Development of suitable IDM approaches for management of Fusarium wilt of Tomato [*Fusarium oxysporum* f.sp. *lycopersici* (Sacc.) Synder and Hansen] under climate change

V. TILAK CHOWDARY, S.K BISWAS*, DEEPAK BABOO AND KISHAN LAL

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Department of Botany,
University of Calcutta,
Kolkata 700 019, India

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V. TILAK CHOWDARY, S.K BISWAS*, DEEPAK BABOO AND KISHAN LAL
Department of Plant Pathology, C. S. Azad University of Agriculture and Technology, Kanpur 208002, Uttar Pradesh

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Integration of different methods for suitable management of Fusarium wilt revealed that the minimum disease severity was found in case of soil application with mushroom spent + combined seedling treatment with *T. harzianum*, *Azotobacter* and *Rhizobium* + first foliar application with Benfil (Carbendazim) + second foliar application with Matco (Metalaxyl + Mancozeb), representing the value 6.50% as against 54.65 per cent in case of control. Growth promoting effect of plants had also been noticed due to application of IDM practices. The maximum shoot length and root length was observed in the treatment of soil application with mushroom spent + combined seedling treatment with *T. harzianum*, *Azotobacter* and *Rhizobium* + first foliar application with Benfil (Carbendazim) + second foliar application with Matco (Metalaxyl + Mancozeb) representing the values 45.50 cm and 37.00 cm, respectively at 45 DAT against 29.50 cm & 10.15 cm in case of control and 23.40 cm & 8.50 cm in case of control 2. Fresh and dry weights of the shoots were also found maximum in the same treatment, representing the values 66.50g and 21.50g, respectively. Similar observations had also been recorded in case of fresh and dry weights of roots with the values 36.50g and 12.30g, respectively. Maximum number of branches and flowers/plant were also found in the T7 treatment where soil application with mushroom spent + combined seedling treatment with T. *harzianum, Azotobacter* and *Rhizobium* + first foliar application with Benfil (Carbendazim) + Second foliar application with Matco (Metalaxyl +Mancozeb) showing 13.60 branches/ plant and 90.60 flowers/ plant where in case of control-1 the values are 5.80 and 50.90 and control-2 values are 3.60 and 16.40. The maximum yield with 1.703kg/plant was also obtained from the same treatment.

Key words: Fusarium wilt, IDM approuch, bio agents, bio-fertiliser, compost , fungicides

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) is considered as one of the most important and remunerative vegetable crops cultivated throughout the world owing to its high nutritive values as well as its antioxidant and curative properties. It is a major contributor to the fruits and vegetables diet of humans throughout the world (Kapasiya *et al.* 2015).Tomato is susceptible to several diseases like damping off, early blight, late blight, Fusarium wilt, verticillium wilt, bacterial wilt, tomato mosaic virus etc. Among them, Fusarium wilt caused by *Fusarium oxyporium* f.sp.*lycopersici* (Sacc.) Snyder and Hansen is an economically important disease of tomato crop worldwide (Hanaa *et al.*2011). The disease is responsible to cause severe losses ranges from 3.58-20.63% . The pathogen is soil, seed and polyphagous in nature and has wide adoptability under climate changes (Singh, 2014; Gill *et al*. 2016, Bhupendra *et al.* 2017). Therefore management of the disease is very difficult and even single method is not sufficient for management of the disease. Narender and Sharma (2015) found that bio fumigation of affected soil for 30 days with taramira crop residues, application of formulation of T. viride after mixing with FYM and inoculation of transplants with culture consortia of indigenous AM fungi resulted in to controlling the Fusarium wilt. An Integrated approach using Carbendazim, *T. viride* along with neem seed kernel extract resulted in reduction of wilt incidence caused by Fusarium

*****Corresponding author : biswas.csa@gmail.com

oxysporum against cumin (Bhatnagar *et al.* 2013). It has been reported that the combination of soil solarization with reduced dosage of Dazomet and methyl bromide controls Fusarium and Verticillium wilts in tomato. Under field conditions, the combination of T. harzianum with soil solarization or with a reduced dose of methyl bromide resulted in significant disease control of Fusarium wilt. Combination of the biocontrol *agent P. fluorescens* with the mineral element zinc significantly reduced disease severity of Fusarium wilt of tomato .Considering the above point in view integrated disease management strategies has been advocated as entitiled "Development of suitable IDM approaches for Fusarium wilt of Tomato [*Fusarium oxysporum* f. sp*. lycopersici* (Sacc.) Synder and Hansen] under climate change" in the present investigation.

