crops. The bioagents required to conduct the experiment were obtained from the Spawn Production Unit, Department of Plant Pathology, V.N.M.K.V., Parbhani.

2.4 Chitosan treatment

The chitosan solution (1 mg/ml) made in 100 mM acetate buffer (pH 4.5) and adjusted with 1 N NaOH to pH 6.5 was sprayed on the upper and lower surfaces of the leaves at 25 DAS.

2.5 Experimental site

An experiment was carried out on the experimental farm of the Department of Plant Pathology, College of Agriculture Latur, during the Kharif seasons of 2025-2026. Three replications of the tomato cultivar "Aryaman," which is prone to leaf curl, were cultivated using a randomized block design (RBD).

2.6 Details of the experiment

Experimental design: Randomized Block Design

Season: Kharif -2025

Crop: Tomato

Variety: Aryaman

Spacing: 60cm × 60cm

Replications: 3

Treatments: 9

Plot Size: 3m × 3m

Table 1: Treatment Details

Tr. No	Treatments	Dose
T ₁	Imidacloprid 17.8% SL	0.5 ml/L
T ₂	Thiamethoxam 25% WG	0.5g/L
T ₃	Neem oil 10%	5.0 ml/L
T ₄	Karanj Oil 10%	5.0 ml/L
T ₅	<i>Pseudomonas fluorescens</i>	10 ml/L
T ₆	<i>Pseudomonas fluorescens</i> + Chitosan	10 ml/L +10 ml/L
T ₇	<i>Beauveria bassiana</i>	10 ml/L
T ₈	<i>Beauveria bassiana</i> + Chitosan	10 ml/L +10 ml/L
T ₉	Control	-

2.7 Statistical Analysis

A statistical analysis was performed on the data gathered from different field experiments. Percentage data were transformed into arcsine values prior to analysis, and standard error (S.E.) and critical difference (C.D.) at the 5% significance level were

computed using the approach of Panze and Sukhatme (1978).

3. Results and Discussion

3.1 Disease incidence

The results, as detailed in Table 1, demonstrate that all evaluated treatments had a statistically significant effect on the management of tomato leaf curl virus (ToLCV) under field conditions. Per cent disease incidence recorded before the first spray ranged between 5.33% and 6.67% and was statistically non-significant (NS), indicating uniform initial disease pressure across all treatment groups and the untreated control. However, after the first and second sprays, the applied treatments exhibited significant variations in disease incidence compared to the control group.

After the first spray, ToLCV incidence across all treatments ranged from 2.67% to 14.47%, compared to 22.67% in the untreated control (T₉). Treatment T₂ (Thiamethoxam @25% WG) emerged as the most effective treatment, recording the significantly lowest incidence (2.67%). This was followed by T₁ (Imidacloprid 17.8 SL @ 0.1%) at 4.00% and T₆ (*Pseudomonas fluorescens* + Chitosan) at 6.67%. Higher incidence levels among the treatments were observed in the botanical plots, specifically T₃ (Neem oil @ 5ml/L) at 13.33% and T₄ (Karanj oil @ 5ml/L) at 14.47%, while the untreated control exhibited the maximum disease prevalence.

Observations after the second spray showed a disease incidence range of 1.33% to 17.33% among the treated plots, whereas the untreated control reached 36.00%. Treatment T₂ remained the most superior treatment, maintaining the lowest incidence (1.33%). It was closely followed by T₁ (2.67%), T₆ (5.33%), and T₈ (*Beauveria bassiana* + Chitosan) at 6.67%. Treatments T₃ and T₄ recorded higher incidence rates of 14.67% and 17.33% respectively, though all treatments remained significantly more effective than the untreated control, which recorded the highest overall incidence of ToLCV.

In terms of overall effectiveness, the maximum per cent disease reduction over the control was achieved by T₂ (93.18%), followed closely by T₁ (88.63%). Notably, combining biocontrol agents with chitosan enhanced their efficacy; T₆ (*Pseudomonas fluorescens* + Chitosan) and T₈ (*Beauveria bassiana* + Chitosan) achieved substantial disease reductions of 79.55% and 75.00% respectively, visibly outperforming their standalone applications (T₅ at 68.20% and T₇ at 63.63%).

