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Sustainable Management of Tomato Leaf Curl Virus Disease and Its Vector, Bemisia Tabaci through Integration of Physical Barrier with Biopesticides

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Abstract:
Field experiments were conducted to evolve a suitable management strategy against Tomato leaf curl virus (ToLCV) disease and its whitefly vector, Bemisia tabaci. White nylon net as a physical barrier against whitefly in the nursery bed as well as two neem based formulations viz., Neembicidine and Bioneem as biopesticides were used in the main field, reduced ToLCV incidence, whitefly population and increased yield. The seedlings raised in the nursery bed covered with nylon net showed no ToLCV incidence, whereas, 8.0 percent incidence was recorded in the uncovered nursery bed. The best treatment was found where seedlings raised under nylon net cover in the nursery bed along with spraying of Neembicidine @ 2.0 per cent at 20 and 35 days after transplanting (DAT) showed no ToLCV disease incidence (0.00%) with highest yield (322.22 q/ha) followed by the treatment where seedlings were raised under covered condition as well as spraying of Bioneem @ 2.0 per cent at 20 and 35 DAT showed a low disease incidence of 5.33 per cent with 318.89 q/ha yield. Whereas seedlings raised under covered condition along with recommended conventional insecticide, Dimethoate @ 0.2% at 20 and 35 DAT showed disease incidence of 13.33 per cent with lower yield of 285.19 q/ha. The highest disease incidence was recorded in the untreated control plot as 89.33 per cent corresponding with lowest yield of 98.89q/ha.

Key words: *Tomato leaf curls virus disease, whitefly, insecticides, and management*

1. Introduction

Importance of tomato (Lycopersicon esculentum Mill.) is well established because of its nutritive value, high productivity, greater processing potentiality and wide ecological amplitude (Kalloo, 1989). The main constraint of tomato cultivation is the infection by the number of diseases among which Tomato leaf curl virus (ToLCV) disease is a serious threat to its production in India (Sastry and Singh, 1973). Losses due to this disease have been estimated to the extent of 90 to 100 per cent depending on the stage at which the crop is infected (Saikia and Muniyappa, 1989). The incidence of ToLCV disease in the crop depends primarily on the immigration of vectors from alternative hosts, which act as reservoir of both virus and vector and the ease with which the vectors could acquire the virus from infected plants had little impact on disease incidence in the tomato crop (Ramappa, 1998). It is also appeared that very low rate of vector immigration into tomato crop would suffice to cause almost total infection (Holt, 1998). Though it is an evident that in the infectivity test, 4 to 46 per cent of the whiteflies B. tabaci collected from ToLCV infected fields were found viruliferous (Ramappa, 1993). B. tabaci trapped on cylindrical sticky yellow traps on the day of tomato transplanting in the main field, the migration of B. tabaci increased in subsequent days of planting, indicating that only the migrating B. tabaci are highly responsible for the ToLCV spread (Venkatesh, 2000). Hence, pesticides play an important role in managing vector populations by reducing the number of individuals that can acquire and transmit a virus, thereby potentially lowering disease incidence. Despite the inherent difficulties associated with vector borne viruses, several insecticides were evaluated by spraying of insecticides. Management of ToLCV has been attempted by several workers by controlling vectors either by using insecticides or by other cultural practices as well as by growing tolerant or resistant genotypes (Singh et al., 2000; Singh and Awasthi, 2004), but satisfactory control has been hard to achieve. In the recent years due to over reliance on commercial insecticides resulted the evolution of several highly insecticide resistant biotypes of whitefly in India (Cock, 1986). There is a need to find out alternative agents that are pest specific, non-toxic, biodegradable, safe to predators and parasites, less prone to pest resistance and less expensive. Taking this background into account, a

field experiment was conducted to develop a suitable management strategy against ToLCV disease and its vector by integrating physical barrier in the nursery bed to combat early infection along with eco-friendly neem-based pesticides in the main field.

