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Integrated disease management for tomato in island ecosystem of Andaman

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ABSTRACT

Integrated disease management modules were developed for the management of disease complex in tomato during 2008-09, 2009-10 and 2010-11, under Island ecosystem of Andaman and Nicobar Islands. All isolates of biocontrol agents significantly parasitized the test pathogens *in vitro* but the isolate Tv-CARI-73 was most effective against all the pathogens, *viz*., *Pythium* sp., *Phytophthora* sp., *Rhizoctonia solani*, *Sclerotium rolfsii* and *Fusarium oxysporum* f.sp. *lycopersici* followed by Th-CARI-50, Tv-CARI-85 and Th-CARI-70. In IDM module - I, T_{10} (combination of seed treatment + seedling dip + soil application of biocontrol agents) treatment was most effective in reduction of disease incidences in tomato (except bacterial wilt) followed by T_{11}, T_{12}, T_{11} and T_9. This treatment was also recorded with highest yield (227.5 q/ha). In IDM module - II, T_7 (integration of bioagents with the fungicides) treatment was recorded with highest percent reduction in incidence of all diseases (86.0% bacterial wilt, 56.2% leaf curl, 76.4% basal stem rot and 74.8% fusarial wilt) and increase in yield (75.3%) followed by T_1, T_9, T_8, T_{13} and T_{14}. Similarly, T_2 treatment in IDM module - III, was most effective in reduction of disease incidence (89.9% bacterial wilt, 56.5% leaf curl, 77.0% basal stem rot and 75.7% fusarial wilt) and corresponding yield increase (83.6%) of tomato, followed by T_3, T_4 and T_1 treatments.

Key words: Andaman island, biocontrol, integrated disease management modules, tomato.

INTRODUCTION

Tomato (*Lycopersicon esculentum* L.) is one of the important vegetable crops in India. India occupies important position in area and production of tomato in the world. Tomato is most common vegetable crops among the farmers and is cultivated across the Bay Islands to meet local demand. But production of tomato is severely affected by several biotic and abiotic factors. High incidence of diseases in tomato is primarily due to high temperature, rainfall, relative humidity round the year and existence of dense forest areas. Among the diseases, damping off of seedlings (*Pythium* sp., *Phytophthora* sp., *Rhizoctonia solani, Sclerotium rolfsii, Fusarium solani*, etc.), bacterial wilt (*Ralstonia solanacearum*), fusarial wilt (*Fusarium oxysporum* f. sp. *lycopersici*), basal stem rot (*Sclerotium rolfsii*), leaf mosaic (Tomato mosaic virus) and leaf curl (Tomato leaf curl virus) are major diseases causing considerable loss in yield (Bhagat *et al*., 2). The use of chemical pesticides is the most common practice to save the crop infestation by the various diseases. Protection of tomato plants from plant diseases by application of chemical pesticides is often difficult, particularly when plant foliage is expanded, dense and covers the crown zone, where infection of pathogens usually initiate. Emerging strategies for plant disease management involve biological and integrated control by applying antagonistic microorganisms alone or in combination and/or alternating with fungicides or natural botanicals or bioagents (Bhagat *et al*., 1). *Trichoderma* spp. are among the most frequently isolated soil fungi and present in plant root systems (Bhagat and Pan, 5; Bhagat *et al*., 2). Similarly, *Pseudomonas fluorescens,* a bacterial antagonist, have been used as biofungicides against several soil borne and foliar pathogens under greenhouse and field conditions (Kumar *et al*, 9; Sharma *et al*., 11). Both bioagents are opportunistic, avirulent plant symbionts and functions as parasites and antagonists of many phytopathogenic fungi, thus protecting plants from disease (Bhagat and Pan, 3). The bioefficacy of chemical pesticides in tomato, particularly in Island ecosystem (humid tropical climate) is very low due to run off loss by high rain fall or rapid degradation of chemicals by high sunshine intensity. The integration of cultural practices, botanical and biocontrol agents not only helpful in suppression of disease complexes in tomato but also reduce the quantity as well as number of sprays of chemical pesticides. Therefore, present investigation was aimed to develop integrated disease management module for tomato under island ecosystem by integration of cultural practices, botanicals, biocontrol agents and need based chemical pesticides.

