Vegetable Science (2020) 47(2): 201-206

Evaluation of IDM modules for tomato leaf curl disease management in Madhya Pradesh

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Received: December 2020/ Accepted: February 2021

Abstract

Comparative suitability assessment field trials of four different IDM modules for the management of leaf curl disease of tomato were conducted at farmer's field. The trial cites were located in Chorgarhi, Mankesher and Upani village of district Sidhi, Madhya Pradesh. The trials were conducted during 2014-15, 2015-16 and 2016-17 as On Farm Trial. Trend of results obtained during past three years of experimentation indicated that all the management modules tested were found superior over predominant farmer's practice (M_1). The module M_4 having tolerant variety, seed treatment with insecticide, nursery raising in nylon net cages of 40 mesh, root dip of seedling with systemic insecticide Imidacloprid, as to enable nursery to be transplanted, remain uninfestable by white flies and thrips at least up to 2 weeks after transplanting. Further, initial roughing at 3 weeks after transplanting and two subsequent sprays of systemic insecticide before flowering, at 25 and 45 DAT was found effective not only in reducing disease incidence but decreased total number of white fly per plant as well. This package of practice was also able to enhance tomato yield with favorable cost benefit ratio. Module 4 was followed by module T_3, where most of the measures mentioned in module 4 were followed except use of nylon net. Therefore, it is very much evident that the seed treatment with insecticide and seedling dip measures along with physical intervention to deploy nylon net to prevent assess of vectors to nurseries inside the cage, hold the great promise to have an almost leaf curl free crop.

Key words: Tomato, Leaf curl, Integrated Disease Management, On Farm Trial (OFT)

Introduction

India ranks fourth in tomato production, producing nearly 18.22 mt of tomato from an area of 8.80 lakh ha with an average of 20.70 t/ha (Anonymous 2013). Among all the vegetable crops, tomato stand second after Potato in the term of production. Madhya Pradesh state is one of the major tomato producers and occupies second position in acreage. During 2012-13, in Madhya Pradesh, tomato had been grown in 62.59 thousand ha area with 1845.0 thousand metric ton production and 29.48 metric ton per hectare productivity (Anonymous 2013). The Madhya Pradesh state has shown profound growth in tomato production and rank third among all the tomato producing states of India with an estimated production of 1937.37 thousand metric ton in the cropping year 2013-14. Shahdol, Jhabua, Ratlam, Sagar are among the major tomato producing districts in the state.

As for as pest problem in Madhya Pradesh is concern, the leaf curl is one of the precarious diseases of tomato, inflicting sizable losses in yield and quality. It is caused by tomato leaf curl virus, a Geminivirus. The whitefly (*Bemisia tabaci*) apart from being a most economically important pest throughout the world causing extensive direct damage as a sucking pest, it transmits tomato leaf curl virus (ToLCV), as well and in turn causes heavy losses round the year (Patel and Khare2013., Sangeeta et al. 2021). ToLCV has very vast host range and is capable of infecting more than twenty-five species across dozens of plant families. Whiteflies were supposed to acquire virus inoculum from infected plants and transmit it to tomato (Green et al.1987). It is also established in various literatures that symptomless pepper and other asymptomatic host plants of Solanaceae and some other plant families may also serve as reservoir for the acquisition and transmission of ToLCV. The vector also has very large host range on which it can thrive and reproduce and that to may vary from region to region. Quantum of loss due to this disease depends on the time of infection and is reported to go up to 99.7%

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(Kalloo 1996). Shashti and Singh (1973) recorded 92.3% loss when symptom occurred within 30 days after transplanting. However, some tolerant tomato cultivars can produce fair enough yield even after harbouring hidden ToLCV infection. To manage leaf curl problem, farmers often use numerous insecticides (Singh and Prajapati 2014, Ahmed et al. 2001) either singly or in combination to protect their crop, however, most of the times they fail to succeed. Farmers often indiscriminately use huge amount of insecticides which some time leads to pest resurgence, residual toxicity in tomato fruits and destruction of earthworm and health hazards. Keeping all in view, management of tomato leaf curl diseases through Integrated Disease Management methods is immensely needed. This is also the facts that management of viral disease is very difficult and almost impossible because of the special pathogenic nature of the virus. The impetus for present study was our initial survey programme which we have conducted in Sidhi district during 2013-14 where we have seen that even after multiple spraying farmers are unable to manage the leaf curl problem. Therefore, in this regards present study focus on analyzing prevalence, severity of tomato leaf curl disease to achieve reduction in disease incidence and severity through validation of residue free IPM packages which has already been standardized elsewhere (Pandey et al. 2005).

