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SUSTAINABLE INTEGRATED APPROACH FOR MANAGEMENT OF EARLY BLIGHT AND THEIR EFFECT ON CROP GROWTH PARAMETERS IN TOMATO

YOGESH MISHRA, S. K. BISWAS*, KISHAN LAL, PREM NARESH, AMLAN SUSHREE AND NARENDER KUMAR
Department of Plant Pathology,
C.S. Azad University of Agriculture and Technology, Kanpur - 208 002, Uttar Pradesh, INDIA
e-mail: samirkrbiswas@rediffmail.com

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***Corresponding author**

ABSTRACT
Integrated approach on disease severity and growth parameter of tomato revealed that minimum disease severity with 8.56% was found in case of soil application of FYM + seedling treatment with bio formulation of *T. harzianum* + spray of Mancozebfollowed by soil application of FYM + seedling deep in Mancozeb + spray of Mancozeb (08.32%) against 95.50% in case of control. Soil application with FYM+ seedling treatment with bio formulation of *T. harzianum* + spray of Mancozeb also stimulate shoot length of tomato, representing the value15.36, 17.20, 22.46, 26.93 and 31.43 cm against 10.10, 12.06, 17.06, 21.46 and 26.40 cm in case of control at 6, 12, 18, 24, and 30 days age of plant commences after 10 days of trans planting.The fresh and dry shoot and root weight was also found maximum with 25.3 g & 7.27gm and 22.00gm & 4.25gm respectively in treatment $T_8$where treatment was given as soil application of FYM + seedling deep in *T. harzianum* formulation + spray with mancozed.Width of root zone was maximum found in case of soil application of FYM + seedling treatment with bio formulation of *T. harzianum* + spray of Mancozeb with 22.66cm. Thus, the finding may be concluded thatsoil application of FYM + seedling treated with bio formulation of *T. harzianum* + spray of Mancozeb not only reduced disease severity but also stimulate plant growth parameters.

INTRODUCTION

Tomato [(*Solanum lycopersicum*L.) Krust] also known as "Love apple" ranked thirds among vegetables next to potato and onion in terms of production but ranks first among canned vegetables. The crop is cultivated across all countries in the field as well as in protected conditions. The crop is attacked by number of diseases caused by fungi, bacteria, virus, mycoplasma, nematodes etc. and causeshudge amount of crop loss across the world. Among the diseases, early blight also known as target spot disease incited by *Alternariasolani* (Ellis and Martin) Jones and Grout, is one of the world's most catastrophic disease of tomato (Abada *et al*., 2008). The disease causes loss from 50 to 86 percent in fruit yield in different parts of the country. (Mathur and Shekhawat, 1986, Datar and Mayee, 1981). The pathogen survive for a long time in the diseased plant parts, soil and on alternative/ collateral hosts in the absence of main host, determine the wide ability of the pathogen to perpetuate (Moore and Thomas, 1942; Basu, 1971 and Rands, 1917a). The management of disease can be done through the cultural practices (Rashmi Tewari*et al.,* 2012), biological control (Kokalis-Burelle, 2002), chemical measures (Nguyen Khanh *et al.,* 2013, Sahu, *et al.*, 2013.) and use of resistance variety (Biswas *et al*., 2015). Cultural practice like field sanitation, deep summer ploughing, soil solarisation, soil amendments and crop rotation etc. can minimize the possibility of disease but cannot completely control the disease in standing crops. Another alternative method of disease management strategy is biological control. In this context, *Trichoderma harzianum*, *Trichoderma viride*, *Chaetomiumglobosum*, *Gliocladiumvirens* etc. have been exploited for management of diseases but biological control alone cannot manage the disease completely because of little fluctuation in temperature, pH, moisture, etc. largely affects the efficacy of bio-agent. The use of resistance variety is another important method which is reliable and cheep for management of plant disease but due to development of new races of pathogen, the resistance variety becomes susceptible one. Hence, the use of chemicals is the last and only method for plant disease management. It is also so effective in control of disease but man started using it indiscriminately. Excessive use of chemicals has caused soil, air, surface and ground water pollution besides effecting crop produce. The chemicals have entered our food chain also. Other detrimental effects of excessive use of chemicals are development of pesticide resistance strain in pathogen contamination of food by toxic residues, resurgenceof pest and detrimental effect on non target organism and also cost of production. Under these circumstances, a sound disease management strategy is the need of the day to provide long lasting protection in an eco-friendly manner to obtain eco-friendly safe and a sustainable agriculture. The successful integrated approach for management of diseases have found in tomatoagainst Fusarium wilt (Raviendra *et al*., 2015), in rice against brown leaf spot (Biswas *et al*., 2008, Kumawat, *et al.*, 2010), in wheat against spot blotch (Umashanker, 2014).Therefore, the study was undertaken in the present investigation as sustainable integrated approach for management of early blight and their

