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Efficacy of Certain Bio-Agents and Plant Extracts against Late Blight (*Phytophthora infestans*) of Tomato (*Lycopersicon esculentum* L.)

Lal Chand Yadav[1], Abhilasha A. Lal[1], S.S. Kakraliya[2], M.R. Bajiya[3] and Mukesh Sheshma[4]

[1]Department of Plant Pathology, Sam Higginbottom Institute of Agriculture, Technology and Sciences (Deemed-to-be-University), Allahabad-211007, Uttar Pradesh, India
[2]Division of Plant Pathology, [3]Division of Entomology, SKUAST-Jammu, India
[4]Division of Plant Pathology, SKRAU, Bikaner, India
**Corresponding author*

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A B S T R A C T

An experiment was conducted under field conditions to observe the effect of bio-agents, botanicals and fungicide against *Phytophthora infestans*. Seven treatments were taken up with three replications and data collected was analyzed using randomized block design (RBD). Two botanicals (Neem extract and Garlic extract), three bio-control agents (*Trichoderma viride, T. harzianum and Pseudomonas fluorescens*) and treated control were used. Minimum disease intensity percent and maximum production of tomato was recorded in treatment *P. fluorescens*@5g/l (33.30% and 223.10 q/ha, respectively) followed by *T. viride* @5g/l (34.79% and 213.36 q/ha, respectively), as compared to treated control (30.80% and 244.50 q/ha) and untreated control (55.88% and 103.50 q/ha). *P. fluorescens* was found significantly superior over other treatments. In other parameters, plant height (cm), fresh shoot weight (g), fresh root weight (g), root length (cm), dry shoot weight(g) and dry root weight (g)of *T. viride* (62.41cm, 53.30 g, 7.02 g, 22.02 cm, 8.28 g and 4.70 g respectively) shoot weight (g), fresh root weight (g), root length (cm), dry shoot weight(g) and dry root weight (g)of *T. viride* (62.41cm, 53.30 g, 7.02 g, 22.02 cm, 8.28 g and 4.70 g respectively) was found(best treatment) and was significantly superior over other treatments.

Introduction

Tomato (*Lycopersicon esculentum* Mill, n = 12) belongs to the family solanaceae and is one of the most remunerable and widely grown vegetables in the world. Tomato is grown for its edible fruits, which can be consumed either fresh or in processed form and is a very good source of vitamins A, B, C and minerals. Being the world's second most cultivated crop, with a production estimated at 150 million tones and acreage of 5.2 million hectares, the tomato is an indispensible vegetable crop world over and, of course, for India. China is the world's largest producer of the tomato (48.1 mt) followed by India (19.5 mt) (Balanchard, 1992; Sallam *et al.*, 2012). Late blight of tomato, the disease that was responsible for the Irish potato famine in the mid-nineteenth century, is caused by *Phytophthora infestans* (Mont.) De Bary. It can infect and destroy the leaves, stem, fruits, and tubers of potato and tomato plants. Reproduction occurs via sporangia that are

produced from infected plant tissues and is most rapid during conditions of high moisture and moderate temperatures (15-25^{0}C). Sporangia disperse to healthy tissues via rain splash or on wind currents. The first symptoms usually appear on leaves as water-soaked, oily, pale or dark-green or brown/ black, circular or irregular lesions. Typically, younger, more succulent, tissue is affected first. During periods of abundant moisture, sporulation of the pathogen can be seen by the naked eye as a white, cottony growth on the underside of affected leaves and/ or on fruit lesions. When wet and cool conditions are prevalent, the disease usually progresses rapidly through the plant canopy and crop, resulting in brown, shriveled foliage (Waterhouse, 1963; Newhook *et al.*, 1978; Ribeiro, 1978 and Erwin *et al.*, 1983).

