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Integrated management of major tomato diseases

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ABSTRACT: Five integrated pest management (IPM) packages for management of major tomato diseases were evaluated during *kharif* seasons of 2015-18 using tomato cv.NS501. The most effective integrated schedule comprised of (a) seed priming with Seed pro (combination product of *Bacillus subtilis* and *Trichoderma harzianum*) @4g/ kg of seed followed by soil application of Seed pro @10g/kg of soil while filling of pro trays and soil drenching of Seed pro @5% after seed germination (b) Covering nursery with 50- mesh nylon net, (c) border planting with two rows of maize at least 15 days before transplanting of seedlings in the main field, (d) seedling dip with 0.1% (carbendazim 12%+mancozeb 63% WP) at the time of transplanting. (e) Main field sequential spraying with acephate 75% WP @1.5g/l on 10 days after transplanting (DAT), fipronil 5% SC @1.5ml/l on 20 DAT, copper hydroxide 77% WP (2.0g/l) on 25 DAT, imidacloprid 70% WG @2g/15l on 40 DAT, and fenamidone 10% + mancozeb 50% WDG (0.25%) three times from 45 DAT at 10 days interval. Analysis of pooled data indicated that the treatment involving IPM schedule was found statistically significant and superior with consistent reduction of late blight by 31.40%, early blight by 41.17% and tomato leaf curl by 67.47% over control with highest yield (377.77 q/ha) and incremental cost benefit ratio (10.3). Pesticide residue analysis revealed no detection of residues in harvested fruits.

Keywords: Integrated pest management schedule, pesticide residues, tomato diseases, seed Pro

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is one of the predominantly cultivated vegetable crops in India. Tomato production is limited by pests and diseases. In India, late blight (*Phytophthora infestans* (Mont.) de Bary), early blight (*Alternaria solani* (Ellis & G. Martin) L.R. Jones) and tomato leaf curl (ToLcV) are reported as the major diseases affecting tomato crop (Sastry and Singh, 1973; Datar and Mayee, 1981; Chowdappa *et al*., 2013). In India these diseases are being managed mainly using pesticide application. Pesticide residues present on vegetables is a serious health concern. This may be attributed to non-judicious use of pesticides and its application methods. In this context, pesticide safety, regulation of pesticide use, proper application technologies and integrated pest management are some of the key strategies for minimizing human exposure to pesticides. There is a need for studies related to these issues in India (Abhilash and Singh, 2009; Bhardwaj, and Sharma, 2013).

Food and Agriculture Organisation guidance document on pest and pesticide management policy development gives stronger emphasis on development and adoption of improved integrated pest management (IPM) practices. IPM helps minimize pesticide usage and associated health and environmental risks (FAO, 2010). In India, there are limited works on these aspects in tomato except for few studies against limited diseases (Gajanana *et al*., 2006; Sharma *et al*., 2009). In this context, the present study was undertaken with an objective to formulate and evaluate an integrated pest management (IPM) schedule for management of major diseases of tomato.

MATERIALS AND METHODS

Field trials were conducted during 2015-18 kharif seasons at Hesaraghatta research farm of ICAR-Indian Institute of Horticultural Research, Bengaluru. The experiment site is located at an altitude of 890 m above mean sea level with coordinates 13°8'11.96"N, 77°29'52.70"E. The site receives annual rainfall of 805 mm. In four years of the trial, the plots were located in the same field.

Raising of crop

Thirty five days old seedlings of tomato hybrid NS-501 with known susceptibility to pest and diseases were transplanted in open field conditions on 20th July. The experiment was laid in randomized complete block design with four blocks (replications). Each plot measured 4m × 3m with 25 plants transplanted on raised beds with polythene mulch at spacing 100 cm × 45 cm. Plots were drip irrigated. Fertilizer application and weeds management were made as per standard package of practice of ICAR-Indian Institute of Horticultural Research, Bengaluru, for open field cultivation of tomato for vegetable production (Sadashiva *et al*., 2018). No pesticide applications were made other than the pesticides treatment imposed in the trial. In all treatments fruit borers were managed with two sprays of spinosad 45.0% SC. Data on marketable yield per plot were recorded and converted in to yield per hectare and expressed in quintal per hectare.

Management interventions and disease assessment

The treatment 1 comprised of only biological and cultural interventions; seed priming with Seed Pro @ 4g/ kg of seed followed by soil application of Seed pro @10g/ kg of soil while filling of pro trays and soil drenching of Seed pro @ 5% after seed germination. Covering nursery with 50 mesh nylon net, border row planting (two rows) of maize at least 15 days before transplanting of seedlings in the main field. In main field three sprays with Seed pro @1.0% at 10 days interval starting from 45 days after transplanting (DAT). Seed pro is a microbial formulation developed at ICAR-IIHR, Bengaluru. It is a consortium of *Bacillus subtilis* OTPB1 and *Trichoderma harzianum* OTPB3 which are known to promote plant growth and induce systemic resistance against early and late blight pathogens in Tomato (Chowdappa *et al*., 2013; Kumar *et al.,* 2015).