3.2 Whitefly Population

The results, as detailed in Table 2, demonstrate that every treatment applied had a statistically significant effect on the whitefly population per plant under field conditions. The whitefly population recorded prior to the first spray was statistically non-significant (NS), ranging from 3.00 to 4.00 per plant, indicating no initial differences between the treatment groups and the unsprayed control. However, after the first and second sprays, the treatments showed significant variation compared to the control group.

After the first spray, the whitefly population across all treatments ranged from 0.47 to 3.80 per plant, compared to 4.40 in the untreated control. T₂ (Thiamethoxam @25% WG) emerged as the most effective treatment, recording the significantly lowest population (0.47 whiteflies/plant). This was followed by T₁ (Imidacloprid 17.8 SL @ 0.1%) with 1.27, and T₆ (*Pseudomonas fluorescens* + Chitosan) with 1.73. Higher populations were observed in the botanical treatments, specifically T₃ (Neem oil @ 5ml/L) at 3.26 and T₄ (Karanj oil @ 5ml/L) at 3.80, while the untreated control exhibited the maximum whitefly prevalence.

Table 2: Integrated Disease management of ToLCV of tomato under field condition

Sr. No.	Treatments	Per cent incidence of ToLCV			Mean	% Disease reduction over control
		Before Spray	After I spray	After II spray		
T ₁	Imidacloprid 17.8 SL @ 0.1%	6.67 (14.96)*	4.00 (11.54)	2.67 (9.40)	3.34	88.63
T ₂	Thiamethoxam @25% WG	6.67 (14.96)	2.67 (9.40)	1.33 (6.62)	2.00	93.18
T ₃	Neem oil @ 5ml/L	6.67 (14.96)	13.33 (21.41)	14.67 (22.52)	14.00	52.28
T ₄	Karanj oil @ 5ml/L	5.33 (13.34)	14.47 (22.36)	17.33 (24.60)	15.90	45.80
T ₅	<i>Pseudomonas fluorescens</i>	5.33 (13.34)	9.33 (17.78)	9.33 (17.78)	9.33	68.20
T ₆	<i>Pseudomonas fluorescens</i> + Chitosan	5.33 (13.34)	6.67 (14.96)	5.33 (13.34)	6.00	79.55
T ₇	<i>Beauveria bassiana</i>	6.67 (14.96)	10.67 (19.06)	10.67 (19.06)	10.67	63.63
T ₈	<i>Beauveria bassiana</i> + Chitosan	5.33 (13.34)	8.00 (16.43)	6.67 (14.96)	7.34	75.00
T ₉	Untreated (Control)	6.67 (14.96)	22.67 (28.43)	36.00 (36.87)	29.34	-
	S.E.m ±	-	1.17	1.47		
	C.D. @ 5%	NS	3.49	4.37		

* Figures in parenthesis are angular transformations.

Observations after the second spray showed a range of 0.13 to 3.93 whiteflies per plant among treatments, while the untreated control reached 5.40. T₂ remained the most superior treatment with the lowest population (0.13). It was followed by T₁ (0.73), T₆ (1.27), and T₈ (*Beauveria bassiana* + Chitosan) with 1.73. Treatments T₃ and T₄ recorded 3.33 and 3.93 respectively, with the untreated control recording the highest overall whitefly population.

In terms of overall efficacy, T₂ recorded the maximum per cent

reduction over the control (93.88%), followed closely by T₁ (79.59%). The integration of chitosan with biocontrol agents notably enhanced their performance; T₆ (*Pseudomonas fluorescens* + Chitosan) achieved a 69.39% reduction compared to 51.02% in T₅ alone, and T₈ (*Beauveria bassiana* + Chitosan) achieved a 60.61% reduction compared to 42.86% in T₇ alone. The botanical treatments (T₃ and T₄) recorded the lowest overall reductions at 32.65% and 21.02%, respectively.

