The Pharma Innovation Journal 2022; 11(9): 2580-2586

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(9): 2580-2586

www.thepharmajournal.com
Received: 01-06-2022
Accepted: 08-07-2022

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Efficacy of some selected essential oils against Alternaria leaf spot of brinjal (*Solanum melongena* L.)

Parimi Supraja and Shashi Tiwari

Abstract
Brinjal (*Solanum melongena* L.) belongs to the family solanaceae, is an important vegetable crop grown throughout the world. In India, it is grown in subtropics and tropics. Area, Production and Productivity in India 730.4 ha, 12800.8 MT and 17.5 MT/ha respectively. The productivity of brinjal is quite low (17.4 MT/ha) in India compared to those countries, where the productivity ranges from 17.8 - 35.9MT/ha. Low productivity of brinjal is due to insect pests and disease. There are many diseases that affect brinjal *i. e.* Damping off caused by *Pythium aphanidermatum*, leaf spot (*Alternaria alternata* and *Cercospora melongena*), Phomopsis blight (*Phomopsis vexans*). Among them Alternaria leaf spot of brinjal is severe and appears regularly, causing heavy losses in yield. *Alternaria alternata* attacks leaves and then spreads to fruits which subsequently rot and become unfit for consumption. Plant essential oils have volatile compounds, anti-fungal activity and are eco-friendly. An experiment was conducted in the *Zaid* season to check the efficacy of essential oils against *Alternaria alternata* on field conditions. Essential oils *viz.*, garlic oil, castor oil, neem oil, eucalyptus oil, clove oil @ 5% as seed treatment. An untreated replication served as control. At the desired number of days readings were taken for growth parameters and disease intensity. On the basis of a single trial, it was observed that among all treatments seed treatment with neem oil @ 5% showed the most significant with minimum disease intensity results followed by eucalyptus oil @ 5%. However, the lowest inhibition was seen in the control plot. Subsequently the highest incremental cost benefit ratio was obtained with treatment of neem oil @ 5% and lowest cost benefit ratio was obtained with untreated (control) plot followed by castor oil @ 5%.

Keywords: Alternaria leaf spot, Brinjal, castor oil, clove oil, garlic oil, neem oil

Introduction
Brinjal (*Solanum melongena* L.) also known as eggplant, belongs to family Solanaceae, is an important vegetable crop grown throughout the world. In India it is grown in Subtropics and tropics. The name brinjal is derived from Arabic and Sanskrit whereas the name eggplant has been derived from the shape of the fruit of some varieties, which are white and resemble in shape to chicken eggs. It is also called aubergine (French word) in Europe. It is known by different names like Begun (Bengali), ringna (Guajarati), baingan (Hindi), badane (Kannada), Waangum (Kashmiri), vange (Marathi), baigan (Oriya), Vashuthana (Malayalam), Kathiri (Tamil), Venkaya (Telugu) and Peethabhala (Sanskrit). Its centre of origin was from the Indo-Burma region (Vavilov, 1928) [13]. India is second in the world after China. In India, it is grown in subtropics and tropics. Area, Production and Productivity in India 730.4 ha, 12800.8 MT and
17.5 MT/ha respectively. In India, brinjal is mainly grown in the states like West Bengal, Orissa, Bihar, Gujarat, Maharashtra, Andhra Pradesh, Karnataka *etc.* (National horticulture board, 2018-19) and in Uttar Pradesh 55.39-thousand-hectare area with an annual production of 23.21 million tonnes.
The composition per 100 g of edible portion of brinjal is calories (24), Protein (g)-1.4, Fat (g)-0.3, Calcium (mg)-18, Magnesium (mg)-15, Phosphorus (mg)-47, Iron (mg)-0.38, Zinc (mg)-0.22, Vitamin A (I.U.) -124, Vitamin C (mg) -12, Thiamine (mg) -0.04 (Gopalan *et al.*, 2007) [3]. Brinjal is affected by fungal diseases. They are damping off caused by *Pythium aphanidermatum*, leaf spot (*Alternaria alternata* and *Cercospora melongena*), Phomopsis blight (*Phomopsis vexans*). Alternaria leaf spot of brinjal is severe and appears regularly, causing heavy losses in yield. Prasad and Ahir (2013) [10] reported up to 25% yield losses from Jaipur district due to leaf spot of brinjal. The disease first makes its appearance in young seedling. 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. The spots are mostly irregular, 4-8 mm in diameter and may coalesce to cover large areas of the leaf blade. Severely affected leaves may drop off. They also infect the fruits causing large deep-seated spots. Use of eco-friendly alternative approaches for the management of plant diseases is the best for control of fungal diseases because medicinal plants represent a rich source of antimicrobial agents **(**Mahesh and Satish, 2008) [5]. Plant essential oils are volatile compounds, broad spectrum, anti- fungal activity, eco-friendly and more acceptable to the public. The mechanism of plant essential oils involves, inhibition of hyphal growth, interruption in nutrient uptake, disruption of mitochondrial structure and eventually disorganization of fungal pathogens discussed by (Patel and Jasrai, 2011) [9].