Treatment 2 included fungicides and cultural interventions; Seed treatment with captan 50% WP (2g/kg) + drenching with fosetyl Al 80% WP @0.1% immediately after germination + spray with copper hydroxide 77% WP (2.0g/l) at 3-5 leaf stage. seedling dip with 0.1% (carbendazim 12% + mancozeb 63% WP) at the time of transplanting, spraying with copper hydroxide 77% WP (2.0g/l) on 25 DAT and fenamidone 10% + mancozeb 50% WDG (0.25%) three times from 45 DAT at 10 days interval.

Treatment 3 included insecticides and cultural interventions; covering nursery with 50-mesh nylon net, border row sowing of two rows maize at least 15 days before transplanting of seedlings in the main field, followed by main field sequential spraying with acephate 75% WP @1.5g/l on 10 DAT, fipronil 5% SC @1.5ml/l on 20 DAT, copper hydroxide 77% WP (2.0g/l) on 25 DAT, imidacloprid 70% WG @2g/15l on 40 days after transplanting.

Treatment 4 comprised of cultural interventions, fungicides and insecticides treatment. The interventions were seed treatment with captan 50% WP (2 g/kg) + drenching with fosetyl Al 80% WP @0.1% immediately after germination + spray with copper hydroxide 77% WP (2.0 g/l) at 3-5 leaf stage in nursery. In main field the interventions were seedling dip with 0.1% (carbendazim 12%+mancozeb 63% WP) at the time of transplanting, sequential spraying with acephate 75% WP @1.5 g/l on 10 DAT, fipronil 5% SC @1.5 ml/l on 20 DAT, copper hydroxide 77% WP (2.0 g/l) on 25 DAT, imidacloprid 70% WG @ 2 g/15 l on 40 DAT, and fenamidone 10% + mancozeb 50% WDG (0.25%) three times from 45 DAT at 10 days interval.

Treatment 5 was integrated management schedule with cultural, biological and chemical components. The interventions were; seed priming with Seed pro @4g/ kg of seed followed by soil application of Seed pro @10g / kg of soil while filling of pro trays and soil drenching of Seed pro @5% after seed germination. Covering nursery with 50- mesh nylon net, border row planting (two rows) of maize at least 15 days before transplanting of seedlings in the main field, followed by seedling dip with 0.1% (carbendazim 12% + mancozeb 63% WP) at the time of transplanting. Main field sequential spraying with acephate 75% WP @1.5g/l on 10 DAT, fipronil 5% SC @1.5ml/l on 20 DAT, copper hydroxide 77% WP (2.0g/l) on 25 DAT, imidacloprid 70% WG @ 2g/15l on 40 DAT, and fenamidone 10% + mancozeb 50% WDG (0.25%) three times from 45 DAT at 10 days interval.

Treatment 6 was non spray control with cultural components

Spraying was done manually with battery operated knapsack sprayer. The trial was conducted under natural epiphytotics without any artificial inoculation of the pathogen. Early blight severity was assessed based on assessment key of 0-5 scale (Pandey *et al.,* 2003) where 0 = free from infection, 1= one or two necrotic spots on a few lower leaves of plant, 3= many spots coalesced on the leaves, covering 25% of the surface area of the plant, 4= irregular, blighted leaves and sunken lesions with prominent concentric rings on stem, petiole, and fruit, covering 40%-50% of the surface area, 5= whole plant blighted, leaves and fruits starting to fall.

Late blight severity on leaves was assessed by using 0-5 scale where, 0=no symptoms, 1=1 to 11% disease (midpoint 6%), 2=12 to 38% disease (midpoint 25%), 3=39 to 61% disease (midpoint 50%), 4=62 to 88% disease (midpoint 75%), 5=89 to 100% disease (midpoint 95%) (Seidl - Johnson *et al.,* 2015).

Per cent disease index (PDI) was calculated based on field scoring data by using the formula.

$$PDI = \frac{\text{Sum of all numerical disease rating}}{\text{Total number of observations} \times \text{Maximum disease grade}} \times 100$$

For leaf curl assessment, per cent incidence was recorded. PDI and incidence data were subjected to angular transformation before analysis. Data were subjected to ANOVA at p=0.05% significance using SAS 9.3. Critical differences between treatments were compared by Duncan's multiple range tests at 5%.