effect on crop growth parameters in tomato.

MATERIALS AND METHODS

Collection and preparation of plant extract

The plant leaves were collected from the university campus. The collected leaves were washed in the distilled water and dry with blotter paper. Exactly, 4 gm of leave from each plant was weight in an electric balance and were cut into small pieces. The leaves were then crushing in pestle and mortar along with 20ml distilled water at 1:5 ratios (Arzoo *et al*. 2012). The pulverized mass was squeezed through 3 folds of fine cotton cloth. The extract was then diluted in water at 1:5 ratios and used for seedling treatment by root deep method as per treatment given below

Seedling treatment

Tomato seedlings of a variety*Azad T6* were treated by root deep method with Azotobacter formulation @ 20% conc. for a period of four hours (Biswas *et al*. 2015). The packets of Azoto bacter containing 200gm inoculums were obtained from Department of Soil Science (Microbiology), Chandra Shekhar Azad University of Agriculture and Technology Kanpur.On the other hands, seedling was also treated with solution of neem cake @ 25%, plant extract of *sailyx*sp. *&Holoptelia* sp.@1:5w/v, fungicide like Mancozeb @0.25% and Carbendazim @ 0.5%., bio formulation of *Trichoderma viride*& *Trichoderma harzianum*@5%. All these biocides and fungicide were obtained from local market, Kanpur.

Effect of seedling treatments with fungicides and biocides on tomato cultivation

The experiment was conducted at glasshouse complex, Department of Plant Pathology, C.S. Azad University of Agriculture and Technology, Kanpur. The tomato variety Azad T-6 were sown in the glasshouse in 30cm earthen pot, which was previously filled with a mixture of sandy loam and Farm Yard Manure in the ratios of 2:1. The treatment were given as:–

T_1 = Soil application of FYM@ 250gm/pot + seedling treatment with bio formulationof *Azotobactor*@ 5% + foliar spray with Mancozeb@0.25%.

T_2 = Soil application of FYM@ 250gm/pot + seedling treatment with neem cake solution@ 25% + foliar spray with Mancozeb@0.25%.

T_3 = Soil application of FYM@ 250gm/pot + seedling treatment with plant extract of salyx@1:5 w/v + foliar spray with Mancozeb@0.25%.

T_4 = Soil application of FYM@ 250gm/pot + seedling treatment with plant extract of holoptelia@1:5 w/v + foliar spray with Mancozeb@0.25%.

T_5 = Soil application of FYM@ 250gm/pot + seedling treatment with fungicide Carbendazim@0.05% + foliar spray with Mancozeb@0.25%.

T_6 = Soil application of FYM@ 250gm/pot + seedling treatment with fungicide Mancozeb@0.25% + foliar spray with Mancozeb@0.25%.

T_7 = Soil application of FYM@ 250gm/pot + seedling treatment with bio-agent formulation of *T.viride*@ 5% + foliar spray with Mancozeb@0.25%.