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MATERIALS AND METHODS

Four isolates of *Trichoderma* (Accession No.: MTCC 9993, MTCC 9990, MTCC 9997 and MTCC 9681) and one isolate of *P. fluorescens* (Psf-1) isolated from rhizosphere soil of tomato, were evaluated against five pathogens, *viz*., *Pythium* sp., *Phytophthora* sp., *R. solani, S. rolfsii* and *F. o.* f. sp*. lycopersici* by dual culture test (Bhagat *et al*, 2). The fresh culture of *P. fluorescens* was streaked on the solidified PDA medium opposite to the respective pathogen. Per cent inhibition of mycelial growth of pathogen was calculated as per formula adopted by Bhagat *et al.* (2). Mass production of *Trichoderma* isolates was made on wheat bran + 20% mustard cake as per method followed by Bhagat and Pan (3, 5) and effective c.f.u. (1×10^8 cfu/g) was maintained in the formulated product. *P. fluorescens* was mass multiplied in Potato Dextrose Broth (PDB) and mixed with talc powder (2:1, talc powder: *Psuedomonas* culture) to attain final inocula (1×10^{10} cfu/g).

A field trial for three IDM modules was conducted at Sippighat Farm during the year 2008-09, 2009-10 and 2010-11. The cultivar LE -3704 was used and the experiment was laid out in randomized block design with three replications.

Module-I comprised of bioagents, neem cake and neem seed oil for management of disease complexes of tomato. The details of treatment schedules were: T_1: Seed treatment with Tv-CARI-73 @10 g/kg of seed; T_2: Seed treatment with Th-CARI-50 @10 g/kg of seed; T_3: Seed treatment with Tv-CARI-85 @10 g/ kg of seed; T_4: Seed treatment with Psf-CARI-1@10 g/kg of seed; T_5: T_1 + seedling dip @10 g/l of water + soil application of Tv-CARI-73 enriched FYM and neem cake @ 5.0 kg/m^2; T_6: T_2 + seedling dip @10 g/l of water + soil application of Th-CARI-50 enriched FYM and neem cake @ 5.0 kg/m^2; T_7: T_3 + seedling dip @10 g/l of water + soil application of Tv-CARI-85 enriched FYM and neem cake @ 5.0 kg/m^2; T_8: T_4 + seedling dip @10 g/l of water + soil application of Psf-CARI-1 enriched FYM and neem cake @ 5.0 kg/m^2; T_9: T_5 + two sprays of neem oil (2%); T_{10}: T_6 + two sprays of neem oil (2%); T_{11}: T_7 + two sprays of neem oil (2%); T_{12}: T_8 + two sprays of neem oil (2%) and T_{13}: Control

Module-II comprised of biocontrol agents, botanicals and fungicides for management of disease complexes of tomato. The details of treatment schedules were: T_1: Seed treatment (2 g/kg seed) + seedling dip + soil drenching with copper oxychloride @ 2 g/l of water; T_2: seed treatment (2 g/kg seed) + seedling dip + soil drenching with carbendazim @ 2 g/l of water; T_3: Seed treatment (2 g/kg seed) + seedling dip + soil drenching with metalaxyl + mancozeb @ 2 g/l of water; T_4: Seed treatment (10 g/kg seed) + seedling dip @10 g/l of water for half an hour + soil application of Th-CARI-50 enriched FYM and neem cake (5.0 kg/m^2); T_5: Seed treatment (10 g/kg seed) + seedling dip @10 g/l of water for half an hour + soil application of Tv-CARI-73 enriched FYM and neem cake (5.0 kg/m^2); T_6: Seed treatment + seedling dip @10 g/l of water for half an hour + soil application of Psf-CARI-1 enriched FYM and neem cake (5.0 kg/m^2); T_7: Seed treatment (2 g/kg seed) + seedling dip with copper oxychloride (2 g/l water) + soil application of Th-CARI-50 enriched FYM and neem cake (5.0 kg/m^2) + two sprays of neem oil (2%); T_8: Seed treatment (2 g/kg seed) + seedling dip with copper oxychloride (2 g/l water) + soil application of Tv-CARI-73 enriched FYM and neem cake (5.0 kg/m^2) + two sprays of neem oil (2%); T_9: Seed treatment (2 g/kg seed) + seedling dip with copper oxychloride (2 g/l water) + soil application of Psf-CARI-1 enriched FYM and neem cake (5.0 kg/m^2) + two sprays of neem oil (2%); T_{10}: Seed treatment (2 g/kg seed) + seedling dip with carbendazim (2 g/l of water) + soil application of Th-CARI-50 enriched FYM and neem cake (5.0 kg/m^2) + two sprays of neem oil (2%); T_{11}: Seed treatment (2 g/kg seed) + seedling dip with carbendazim (2 g/l water) + soil application of Tv-CARI-73 enriched FYM and neem cake (5.0 kg/m^2) + two sprays of neem oil (2%); T_{12}: Seed treatment (2 g/kg seed)+ seedling dip with carbendazim (2 g/l water) + soil application of Psf-CARI-1 enriched FYM and neem cake (5.0 kg/m^2) + two sprays of neem oil (2%); T_{13}: Seed treatment (2 g/kg seed) + seedling dip with metalaxyl + mancozeb (2 g/l water) + soil application of Th-CARI-50 enriched FYM and neem cake (5.0 kg/m^2) + two sprays of neem oil (2%); T_{14}: Seed treatment (2 g/kg seed) + seedling dip with metalaxyl + mancozeb (2 g/l water) + soil application of Tv-CARI-73 enriched FYM and neem cake (5.0 kg/m^2) + two sprays of neem oil (2%); T_{15}: Seed treatment (2 g/kg seed) + seedling dip with metalaxyl + mancozeb (2 g/l water) + soil application of Psf-CARI-1 enriched FYM and neem cake (5.0 kg/ m^2) + two sprays of neem oil (2%) and T_{16}: Control.