Table 3: Whitefly Population of ToLCV of tomato under field condition

Sr. No.	Treatments	Whitefly population/plant			Mean	% reduction over control
		Before Spray	After I spray	After II spray		
T ₁	Imidacloprid 17.8 SL @ 0.1%	3.33 (1.96)*	1.27 (1.33)	0.73 (1.11)	1.00	79.59%
T ₂	Thiamethoxam @25% WG	3.67 (2.04)	0.47 (0.98)	0.13 (0.79)	0.30	93.88%
T ₃	Neem oil @ 5ml/L	4.00 (2.12)	3.26 (1.94)	3.33 (1.96)	3.30	32.65%
T ₄	Karanj oil @ 5ml/L	3.33 (1.96)	3.80 (2.07)	3.93 (2.10)	3.87	21.02%
T ₅	<i>Pseudomonas fluorescens</i>	3.00 (1.87)	2.47 (1.72)	2.33 (1.68)	2.40	51.02%
T ₆	<i>Pseudomonas fluorescens</i> + Chitosan	3.67 (2.04)	1.73 (1.49)	1.27 (1.33)	1.50	69.39%
T ₇	<i>Beauveria bassiana</i>	3.33 (1.96)	2.80 (1.82)	2.80 (1.82)	2.80	42.86%
T ₈	<i>Beauveria bassiana</i> + Chitosan	3.33 (1.96)	2.13 (1.62)	1.73 (1.49)	1.93	60.61%
T ₉	Untreated (Control)	4.0 (2.12)	4.40 (2.21)	5.40 (2.43)	4.90	-
	S.E.m ±	-	0.05	0.08		
	C.D. @ 5%	NS	0.16	0.23		

* Figures in parenthesis are Square root transformed values.

**Plate 1:** Field view of integrated management of tomato leaf curl virus disease

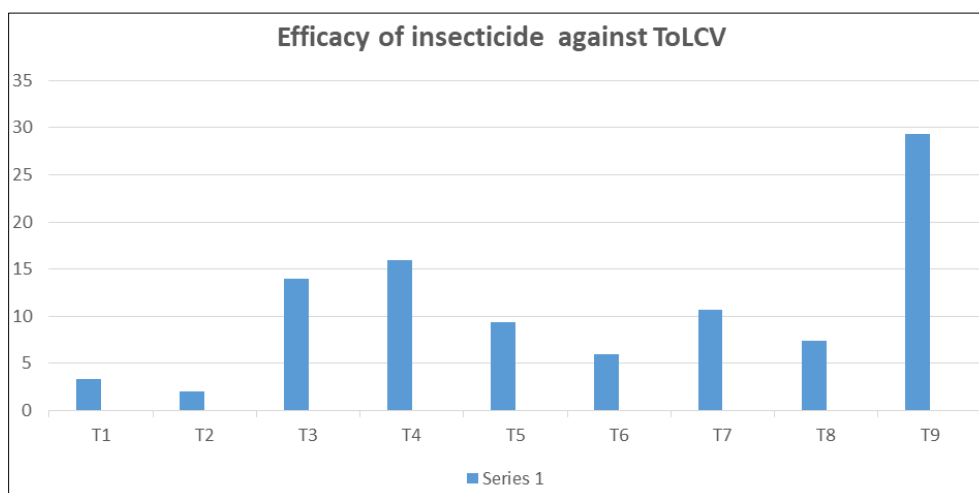


Fig 1: Efficacy of insecticides against ToLCV of tomato under field condition

Similar results on the superior efficacy of neonicotinoid insecticides, particularly Thiamethoxam and Imidacloprid, in suppressing whitefly (*Bemisia tabaci*) vector populations and significantly reducing Tomato leaf curl virus (ToLCV) incidence under field conditions have been previously reported by Mandal *et al.* (2010) [5], Walia *et al.* (2015) [11], and Sahu *et al.* (2018) [10]. The enhanced disease reduction observed when combining chitosan with biocontrol agents such as *Pseudomonas fluorescens* attributed to the synergistic induction of systemic resistance (ISR) and antiviral defense enzymes in tomato plants was similarly documented by Mishra *et al.* (2014) [7] and El-DougDoug *et al.* (2018) [2]. Furthermore, the moderate but statistically significant suppression of ToLCV incidence using botanical formulations like neem oil and karanj oil, compared to untreated control plots, is consistent with findings reported by Singh *et al.* (2012) and Naqvi *et al.* (2019) [8].