T_8 = Soil application of FYM@ 250gm/pot + seedling treatment with bio-agent formulation of *T. harzianum* @ 5% + foliar spray with Mancozeb @ 0.25%.

T_9 = Control (Only FYM).

The observations have taken on the following parameters:-

Plant height (cm) from days after transplanting at 6 days interval up to 30 days.

Root length (cm) 85 days after transplanting.

Fresh weight of shoot (g) 85 days after transplanting.

Dry weight of shoot (g) 85 days after transplanting

Fresh weight of root (g) 85 days after transplanting

Dry root weight (g) 85 days after transplanting

Shoot and root length

Shoot length

The observation on shoot length of tomato was started after 10 days of transplanting at every 6 days interval upto 30 days age of tomato plants. The shoot length was measure with help of meter scale. This is well known that same height of seedling was choice for transplanting.

Root length

Prior to measure the root lengths of tomato plants, pots were irrigated and the seedlings were uprooted carefully (Biswas *et al.,* 2015). The roots of 85 days of plant were separated from the shoots and washed with water to remove soil particles and then root lengths (cm) were measured with the help of meter scale. The photograph of the root was also taken at that time.

Fresh and dry weight of shoot and root

Fresh weight

The shoot and root of eighty five days age of tomato plant were weight on an electronic balance and the data was recorded as grams.

Dry weight

At eighty five days age of plant, fresh shoot and roots were dried in an oven at 70ºC until constant weight. Then it was weighted on an electronic balance and the data was record as grams.

Disease severity

Inoculation of pathogen

At 40 days age, plants were inoculated with spore suspension of *A. solani*. The concentration of spore was measured @ 10^6 spore ml^{-}.Spore suspension was prepared from 7 days old culture of the pathogen. After 2 days of pathogen inoculation, plants were spray with Mancozeb @0.25%. and the disease severity was recorded at 50, 60 and 70 days age of plant.

Measurement of disease severity

Disease severity was measured after 7 days of pathogen inoculation. The disease severity was recorded using 0-4 scale (Weitang *et al.,* 2004) where zero representing no infection and four denoting completely infected plant. 2 representing moderate infection and 3 denoting extensive infection.

The disease severity was calculated by following formula-

$$\text{Disease severity (PDI)} = \frac{\Sigma \text{ Class rating X Class frequently}}{\text{Total no of leaves X maximum class}} \text{ X } 100$$

RESULTS AND DISCUSSION

Growth parameters

Shoot length

Growth of the plant is important parameters for higher yield and quality production. In the present investigation, growth of plant was recorded at 6 days interval upto30 days age of plant commences after 10 days of transplanting. The data presented in the table 1 showed that the maximum shoot length was recorded from combine effect of soil application of FYM + seedling treatment with solution of *T. harzianum,* representing the value 15.36, 17.20, 22.46, 26.93 and 31.43 cm against 10.10, 12.06, 17.06, 21.46 and 26.40 cm in case of control at 6, 12, 18, 24, and 30 days age of plant after 10 days of transplanting. The combine treatment of soil application of FYM @ 250g/pot + seedling deep in solution of *T. viride* showing 14.40, 15.86, 21.06, 25.96 and 30.96 cm shoot length at 6, 12, 18, 24, and 30 days age of plant after 10 days of transplanting, representing the second highest among the treatment. The rest of the treatments were also showing superior over control in case of shoot length of tomato plant.

From the table, it is also cleared that all the treatments were able to increase shoot length over control. Kachroo and Razdan (2006)reported that combined application of *Azotobacter*+ *Azospirillium* (1:1) with different levels of N significantly increase the grain yield of wheat. Tippannaves *et al*. (2005) had observed that the Azotobactor significantly increase the tillering, dry matter accumulation and growth parameter. Datnoff *et al*. (1995) found that *Trichoderma* spp. enhance the growth of tomato plants. Mansoor *et al*. (2001) observed that the Azotobacter improved plant height and dry weight of shoot, significantly. Biswas *et al*. (2015) found that seed treatment with *A. Chrooccocum* and soil application with *A.chrooccocum* significantly increased shoot and root length of wheat.