Module- III comprised of cultural practices, biocontrol agents and fungicides, the details of the treatment schedules were: T_1: Seedlings raised in nursery beds and transplanted in main field + Th-CARI-50 + Psf-CARI-1 + mixture of FYM and neem cake + copper oxychloride + neem oil; T_2: seedlings raised in plastic cup and direct planting + Th-CARI-50 + Psf-CARI-1 + mixture of FYM and neem cake + copper oxychloride + neem oil; T_3: T_1 + Crop rotation with sorghum; T_4: T_1 + Intercropping with Burma *dhania* and T_5: Control (seedlings raised in nursery bed and transplanted in main field).

The disease incidences of bacterial wilt, tomato leaf curl, basal stem rot and fusarial wilt were recorded at 15 days intervals starting from 30 DAT. The data on disease incidence during three years was pooled and per cent reduction in incidences of four diseases in tomato was calculated at 60 DAT. Per cent reduction in disease incidence (RDI) was calculated as per formula (Dubey *et al*., 6; Bhagat *et al*., 2). All data recorded were given appropriate statistical treatments and subjected to ANOVA test and the analysis of variance was done at 0.05% (*in vitro* test). Three years data of field trials was pooled and significance was analyzed as per DMRT test at 0.05%.

RESULTS AND DISCUSSION

The results presented in Table 1 revealed that all isolates of biocontrol agents significantly inhibited mycelial growth of all test pathogens but the isolate Tv-CARI-73 was most effective in per cent inhibition followed by Th-CARI-50, Tv-CARI-85 and Th-CARI-70. Highest per cent inhibition by *Trichoderma* isolates was recorded with *R. solani* followed by *Pythium* sp., *Phytophthora* sp., *F.o. f.*sp. *lycopersici* and *S. rolfsii.* The lone isolate of *Pseudomonas fluorescens* was also very effective in suppression of mycelial growth of all test pathogens.

In vitro evaluation of biocontrol agents against target pathogens is necessary step in developing any biocontrol technology as well biocontrol based integrated disease management practices under greenhouse and field conditions (Bhagat *et al.*, 1,2). The biocontrol agents, *Trichoderma* spp. and *P. fluorescens* are the most common biocontrol agents, which have been used *in vitro* and *in vivo* against several soil borne and foliar pathogens (Harman *et al*., 7; Vinale *et al*., 12; Bhagat and Pan, 5; Kumar *et al*, 9). In the present investigation, biocontrol isolates differed with test pathogen with respect to their antagonistic potential and per cent inhibition of mycelial growth of pathogens. Several researchers have reported the variability of these biocontrol agents against test pathogens (Dubey *et al*., 6; Kumar *et al*., 9; Sharma *et al*., 11).

The results presented in Table 2 revealed that all the treatments had significantly reduced disease incidences in tomato as compared to untreated control (IDM module-I). But T_{10} [Seed treatment @10 g/kg seed + seedling dip @10 g/l water + soil application of Th-CARI-50 enriched FYM and neem cake @ 5.0 kg/m^2 + 2 sprays of neem oil (2%)] treatment was most effective in reduction of disease incidence in tomato followed by T_{11}, T_{12}, T_{11} and T_9 . However, maximum reduction in bacterial wilt of tomato was recorded with T_{12} and T_8 treatments. Treatment T_{10} was also recorded with highest yield (227.5 q/ha). The results suggested that the combination of seed treatment + seedling dip + soil application of biocontrol agents were more effective than seed or seedling dip or soil treatment alone with in their potentiality in reducing the disease incidence.