Materials and Methods

Survey of the Field: During 2013-14 survey were conducted for the presence of leaf curl disease of tomato in 10 different villages viz., Upani, Panwar, Mankesher, Jhalwar, Chorgarhi, Chuwahi, Tikari, Tamsar, Khorba and Padaria with varying latitudes and longitudes (Table-2) in three different fields were chosen from each village of five different blocks of Sidhi district of Madhya Pradesh during month of December- January. In the each visited field three plots of size 5x5 meter were selected to observe overall disease incidence and severity based on visual symptoms. Data were recorded on disease incidence (%) by counting total number of plant as well as diseased plant. Per cent disease incidence was calculated by following formula as suggested by Nene (1972).

% Disease Incidence = (No. of diseased units/ total no. of assessed units)x 100

Severity of leaf curl disease of tomato was determined by the observation of disease symptoms. Disease severity was scored by using 0-6 scale (Shelat et al. 2014), where 1= no disease, 2= 1-5%, 3= 5-12 % , 4= 12-25 % , 5= 25-50 % and 6= >50 % infection.

Field Experiment: To study the effect of different management practices and their combination on disease progress, whiteflies population dynamics, disease incidence and yield of tomato, the field experiments (OFT) were conducted during the rabi season of 2014-15, 2015-16 and 2016-17 at 18 farmers' fields of Chorgarhi, Jhalwar and Upani Villages of Sidhi district by Krishi Vigyan Kendra, Sidhi (M.P.). The trials were laid out in completely randomized block design having four leaf curl management modules (with control treatments) (Table 1) with 6 replications. The experimental field was prepared by ploughing thrice with cultivator followed by planking for fine tilt and smooth surface. Recommended dose of FYM (1 t/ha^{-1}) were mixed in soil 30 daysbefore transplanting of seedlings and also apply recommended dose of fertilizers (50:250:100 kg NPK / ha^{-1} with 10 kg ^{1}borax and 50 kg-^{1} zinc sulfate).Twenty-five days old seedlings of variety Abhishek-1 were transplanted at 60 X 45 cm spacing. Standard agronomic practices were followed to grow the crop. Incidence of the disease was recorded by taking counts of twenty randomly selected and tagged plants leaving the borders at seventh day after applying the treatment. Percent disease incidence and reduction in disease incidence were calculated by following formulae suggested by Nene (1972).

$$\text{Disease Incidence (\%)} = \frac{\text{No. of diseased Plants x 100}}{\text{Total no. of assessed Plants}}$$

$$\text{Reduction in Disease Incidence (\%)} = \frac{\text{Disease Incidence in Untreated Plots x 100}}{\text{Disease Incidence in Treated Plots}}$$

Estimation of Vector Population: To study the vector population five plant per treatment and three terminal leaves per plant were randomly selected and tagged. White fly populations were recorded directly on leaves early in the morning when they were less active. Observations were recorded at seven days interval starting from 7th days after transplanting (DAT) up to last harvesting of fruits.

Estimation of Cost-Benefit Ratio: Tomato yield of each plot was taken separately and yield of each module was calculated by cumulating the successive plucking from respective field and computing the yield to quintal per hectare. The data were pooled and evaluated and finally arranged according to their yield performance. The benefit cost ratio (C:B Ratio) of different modules was calculated by estimating cost of cultivation /ha and return due to yield yield/ha. Average market price of Tomato was assumed to Rs 5-9/kg. Cost benefit ratio was calculated by using following formula: CBR = Grass income/ total cost of cultivation

The field data was analyzed in Randomized Block design by F test for significance and critical difference of values were calculated at 5% level.

