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Eco-friendly Management of Leaf Spot of Brinjal (*Solanum melongena* L.) caused by *Alternaria* spp

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A B S T R A C T

Brinjal (*Solanum melongena* L.) is one of the most important vegetable crops being grown both during warm and rainy season in India. It has wide genetic diversity and is grown throughout the tropics and subtropics of the world. But the crop is attacked by a number of diseases such as Alternaria leaf spot, collar rot, damping off, early blight, fruit rot, leaf spot, phomopsis blight, bacterial wilt, mosaic and mottle and little leaf, among which leaf spot caused by *Alternaria* spp is found to cause serious losses throughout U.P and other states. A field trail was done in *Rabi* season in the month of December 2019, the effect of seedling treatment with *T. viride,* neem oil, castor oil, clove oil and its combinations were used to minimize the Alternaria leaf spot disease intensity of brinjal. Based on single trail, it was observed that seedling treatment with neem oil @ 2.5% + *T. viride* @ 2.5% was most effective against Alternaria leaf spot disease.

Introduction

Brinjal (*Solanum melongena* L.) also known as eggplant, belongs to family solanaceae, is an important vegetable crop grown throughout the world. In production and productivity of brinjal, India is second in the world after China. Brinjal has three main botanical varieties under the species *melongena*, the round or egg-shaped cultivars grouped under *var. esculamtum*, the long slender types are under var. *serpentinum* and the dwarf brinjal plants are under *var. depressum*. The family contains more than 2000 species distributed in 75 genera.

Botanically brinjal fruit is classified as a berry contains numerous small, soft seeds which, though edible but the taste is bitter because, the plant being related to tobacco, they contain nicotinoid alkaloids. The immature tender fruits are used as vegetable, pickle making and in dehydration industries. Cooked vegetables are prepared in various ways. The brinjal is rich source of minerals (calcium, magnesium, phosphorus, sodium, potassium, chlorine, iron etc.), vitamins and has some medicinal importance. White brinjal are good for diabetic patients. It is quite high in nutritive value and per 100g of edible portion contains 92.7g moisture, 6.4g carbohydrate, 1.3g protein, 0.3g fat, 1.3g fibre, 124 IU vitamin A, 0.09mg nicotinic acid, 120mg vitamin C, 200mg potassium, 18mg calcium, 16mg magnesium, 47mg phosphorus and 0.9 irons (Aykroyd, 1963).

The crop suffers from many diseases like wilt (Crawford, 1934), blight (Bremer, 1945), downy mildew (Aramstrong and Albert, 1933), damping off (Baker, 1947), Phompsis blight (Walker, 1951), root rot (Marschil, 1981). Among these Alternaria leaf spot is an important disease of brinjal. In India this disease was first reported from IARI, New Delhi (Kapoor & Hingorani 1958).

This disease is severe and appears regularly, causing heavy losses in yield. Prasad and Ahir (2013) reported up to 25% yield losses from Jaipur district due to leaf spot of brinjal. The disease first makes its appearance in young seedling. It attacks leaves and then spreads to fruits which subsequently rot and become unfit for consumption (Bochalya *et al.*, 2012).

Initially disease appears as small, dark brown and sunken spots, which subsequently converted in concentric rings and then become olivaceous dark brown lesion due to spore formation.

Alternaria species are potential cosmopolitan fungi under the division of Deuteromycotina and can be found in soil, plant, food, feed and indoor air (Nayyar *et al.*, 2014). It is an opportunistic pathogen on numerous hosts causing at least 20% of agricultural spoilage, most severe losses may reach up to 80% of the yield(Marcin *et al.*, 2012). Biological control of plant pathogens has been considered as a potential disease control strategy in recent years and appears to be the most promising in disease management. Biological control agents colonize rhizosphere and provide protection against various soil borne plant pathogens (Kloepper *et al.*, 1989). Fungi in the genus *Trichoderma* are of increasing interest as bio protectants. Singh *et al.*, (1980) reported fungicidal impact of neem oil against four pathogenic fungi. Clove (*Syzygium aromaticum* L. Merrill and Perry) is one of the most valuable spices that have been used from centuries as food preservative and for many medicinal purposes. Flower bud have many medicinal proprieties like antiviral, antimicrobial, antifungal general stimulating, hypertensive aphrodisiac, light stomachic, carminative and anaesthetic (Di Paoli *et al.*, 2007; Politeo *et al.*, 2010; Koba *et al.*, 2011; Machado *et al.*, 2011).