The comparative evaluation of three fungicides (IDM module-II) and bioagents (Table 3) revealed that carbendazim and mixture of metalaxyl + mancozeb were not effective against both bacterial wilt and leaf curl of tomato, whereas, copper oxychloride was most effective in reducing disease complex of tomato except tomato leaf curl. All fungicides were very effective against basal stem rot and fusarial wilt of tomato. T_7 treatment (seed treatment + seedling dip with copper oxychloride + soil application of Th-CARI-50 along with FYM and neem cake @5.0 kg/m^2) + two sprays of neem oil (2%), was recorded with highest per cent reduction in incidence of all diseases (86.0% bacterial wilt, 56.2% leaf curl, 76.4% basal stem rot and 74.8% fusarial wilt) and increase in yield (75.3%) followed by T_1, T_9, T_8, T_{13}, T_4.

The combination of cultural practices, biocontrol agents and need based application of chemical

Table 1. *In vitro* antagonistic potential of biocontrol agents against soil-borne pathogens of tomato.

Biocontrol agent	Radial mycelial growth* (mm)				
	Pythium sp.	*Phytophthora* sp.	*R. solani*	*S. rolfsii*	*F.o*.f. sp. *lycopersici*
Th-CARI-50	29.8 (#66.7%)	30.0 (66.7%)	25.5 (71.7%)	32.8 (63.5%)	33.2 (63.1%)
Th-CARI-70	34.6 (61.5%)	35.2 (60.9%)	28.6 (68.2%)	36.2 (59.8%)	35.4 (60.7%)
Tv-CARI-73	28.5 (68.3%)	29.4 (67.3%)	24.6 (72.7%)	30.7 (65.9%)	30.5 (66.1%)
Tv-CARI-85	31.8 (64.7%)	32.0 (64.4%)	26.0 (71.1%)	33.0 (63.3%)	32.4 (64.0%)
Psf-CARI-1	32.0 (64.4%)	32.5 (63.4%)	29.6 (67.1%)	35.1 (61.0%)	34.8 (61.3%)
Control	90.0	90.0	90.0	90.0	90.0
$CD_{(0.05)}$	1.26	1.40	1.06	1.46	1.18

*Mean of four replications; #The values in the parentheses indicates percent inhibition of pathogens.

Table 2. Evaluation of bioagents and neem products against disease complex of tomato.

Treatment	% Reduction of disease incidence				Yield (q/ha)	% increase in yield
	Bacterial wilt	Leaf curl	Basal stem rot	Fusarial wilt		
T_1	16.4 f	21.9 f	15.8 e	24.2 e	195.0 g	30.0
T_2	22.5 e	25.1 d	19.8 d	29.2 d	200.0 e	33.3
T_3	14.6 f	19.9 f	13.4 ef	22.0 f	192.0 h	28.0
T_4	20.0 e	20.5 f	14.0 ef	22.5 f	189.0 i	26.0
T_5	48.1 c	22.5 e	54.2 b	65.2 b	202.5 f	35.0
T_6	55.5 b	26.0 d	59.6 a	75.0 a	213.9 d	42.6
T_7	45.2 d	20.3 f	52.0 bc	63.4 bc	206.5 e	37.7
T_8	58.0 a	20.8 f	50.0 c	65.0 b	200.0 f	33.3
T_9	46.0 d	51.0 b	52.9 bc	64.0 b	220.0 c	46.7
T_{10}	56.0 b	58.5 a	60.8 a	75.8 a	227.5 a	51.7
T_{11}	55.0 b	54.5 b	55.0 b	66.0 b	221.8 b	47.9
T_{12}	58.2 a	50.0 c	51.0 c	61.7 c	216.0 b	44.0
T_{13}	0.0	0.0	0.0	0.0	150.0j	-

The letter indicating same letter was significantly not differed as per DMRT test (0.05%)

Table 3. Integrated effects of biocontrol agents and fungicides against disease complex of tomato.