Materials and Methods

The experiment was laid out in a randomized complete block design with seven treatment and three replications. The unit plot size was 2m × 1m which was separated by 1.0 m wide drains. Row to row and plant to plant distances to be were 60 cm and 45 cm, respectively. The soil was sandy loam with pH 5.6. The soil was raised and drains were made to remove excess water. The symptoms appeared after 45 days of transplanting. On the basis of symptoms and sporangium characteristics (Figure 1), the fungus was identified as *Phytophthora infestans* causative agent of late blight of tomato (Erwin *et al.*, 1983). The treatments comprised of *Trichoderma harzianum* @ 5 g/l, *T. viride* @ 5 g/l, *Pseudomonas fluorescens* @ 5 g/l, Neem leaf extract @ 10 % concentration, Garlic extract @ 10 % concentration, mancozeb (treated control) @ 1.5g/l and untreated control. The crop was sprayed three times at 40, 50, and 60 DAT. The disease intensity of late blight was recorded after five days of spray.

The disease intensity was recorded on 0 - 9 scale (Singh, 2005). Five infected plants were selected randomly from each plot and five leaves were selected from each selected plant for scoring the disease intensity data. Each disease was identified on the basis of following symptoms (Figure 2).

Disease intensity (%) was calculated by used the following formula:

$$\text{Disease index (\%)} = \frac{\text{Sum of disease ratings}}{\text{Total No. of ratings} \times \text{Maximum disease grade}} \times 100$$

(Wheeler, 1969)

Results and Discussion

The results obtained during the present investigation are presented under appropriate headings with the observation concerning various aspects of disease intensity(%) @75 DAT, plant height (cm) @ 65 DAT, fresh shoot weight (g) @ 110 DAT, fresh root weight (g) @ 110 DAT, root length (cm) @ 110 DAT, dry shoot weight (g) @ 120 DAT, dry root weight (g) @ 120 DAT and yield (q/ha) attributes of tomato are presented in table 1.

The results presented in table 1 revealed that all the treatments were statistically significant and decreased disease intensity as compared to control. Among the bio-agents and botanicals used the minimum disease intensity percent was recorded in *Pseudomonas flourescens* @ 5g/l (33.30 %) as compared to treated and untreated control (30.80% and 55.88%, respectively). *P. flourescens* treatment was followed by *Trichoderma viride* @ 5g/l (34.79%), *T. harzianum* @ 5g/1(36.75%), Neem leaf extract @10% (43.31%) and Garlic extract @ 10% (46.25%) as compared to control (55.88%). Among the treatments lowest percent disease intensity was recorded in

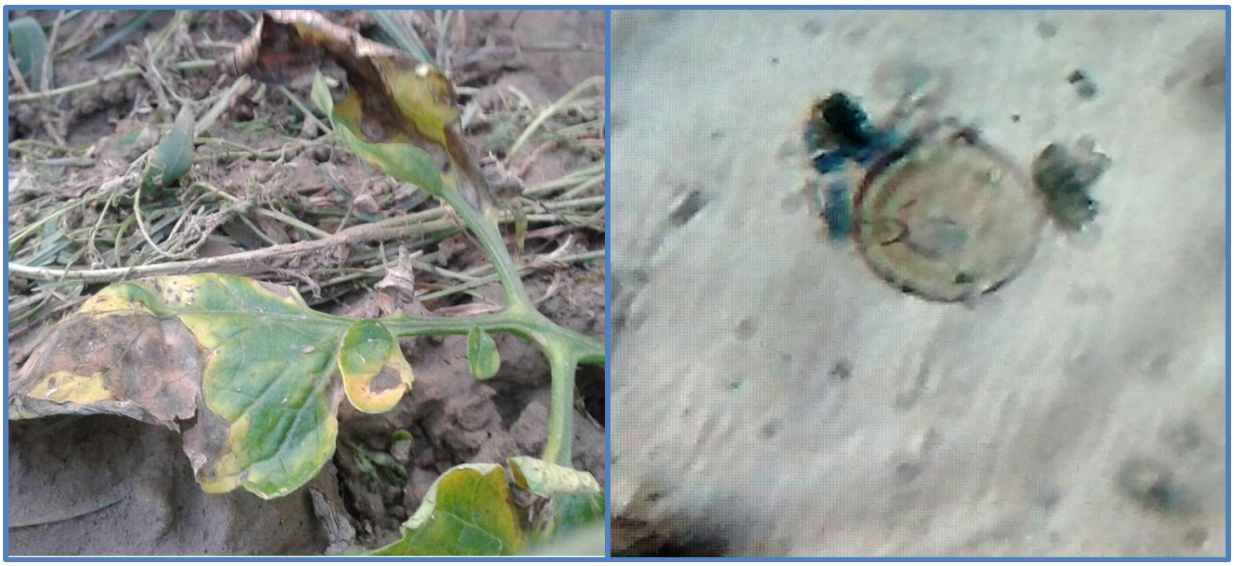
Mancozeb @ 1.5g/l (38.80%) and *Pseudomonas flourescens* @ 5g/l (33.30 %). maximum plant height (cm) was recorded in *T. viride* @ 5g/l (62.41 cm) as compared to treated and untreated control (53.37 cm and 51.48 cm, respectively) followed by *Trichoderma harzianum* @ 5g/1(60.60cm), *Pseudomonas flourescens* @ 5g/l (58.73cm) Neem leaf extract @10% (56.33cm) and Garlic extract @ 10% (54.57cm) as compared to control (51.48cm).