MATERIALS AND METHODS

Isolation of pathogen

The diseased plant showing typical wilt symptom was used for isolation of the pathogen. The diseased plant's roots were taken and washed thoroughly with tap water and finely with distilled water to remove all dust particles. The diseased part of the root was cut into small pieces by sterilized knife in such a way that each piece had small bits of diseased and healthy parts. The chopped pieces were dipped in mercuric chloride solution (0.1%) for 30 seconds rinsed in sterilized distilled water thrice and dried off with sterilized filter paper. The small pieces were then placed on PDA based media which was previously pour in sterilized Petri plates. The plates were finally sealed with par film tape and were incubated at 25± 1^0 C. The Petri plates were observed daily to find out the presence of mycelium around the bits. As soon as mycelial growth was noticed around the bits, the pathogen was purified by hyphal tip culture method.

Collection of biofertilizers

Biofertilizers viz.,*Rhizobium* and *Azotobacter* were collected from Department of Soil Science and Agriculture Chemistry, Chandra Shekhar Azad University of Agriculture & Technology, Kanpur to conduct the present study. The biofertilizers were used to conduct the experiment at Glass house complex of Department of Plant Pathology, C.S. Azad University of Agriculture and Technology, Kanpur during Kharif season of 2016-18.

Collection of bioagents

Bioagents viz., *Trichoderma harzianum* and *Trichoderma viride* of 10^8 CFU were collected from Department of Plant Pathology, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur to conduct the present investigation.

Collection of seedlings

Tomato seedling of variety Azad T-6 were obtained from Vegetable Research Farm, C.S.A. University of Agriculture and Technology, Kanpur to conduct the experiment.

Seedling treatment

Seedling were placed in each jar containing require concentration of each solution of *T.harzianum, Rhizobium* and *Azotobacte*r for two hours and are kept in shade before transplanting into the pots.

Effect of IDM apprach on growth parameters and separately disease incidence of fusarium wilt of tomato

The experiments were conducted during 2016-2018 at Glasshouse complex, Department of Plant Pathology, C.S.A. University of Agriculture and Technology, Kanpur. The tomato seedling of variety '*Azad T-6'* was used to conduct the experiment.

The details of the treatments were given as follows:-
T1 = Soil application with mushroom spent @ 3:1 ratio in proportionate to soil + seedling treatment with *T. harzianum* @ 107 CFU+ first foliar application with Benfil (Carbendazim 50% WP) @0.1% at 30 DAT+ second foliar application with Matco (Metalaxyl (8%)+ Mancozeb (74%).72%WP) @ 0.2% at 45 days after transplanting (DAT).

T2 = Soil application with mushroom spent @ 3:1 ratio in proportionate to soil + seedling treatment with Rhizobium @ 4g/lit water+ first foliar application with Benfil (Carbendazim 50% WP) @0.1% at 30 DAT+ second foliar application with Matco (Metalaxyl (8%)+ Mancozeb (74%).72%WP) @ 0.2% at 45DAT.

T3 = Soil application with mushroom spent @ 3:1 ratio in proportionate to soil + seedling treatment with *Azotobacter* @ 4g/lit of water+ first foliar application with Benfil (Carbendazim 50% WP) @0.1% at 30 DAT+ second foliar application with Matco (Metalaxyl(8%)+ Mancozeb(74%).72%WP) @ 0.2% at 45DAT.

T4 = Soil application with mushroom spent @ 3:1 ratio in proportionate to soil + combined seedling treatment with *T. harzianum* @ 103 CFU and Rhizobium@ 2g/lit of water + first foliar application withBenfil (Carbendazim 50% WP) @0.1% at 30 DAT+ second foliar application with Matco (Metalaxyl(8%)+ Mancozeb (74%).72%WP) @ 0.2% at 45DAT.