Fresh and dry weight of shoot

The result presented in the table showed that fresh shoot weight was found increase in all the treatments (Table2). The maximum fresh shoot weight was recorded in the treatment T_8 (soil application of FYM + seedling deep in solution of *T. harzianum*+ spray of Mancozeb), representing the value 25.30gm which was followed byT_7 treatment (soil application of FYM + seedling deep in solution of *T. viride*) showing the value 24.98gm.The rest of the treatments were also sowing superior of fresh shoot weight over control.

Similarly,dry shoot weight was also found increase in all the treatments but maximum with 7.27gm was recorded in treatment $T_8$where treatment was given as soil application of FYM + seedling deep in *T. harzianum* formulation +spray of Mancozeb. On the other hands, the minimum with 3.60gm

Table 1: Effect of different treatments on plant height of tomato at different days at 6, 12, 18, 24, and 30 days after transplanting.

Treatment	Seedling height at time of transplanting (cm)	Plant height (in cm)				
		6	12	18	24	30
T_1	8.80	13.53	15.16	20.26	24.66	29.40
T_2	8.80	13.50	14.83	20.53	25.06	29.26
T_3	8.80	9.86	11.26	16.43	21.66	26.43
T_4	8.80	10.53	12.20	17.56	23.10	27.80
T_5	8.80	12.06	13.70	18.56	23.66	28.20
T_6	8.80	11.70	13.3	18.56	22.60	27.23
T_7	8.80	14.40	15.86	21.06	25.96	30.96
T_8	8.80	15.36	17.20	22.46	26.93	31.43
T_9	8.80	10.10	12.06	17.06	21.43	26.40
C.D.(0.05)		1.458	1.152	1.116	2.028	2.081
S.E. (diff.)		0.689	0.544	0.527	0.958	0.983
C.V. %		6.835	4.778	3.368	4.909	4.212

Table 2: Effect of different treatments on branching pattern, fresh and dry shoot weight of tomato

Treatment	Fresh Weight of Shoot/Plant(gm)	% Increase overControl	Dry Weight of Shoot /Plant(gm)	% Increase overControl	Average No. of BranchesPer plant	% Increase over Control
T_1	24.54	32.64	6.45	79.16	6.75	50.00
T_2	22.25	20.27	5.07	40.83	5.38	19.55
T_3	19.53	05.56	4.75	31.94	5.20	15.55
T_4	22.28	20.43	5.63	56.38	5.80	28.88
T_5	19.40	04.86	4.96	37.77	6.05	34.44
T_6	19.00	02.70	4.00	12.12	5.02	11.55
T_7	24.98	35.02	6.95	93.05	7.85	74.44
T_8	25.30	36.75	7.27	101.38	8.03	78.44
T_9	18.50	00.00	3.60	00.00	4.50	00.00
CD (0.05)	1.846		0.692		0.534	
SE (d)	0.872		0.327		0.252	
C.V. %	4.908		7.396		5.094	

Table 3: Effect of different treatments on length, width of root zone,morphological characters andfresh & dry root weight of tomato.