Result and Discussion

High occurrence of tomato leaf curl incidence was observed in all surveyed fields of Sidhi district of Madhya Pradesh (Table-2). Maximum leaf curl infestation was recorded in Chorgarhi village of Rampur Naikin developmental block followed by Padaria in Sihawal block. Although variation in leaf curl incidence was observed in different fields of surveyed villages. The minimum disease incidence of leaf curl in tomato was reported in Jhalwar village of Rampur Naikin developmental block. Such findings may be attributable to variety grown and prevalence of white flies at initial stages of crop. The present findings further supported the view of Shelat et al. (2014). During the present study, the impact of different IDM modules on the severity of leaf curl disease and population of white flies in tomato were observed. The data presented in table 3 revealed that all the treatments caused significant reduction in disease incidence and population of whitefly. Lowest leaf curl disease incidence was recorded in the treatment M_4 followed by the treatments M_3 and then treatment M_2. The highest disease incidence was recorded in T_1 (Control farmers practice). The leaf curl disease incidence was found varied from 9.13 to 69.78 per cent depending on module followed. Percent diseases decrease across the years clearly indicating the high degree of consistency and that to Treatment T_4 was most consistent (Av 87%).

Since disease transmission is mediated by whiteflies and number of whiteflies per plant has direct bearing on disease incidence, so average number of whiteflies present on tomato plant in different treatment was observed. The present findings revealed that lower population of white flies were found in the treatment T_4 (0.66 to 1.16 whiteflies/ three terminal leaves) followed by the treatment T_3 (1.5 to 1.66 white flies/ three terminal leaves) and T_2 (4.5 to 5.16 whiteflies/ three terminal leaves). The control plot (T_1) harbors significantly higher population of white flies, in all the three years (9.66 to 10.16 whiteflies/ three terminal leaves). It was found that performance of IDMs across the years was consistent and that to the T_4 was found best (Table 4). The results depicted in Table 5 clearly indicates that significantly maximum yield of tomato was recorded in

Table 1: Details of different Integrated leaf curl management modules in tomato

IDM Modules	Details
M_1	Three sprays of Dimethioate @ 1ml/ litre of water (farmers practice) Check
M_2	Seed treatment with Imidachloprid -17.8SL @ 3ml/ 10 lit.+ Two spray of Neem oil @ 1 per cent at 25 and 45 DAT).
M_3	Seed treatment with Imidachloprid -17.8SL @ 4ml/ 10 lit. of water + spray of Neem oil @ 1 per cent in nursery and 25DAT+ need based spray of Imidachloprid -17.8SL @125 ml/ ha before flowering)
M_4	Tolerant variety +seed treatment with Thiomethoxam-75 WG@5 gram / kg seed + Nursery raised in nylon net of 40 gauge mesh for leaf curl management + before transplanting root dip in Imidachloprid -17.8SL(@ 4ml/10 lit. of water) for 30 minute + rouging out and burning of infected plants + two spray of Thiomethoxam-25WG@125 gram/ha before flowering at 25 and 45 DAT

Table 2: Incidence of leaf curl of tomato in across the Blocks of District Sidhi

Locations	Block	Variety	GPS Location		Disease Incidence (%)	
			Latitude	Longitude	Range	Average
Upani	Sidhi	VNRT-98, Abhinav, Laxmi	24^{0}24' 24.8"	81^{0}57'23.8"	21-79	51.5
Panwar	Sidhi	NS-816	24^{0}23' 53.0"	81^{0}50'34.5"	46-82	65.3
Mankesher	Rampur Naikin	Vaibhav	24^{0}24' 24.8"	81^{0}57'23.8"	31-83	59.3
Jhalwar	Rampur Naikin	VNRT-98	24^{0}24' 1.8"	81^{0}34'34.3"	8-69	28.0
Chorgahi	Rampur Naikin	Abhishek	24^{0}18' 53.3"	81^{0}24'40.5"	38-894	70.5
Chuwahi	Majhauli	Roshani	24^{0}08' 29.5"	81^{0}36'6.2"	32-76	39.0
Tikari	Majhauli	Nirmal-449	24^{0}10' 6.3"	81^{0}51'35.5"	0-89	45.0
Tamsar	Kushmi	Abhishek	24^{0}12' 1.3"	81^{0}50'49.5"	43-82	67.5
Khorba	Sihawal	NS-816	24^{0}33' 59"	81^{0}07'32.4"	11-65	41.7
Padaria	Sihawal	Abhishek	24^{0}26' 6.4"	82^{0}06'57.0"	35-88	69.0