T5 =Soil application with mushroom spent @ 3:1 ratio in proportionate to soil + combined seedling treatment with *Rhizobium* @ 2g/lit water and Azotobacter@2g/lit of water+ first foliar application with Benfil (Carbendazim 50% WP) @0.1% at 30 DAT+ second foliar application with Matco (Metalaxyl(8%) + Mancozeb (74%).72%WP) @ 0.2% at 45DAT.

T6 = Soil application with mushroom spent @ 3:1 ratio in proportionate to soil + combined seedling treatment with *T. harzianum* @ 103 CFU and Azotobacter @ 2g/lit of water + first foliar application with Benfil (Carbendazim 50% WP) @0.1% at 30 DAT+ second foliar application with Matco (Metalaxyl (8%)+ Mancozeb (74%).72%WP) @ 0.2% at 45DAT.

T7 = Soil application with mushroom spent @ 3:1 ratio in proportionate to soil + combined seedling treatment with *T. harzianum* @ 103 CFU and *Azotobacte*r @ 2g/lit of water and *Rhizobium*@ 2g/lit of water + first foliar application with Benfil (Carbendazim 50% WP) @0.1% at 30 DAT+ second foliar application with Matco (Metalaxyl(8%)+ Mancozeb (74%).72%WP) @ 0.2% at 45DAT.

T8 = Soil application with of mushroom spent @ 250g/pot.

T9 = Soil application with mushroom spent @ 250g/pot + inoculation with pathogen.

At 28 DAT plants were inoculated with spore suspension of *F. o*. f sp. *lycopersicae* @ 10^6 conidia/ml. Four replications per treatment were kept to conduct the experiment. Observations pertaining to the effect of different treatments were recorded as per following parameters and days, (1) Plant height (cm) at 30, 45 and 60 days after transplanting; (2)Fresh weight of shoot (g) at 45 days after transplanting; (3) Dry weight of shoot (g) at 45 days after transplanting ;(4)Root length (cm) and morphology at 45 days after transplanting ;(5) Fresh weight of root (g) at 45 days after transplanting ;(6) Dry root weight (g) at 45 days after transplanting ;(7) Average number of branches per plant at 45 days;(8)Disease incidence (%) at 45 days after transplanting; and (9) Fruiting parameters and yield of crop (g)

Growth parameter

Shoot length: Tomato seedlings were transplanted in earthen pots in the glasshouse and shoot length was measured 30, 45 and 60 days age of tomato plants with the help of scale.

Root length: The root length tomato was measure at 45 days age of plant. Prior to measure the root lengths of tomato plants, pots were irrigated and the seedlings were up rooted carefully. The roots of seedlings were separated from the shoots and washed with water to remove soil particles and then root length (cm) were measured with the help of scale.

Fresh weight : Forty five days after transplanting, the shoots and roots of tomato plant were weighted on an electronic balance and the data was recorded as g.

Dry weight: The fresh plant sample of forty five days age of plants are being collected and then shoots and roots were dried in an oven at 70^0C until constant weight. It was then weighted on an electronic balance and the data was recorded as g.

Measurement of Disease severity: The disease severity was monitored visually after inoculation with pathogen. The disease severity was recorded using 0-5 scale where zero representing no infection and four denoting plants completely infected. The 0-5 scale of the disease Incidence was classified as follows:- (1)No infection; (2)Slight infection which is about 25% of full scale, one or two leaves become yellow ;(3)Moderate infection, two or three leaves become yellow, 50% of leaves become wilted ;(4)Extensive infection,all plant leaves become yellow, 75% of leaves become wilted, and the plants die ; and (5)Complete infection, the whole plant leaves become yellow, 100% of leaves become wiltedand the plants die

The percentage of disease incidence was determined using the formula:-

Disease incidence (%) =

$$\frac{(\Sigma \text{ Scale} \times \text{number of plants infected})}{(\text{highest scale} \times \text{Total number of Plants})} \times 100$$

Yield/plant

The edible fruits were harvested twice a week from each selected plant and weighted with the help of physical balance and graded as per weight. The total weight of all picking was recorded after adding weight of fruits at each picking and represented as g.

RESULTS AND DISCUSSION

Seven various effective management components using seedling treatments (*T. harzianum, Azotobacter and Rhizobium*),soil treatments (mushroom spent)and foliar applications (Carbendazim 50% WP, (Metalaxyl(8%)+ Mancozeb(74%).72%WP) were used to suppress the population of wilt causing pathogen (*Fusarium oxyporium* f.sp.*lycopersi*ci) in tomato and their effects on shoot length (cm), root length (cm), fresh and dry weight of shoot (gm), fresh and dry weight of root (g), disease severity (%), flowering , branching and yield of tomato.