2. Materials and Methods

The field investigations were carried out in the experimental field of Assam Agricultural University (AAU), Jorhat at two stages. Tomato cv. 'Arka Alok' was selected for the experiments. In the first stage, two nursery beds of size 5x1m were prepared. Immediately after sowing, one nursery bed was covered with 40 mesh nylon net and the other bed kept uncovered for 30 days. In the second stage, the field experiment was laid out in a split plot design with 2 main plots viz., M_1 = Nursery bed with nylon net cover and M_2 = Nursery bed without nylon net cover with 8 sub plot treatments applied were (1) Control(To), (2) Nimbicidine @0.5 per cent(T_1), (3) Nimbicidine @1 per cent(T_2), (4) Nimbicidine @2 per cent(T_3), (5) Bioneem @0.5 per cent(T_4), (6) Bioneem @1 per cent(T_5), (7) Bioneem @2 per cent(T_6) and (8) Dimethoate @0.2% (T_7) each in three replication.

The treatments were imposed on 20 and 35 DAT when there was significant vector population. Thirty days old seedlings were transplanted in the plots of 3x1.5 m with a spacing of 60 x 30cm. All the package of practices recommended by AAU was followed except vector management practices. The natural incidence of ToLCV and whitefly population were recorded by direct count method separately for each treatment at 7 days interval starting from 7 days after sowing(DAS) upto 28 DAS in the nursery beds and at 10 days interval starting from 10 DAT upto 100 DAT. Observations on vector population were recorded from ten randomly selected plants from the net area of each plot. Direct counting of whitefly was done on tomato leaves between 5.00am-7.00am.The yield of tomato was recorded per plot and expressed in quintals per hectare (q/ha). The data from field observations were analysed by using split plot and randomized block design described by Panse and Sukhatme (1978).

3. Results and Discussion

3.1. Detection of ToLCV disease and Whitefly in the nursery seedlings

The results presented in the table1 showed that the seedlings raised in the nursery bed with nylon net, covering (M_1) were free from ToLCV disease infection with no record of whitefly. While, seedlings without nylon net, covering (M_2) were free from ToLCV disease incidence upto 14 DAS. An initial disease incidence of 4.00 and 8.00 percent, corresponding to whitefly population of 2 and 4 were recorded at 21 and 28 days respectively. The effect of protection in the nursery bed revealed that the seedlings raised with nylon net covering against whitefly vector greatly reduced the percentage of ToLCV disease incidence (0.00%) as compared to uncovered nursery bed (8.00%). These results conform to those described by Saikia and Muniyappa(1989), Hyadar et. al.(1990).

3.2. Effect of different treatments under field condition

There was a significant reduction of ToLCV disease incidence in all the treatments where seedlings raised with nylon net covering (Fig.1&2). The treatments where seedlings raised under nylon net covering with two spraying of Nimbicidine @ 2.0 per cent at 20 and 35 DAT was completely free from ToLCV disease incidence. The treatments where conventional insecticides, Dimethoate @ 0.2% were used in both protected and unprotected conditions recorded 13.33 and 70.67 per cent, respectively. The disease incidence in all the treatments ranged from 0.00 to 82.67 per cent while the infection in the control plot was 89.33 per cent (Table 2). The per cent reduction of disease over control was the highest in seedlings raised with nylon net covering plus 2.0 per cent Nimbicidine (100.00) followed by 97.01 and 94.03 in the treatments where seedlings raised with nylon net covering plus Nimbicidine @ 1.0 per cent and seedlings raised with nylon net covering plus Bioneem @ 2.0 per cent , respectively. While the lowest (7.45 per cent) was observed in the treatment where seedlings were raised without nylon net covering plus Bioneem @ 0.5 per cent.