To develop an effective disease management programme the compatibility of potential bioagents with and essential oils is essential. Combining antagonists with synthetic and non-synthetic chemicals eliminates the chance of resistance development and reduces the fungicides application. In view of this, experiments were conducted to test the possibility of combining *Trichoderma viride* with essential oils. Considering the above mentioned facts, a study entitled “Eco-friendly management of leaf spot of Brinjal (*Solanum melongena* L.*)*caused by *Alternaria* spp” was undertaken.

Materials and Methods

The study was conducted field condition at department of Plant Pathology, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, during the Rabi season of 2018-19. Field experiment was laid-out in Randomized block design with three replications.

Field Preparation

The selected field area was well prepared and plot marked as per the layout plan. The selected field was ploughed, cleaned and the soil was well pulverized after which the total area was divided into sub-plots.

Experimental site

The present study was carried out in the Central Research Field under the Department of Plant Pathology, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj, during Rabi 2019-2020.

The field experiment was laid-out in Randomized Block Design (RBD) with three replications of eight treatments, each in 2×1 m sized plots and 75×60 cm plant spacing was used.

Seedling treatment

5% each of neem oil, castor oil and clove oil suspensions were separately prepared by mixing 50 ml oil in 1000 ml distilled water. For *T. viride*, 50 g per litre rate was used to prepare suspension in 1000 ml of water. For the botanicals and bio agent combinations, 25 ml oil and 25 g *T. viride* formulation were mixed in distilled water to make 1000 ml treatment solution.

The roots of the seedlings were dipped in the allotted suspensions for 25-30 minutes and then allowed to air dry in shade for 15 minutes, followed by transplanting in the designated treatment plots (Jadon, 2009).The transplanting was done on 27th December 2019. Disease intensity was recorded as grades in five randomly selected plants tagging in each plot and at 60, 75 and 90 days after transplanting observed disease intensity as per the scale of Mayee and Datar (1986).

Disease intensity (%) was calculated by using the following formula

$$\text{Disease intensity (\%)} = \frac{\text{Sum of all individual ratings}}{\text{Total no. of ratings} \times \text{maximum disease grade}} \times 100$$

Symptoms

Symptoms first appear as small, isolated, scattered, pale brown necrotic brown spots on the leaves. In these necrotic spots, concentric rings appear on the older leaves and darkened areas on the stem. There is usually a narrow chlorotic zone around the spots, which fades into normal green and increases with an increase in the size of the leaf. When the leaf lesions involve larger veins, chlorosis commonly extends well beyond the necrotic spots. This is due to the toxin-alternaric acid, produced by the fungus and translocated through the veins.

Results and Discussion

Effect of treatments on plant growth parameters

Plant height

The data presented at 30, 60 and 90 DAT table 1 and figure 1 shows maximum plant height was recorded in treatment T_5 neem oil+ *T. viride* (17.4, 36, 57.59 respectively) followed by the T_1 neem oil (16.8, 34.5, 54.2 respectively), T_6 clove oil+ *T.virde* (16.4, 32.74, 52.18 respectively), T_3clove oil (16.1, 32.04, 51.24 respectively), T_4 *Trichoderma viride* (15.9, 30.84, 49.34 respectively), T_7 *T.viride* + castor oil (15.8, 28.98, 46.36 respectively), T_2 castor oil (15.5, 27.84, 44.4 respectively) and the lowest treatment is T_0 control (15.3, 26.16, 41.85 respectively).