Effect of different IDM practices on growth parameters and disease severity of Fusarium wilt of tomato

Shoot length

The data presented in the Table 1, showed that all the treatments were able to significantly increase the shoot length over both the controls at 30, 45 and 60 days after transplanting. Among the various IDM practices, the maximum shoot length was recorded in the treatment T7 (soil application with mushroom spent + combined seedling treatment with *T. harzianum, Azotobacter* and *Rhizobium* + two foliar sprays with Benfil (Carbendazim)and Matco (Metalaxy+ Mancozeb) representing 28.90, 45.50 and 57.90 cm at 30, 45 and 60 days after transplanting, followed by T6 treatment (soil application with mushroom spent +combined seedling treatment with *T.harzianum* and *Azotobacter* + two foliar spray with Carbendazim and Metalaxy+ Mancozeb)showing 26.50, 42.10 and 54.70 cm against control-1 (healthy) representing as 17.50, 29.50, 36.40 cm and control-2 (diseased) as 14.30, 23.40 and 30.20 cm at 30, 45 and 60 days after transplanting. Ravindra *et al*. (2015) also found that seed treatment with *T. harzianum* + soil application of neem cake powder + foliar spray of carbendazim significantly increased shoot and root lengths of tomato. Yogesh *et al*. (2015) also reported that among the different integrated approaches, soil application of FYM + seedling treatment with bio-formulation of *Trichoderma harzianum* + foliar spray of mancozeb reduced the disease severity of early blight of tomato and increased the growth parameters and branching pattern of plant.

Fresh and dry weight of shoot

Fresh and dry shoots were weighted on an electronic balance and the data presented in the Table 1 , showed that all the treatments were able to increase the fresh and dry weights of shoots over control-1 and control-2. The maximum fresh and dry weight of shoots was recorded in T7 treatment where treatment was given as soil application with mushroom spent + combined seedling treatment with *T. harzianum, Azotobacter* and *Rhizobium* + two foliar sprays with Benfil (Carbendazim) and Matco (Metalaxy+ Mancozeb) representing 66.50g and 21.50 g respectively, at 45 days after transplanting, which is increased by 92.75 and 146.30 and 91.96 & 123.70 per cent over contol-1 (Healthy) and control-2 (Diseased plant), respectively. The T6 treatment (Soil application with mushroom spent + combined seedling treatment with *T. harzianum* and *Azotobacte*r + foliar spray with Benfil (Carbendazim) and with Matco (Metalaxyl+ Mancozeb) showing the values 63.15g and 19.00g at 45 days after transplanting representing second highest among the treatments. Among the all combinations, the minimum fresh and dry weight was recorded in T2 (soil application with mushroom spent +seedling treatment with Rhizobium + two foliar spray with Benfil (Carbendazim) and with Matco (Metalaxyl+ Mancozeb) treatment, representing 48.60 and 12.70g which are also superior as 40.865 and 13.40 and 80.00 and 32.3 per cent increased over control-1 and control-2. Ravindra *et al*. (2015) found that the fresh and dry weight of shoot in tomato crop significantly increased by the combine application of seed treatment with *T. harzianum* + soil application of neem cake powder + foliar spray of Carbendazim. Chandanie *et al*. (2009) found that, the combination inoculation of Arbuscular

mycorrhizal fungi with *Trichoderma* synergistically increased dry shoot mass when compared with inoculation of *Trichoderma* and Arbuscular mycorrhizal fungi alone.