Materials and Methods

The Present study on the "Efficacy of some selected essential oils against Alternaria leaf spot of brinjal (*Solanum melongena* L.)" caused by *Alternaria alternata* were carried out with a view to manage the Alternaria leaf spot disease on brinjal with the help of essential oils as seedling treatment was carried out during *Zaid* season 2021 at the central research farm of Department of Plant Pathology, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj. Field experiment was laid-out in Randomized block design with three replications. The symptoms were appeared at 60 Days after transplanting.

Isolation and Identification of pathogen

Morphological studies of the pathogen were conducted from infected leaf by placing the half-infected portion and healthy portion on a slide, later stained using lactophenol and cotton blue and morphological characters were noted with help of microscope. And using a sterile needle, a small portion of the culture is taken and placed on a sterile glass slide, stained using lactophenol and cotton blue. Then, the microscope is used for the examination of morphology and culture characteristics of fungi. **(**Ellis, 1976) [2]. The pathogen isolated from brinjal leaves was identified as *Alternaria alternata* causative agent of Alternaria leaf spot of brinjal on the basis of symptoms and conidial characteristics.

Disease intensity

Disease intensity of plants was recorded at 30, 60, 90 DAT. In each plot, five plants were examined randomly and scored for disease severity by following 0-5 scale as given by (Pandey *et al.*, 2003) [8].

Percent Disease Index (PDI) was calculated by using formula as given below Wheeler (1969) [14].

$$\textbf{PDI} = \frac{\text{Sum of numerical disease ratings}}{\text{No. of plants observed X Maximum disease rating}} \text{X } 100$$

Table 1: Description of Disease scale for the Alternaria leaf spot of Brinjal (Pandey *et al.*, 2003) [8]

Grade	Leaf area covered	Reaction
0	No symptoms of disease on leaves.	Immune
1	One or two necrotic spots on a few lower leaves of plants, covering nearly 1-10% of the surface area of the plant	Highly resistant
2	A few isolated spots on leaves, covering nearly 11-25% of the surface area of the plant	Resistant
3	Many spots coalesced on the leaves, covering 26-50% of the surface area of the plant	Moderately resistant
4	Irregular, blighted leaves and sunken lesion with prominent concentric rings on the stem petiole, fruit, covering 51-75% leaf area of the plant.	Moderately susceptible
5	Whole plants blighted, leaf and fruits starting to fall, covering more than 75% leaf area of plant.	Highly susceptible

Cost Benefit Ratio

Cost benefit ratio is the ratio of gross return to cost of cultivation, which can also be expressed as return per rupee invested. This index provides an estimate of the benefit a farmer derives from the expenditure he incurs in adopting a particular cropping system. Any value above 2.0 is considered safe as the farmer gets Rs. 2 for every rupee invested. The cost benefit ratio was calculated using the following formula The value of c:b ratio of different treatments will be calculated by following formula

$$\text{C: B} = \frac{\text{Gross returns}}{\text{Cost of cultivation}}$$

Where,
C: B – Cost Benefit Ratio

Results and Discussion

Effect of different essential oils on plant height, No. of leaves and No. of branches at 30, 60 and 90 DAT of Brinjal Observations on plant height**,** No. of leaves and No. of branches of brinjal were taken first at 30 DAT then followed by 60 DAT and 90 DAT. Of all the treatments, T3 – Neem oil showed maximum growth in Plant height and maximum No. of leaves and No. of Branches followed by T4 -Eucalyptus oil.