Imidacloprid (0.02%) and thiamethoxam (0.005%) both showed strong systemic suppression of *Bemisia tabaci*, with imidacloprid exhibiting prolonged persistence against viral symptom expression under varying seasonal conditions. Kumar *et al.* (2012) [4] reported similar results regarding the comparative efficacy of neonicotinoids across multi-season field evaluations. Additionally, both imidacloprid and thiamethoxam dramatically inhibit phloem sap consumption by about 90%, according to behavioral and electropenetrography (EPG) investigations by He *et al.* (2013) [3] and Miranda *et al.* (2016) [6]. Since the tomato leaf curl virus (ToLCV) is mostly infected during prolonged periods of vascular probing and feeding, this feeding inhibition is essential for disease control. Furthermore, the increased mortality and population decrease seen when chitosan is combined with bacterial antagonists (*Pseudomonas fluorescens*) or entomopathogenic fungi (*Beauveria bassiana*) are consistent with research by Sahayaraj *et al.* (2018) [9] and Mishra *et al.* (2014) [7], who attributed this synergy to chitosan's capacity to both disrupt insect cuticle integrity and stimulate host plant defense pathways.

4. Conclusion

The remarkable effectiveness of chemical insecticides in reducing the virus and its vector was demonstrated by field tests evaluating integrated management options. With the lowest whitefly population (0.13 per plant) and illness incidence (1.33%), as well as a 93.18% disease reduction over the control, thiamethoxam 25% WG proved to be the most successful and economically feasible treatment.

Disclaimer (Artificial Intelligence)

Author(s) hereby declare that no generation at technologies such as large language models (ChatGpt, COPILOT, etc.) and text to image generators have been used during the writing or editing of this manuscript.

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References

- Anonymous. Annual report of Ministry of Agricultural and Farmers Welfare. Directorates of Pulses Development, Government of India; 2025.
- El-DougDoug KA, Megahed AA, Othman BA. Induction of systemic resistance in tomato plants against tomato yellow leaf curl virus using chitosan and plant growth-promoting rhizobacteria. *International Journal of Virology*. 2018;14(1):32-41.
- He Y, Zhao J, Zheng Y, Desneux N. Assessment of neonicotinoid insecticides on feeding behavior and transmission efficacy of *Bemisia tabaci* vectors using electrical penetration graph (EPG) monitoring. *Journal of Pest Science*. 2013;86(2):261-269.
- Kumar SP, Patel SK, Kapopara RG, Jasrai YT, Pandya HA. Evolutionary and molecular aspects of Indian tomato leaf curl virus coat protein. *International Journal of Plant Genomics*. 2012;2012(1):417935.
- Mandal B, Mandal S, Pun KB, Varma A. Management of tomato leaf curl virus disease in tomato by using newer insecticides and border crops. *Indian Journal of Agricultural Sciences*. 2010;80(6):543-547.
- Miranda MP, Silva FC, Oliveira EE. Neonicotinoids impaired phloem sap ingestion by *Bemisia tabaci* and reduced secondary spread of begomoviruses. *Pest Management Science*. 2016;72(8):1533-1541.
- Mishra S, Jagadeesh KS, Krishnaraj PU, Prem S. Bio-control of tomato leaf curl virus (ToLCV) in tomato with chitosan supplemented formulations of under field conditions. *Australian Journal of Crop Science*. 2014;8(3):347-355.
- Naqvi SA, Perveen R, Rashid A. Comparative efficacy of

- biorational and botanical formulations against whitefly population and incidence of tomato leaf curl disease. Pakistan Journal of Agricultural Sciences. 2019;56(3):681-688.
9. Sahayaraj K, Madasamy P, Radhika S. Synergistic interaction of entomopathogenic fungus and chitosan formulations against sucking insect pests under field conditions. International Journal of Tropical Insect Science. 2018;38(1):44-52.
 10. Sahu RK, Roy D, Shafi Z. Evaluation of insecticides and biopesticides against whitefly (*Bemisia tabaci* Genn.) and tomato leaf curl virus (ToLCV) incidence. Journal of Pharmacognosy and Phytochemistry. 2018;7(5):2411-2415.
 11. Walia S, Kumar N, Sharma R. Bio-efficacy of chemical and biological treatments against and tomato leaf curl virus disease in tomato. International Journal of Tropical Agriculture. 2015;33(2):485-490.