Analysis of data on effect of the main plots with different treatments and its interaction with a ToLCV disease incidence revealed a highly significant result between the two main plots recording a low mean of 11.83 per cent in a nursery bed with nylon net cover in comparison to a highest mean of 72.00 per cent in nursery bed without nylon net cover. Effect of different treatments on per cent ToLCV disease incidence revealed a low mean record of 29.33 per cent in Nimbicidine @ 2.0 per cent followed by 34.67, 37.33 and 38.00 per cent in Nimbicidine @ 1.0 per cent, Bioneem @ 2.0 per cent and Dimethoate @ 0.2 per cent, respectively which were statistically at par (Table 3). The analysis of data on effect of main plots with different treatments and its interaction with whitefly population revealed highly significant results between the two main plots recording a low mean of 6.29 number of whitefly in seedlings raised with nylon net covering in comparison to a high mean of 18.79 in seedlings raised without nylon net covering. Mean effect of different treatments on whitefly population showed a mean number of whitefly 9.00 in the treatment with 2.0 per cent Nimbicidine which was statistically at par with remaining treatments excepting treatments control and 0.2 per cent Dimethoate (table 4). The effect of different treatments in the main field on the yield of tomato revealed a highly significant results of yields between the two main plots recording a high mean of 290.50 q/ha in seedlings raised under nylon net covering as against 137.63 q/ha in seedlings raised without nylon net covering. Mean effects of different treatments recorded a high yield of 246.30 q/ha in 2.0 per cent Nimbicidine which was statistically at par with 2.0 per cent Bioneem and 1.0 per cent Nimbicidine with 242.78 and 237.59 q/ha of yield, respectively (table 5). The results of the experiments presented in the table 3, 4 & 5 showed that both Nimbicidine and bioneem had significant effect on ToLCV disease incidence, whitefly population and yield of tomato plants. The two most promising treatments where seedlings raised under nylon net covering followed by 2 sprayings of Nimbicidine @ 2.0 per cent and seedlings raised under nylon net covering followed by 2 sprayings of bioneem @ 2.0 per cent recorded 0.00 and 5.33 per cent incidence of ToLCV and 322.22 and 318.89 q/ha yield(Fig.3). However the control treatment where seedlings raised without net covering and

seedlings raised with nylon net covering plus two sprayings of Dimethoate @ 2.0 ml/l recorded 44.00 and 13.33 per cent ToLCV disease incidence along with 177.78 and 285.19 q/ha yield, respectively. Hence, low mean ToLCV disease incidence (11.83%), low mean whitefly population (6.29), and high mean yield (290.50q/ha) was recorded in the field with different treatments where seedlings were raised under nylon net cover. These findings elucidate the efficiency of nylon net barrier in combination with application of neem based formulations in managing the ToLCV disease in a sustainable and highly cost effective manner. These results were confirmatory to the earlier works conducted by researchers on management of whitefly through application of neem formulations (Patel et al., 1994; Dimetry et al., 1996; Tandale et al., 1997; Mann et al., 2001; Senguttuvan et al., 2005).

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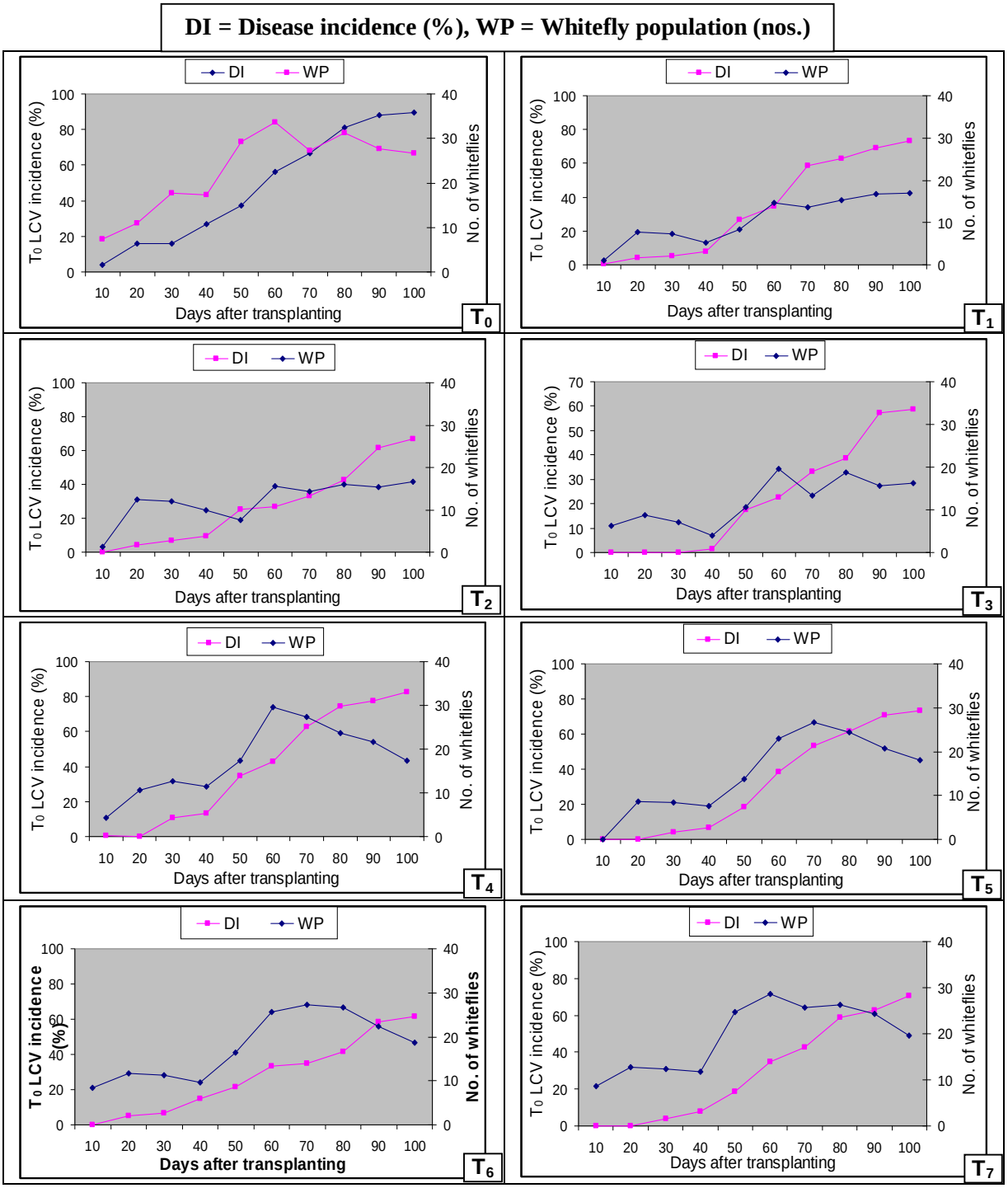