However, neem oil+ *T. viride*@ (2.5%+2.5%) seedling treatment found best among all the treatments giving good plant height followed by neem oil (5%). At 30 DAT treatment (T_1, T_6, T_3), (T_3, T_4), (T_4, T_7, T_2) were found non-significant among themselves. And all treatments were found significant over control. At 60 DAT (T_6, T_3),(T_2, T_0) were found non-significant among themselves. And all treatments were found significant over control. At 90 DAT (T_6, T_3) were found non-significant among themselves. And all treatments were found significant over control.

Effect of treatments on plant leaves at 30, 60 and 90 DAT of brinjal (*Solanum melongena* L.)

The data presented at 30,60 and 90 DAT in table no. 4.2 and fig no 4.2 shows maximum plant leaves was recorded in treatment T_5 neem oil + *T. viride* (9.2, 17.4, 38.4 respectively) followed by the T_1 neem oil(8.6, 16.8, 37.2 respectively), T_6 clove oil + *T.virde* (8.4, 15.9, 35.1respectively), T_3clove oil (8.1,15.3, 33.8 respectively), T_4 *Trichoderma viride* (7.6, 14.4, 31.7 respectively), T_7 *T. viride* + castor oil(7.2,13.6,30.0respectively), T_2 castor oil (6.6, 13.1, 28.8 respectively) and the lowest treatment is T_0 control (6.4,12.1,26.7respectively).

However, neem oil+ *T. viride*@ (2.5%+2.5%) treatment found best among all the treatments by giving maximum plant leaves followed by neem oil (5%). At 30 DAT (T_1, T_6, T_3), (T_4, T_7) were found non-significant over control. And all treatments were found significant over control. At 60 DAT (T_6, T_3), (T_7, T_2) were found non-significant among themselves. And all treatments were found significant over control. At 90 DAT (T_5, T_1), (T_4, T_7) were found non-significant among themselves. And all treatments were found significant over control.

Effect of treatments on plant branches at 30, 60 and 90 DAT of brinjal (*Solanum Melongena* L.)

The data presented at 30,60 and 90 DAT in table no. 4.3 and fig no 4.3 shows maximum plant branches was recorded in treatment T_5 neem oil+ *T. viride* (3.2, 8.0, 12.0 respectively) followed by the T_1 neem oil(2.9, 7.2, 10.9respectively), T_6 clove oil+ *T.virde* (2.7, 6.7, 10.1 respectively), T_3clove oil (2.5, 6.2, 9.3 respectively), T_4 *Trichoderma viride* (2.1, 5.2, 7.8 respectively), T_7*T. viride* + castor oil(2.0, 4.9, 7.4respectively), T_2 castor oil(1.9, 4.6, 7.0 respectively) and the lowest treatment is T_0 control (1.8, 4.5, 6.7 respectively). However, neem oil+ *T. viride*@ (2.5%+2.5%) treatment found best among all the treatments on maximum no. of branches followed by neem oil (5%).

Table.1 Details of Treatment

Sr. No.	Treatment No.	Treatment Name	Concentration %
1.	T_0	Control	--
2.	T_1	Neem oil	5%
3.	T_2	Castor oil	5%
4.	T_3	Clove oil	5%
5.	T_4	*Trichoderma viride*	5%
6.	T_5	Neem oil+ T.*viride*	2.5%+ 2.5%
7.	T_6	Clove oil+*T.viride*	2.5%+ 2.5%
8.	T_7	Castor oil + *T.viride*	2.5%+ 2.5%

Table.2 Effect of treatments on plant height (cm) at 30, 60 and 90 DAT of brinjal (*Solanum melongena* L.)

Treatment Details	Plant height (cm)		
	30 DAT	60 DAT	90 DAT
T_0 control	15.3	26.16	41.85
T_1 Neem oil	16.8	34.5	54.2
T_2 Castor oil	15.5	27.84	44.4
T_3 Clove oil	16.1	32.04	51.24
T_4 *T.viride*	15.9	30.84	49.34
T_5Neem oil+*T.viride*	17.4	36	57.59
T_6Clove oil+*T.viride*	16.4	32.74	52.18
T_7Castor oil+*T.viride*	15.8	28.98	46.36
SEd(±)	0.231	0.500	0.608
CD (5%)	0.501	1.082	1.317

Table.3 Effect of treatments on plant leaves at 30, 60 and 90 DAT of brinjal (*Solanum melongena* L.)