Root length

Forty five days after transplanting, the tomato plant was uprooted and the root length was measured by using scale. It is evident from the data showed that the maximum root length was recorded in the treatment T7 where the treatment was given as soil application with mushroom spent + combined seedling treatment with *T.harzianum, Azotobacter* and *Rhizobium*+ two foliar sprays with Benfil (Carbendazim) and Matco (Metalaxyl+ Mancozeb) representing 37.00 cm against 10.15 and 8.5 cm in case of control-1 and control-2, respectively at 45 days after transplanting (Table 2) which was followed by the T6 treatment (soil application with mushroom spent + combined seedling treatment with *T. harzianum* and *Azotobacter* + two foliar sprays with Benfil (Carbendazim) and Matco (Metalaxyl+ Mancozeb), representing 29.00 cm at 45 days after transplanting. The morphology of the roots were also found variable among different treatments. Among the various combinations,spreading robust root system was found maximum in T7 treatment. From the Table, it is cleared that all the treatments were able to increase the root length over control which are also statistically significant to each other. Kishan *et al*. (2017) found that integrated approaches changes the morphology of root. The well developed robust root system is found in combine treatment with soil application of FYM @100g/pot+ neem cake@ 100g/pot + seedling treatment with bioformulation of Azotobactor @5% +foliar spray of Carbendazim @0.1%) whereas, in case of control, poorly developed, less branching and less fibrous root system are found. Gopinathan and Prakesh (2014) found that vermicompost enriched with biofertilizer increased plant height, root length, number of branches, number of leaves and the productivity of tomato.

Fresh and dry weight of root

Fresh and dry roots were weighted on an electronic balance and the data presented in the Table 2, showed that all the treatments were able to increase the fresh and dry weights of roots over control-1 and control-2. The maximum fresh and dry weight of root was recorded in T7 treatment (Soil application with mushroom spent + combined seedling treatment with *T. harzianum, Azotobacter* and *Rhizobium*+ two foliar sprays with Benfil(Carbendazim) and Matco (Metalaxyl+ Mancozeb) representing 36.50 and 12.30g at 45 days after transplanting which is increased 114.7 and 192.80 per cent over control-1 and 160.70 and 215.00 per cent over control-2. Similar observations have also been reported by several workers (Yogesh *et al*. 2015; Singh *et al*. 2016; Ravindra *et al*. 2015).

Disease severity

Disease is major constraints of increase production and productivity of any crops. In contrast, adoption of suitable management practices is more important to reduce disease severity and to get maximum profit. In the present study also, among the various IDM packages maximum reduction of disease severity was found in treatment T7 where treatments were given as soil application with mushroom spent + combined seedling treatment with *T.harzianum*, *Azotobacter* and *Rhizobium*+ two foliar sprays with Benfil (Carbendazim) and Matco (Metalaxyl+ Mancozeb) representing only 6.50% disease severity against 54.65% in case of control. Effectiveness of mushroom composts use as soil amendments in controlling the disease could possibly be due to enhanced activity of other non-parasitic microbes (fungi/bacteria) providing antagonism to the tomato wilt pathogen and/or decomposition products of composts being non-favourable for the multiplication of the inoculum. Ganie *et al*. (2013) observed that the application of bioagents viz., *T.viridae* and *Azotobacter* is effective in reducing disease severity of Fusarium wilt in tomato caused by *F. o*. f.sp. *lycopersici.*

Effect of IDM practices on yield attributing characters and yield of tomato

Yield attributing characters like number of branches, flowers and fruit yield have been gradually increased in the treated plants where the maximum number of branches and flowers were produced in treatment T7 with 13.60 branches/plant and 90.60 flowers/plant, respectively followed by treatment T6 with 12.04 branches/plant and 82 flowers /plant.

The matured fruits were harvested and were graded according to the weight viz., (<25gm, 25-

Table 1: Effect of different IDM practices on Shoot length at different days after transplanting and disease severity of *Fusarium* wilt of tomato