Pesticide residue analysis

The persistence of harmful residues of insecticides and fungicides applied in the present study in tomato fruits was assessed after harvest. Pesticide residue of tomato fruit samples of NS 501 from best treatment i.e. integrated management practices were analyzed at Food Safety Referral Laboratory (Lab ID FSRL-20181102-139), ICAR-Indian Institute of Horticultural Research, Hessaraghatta Lake post, Bengaluru-560089 by following AOAC official method 2007.01(Lehotay, 2007).

RESULTS AND DISCUSSION

The results on early blight, late blight and tomato leaf curl disease reduction over the years are presented in Tables1, 2 and 3. Analysis of pooled data indicated that the treatment involving IPM schedule was found statistically significant and superior with consistent reduction of late blight by 31.40%, early blight by 41.17% and tomato leaf curl by 67.47% over control. Among three major diseases, the schedule was found very effective in tomato leaf curl management where as moderately effective in early and late blight reduction. This may be attributed to bio efficacy of pesticides used in the study and lack of resistance component.

Three years, 2015, 2016, 2018 and pooled yield data of tomato is presented in the Fig.1. In 2017, the fruits could not be harvested owing to crop damage by heavy rain and flooding stress but disease severity assessment were done at flowering and fruiting stage. Among different treatments, integrated treatment T5 recorded highest yield of 377.77 Q/ha followed by 326.09 t/ha in T4. Least yield of 148.37 Q/ha was recorded in untreated control. Modules 4 and 5 were statistically at par with each other in disease control, but module 5 was better than 4 in yield and economic returns. Increased yield recorded in integrated module may be attributed to growth stimulation activity of microbial consortia present in Seed pro formulation. Seed pro is known to promote plant growth in Tomato (Chowdappa *et al*., 2013; Kumar *et al.,* 2015).The incremental cost benefit ratio of 10.3 was recorded for this best treatment.

Pesticide residue analysis of harvested tomato fruit samples from the best treatment revealed no detection of acephate, fipronil, imidacloprid, fenamidone, carbendazim and mancozeb residues in tomato samples. It is evident from results of the present investigation that integrated management schedule developed incorporating cultural, biological and sequential spray of pesticides, interventions was effective in management of three major diseases of tomato *viz.,* late blight, leaf curl and early blight in kharif season. Further, this schedule was not only economical but also addressed the residue

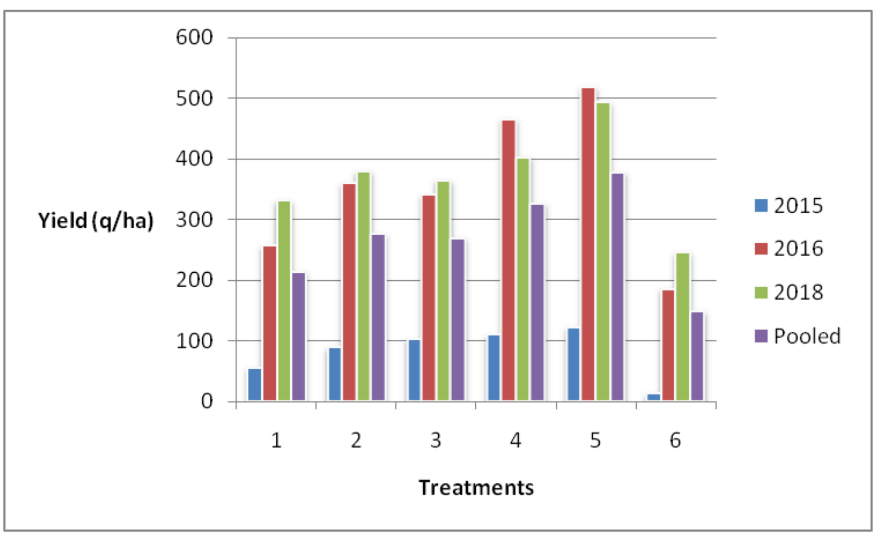

Fig 1. Yield in different treatments in tomato hybrid NS501 over three years at Bengaluru

Table 1: Effect of different modules on early blight disease severity

Treatment	Early blight (PDI)					Per cent disease reduction over control
	2015	2016	2017	2018	Pooled	
T_1	13.63 (21.66)*	30.43 (25.73)	30.00 (33.15)	29.97 (33.14)	26.01 (28.42)	21.89
T_2	14.87 (22.67)	28.87 (23.47)	23.34 (28.80)	27.23 (31.43)	23.58 (26.59)	29.18
T_3	20.23 (26.72)	34.05 (31.39)	31.12 (33.78)	27.92 (31.86)	28.33 (30.94)	14.92
T_4	12.03 (20.29)	18.97 (25.62)	28.89 (32.42)	26.13 (30.73)	21.51 (27.27)	35.40
T_5	7.13 (15.48)	22.62 (27.17)	25.56 (30.26)	23.03 (28.66)	19.59 (25.39)	41.17
T_6	24.4 (29.59)	40.95 (43.03)	35.56 (36.58)	32.28 (34.60)	33.30 (35.95)	
CD (p=0.05)	2.27	3.26	NS	1.51	4.63	
CV%	21.78	24.41	-	6.60	20.18	