Treatment Details	No. of leaves/plant		
	30 DAT	60 DAT	90 DAT
T_0 control	6.4	12.1	26.7
T_1 Neem oil	8.6	16.8	37.2
T_2 Castor oil	6.6	13.1	28.8
T_3 Clove oil	8.1	15.3	33.8
T_4 *T.viride*	7.6	14.4	31.7
T_5Neem oil+*T.viride*	9.2	17.4	38.4
T_6Clove oil+*T.viride*	8.4	15.9	35.1
T_7 Castor oil+*T.viride*	7.2	13.6	30.0
SEd(±)	0.198	0.084	0.0274
CD (5%)	0.429	0.183	0.158

Table.4 Effect of treatments on plant branches at 30, 60 and 90 DAT of brinjal (*Solanum melongena* L.)

Treatment Details	No. of branches/plant		
	30 DAT	60 DAT	90 DAT
T_0 control	1.8	4.5	6.7
T_1 Neem oil	2.9	7.2	10.9
T_2 Castor oil	1.9	4.6	7.0
T_3 Clove oil	2.5	6.2	9.3
T_4*T.viride*	2.1	5.2	7.8
T_5Neem oil+*T.viride*	3.2	8.0	12.0
T_6Clove oil+*T.viride*	2.7	6.7	10.1
T_7 Castor oil+*T.viride*	2.0	4.9	7.4
SEd(±)	0.033	0.001	0.003
CD (5%)	0.072	0.002	0.006

Table.5 Effect of treatments on leaf spot disease intensity at 60,75and 90 DAT of brinjal (*Solanum melongena* L.)

Treatment Details	Disease Intensity		
	60 DAT	75 DAT	90 DAT
T_0 control	15.16	22.75	42.32
T_1 Neem oil	10.9	16.35	29.43
T_2 Castor oil	14.96	21.77	39.16
T_3 Clove oil	12.83	19.26	34.66
T_4*T.viride*	13.53	20.26	36.46
T_5Neem oil+*T.viride*	10.6	15.98	28.77
T_6Clove oil+*T.viride*	11.7	17.62	31.72
T_7 Castor oil+*T.viride*	14.1	21.15	38.07
SEd(±)	0.251	0.409	0.785
CD (5%)	0.543	0.885	1.701

Fig.1 Microscopicview of *Alternaria* spp.

Fig.2 Infected leaf of brinjal

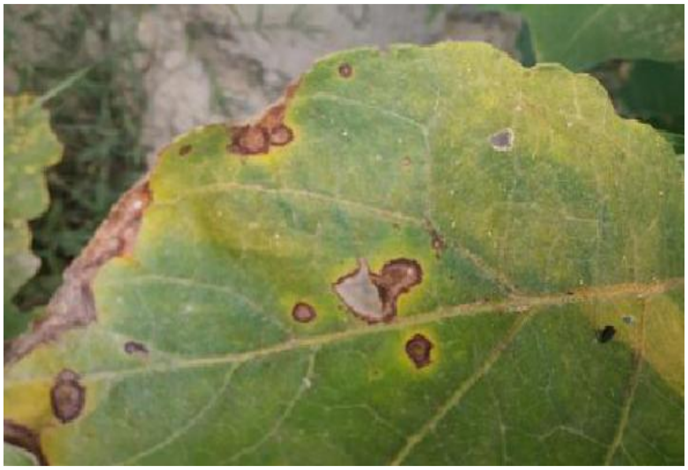


Fig.3 Effect of treatments on plant height (cm) at 30, 60 and 90 DAT of brinjal (*Solanum melongena* L.)