At 90DAT all the treatments significantly increase the plant height of brinjal from T0- control and among treatments T3-Neem oil (44.33 cm) showed significantly increased the plant height of brinjal followed by T4-Eucalyptus oil (39.53 cm), T5-Clove oil (35.83 cm), T1-Garlic oil (34.1 cm) and T2-Castor oil (33.2 cm).

At 90 DAT all the treatments significantly increase the number of leaves of brinjal from T0 -control and among treatments T3-Neem oil (79.267) showed significantly increased number of leaves of brinjal followed by T4-Eucalyptus oil (73.13), T5-Clove oil (71.6), T1-Garlic oil (69.6) and T2-Castor oil (66.2).

At 90 DAT all the treatments significantly increase the number of branches of brinjal from T0 -control and among treatments T3-Neem oil (29.26) showed significantly increased Number of branches of brinjal followed by T4-Eucalyptus oil (25), T5-Clove oil (24.06), T1- Garlic oil (23.33) and T2-Castor oil (21.73).

Similar findings were reported by Najibullah *et al.* (2017) [7], Ragupathi *et al.* (2020) [11] and Kanna *et al.* (2021) [4] reported that seedling treatment with neem oil was more highly effective in increasing plant growth parameter

Table 2: Effect of essential oils on plant height at 30, 60 and 90 DAT of brinjal.

Treatments		30DAT	60DAT	90DAT
T0	Control	9.413	25.87	30.01
T1	Garlic oil	14.61	30.79	34.1
T2	Castor oil	12.27	29.44	33.2
T3	Neem oil	19.03	36.91	44.33
T4	Eucalyptus oil	17.83	33.46	39.53
T5	Clove oil	15.58	32.39	35.83
Result		S	S	S
C.D at 5%		2.63	2.73	3.02
SE d (±)		1.18	1.23	1.36

Table 3: Effect of essential oils on number of leaves at 30, 60 and 90 DAT of brinjal.

Treatments		30DAT	60DAT	90DAT
T0	Control	3.6	29.53	49.47
T1	Garlic oil	7.73	40.73	69.6
T2	Castor oil	5.07	39.73	66.2
T3	Neem oil	10.13	50.47	79.27
T4	Eucalyptus oil	8.93	45.07	73.13
T5	Clove oil	8	43.07	71.6
Result		S	S	S
C.D at 5%		0.77	2.85	3.65
SE d (±)		0.35	1.28	1.64

Table 4: Effect of essential oils on number of branches at 30, 60 and 90 DAT of Brinjal

Treatments		30DAT	60DAT	90DAT
T0	Control	1.93	7.4	17.27
T1	Garlic oil	3.07	12.27	23.33
T2	Castor oil	2.33	9.47	21.73
T3	Neem oil	6.53	18.87	26.27
T4	Eucalyptus oil	4.2	15.47	25
T5	Clove oil	3.8	14.47	24.07
Result		S	S	S
C.D at 5%		0.71	1.5	2.79
SE d (±)		0.32	0.67	1.25

Disease intensity at 90 DAT

Observations on disease intensity (%) of brinjal were taken first at 60 DAT then followed by 75 DAT and 90 DAT. Among treatments T3-Neem oil (33.94%) showed significantly minimum Disease intensity of Brinjal followed by T4-Eucalyptus oil (38.93%), T5-Clove oil (39.86%), T1-Garlic oil (41.55%) and T2-Castor oil (41.77%) and maximum disease intensity was recorded in control T0 (50.58%). However, Neem oil showed that significant decrease in disease intensity compared to other treatments.