Figure 1: Effect of Different Treatments on Tomato Leaf Curl Virus Disease Incidence And Whitefly Population Recorded At 10 Days Interval in the Main Field

- M_2 = Nursery bed without nylon net cover [T_0 = Control; T_1 = Spraying of 0.5% Nimbicidine; T_2 = Spraying of 1% Nimbicidine; T_3 = Spraying of 2% Nimbicidine; T_4 = Spraying of 0.5% Bioneem; T_5 = Spraying of 1% Bioneem; T_6 = Spraying of 2% Bioneem; T_7 = Dimethoate @ 1 ml/lit] at 20 and 35 DAT

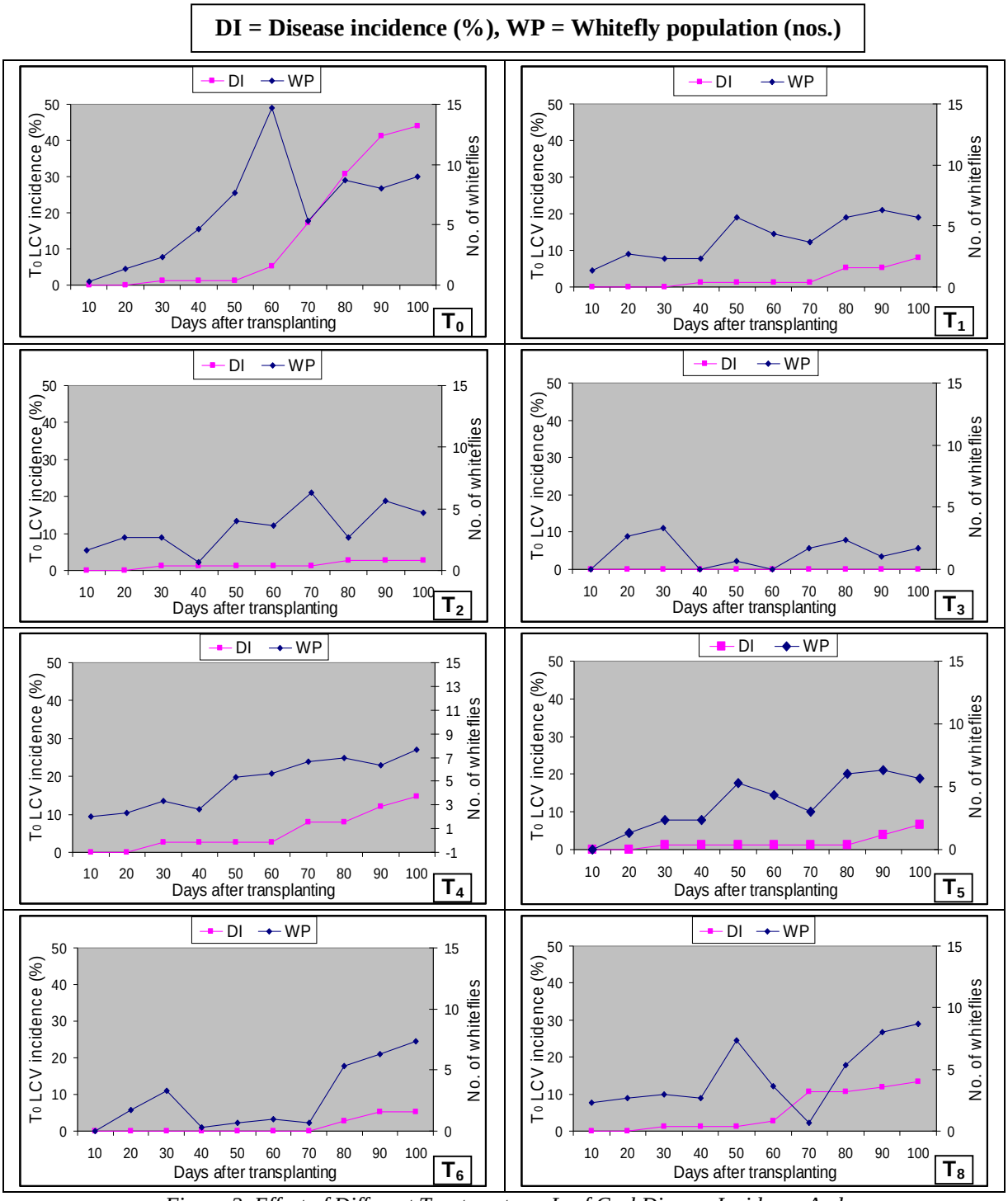

Figure 2: Effect of Different Treatments on Leaf Curl Disease Incidence And Whitefly Population Recorded At 10 Days Interval in the Main Field