Treatment	% Reduction of disease incidence				Yield (q/ha)	% increase in yield
	Bacterial wilt	Leaf curl	Basal stem rot	Fusarial wilt		
T_1	84.9b	0.0	75.3ab	73.6b	256.0a	70.7
T_2	0.0	0.0	72.5bc	68.4cd	203.0h	35.3
T_3	0.0	0.0	76.0a	76.0a	214.0g	42.7
T_4	55.6de	55.4a	65.6f	60.0g	210.0 b	40.0
T_5	41.6e	52.1b	60.0g	56.8h	220.0f	46.7
T_6	63.4c	48.5	58.2gh	53.0i	224.0f	49.3
T_7	86.0ab	56.2a	76.4a	74.8b	263.0a	75.3
T_8	84.0b	52.6b	73.2b	65.0e	248.0b	65.3
T_9	87.5a	49.0c	62.9de	62.0f	254.0ab	69.3
T_{10}	57.0d	56.0a	76.0a	70.0c	233.0c	55.3
T_{11}	42.2e	53.0b	74.1b	62.3f	226.6e	51.1
T_{12}	65.0c	49.3c	60.0d	60.5g	221.0d	47.3
T_{13}	57.8d	55.5a	77.0a	70.1c	236.6b	57.7
T_{14}	43.0e	52.7b	74.0b	64.0e	232.2d	54.8
T_{15}	65.0c	48.6c	63.2d	60.5g	229.5d	53.0
T_{16}	0.0	0.0	0.0	0.0	150.0i	0.0

The letter indicating same letter was significantly not differed as per DMRT test (0.05%)

pesticides (IDM module-III) has resulted into lowest incidence of disease complex of tomato as compare to biocontrol alone (Module-I) and biocontrol agents + chemical pesticides (Module-II). It is evident from the Table 4 that all the treatments significantly reduced the incidence of disease complex in tomato as compare to control. But the combination of biocontrol agents, fungicide and botanicals in different method of delivery system was proved superior when the seedlings were transplanted directly in the main field without disturbing the root system as compared to uprooting of seedlings and

Table 4. Integrated effects of biocontrol agents and fungicides against disease complex of tomato

Treatment	% Reduction of disease incidence				Yield (q/ha)	% increase in yield
	Bacterial wilt	Leaf curl	Basal stem rot	Fusarial wilt		
T_1	62.0 c	45.4 c	70.5 b	69.3 b	263.7 b	75.8
T_2	89.9 a	56.5 b	77.0 a	75.7 a	275.4 a	83.6
T_3	86.5 a	57.2 b	66.6 bc	74.0 a	264.4 b	76.3
T_4	70.4 b	70.5 a	71.5 b	70.0 b	263.2 b	75.5
T_5	-	-	-		150.0 c	-

The letter indicating same letter was significantly not different as per DMRT test (0.05%)

subsequent transplantation in the main field. The treatment T_2 was most effective in per cent reduction of disease incidence (89.9% bacterial wilt, 56.5% leaf curl, 77.0% basal stem rot and 75.7% fusarial wilt) and corresponding yield increase of tomato (83.6%). The results also suggested that crop rotation with non host crop like sorghum (fodder crop) and intercropping with *Burma Dhania* (spice crop) with tomato resulted into improved disease control and yield of tomato.

In the present investigation, three integrated modules were developed by use of biocontrol approach alone (Module-I), biocontrol and need based application of chemicals (Module-II) and Integration of cultural practices, biocontrol agents, botanicals and fungicides (Module-III). Present investigation suggests that either seed treatment or seedling dip or soil application alone, has only limited effect in minimizing the disease incidence in tomato, it can be improved many fold by different method of deliveries. Our findings are in the line of several researchers who have reported that many fungal and bacterial biocontol agents have ability to reduce disease incidence of several diseases under field condition (Harman *et al*., 10; Dubey *et al.*, 8; Bhagat *et al*., 6; Bhagat and Pan, 5, 7).

In view of environmental and health concerns about indiscriminate use of pesticides, there is considerable interest in finding alternative control approaches for use in integrated pest management strategies for crop diseases (Bhagat *et al.*, 2014). A single application of biocontrol strains as a seed treatment provided significant disease reduction through various mechanisms including induced systemic resistance in the field, is particularly encouraging for the use of biocontrol agents as components of integrated pest management systems (Bhagat *et al.*, 2-3). Further, seed treatments provide targeted application of biocontrol strains, allowing earlier protection than could be provided with foliar sprays. Hence, integration of biocontrol agents with suitable cultural practices and need based application of chemical pesticides, is necessary to control disease complex of tomato under field conditions. Present investigation has encouraging result in this regard and IDM module-III (integration of cultural practices, biocontrol agents and need based application of chemical fungicides at half of recommended dose) was most effective than that of IDM-I (biocontrol agents) and IDM module-II (integration of biocontrol agents and chemical fungicides at half of recommended dose) in reducing disease incidence and increasing yield in tomato. Similar findings have also reported by several researchers (Dubey *et al*., 6; Sharma *et al.*, 11; Joshi *et al*., 8; Bhagat *et al.*, 2, 5) in management of chickpea, cauliflower and tomato diseases.

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