Table 3: Effect of IDMs on Leaf curl disease incidence

Treatment	Disease incidence (%)			Per cent disease decrease over check (T_1)		
	2014-15	2015-16	2016-17	2014-15	2015-16	2016-17
T_1	65.7	68.06	69.78	-	-	-
T_2	36.83	35.4	31.25	44.78	47.98	55.21
T_3	12.56	17.63	14.66	81.16	74.09	78.99
T_4	9.133	10.16	8.86	86.30	85.07	88.21
CD at 5%	6.21	4.62	6.0	-	-	-
SE	2.04	1.52	1.97	-	-	-

Table 4: Effect of IDMs on population of vector (White fly)

Treatment	White fly population (No. per 3 terminal leaf)		
	2014-15	2015-16	2016-17
T_1	10	10.16	9.66
T_2	5.16	4.5	4.66
T_3	1.66	1.5	1.51
T_4	1.16	0.66	0.66
CD at 5%	0.9	1.69	0.99
SE	0.29	0.78	0.33

Table 5: Effect of different treatments on yield and yield component of tomato

Treat ment	Yield of Tomato (Tonnes /ha)			% Yield increase over local check(T_1)			No. of fruits/ plant			% no. of fruits increase over Local check		
	Ist Year	IInd Year	IIIrd Year	Ist Year	IInd Year	IIIrd Year	Ist Year	IInd Year	IIIrd Year	Ist Year	IInd Year	IIIrd Year
T_1	27.73	27.51	26.63	-	-	-	16.0	15.0	16.33	-	-	
T_2	35.70	35.02	36.59	28.74	27.09	35.92	20.16	18.16	20.83	26.0	19.75	28.13
T_3	39.77	38.18	39.67	43.41	38.48	47.02	23.5	22.83	24.16	46.78	4834	48.94
T_4	41.42	42.46	42.83	49.37	53.91	58.42	25.83	26.33	26.16	61.43	70.81	61.44
CD at 5%	1.62	2.31	1.88	-	-	-	2.85	2.48	2.26	-	-	-
SE	0.53	0.761	0.62	-	-	-	0.93	0.81	0.77	-	-	-

Table 6: Economics of different leaf curl management practices in tomato.

Treat ment	Cost of Cultivation (Rs in Thousand./ha)			Grass income (Rs. in Lakhs /ha)			Net income (Rs. in Lakhs/ha)			B: C ratio 1:		
	Ist Year	IInd Year	IIIrd Year	Ist Year	IInd Year	IIIrd Year	Ist Year	IInd Year	IIIrd Year	Ist Year	IInd Year	IIIrd Year
T_1	48.79	48.81	49.17	1.94	1.92	1.86	1.45	1.43	1.37	3.91	3.94	3.79
T_2	52.59	52.61	52.97	2.49	2.45	2.56	1.97	1.92	2.03	4.75	4.62	4.83
T_3	54.78	54.88	55.64	2.78	2.67	2.77	2.23	2.12	2.22	5.08	4.86	4.99
T_4	56.28	56.32	56.33	2.88	2.97	2.99	2.32	2.42	2.43	5.12	5.41	5.32

@ Rs 700/q.

the treatment T_4 41.42; 42.46 and 42.83 t/ha in Ist year, IInd Year and IIIrd year i.e. 2014-15; 2015-16 and 2016-17, respectively. T_4 followed by T_3 (39.77 ;38.18 and 39.67 tones/ha, respectively, in all three years). Number of fruits/plant were also highest (25.83; 26.33 and 26.16 fruits/plant in the year 2014-15; 2015-16 and 2016-17, respectively) in treatment T_4 followed by T3 (23.5; 22.83 and 24.16 fruits/ plant in 2014-15; 2015-16 and 2016-17, respectively). Whereas the lowest numbers of fruits per plant (16; 15.0 and 16.33 in the year 2014-15; 2015-16 and 20136-17, respectively) were recorded in control plot (T_1). Yield increase compare to check was consistently and significantly very high across the years and Treatment T_4 was found best as for as percent yield increase and percent no of fruit increase was concern.