- M_1 = Nursery bed with nylon net cover [T_0 = Control; T_1 = Spraying of 0.5% Nimbicidine; T_2 = Spraying of 1% Nimbicidine; T_3 = Spraying of 2% Nimbicidine; T_4 = Spraying of 0.5% Bioneem; T_5 = Spraying of 1% Bioneem; T_6 = Spraying of 2% Bioneem; T_7 = Dimethoate @ 1 ml/lit] at 20 and 35 DAT

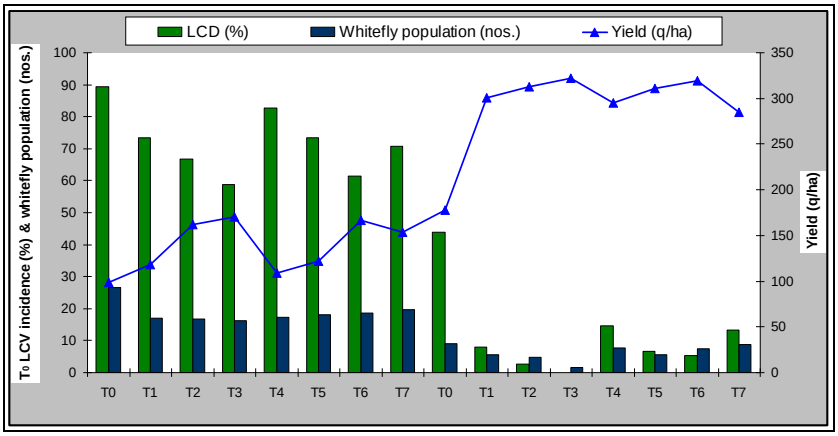

Figure 3: Effect of Different Treatments on Leaf Curl Disease Incidence, Whitefly Population and Yield

- M_2 = Nursery bed without nylon net cover; M_1 = Nursery bed with nylon net cover [T_0 = Control; T_1 = Spraying of 0.5% Nimbicidine; T_2 = Spraying of 1% Nimbicidine; T_3 = Spraying of 2% Nimbicidine; T_4 = Spraying of 0.5% Bioneem; T_5 = Spraying of 1% Bioneem; T_6 = Spraying of 2% Bioneem; T_7 = Dimethoate @ 1 ml/lit] at 20 and 35 DAT.