Treatment	Root length(Cm)	Fresh weight of roots (gm)	% Increase overcontrol	Dry weight overcontrol	% Increasel over contro	Average no. of branchesin roots	% Increase over control	Root width (Cm)	Morphological character of root
T_1	14.66	19.91	92.73	3.75	56.25	6.55	55.95	19.75	Branches are less in number, mostly are secondary root
T_2	11.00	14.75	42.78	2.90	20.83	5.60	33.33	15.07	Less branches, not fibrous
T_3	10.33	13.30	28.75	2.75	14.58	5.45	29.76	14.75	Robust root system, less in number
T_4	12.66	15.66	51.59	3.30	37.50	5.85	39.28	16.66	Poor branches, not fibrous
T_5	13.75	17.85	72.79	3.45	43.75	6.20	47.61	18.06	Roots are fibrous, developed
T_6	08.98	11.98	15.97	2.63	09.58	5.15	22.61	13.55	Thread like roots, tap root branched many times
T_7	15.00	21.08	103.58	4.00	66.67	7.20	71.42	21.03	Sturdy root, well developed
T_8	16.00	22.00	119.30	4.25	77.08	7.50	78.57	22.66	Robust root system, well developed root
T_9(Untreated)	08.66	10.30	00.00	2.40	00.00	4.2	00.00	10.33	Branches not developed, weak roots, less fibrous
C.D. (0.05)	0.726	1.101		0.248		0.384		1.008	
S.E.(diff.)	0.343	0.520		0.117		0.182		0.476	
C.V.%	3.404	3.902		4.384		3.727		3.457	

Table 4: Efficacy of eco-friendly approach on disease severity of early blight of tomato at 7, 14 and 21 days after inoculation

Treatments	Disease severity (%)		
	7 Days	14 Days	21 Days
T1	12.87	19.35	22.90
T2	15.26	21.05	25.20
T3	12.72	20.02	23.08
T4	14.45	17.75	20.12
T5	08.56	12.75	15.07
T6	08.32	14.22	17.50
T7	11.00	13.62	14.02
T8	05.61	10.14	13.90
T9	65.87	82.55	95.50
C.D. (0.05)	3.531	3.609	4.646
S.E.(diff.)	1.668	1.705	2.194
C.V. %	11.885	8.885	9.781

shoot weight was found in case of control. From the data presented in table-4, it is cleared that all the treatments were able to significantly increased dry shoot weight over control at 85 days age of plant. 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. Tippannaves *et al.* (2005) had observed that the Azoto bactor significantly increase the tillering, dry matter accumulation and growth parameter. Kachroo and Razdan (2006) reported that combined application of *Azotobacter* + *Azospirillium*(1:1) with different levels of N significantly increase the grain yield of wheat.

Average number of branches in shoots

Increase number of branches in shoot is an indication of higher yield. The data presented in table-2 indicated that the maximum average number of branches were recorded in treatment T_8 (soil application of FYM + seedling deep in *T. harzianum* formulation + spray of Mancozeb) representing value of 8.03 average number of branches followed by treatment T_7, T_1 and T_5 with the value of 7.85, 6.75 and 6.05 branches in shoots per plant, respectively. It has also found from the table that all the treatments were able to increase number of branches in tomato plant over control. The present finding is also supported by Walke, *et al.* (2014). Mansoor *et al.* (2001) also observed that the Azotobacter improved plant height and shoot dry weight significantly. RasoolAzarmi*et al.* (2011) reported that seed germination rate was affected by *Trichoderma* application but shoot height, shoot diameter, fresh and dry weight of shoot in tomato seedlings were increased significantly. They also found that soil amended by *Trichoderma* sp.had marked increase in leaf number and area of leaf.

Root length and width of root zone

The morphology and size of roots is important parameters for higher yield and quality production. In the present investigation, it has found that among the treatments, the maximum root length was recorded in treatment T_8 (soil application of FYM + seedling deep in solution of *T. harzianum* + spray of Mancozeb), representing 16.00cm (Table 3).The minimum root length with the value of 8.98cm was recorded in T_6 where treatment was given as soil application of FYM + seedling treatment with Mancozeb + spray of Mancozeb. The second highest root length was recorded in treatment T_7 (soil application of FYM + seedling deep in solution of *T. viride* + spray of Mancozeb)with the value of 15.00cm. Similarly, maximum width of root zone was recorded in T_8 (soil application of FYM + seedling deep in *T. harzianum* formulation + spray of Mancozeb), representing 22.66cm followed by T_7 (soil application of FYM + seedling deep in *T. viride* formulation + spray of Mancozeb), T_5 (soil application of FYM + seedling deep in Mancozeb + spray of Mancozeb) and T_4 (soil application of FYM + seedling deep in plant extract of*Holoptelia* + spray of Mancozeb)representing the value 21.03cm, 18.06cm and 16.66cm, respectively. The morphological characters of root system in the treatment T8 showed that there was a well developed robust root system which is unique and well developed from other treatments (Fig. 1). From the table, it is also cleared that the all the treatments were able to increase root length and width of root zone over control (table-4, fig-1). Shanmugaiah *et al.* (2009) describe that *T. viride*was found to be more effective than *P. fluroescens*on shoot and root length and germination. Ravindra *et al.* (2015) studied on 90 days old tomato crop and found that root length was highest in