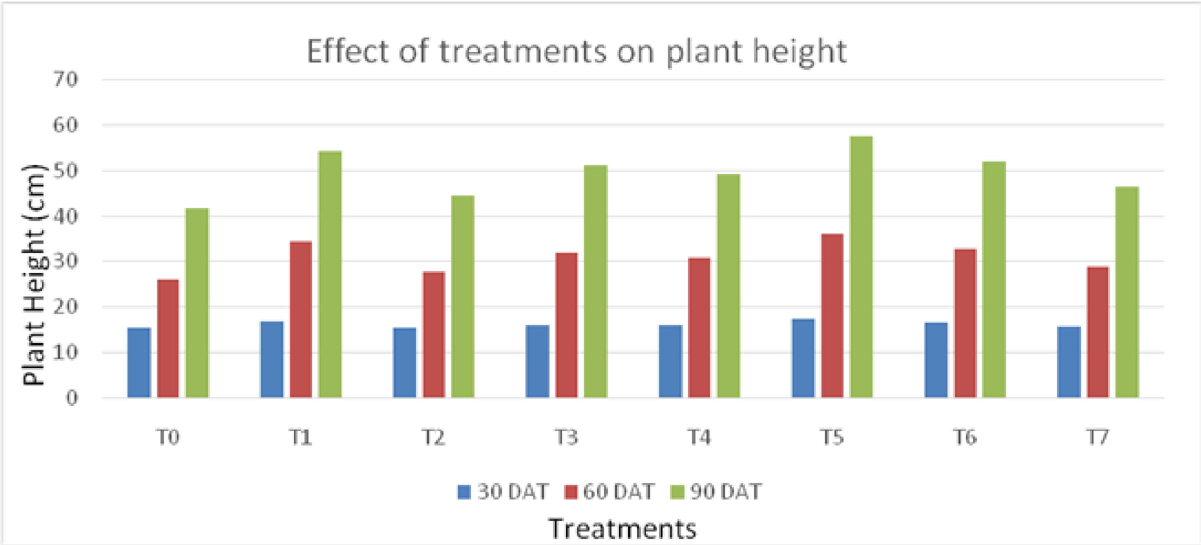


Fig.4 Effect of treatments on plant leaves at 30, 60 and 90 DAT of brinjal (*Solanum melongena* L.)