Similar findings were reported by Najibullah *et al.* (2017) [7], Ragupathi *et al.* (2020) [11] and Kanna *et al.* (2021) [4] reported that seedling treatment with neem oil was more effective in control of Alternaria leaf spot of brinjal with minimum disease intensity (%). Sitara *et al.* (2008) [12] reported similar findings that neem oil showed fungicidal activity against the *Alternaria spp.* Chourasia and Sanjay (2010) [1] reported similar findings that Neem was most effective in controlling *Alternaria spp.* with minimum disease intensity.

Effect of different essential oils on yield (q/ha) and Cost Benefit Ratio of brinjal

Observations on yield (q/ha) of brinjal were taken. All the treatments significantly increase the yield (q/ha) of brinjal from T0-control and among treatments T3-Neem oil (64.92 q/ha) showed significantly increased Number of leaves of brinjal followed by T4-Eucalyptus oil (61.57 q/ha), T5-Clove oil (58.67 q/ha), T1-Garlic oil (55.42 q/ha) and T2-Castor oil (51.32 q/ha). All the treatments found significant to each other. However, T0 was found to be significant over all other treatments.

The treatment wise economics of brinjal production were estimated and the results showed that treatment T3 recorded the highest gross returns ₹ 259680/-, net returns ₹ 130826/- with yield 64.92 q/ha and C: B ratio 1:2.01 followed by T4 with yield 61.57 q/ha and C: B ratio 1:1.77. Thus, according to this single trial T3 Neem oil @ (5%) is highly cost benefited when compared with other treatments. Neem oil @ 5% is highly cost benefited *i. e.* (1:2.01) followed by eucalyptus oil with (1: 1.77), garlic oil with (1: 1.49) and clove oil with (1:1.47) whereas low-cost benefit was recorded in control(untreated) plot (1:1.29) followed by castor oil with (1:1.46).

Similar findings reported by Najibullah *et al.* (2017) [6] that the disease control and maximum yield were highest with Neem oil.

Table 5: Effect of essential oils on leaf spot disease intensity of brinjal at different days of intervals

Treatments		Disease intensity (%)					
		60 DAT	% Reduction over control	75DAT	% Reduction over control	90DAT	% Reduction over control
T0	Control	24.23	-	39.87	-	50.58	-
T1	Garlic oil	16.61	31.44	31.00	22.24	41.55	17.85
T2	Castor oil	18.42	23.97	31.67	20.56	41.77	17.41
T3	Neem oil	12.01	50.43	22.86	42.26	33.94	**32.89**
T4	Eucalyptus oil	15.39	36.48	26.73	32.95	38.93	**23.03**
T5	Clove oil	16.21	33.09	28.83	27.68	39.86	21.19
Results		S		S		S	
C.D at 5%		2.44		2.73		3.36	
SE d (±)		1.1		1.22		1.51	

Table 6: Effect of essential oils on yield (q/ha) of Brinjal

Treatments		Yield (q/ha)
T0	Control	36.97
T1	Garlic oil	55.42
T2	Castor oil	51.32
T3	Neem oil	64.92
T4	Eucalyptus oil	61.57
T5	Clove oil	58.67
Result		S
C.D at 5%		0.14
SE d (±)		0.063