* Values in the parenthesis are arcsine transformed

Table 2. Effect of different modules on late blight severity

Treatment	Percent disease index (PDI)					Per cent disease reduction over control
	2015	2016	2017	2018	Pooled	
T_1	23.4 (28.92)	25.39 (29.09)	64.44 (53.39)	38.90 (38.56)	38.03 (37.49)	11.06
T_2	14.27 (22.19)	18.50 (23.94)	51.12 (45.62)	35.21 (36.38)	29.78 (32.03)	30.35
T_3	21.87 (27.87)	33.51 (30.49)	68.89 (56.10)	41.67 (40.18)	41.49 (38.66)	2.97
T_4	14.53 (22.40)	18.75 (25.40)	53.34 (46.90)	34.21 (35.78)	30.21 (32.62)	29.34
T_5	14.83 (22.64)	16.63 (23.71)	52.23 (46.25)	33.64 (35.43)	29.33 (32.01)	31.40
T_6	29.27 (32.74)	26.83 (34.91)	71.12 (57.54)	43.83 (41.44)	42.76 (41.66)	-
CD (p=0.05)	1.51	3.41	4.13	1.66	2.15	-
CV%	16.78	15.75	10.85	6.56	24.35	-

* Values in the parenthesis are arcsine transformed

Table 3. Effect of different modules on tomato leaf curl incidence

Treatment	(% incidence)					Per cent disease reduction over control
	2015	2016	2017	2018	Pooled	
T_1	20.9 (27.19)	18.15 (25.17)	17.5 (24.15)	18.67 (25.58)	18.81 (25.52)	17.35
T_2	14.3 (22.21)	17.53 (24.7)	20.00 (26.18)	17.95 (25.01)	17.45 (24.53)	23.33
T_3	7.45 (15.83)	11.12 (19.56)	12.5 (20.45)	10.89 (19.17)	10.49 (18.75)	53.91
T_4	11.13 (19.48)	10.72 (19.1)	15.00 (22.49)	12.96 (21.03)	12.45 (20.53)	45.29
T_5	6.7 (15.00)	11.14 (19.45)	15.00 (22.49)	7.34 (15.69)	10.05 (18.16)	67.47
T_6	24.63 (29.74)	21.35 (27.45)	22.5 (27.84)	22.57 (28.34)	22.76 (28.34)	-
CD (p=0.05)	1.52	2.46	NS	2.16	2.88	-
CV%	16.08	11.31	-	20.49	18.61	-

* Values in the parenthesis are arcsine transformed

Table 4. Pesticide residue analysis results of fruit sample

Pesticide	Residues in ppm	LOD (ppm)	Specifications/MRL	Techniques*
Acephate	ND	0.005	NA	LC-MS/MS
Fipronil	ND	0.005	NA	LC-MS/MS
Carbendazim	ND	0.005	NA	LC-MS/MS
Fenamidone	ND	0.005	NA	LC-MS/MS
Imidacloprid	ND	0.005	NA	LC-MS/MS
Mancozeb	ND	0.005	NA	GC-MS/MS

LOD-Limit of Detection, Maximum Residue Limit, ppm-Parts per million (mg/Kg), NA-Not available, ND-Not detected *AOAC official method 2007.01

problem in tomato.

In earlier study conducted at Indian Institute of Horticultural Research, Bengaluru, under NATP project, it was observed that tomato grown as per IPM practices were safer to consume at harvest compared to those grown as per conventional cultivation practices, with chemical control as the sole means of plant protection (Gajanana *et al*., 2006; Sharma *et al*., 2009). In this package not all the major diseases were not addressed. A successful IPM package with safe pesticide residue was developed for cabbage at IIHR which was comprehensive schedule against several insect pests and diseases of economic importance (Sharma *et al*., 2006). The results of this study are in conformity with results of Asit *et al*. (2017) who managed late blight, early blight, target leaf spot, Sclerotium and leaf curl diseases of tomato in the Gangetic plains of eastern India with maize barrier cropping, Seed pro application, covering nursery with insect proof nylon mesh and sequential spraying of insecticides and fungicides.

In this study, a comprehensive IPM schedule for management of major tomato diseases was formulated and validated. This schedule serves as baseline management schedule for further refinement and development of location specific schedules in the region. Future line of work should be on prioritization of available management tactics supported by suitable decision support system to reduce the interventions and input costs. There is a need to integrate the current disease management schedule developed with insect management modules to develop a holistic field-by-field integrated pest management schedule in tomato aided by weather based forecasting and related decision support systems.

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