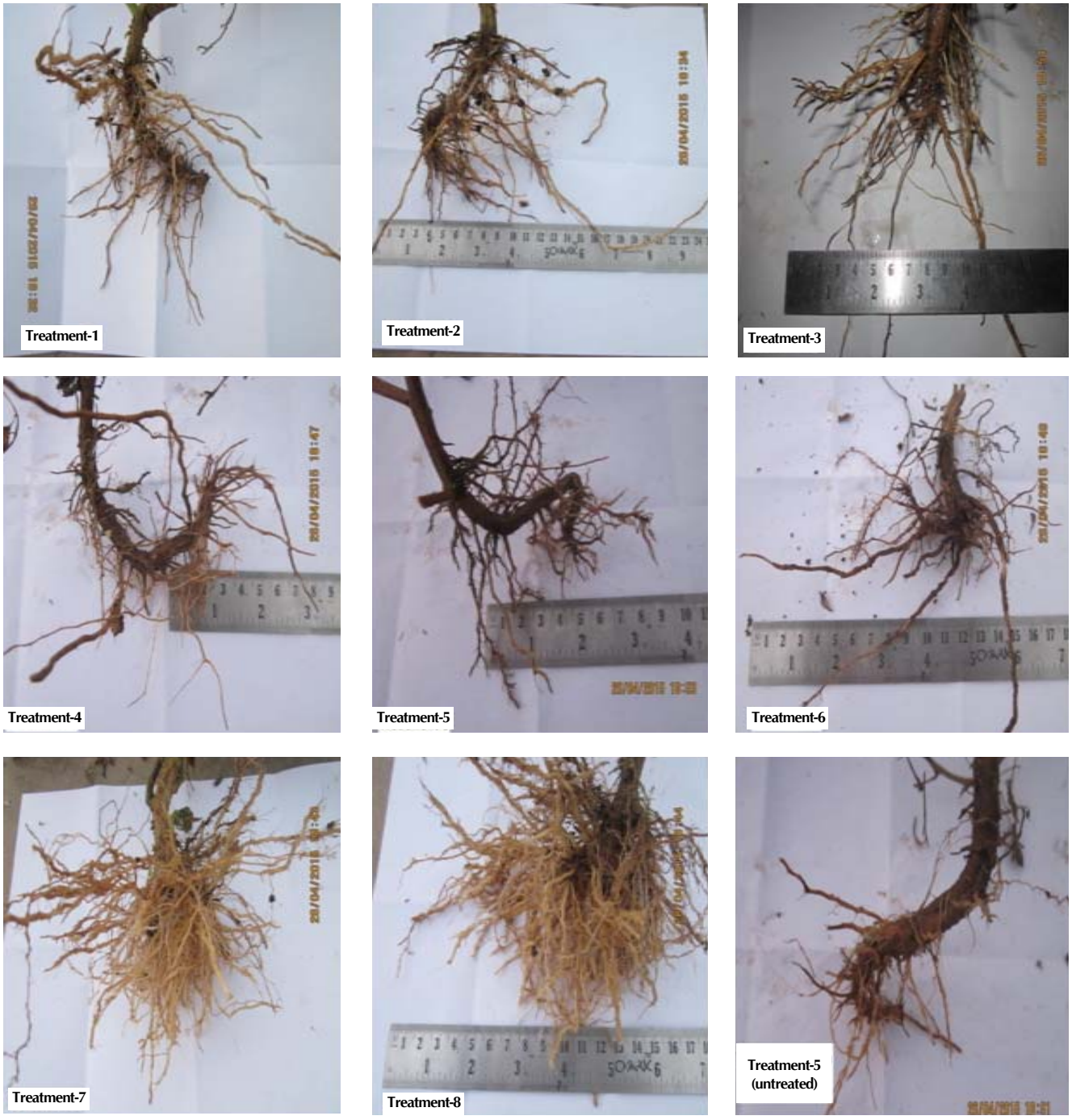

Figure 1: Effect of different treatments on branching pattern of root of tomato

case of seed treatment with *T. harzianum* + soil application of neem cake powder + foliar spray of Carbendazim. Umashanker (2014) also found that the highest fresh shoot and root weight of wheat was notice in case of *Azotobacter* treated plant as seed treatment and soil application.

Fresh and dry weight of roots

In the present investigation, it has been found that all the treatments were able to significantly increased fresh root weight over control at 85 days age of plant. Among the treatments, the maximum with 22.00gm fresh root weight was recorded in treatment T_8 (soil application of FYM + seedling deep in *T. harzianum* formulation + spray of Mancozeb) against 10.30gm in case of control. The treatment T_7 (soil application of FYM + seedling deep in *T. viride*formulation + spray of Mancozeb), representing value 21.08gm, which is second highest among the treatments. Similar trends of observation have also seen recorded in case of dry root weight of tomato (table-3).Elanchezhian and Panwar (1997) had observed that Azotobactor gives positive effect on yield attributes like dry

weight, number of grains and test weight in wheat crop.BombitiNzanza *et al*. (2011) examined that biomass production of 6 week old tomato seedling as influenced by *T. harzianum*and Arbuscular mycorrhizal fungi.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. Combine application of seed treatment with *T. harzianum* + soil application of neem cake powder + foliar spray of Carbendazim, enhance the fresh and dry root weight of tomato (Ravindra *et al.,* 2015).

Disease severity