The economics **(**Table 6**)** was also calculated after the experimentation based on the expenditure incurred for different IDMs imposed and the income from the yield of tomato and the data are presented in table 5. The maximum net profit of Rs. 232396.0 to 243475.0/ ha was obtained from treatment T_4 followed by T_3 (Rs. 212377.9 to 223608.2 / ha) which is significantly higher than the usual practice done by the farmers of that area. On the basis of the observations and the data collected during the experimentation, the role of the whiteflies as disease transmitting vectors on the incidence of leaf curl disease of tomato could be perceived very well. However, it could be reduced by applying integrated package of practices not only for the disease or insect management but also for the overall health of the plants during the crop growth period starting from the field preparation to the nursery management till final harvest. The above findings are also in consonance with the work done by the earlier workers viz., Dhanuj and Verma (1987); Verma et al. (1989); Ramirez and Maxwell (1995) for the role vector in disease development.

Ahmed et al. (2001) reported that application of imidachloprid protected tomato plant against disease and Choskit et al. (2017) suggested that the use of imidachloprid as seed treatment + root dip + foliar application was found very effective to reduce the leaf curl incidence of tomato. Combined application of Carbofuran (Soil application) and Imidachloprid (seed treatment and spray) proved significantly superior and caused maximum reduction in white fly population with highest cost benefit ratio (Sharma et al. 2017). Rajasri et al. (2009) suggested that application of Thiomethaxam effectively controlled the white fly populations and reduced ToLCV incidence, improved yield of tomato fruits with higher net returns. Among the number of insecticides used, imidacloprid, acetamiprid, nitenpyram, thiamethoxam and diafenthiuron give significant result against aphids, whiteflies and other insect pests (Bacci

et al. 2007, Zeshan et al. 2015). But their alone or multiple uses may possesslots of health and environmental problems, which is prime cause of concern now. Since, vector control is very important in viral diseases management and even a single whitefly was able to acquire virus from infected tomato plant and may transmit the same to test plant, after a 24h of acquisition feeding. The whitefly remains viruliferous for 12 days. Muniyappa et al. (2000) reported that female whiteflies were more efficient (around 95%) than males (up to 25%) in transmitting the virus. Therefore, because of the above evolutionary dividends to vector, the systemic and integrated approach to manage vector and in turn viral leaf curl is badly needed. The appropriate stage of and time of management practice is of utmost importance, otherwise even after extensively use of toxicant singly or in combination fail to protect losses to crop.

Therefore, finally it can be concluded that considering pest residual toxicity, Resistance development against pesticide and sustainability, the Integrated Disease Management modules are the need of the hour through which not only yield enhancement but also the sustainability of the soil health and environment, could be achieved. Hence, best effective treatment module which takes into account most of the concerns mentioned above could be recommended for the farmers.

सारांश

मध्य भारत में टमाटर गुर्चा रोग प्रबन्धन हेतु चार एकीकृत रोग प्रबन्धन माड्यूल का तुलनात्मक उपयुक्तता परीक्षण किसान के प्रक्षेत्र पर किया गया। यह प्रायोगिक परीक्षण मध्य प्रदेश स्थित सीधी लिा अन्तर्गत, चोरगढ़ी, मानेश्वर एवं उपानी ग्रामों में आन फार्म ट्रायल (OFT) के रूप में 2015–2017 के मध्य तीन रवी सीजन में लगाया गया। विगत तीन सालों के परीक्षण परिणाम इंगित करते है कि समग्र रूप से कमोलेश सभी परीक्षण माड्यूल किसान की प्रचलित पद्धति से अच्छे पाये गये। इन सभी परीक्षण पाड्यूल में से एम–4 तुलनात्मक तौर पर सबसे अच्छा पाया गया था। इस माड्यूल में रोग सहनशील प्रजाति का चयन कीटनासक से बीच उपजचार, पौध उपचार, धनी (40 मेस) नाइलान जाली का प्रयोग जिससे सफेद मक्खी काटा रोग संचरण रोका जा सके आदि अवयवों के साथ ही साथ, पौध रोपायी के बाद संक्रमित पौधों की छटाई (रोगिंग) के बाद 25 दिन उपरान्त व 40 दिन उपरान्त कीटनाशक का छिड़काव भी सम्मिलत है। यह माड्यूल उत्पादकता वृद्धि के साथ ही साथ लागत व्यय एवं मुनाफा की दृष्टि से भी लाभप्रद है। एम–4 माड्यूल के बाद एम–3 माड्यूल भी उपयोगी है अतः माड्यूल एम–4 एवं एम–3 जो कि दूसरा अच्छा माड्यूल है को किसानो हेतु अनुसंसा की जा सकती है।

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