Among the treatments maximum plant height (cm) was recorded in *T. viride* @ 5g/l (62.41 cm). Maximum plant height was recorded in treatment *T. viride* @ 5g/l (62.41 cm) followed by *T. harzianum* @ 5g/l (60.60 cm) as compared to treated control (53.37 cm) and untreated control (51.48 cm).

Maximum fresh shoot weight was recorded in treatment *T. viride* @ 5g/l (53.30 g) followed by *T. harzianum* @ 5g/l (50.0 g) as compared to treated control (36.18 g) and untreated control (32.35 g). Maximum fresh root weight was recorded in treatment *T. viride* @ 5g/l (7.02 g) was followed by *T. harzianum* @ 5g/l (6.39) as compared to treated control (4.07 g) and untreated control (3.04 g). Maximum root length was recorded in treatment *T. viride* @ 5g/l (22.02 cm) followed by *T. harzianum* @ 5g/l (20.0) as compared to treated control (17.53 cm) and untreated control (15.97 cm).

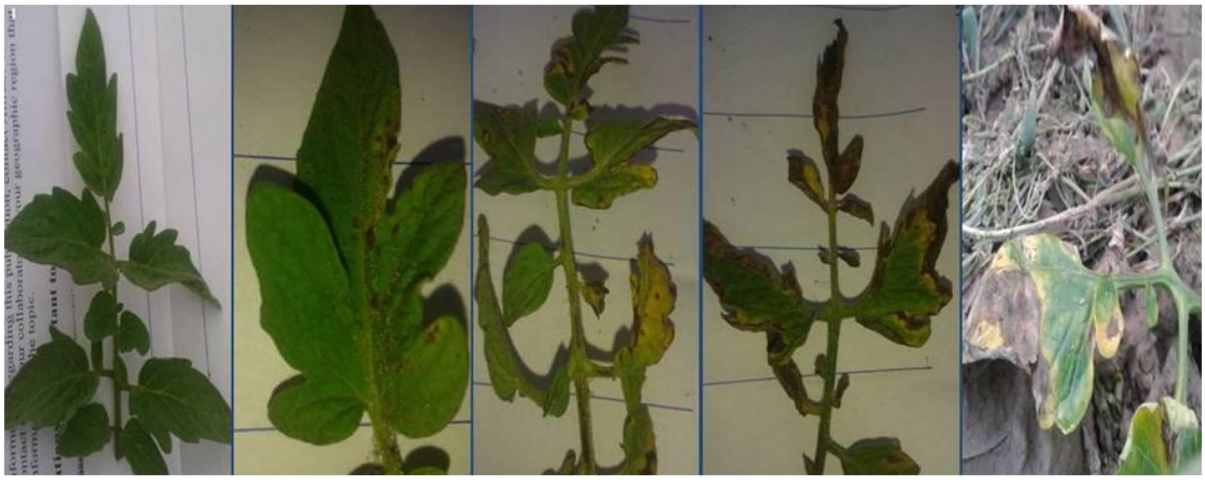
Maximum dry shoot weight was recorded in treatment *T. viride* @ 5g/l (8.28 g) followed by *T. harzianum* @ 5g/l (7.03) as compared to treated control (4.98 g) and untreated control (3.03 g). Maximum dry root weight was recorded in treatment *T. viride* @ 5g/l (4.70 g) followed by *T. harzianum* @ 5g/l (3.85) as compared to treated control (1.61 g) and untreated control (0.92 g). Maximum yield (q/ha) was recorded in treatment *P. fluorescens* @ 5g/l (223.10 q/ha) followed by *T. viride* @ *5g*/l (213.36 q/ha) as compared to treated control (244.50 q/ha) and untreated control (103.50 q/ha).