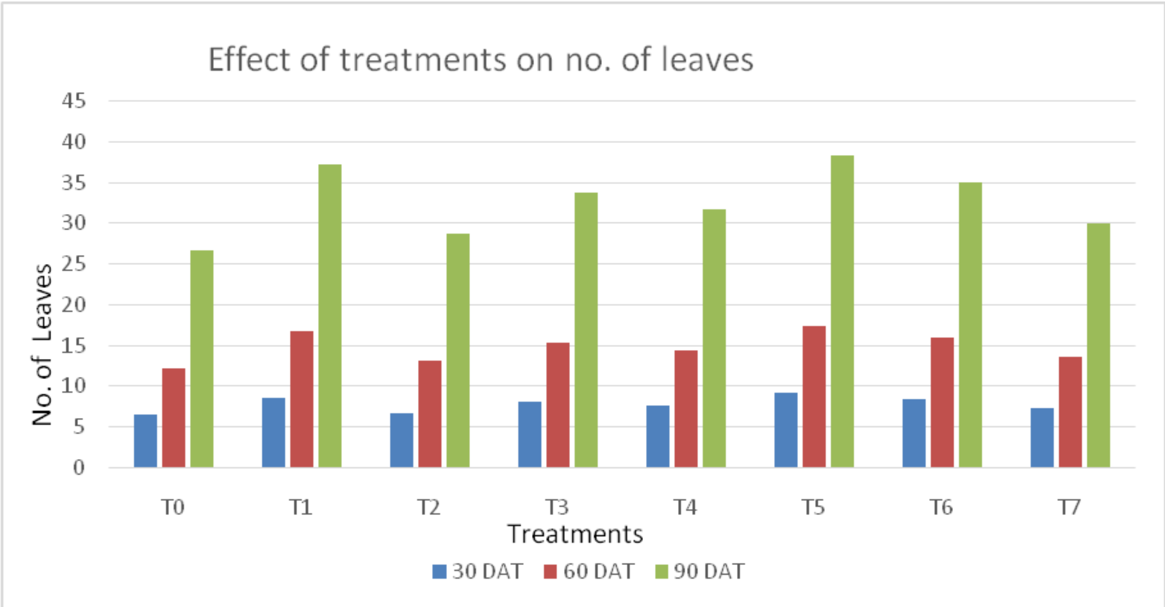


Fig.5 Effect of treatments on plant branches at30, 60 and 90 DAS of brinjal (*Solanum melongena* L.)

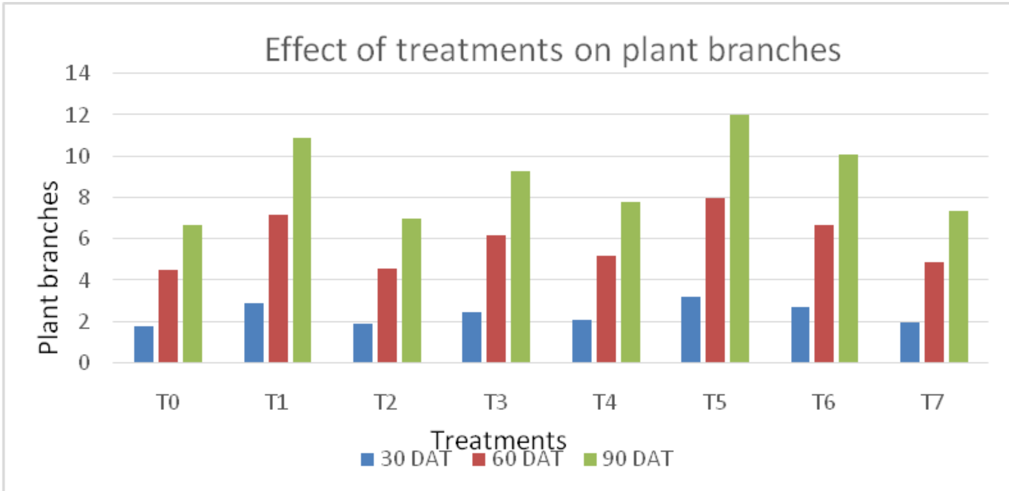
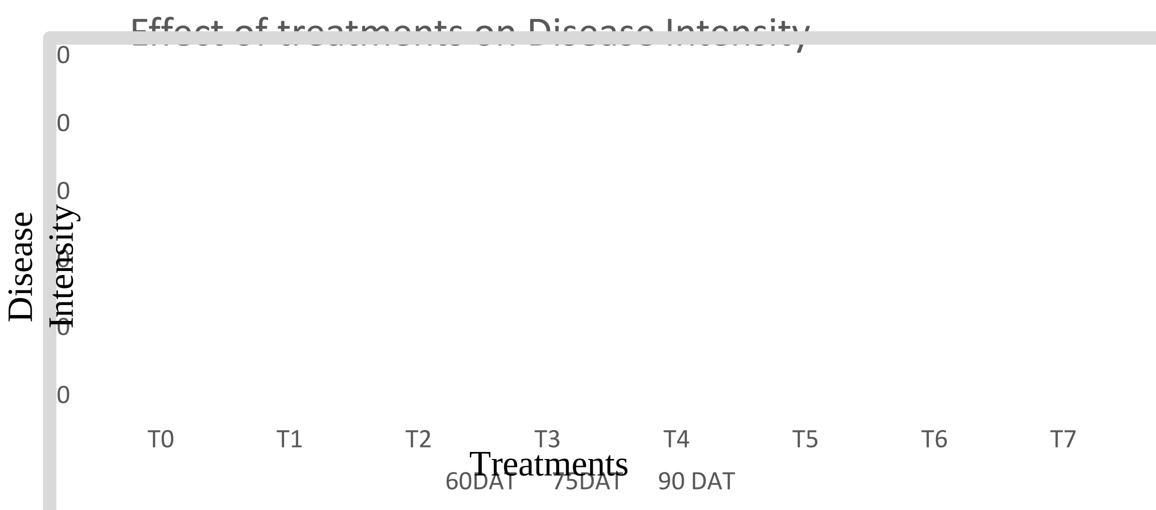


Fig.6 Effect of treatments on Alternaria leaf spot disease intensity at 60, 75 and 90 DAS of brinjal (*Solanum melongena* L.)