Treatment	Shoot length			Fresh weight o f shoot (gm)	% increase of fresh weight over control -1	% increase of fresh weight over control-2	Dry weight of shoot (gm)	% increase of dry weight of shoot over control 1	% increase of dry weight of shoot over control -2	Disease severity (%) 45 DAT
	30 DAT	45 DAT	60 DAT							
T_1- SA with MS + ST with *T. harzianum* + 1st FA with Carbendazim + 2nd FA with Metalaxy+ Mancozeb	22.00	37.60	47.60	57.30	66.08	112.20	15.30	36.60	59.40	14.55
T_2- SA with MS + ST with *Rhizobium* + 1st FA with Carbendazim + 2nd FA with Metalaxy+ Mancozeb.	19.60	34.30	43.50	48.60	40.86	80.00	12.70	13.40	32.30	19.20
T_3- SA with MS + ST with *Azotobacter* + 1st FA with Carbendazim+ 2nd FA with Metalaxy+ Mancozeb	20.40	32.40	44.80	52.40	51.88	94.10	13.60	21.42	41.70	17.30
T_4- SA with MS + ST with *T. harzianum* +*Rhizobium* + 1st FA with Carbendazim + 2nd FA with Metalaxy+ Mancozeb	25.20	40.80	53.10	61.80	79.13	128.80	17.50	56.25	82.30	9.40
T_5-SA with MS + ST with *Rhizobium* and *Azotobacter*+1st FA with Carbendazim + 2nd FA with Metalaxy+ Mancozeb	23.70	39.20	50.30	60.10	74.20	122.60	16.30	45.53	69.80	11.70
T_6- SA with MS+ ST with *T. harzianum* and *Azotobacter* + 1st FA with Carbendazim and 2nd FA with Metalaxy+ Mancozeb	26.50	42.10	54.70	63.15	83.04	133.90	19.00	69.64	97.90	7.25
T_7-SA with MS+ ST with *T. harzianum, Azotobacter* and *Rhizobium* + 1st FA with Carbendazim + 2nd FA with Metalaxy+ Mancozeb	28.90	45.50	57.90	66.50	92.75	146.30	21.50	91.96	123.90	6.50
T_8 Control(Healthy)- Soil application with of MS	17.50	29.50	36.40	34.50		27.70	11.20		16.70	0
T_9 Control(diseased)- Soil application with of MS+inoculation with pathogen	14.30	23.40	30.20	27.00	-21.73		9.60	-14.28		54.65
C.D.(0.05)	1.294	1.164	1.164	1.450			1.422			1.199
SE(m)	0.432	0.389	0.389	0.484			0.475			0.401
SE(d)	0.611	0.550	0.550	0.685			0.672			0.567
C.V.(%)	3.400	1.866	1.448	1.601			5.416			4.443

SA = Soil Application, MS = Mushroom Spent, ST = Seedling Treatment, FA = Foliar Application.

Table 2: Effect of different IDM practices on growth characteristics of roots of tomato at 45 days after transplanting

Treatment	Root length (cm)	% increase of root length over control-1	% increase of root length over control-2	Fresh weight of root (gm)	% increase of fresh weight of root over control-1	%increase of fresh weight of root over control- 2	Dry weight of root (gm)	% increase of dry weight of root over control-1	% increase of dry weight of root over control-2
T_1-SA with MS + ST with *T. harzianum* + 1st FA with Carbendazim + 2nd FA with Metalaxy+ Mancozeb	23.20	128.50	172.90	26.50	55.90	89.30	7.85	86.90	101.20
T_2-SA with MS + ST with *Rhizobium*+ 1st FA with Carbendazim + 2nd FA with Metalaxy+ Mancozeb.	20.50	101.90	141.20	23.00	35.30	64.30	5.70	35.70	46.10
T_3-SA with MS + ST with *Azotobacter*+ 1st FA with Carbendazim+ 2nd FA with Metalaxy+ Mancozeb	22.00	116.70	158.80	24.50	44.20	75.00	6.55	55.90	67.90
T_4-SA with MS + ST with *T. harzianum* +*Rhizobium* + 1st FA with Carbendazim + 2nd FA with Metalaxy+ Mancozeb	27.00	166.00	217.60	29.00	70.60	107.10	9.95	136.90	155.10
T_5-SA with MS + ST with *Rhizobium* and *Azotobacter*+1st FA with Carbendazim + 2nd FA with Metalaxy+ Mancozeb	25.5	151.20	200.00	27.50	61.80	96.40	8.35	98.80	114.10
T_6-SA with MS+ ST with *T. harzianum* and *Azotobacter* + 1st FA with Carbendazim and 2nd FA with Metalaxy+ Mancozeb	29.00	185.70	241.20	33.00	94.10	135.70	10.25	144.00	162.80
T_7-SA with MS+ ST with *T. harzianum, Azotobacter* and *Rhizobium* + 1st FA with Carbendazim + 2nd FA with Metalaxy+ Mancozeb	37.00	264.50	335.20	36.50	114.70	160.70	12.30	192.80	215.30
T_8- Control-1(Healthy)-Soil application with of MS	10.15		19.41	17.00		21.40	4.20		7.70
T_9-Control-2(diseased)-Soil application with of MS+inoculation with pathogen	8.50	-16.25		14.00	-17.64		3.90	-7.10	
C.D. .(0.05)	1.934			2.445			1.006		
SE(m)	0.646			0.816			0.336		
SE(d)	0.914			1.155			0.475		
C.V.(%)	4.956			5.510			7.581		

SA = Soil Application, MS = Mushroom Spent, ST = Seedling Treatment, FA = Foliar Application.