Treatment	Number of seedlings examined	Number of whitefly recorded at different days after sowing				Percent leaf curl disease incidence			
		7 DAS	14 DAS	21 DAS	28 DAS	7 DAS	14 DAS	21 DAS	28 DAS
M_2	25	0	0	2	4	0	0	4.0	8.0
M_1	25	0	0	0	0	0	0	0	0

Table 1: Effect of different treatments employed in nursery bed on whitefly population and leaf curl disease incidence

- DAS = Days after sowing
- M_1 = Nursery bed with nylon net cover
- M_2 = Nursery bed without nylon net cover

Treatment		Whitefly population (nos.)	LCD incidence (%)	Percent disease reduction over control	Yield (q/ha)	Percent increase of yield over control
Main plots	Sub plots					
M_2	T_0	26.67_{a} (5.21)	19.33_{a} (78.08)		98.89_{e}	
	T_1	17.00_{abc} (4.07)	73.33_{b} (58.92)	17.91	118.00_{e}	19.33
	T_2	16.67_{ab} (4.11)	66.67_{b} (56.94)	25.37	162.22_{d}	64.04
	T_3	16.33_{abc} (4.06)	58.67_{bc} (50.38)	34.32	170.37_{d}	75.28
	T_4	17.33_{ab} (4.13)	82.67_{ab} (65.61)	7.45	109.11_{e}	10.34
	T_5	18.00_{ab} (4.29)	73.33_{b} (58.96)	17.91	122.22_{e}	23.59
	T_6	18.67_{a} (4.37)	61.33_{be} (51.66)	31.34	166.67_{d}	68.54
	T_7	19.67_{a} (4.48)	70.67_{b} (57.37)	20.89	153.56_{d}	55.28
M_1	T_0	9.00_{bcd} (3.06)	40.00_{c} (41.55)	50.75	177.78_{d}	79.78
	T_1	5.67_{de} (2.40)	8.00_{d} (16.08)	91.05	300.74_{abc}	204.12
	T_2	4.67_{de} (2.23)	2.67_{de} (7.69)	97.01	312.96_{ab}	216.47
	T_3	1.67_{e} (1.46)	0.00_{e} (0.01)	100.00	322.22_{a}	225.84
	T_4	7.67_{cd} (2.81)	14.67_{d} (22.37)	83.58	295.11_{bc}	198.42
	T_5	5.67_{de} (2.43)	6.67_{de} (14.80)	92.53	311.11_{ab}	214.60
	T_6	7.33_{de} (2.68)	5.33_{de} (13.17)	94.03	318.89_{ab}	222.47
	T_7	8.67_{bcd} (3.00)	13.33_{d} (21.37)	85.08	285.19_{c}	188.39
CD (P=0.05)		1.14	13.49			
CV (%)		19.99	21.04			

Table 2: Effect of different treatments on whitefly population, leaf curl disease incidence and yield of tomato

- Means within columns separated by Duncan's Multiple Range Test (DMRT), P = 0.05
- Means followed by the same letter shown in subscript(s) are not significantly different
- LCD incidence (%) and whitefly population (nos.) are mean of three replications
  M_2 = Nursery bed without nylon net cover; M_1 = Nursery bed with nylon net cover [T_0 = Control; T_1 = Spraying of 0.5% Nimbicidine; T_2 = Spraying of 1.0% Nimbicidine; T_3 = Spraying of 2.0% Nimbicidine; T_4 = Spraying of 0.5% Bioneem; T_5 = Spraying of 1.0% Bioneem; T_6 = Spraying of 2.0% Bioneem; T_7 = Spraying of Dimethoate @ 1 ml/lit] at 20 and 35 DAT.