At 30DAT (T_4, T_7, T_2) were found non-significant among themselves. And all treatments were found significant over control. At 60 DAT T_2were found non-significant among themselves. And all treatments were found significant over control. At 90 DAT all treatments were found significant over control.

Effect of treatments on Disease intensity of *Alternaria* leaf spot of brinjal at 60, 75 and 90 DAT of brinjal (*Solanum melongena* L.)

The data presented at 60, 75 and 90 DAT in table no. 4.4 and fig no 4.4 shows the maximum reduction percentage of disease intensity which was recorded in treatment T_5 neem oil + *T. viride* (10.6, 15.98, 28.77 respectively) followed by the T_1 neem oil (10.9, 16.35, 29.43 respectively), T_6 clove oil+ *T.virde* (11.7, 17.62, 31.72 respectively), T_3clove oil (12.83, 19.26, 34.66 respectively), T_4 *Trichoderma viride*(13.53, 20.26, 36.46 respectively), T_7 *T. viride* + castor oil(14.1, 21.15, 38.07 respectively), T_2 castor oil (14.96, 21.77, 39.16 respectively) and the lowest treatment is T_0control (15.16, 22.75, 42.32 respectively). However, neem oil+ *T. viride@* (2.5%+2.5%) seedling treatment found best among all the treatments giving best control on leaf blight disease intensity followed by neem oil (5%).

At 60 DAT (T_5, T_1) were found non-significant among themselves. And all treatments were found significant over control. At 75 DAT (T_5, T_1, T_6), (T_3, T_4), (T_7, T_2) were found non-significant among themselves. And all treatments were found significant over control. At 90 DAT all treatments were found significant over control. And (T_5, T_1), (T_7, T_2) were found non-significant among themselves.

Similar findings was given by Ravishanker *et al.,(*2018) that by using bio agents and combinations in *in-vivo* and *in-vitro* conditions, *Trichoderma viride*, *Pseudomonas fluorescens* and neem oil and their combinations the results shows the combination of bio agents had a great impact in controlling the blight disease of Alternaria blight followed by fungicide. Vijayalakshmi *et al.*, (2018) reported maximum inhibition of radial growth of *A. helianthi* was observed in *T. viride* (85.33%) which was followed by *T. viride* strain 16 (79.33%), and T. harzianum. Bagwan (2010) results given that, neem oil (5%), neem leaves extract (10%), wild sorghum leaves extract (10%), neem cake, castor cake and mustard cake extract (10%) enhanced the growth of *Trichoderma*. Yadav *et al.*, (2014) conducted the experiment on chemicals, bio-agents and botanicals were used as seed treatment for their antifungal efficacy against the growth of *Alternaria* spp, incidence of Alternaria leaf spot of cabbage (*Brassica olaracea*var. *Capitata* L.). The minimum disease severity on leaves (15.13%) was recorded in neem oil with 3% concentration.

In the present study, based on observation, it is shown that treatment neem oil @2.5%+ *Trichoderma*@2.5%was the effective in comparison to other treatment followed by neem oil @5%. Neem oil @2.5% + *Trichoderma*@2.5% has shown the effective results on plant height, no. of branches, minimum disease intensity and good yield. Hence, from the present study it can be concluded that neem oil @5% in comparison to neem oil @2.5%+*Trichoderma* @2.5% can be used effectively to reduce the disease intensity and get better yield similar to by use of chemicals. As the human population is now heading towards the organically produced and organically managed agriculture products, the above finding will be useful for safe and environment friendly future.

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