Fig.1 Symptoms of Late blight on (A) leaves of Tomato and (B) sporangium of *Phytophthora infestans* (40 X)



A **B**

Fig.2 Degrees of Infection of Late blight of tomato on 0 to 9 Scales (0 =No infection), 1 = (0.1-1.0 per cent leaf area affected,) 3 = (1.1-10 per cent leaf area affected), 5 = (10.1-25 per cent leaf area affected), 7 = (31.1-50 per cent leaf area affected) and 9 = (above 50 per cent leaf area affected)



0 **1** **3** **5** **7**

Table.1 Effect of different treatments on disease intensity against *Phytophthora infestans* and on selected plant growth parameters and yield of tomato

Treatment	Disease intensity (%)	Plant height (cm)	Fresh shoot weight (g)	Dry shoot weight (g)	Fresh root weight (g)	Dry root weight (g)	Root length (cm)	Yield (q/ha)	C:B
	75 DAT	65 DAT	110 DAT	120 DAT	110 DAT	120 DAT	110 DAT		
Control	55.88	51.48	32.35	3.03	3.04	0.92	15.97	103.50	1:3.47
T.harzianum	36.75	60.60	50.00	7.03	6.39	3.85	20.00	206.50	1:6.48
T. viride	34.79	62.41	53.30	8.28	7.02	4.70	22.02	213.36	1:6.70
P fluorescens	33.30	58.73	46.95	6.80	6.11	3.00	19.48	223.10	1:7.00
Neem extract	43.31	56.33	41.05	6.01	5.01	2.29	18.95	180.51	1:5.76
Garlic extract	46.25	54.57	38.11	5.10	4.28	1.73	18.13	155.12	1:3.87
Mancozeb (treated control)	30.80	53.37	36.18	1.98	1.07	1.61	17.53	244.50	1:7.54
Overall Mean	40.15	56.78	42.56	5.89	5.19	2.58	18.86	189.51	1:5.82
C.D.(P=0.5)	2.39	1.27	1.98	0.80	0.85	0.61	0.95	3.62	

The probable reasons for such findings may be due to the inhibitory effect of bio-agents due to hyperparasitism/mycoparasitism, competition for space and nutritional source and antagonistic chemical produced by them, due to their ability to produce antimicrobial compounds, including 2, 4-diacetylphloroglucinol (DAPG), phenazines, hydrogen cyanide and surfactants, which may have hindered the growth of the pathogen, or due to antibiotic compounds (Trichodermin), extracellular enzymes (chitinase, cellulase), unsaturated monobasic acids (Dermadine) and peptides produced by *T. viride*, which may

have damaged the plant pathogen and ultimately resulting in good health of the tomato plants. Similar findings have been reported by Islam and Faruq (2008), Manoranjitham *et al.*, (1999), Bunker and Mathur (2001), Haas and De´fago (2005), Baehler *et al.*, (2006) and Dubuis *et al.*, (2007). Similar findings have also been reported by Karegowda *et al.*, (2009) who found that *T. viride* and *T. harzianum* overgrew and suppressed the growth of *Phytophthora capsici*, Dennis and Webster, (1971) reported that *Trichoderma* spp. have proved their ability as a good bio-control agent against many fungi which is mainly due to production of acetaldehyde.

In conclusion, *Pseudomonas flourescens* @ 5g/l as foliar spray proved to be most effective against late blight of tomato showing minimum disease intensity and producing maximum plant height (cm), fresh shoot weight (g), fresh root weight (g), root length (cm), dry shoot weight (g), dry root weight (g) were recorded in treatment *Trichoderma viride* @ 5g/l it was the most effective treatment. The results of present experiment are limited to one season under Allahabad agro climatic conditions as such more trials should be carried out in future to validate the findings.

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