Table 3: Effect of various IDM practices on yield attributing characters and yield of tomato

Treatment	No of branches	No of flowers /plant	No of fruits/plant			Wt of fruits			Total yield(gm)
			<25gm	25-50gm	>50gm	<25gm	25-50gm	>50gm	
T_1- SA with MS + ST with *T. harzianum*+ 1st FA with Carbendazim + 2nd FA with Metalaxy+ Mancozeb	8.00	71.30	5	12	12	95	468	612	1175
T_2- SA with MS + ST with *Rhizobium*+ 1st FA with Carbendazim + 2nd FA with Metalaxy+ Mancozeb.	6.20	64.50	7	10	8	147	360	424	931
T_3- SA with MS + ST with *Azotobacter*+ 1st FA with Carbendazim+ 2nd FA with Metalaxy+ Mancozeb	7.40	68.20	6	13	9	102	442	486	1030
T_4- SA with MS + ST with *T. harzianum* +*Rhizobium* + 1 st FA with Carbendazim + 2nd FA with Metalaxy+ Mancozeb	10.30	77.50	6	14	14	114	518	742	1374
T_5-SA with MS + ST with *Rhizobium*and*Azotobacter*+1stFA with Carbendazim + 2nd FA with Metalaxy+ Mancozeb	9.60	73.80	7	15	12	133	554	624	1311
T_6- SA with MS+ ST with *T. harzianum* and *Azotobacter* + 1 st FA with Carbendazimand 2nd FA with Metalaxy+ Mancozeb	12.40	82.00	6	17	15	108	629	810	1547
T_7-SA with MS+ ST with *T. harzianum, Azotobacter* and *Rhizobium* + 1st FA with Carbendazim + 2nd FA with Metalaxy+ Mancozeb	13.60	90.60	8	16	18	144	592	972	1703
T_8 Control(Healthy)- Soil application with of MS	5.80	50.90	9	7	5	198	252	280	730
T_9 Control(diseased)- Soil application with of MS+inoculation with pathogen	3.60	16.40	4	2	1	86	37	51	174
C.D..(0.05)	1.309	2.309							0.069
SE(m)	0.437	0.771							0.023
SE(d)	0.618	1.090							0.033
C.V.(%)	8.862	2.019							3.611

SA = Soil Application, MS = Mushroom Spent, ST = Seedling Treatment, FA = Foliar Application.

50g and >50g) using physical balance. It was found that the maximum number of large size fruits with 18 was obtained from T7 Treatment (soil application with mushroom spent + combined seedling treatment with *T. harzianum, Azotobacter* and *Rhizobium* + two foliar sprays with Benfil (Carbendazim) which is also representing hinghest yield as 1.703 kg per plant which was followed by T6 treatment (soil application with mushroom spent + combined seedling treatment with *T. harzianum* and *Azotobacter* + two foliar spray with Benfil (Carbendazim) and Matco (Metalaxyl+ Mancozeb) as 15 large size fruits and total yield 1.547 kg per plant. In case of control-1 and control-2, the number of large size fruits are 5 and 1, respectively and their yield as 730 and 174 g per plant. The maximum number of small size and medium size fruits was obtained from T8 and T6 treatments, respectively. From the Table 3 it is also cleared that the increase number of fruiting ability were found in T7 treatment which is 42 against 7 in case of control-2. The reduction in wilt incidence mediated through bioagents in combination with organic amendments, was found to have direct effect on improving yield attributing characters (number of branches, flowers, plant height etc.) leading to increase in yield. Ravindra *et al.* (2015) found that the yield of tomato crop significantly increased by the combine application of seed treatment with *T. harzianum* + soil application of neem cake powder + foliar spray of carbendazim.

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