Treatments	**Tomato leaf curl virus disease incidence recorded at 100 days after transplanting (per cent)**								
	Sub plots (T)								**Mean**
Main plots (M)	**T_0**	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**	**T_6**	**T_7**	
M_2	89.33 (78.08)	73.33 (58.92)	66.67 (56.94)	58.67 (50.38)	82.67 (65.61)	73.33 (58.96)	61.33 (51.66)	70.67 (57.38)	72.00 (59.74)
M_1	44.00 (41.55)	8.00 (16.08)	2.67 (7.69)	0.00 (0.01)	14.67 (22.37)	6.67 (14.80)	5.33 (13.17)	13.33 (21.37)	11.83 (17.13)
Mean	66.67 (59.81)	40.67 (37.50)	34.67 (32.32)	29.33 (25.19)	48.67 (43.99)	40.00 (36.88)	37.33 (36.51)	38.00 (35.27)	
Effect	CD								
M	13.05								
T	9.33								
M x T	NS								

Table 3: Effect of different treatments and its interaction with Tomato leaf curl virus disease incidence

- Data are mean of 3 replicationsData within parentheses are angular transformed values
- M_2 = Nursery bed without nylon net cover; M_1 = Nursery bed with nylon net cover [T_0 = Control; T_1 = Spraying of 0.5% Nimbicidine; T_2 = Spraying of 1.0% Nimbicidine; T_3 = Spraying of 2.0% Nimbicidine; T_4 = Spraying of 0.5% Bioneem; T_5 = Spraying of 1.0% Bioneem; T_6 = Spraying of 2.0% Bioneem; T_7 = Spraying of Dimethoate @ 1 ml/lit] at 20 and 35 DAT

Treatments	Whitefly population recorded at 100 days after transplanting (nos.)								
	Sub plots (T)								Mean
Main plots (M)	T_0	T_1	T_2	T_3	T_4	T_5	T_6	T_7	
M_2	26.67 (5.21)	17.00 (4.07)	16.67 (4.11)	16.33 (4.06)	17.33 (4.13)	18.00 (4.29)	18.67 (4.37)	19.67 (4.48)	18.79 (4.34)
M_1	9.00 (3.06)	5.67 (2.40)	4.67 (2.23)	1.67 (1.46)	7.67 (2.81)	5.67 (2.43)	7.33 (2.68)	8.67 (3.00)	6.29 (2.51)
Mean	17.83 (4.13)	11.33 (3.24)	10.67 (3.17)	9.00 (2.76)	12.50 (3.47)	11.83 (3.36)	13.00 (3.52)	14.17 (3.74)	
Effect	CD								
M	1.16								
T	0.78								
M x T	NS								

Table 4: Effect of different treatments and its interaction with whitefly population

- Data are mean of 3 replications Data within parentheses are angular transformed values
- M_2 = Nursery bed without nylon net cover; M_1 = Nursery bed with nylon net cover [T_0 = Control; T_1 = Spraying of 0.5% Nimbicidine; T_2 = Spraying of 1.0% Nimbicidine; T_3 = Spraying of 2.0% Nimbicidine; T_4 = Spraying of 0.5% Bioneem; T_5 = Spraying of 1.0% Bioneem; T_6 = Spraying of 2.0% Bioneem; T_7 = Spraying of Dimethoate @ 1 ml/lit] at 20 and 35 DAT

Treatments	Yield(q/ha)								
	Sub plots (T)								Mean
Main plots (M)	T_0	T_1	T_2	T_3	T_4	T_5	T_6	T_7	
M_2	98.89	118.00	162.22	170.37	109.11	122.22	166.67	153.56	137.63
M_1	177.78	300.74	312.96	322.22	295.11	311.11	318.89	285.19	290.50
Mean	138.33	209.37	237.59	246.30	202.11	216.67	242.78	219.37	
Effect	CD								
M	25.28								
T	16.12								
M x T	22.79								

Table 5: Effect of different treatments and its interaction with yield

- Data are mean of 3 replications
- M_2 = Nursery bed without nylon net cover; M_1 = Nursery bed with nylon net cover [T_0 = Control; T_1 = Spraying of 0.5% Nimbicidine; T_2 = Spraying of 1.0% Nimbicidine; T_3 = Spraying of 2.0% Nimbicidine; T_4 = Spraying of 0.5% Bioneem; T_5 = Spraying of 1.0% Bioneem; T_6 = Spraying of 2.0% Bioneem; T_7 = Spraying of Dimethoate @ 1 ml/lit] at 20 and 35 DAT

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