The data presented in table 4showed that all the treatments were able to significantly reduce the disease severity over control. In the present investigation, the eco-friendly approach as soil application of FYM + seedling treatment with *T. harzianum* + spray of Mancozeb,was found most effective in decreasing disease severity, representing 5.16, 10.14 and 13.90 percent disease severity at 50, 60 and 70days age of plant, respectively which was followed by T7 treatment, where treatment was given as soil application of FYM + seedling treatment with *T. viride* + foliar spray of Mancozeb, representing the value 11.0, 13.62 and 14.02 per cent respectively. Among the treatments maximum disease severity was recorded in the treatment T_2 (soil application of FYM + seedling treatment with neem cake formulation + spray of Mancozeb) showing the value of 15.26, 21.05 and 25.20 percent at 50, 60 and 70 days age of plant.

NguyenKhanh, *et al*. (2013) found that the utility of different bio-agents, botanicals and fungicides to manage the early blight of tomato.Ravindra *et al*. (2015) found that integration of seed treatment with *T. harzianum* + soil application of neem cake + foliar spray of Carbendazim reduce the disease severity of Fusarium wilt of tomato. Myresiotis *et al*. (2012) also reported that when PGPR strain combined with pesticides, there was an increased suppression of *F.o.* f. sp. *radicis-lycopersici*(Forl) on tomato plants, and thus it has proved an important integrated approach for management of tomato wilt. Someya *et al*. (2006) reported that combined application of benomyl with *Pseudomonas fluorescence* strain LRB3W1 was more effective than treatment with the bacterium alone for management of tomato wilt. Varma, *et al*. (2008) reported that the foliar spray of *T. viride* (10^7 CFUs ml^{-1}) 24 h before challenge inoculation with the test fungus was found effective in reducing the disease severity under screen house conditions.

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