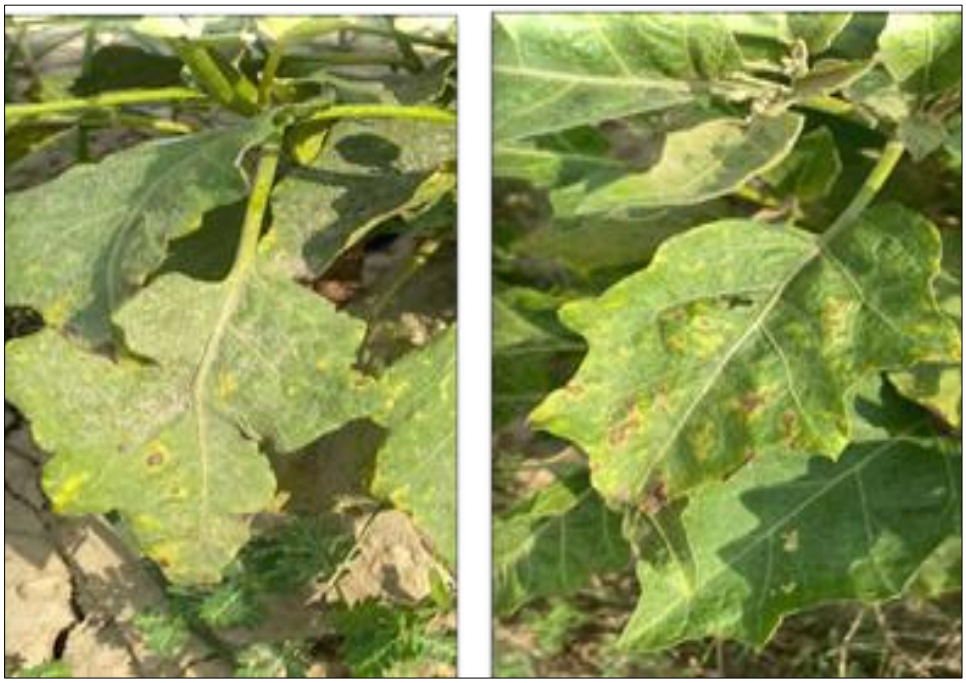

Plate 1: An overview of symptoms of Alternaria leaf spot of Brinjal

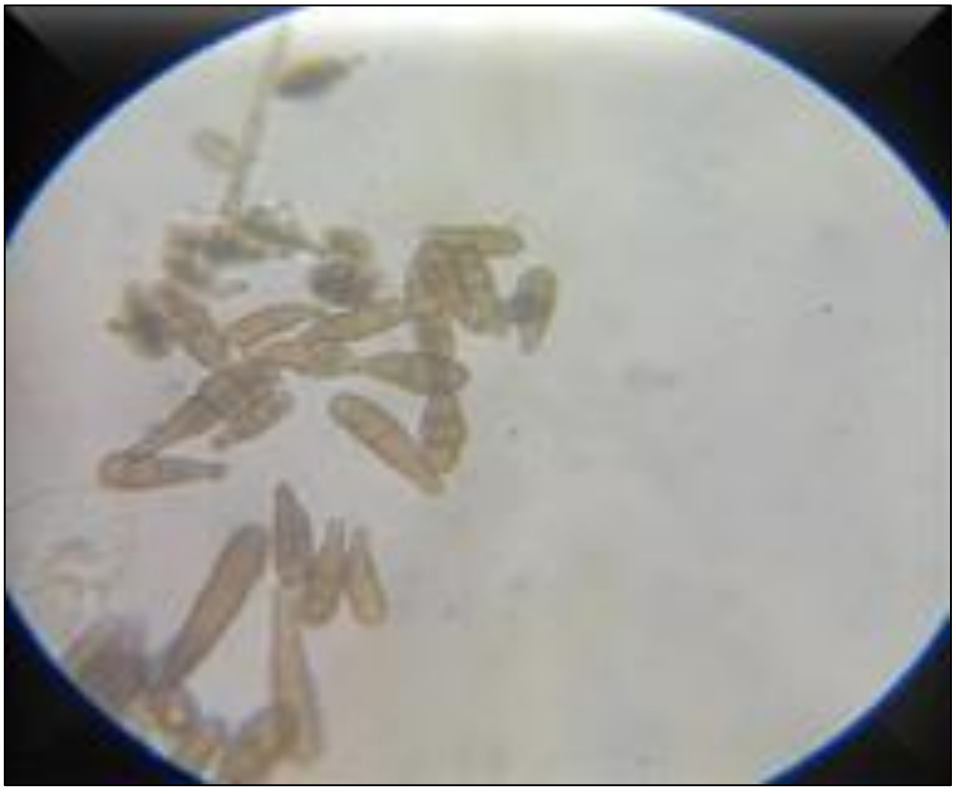

Plate 2: A Microscopic view of *Alternaria alternata*

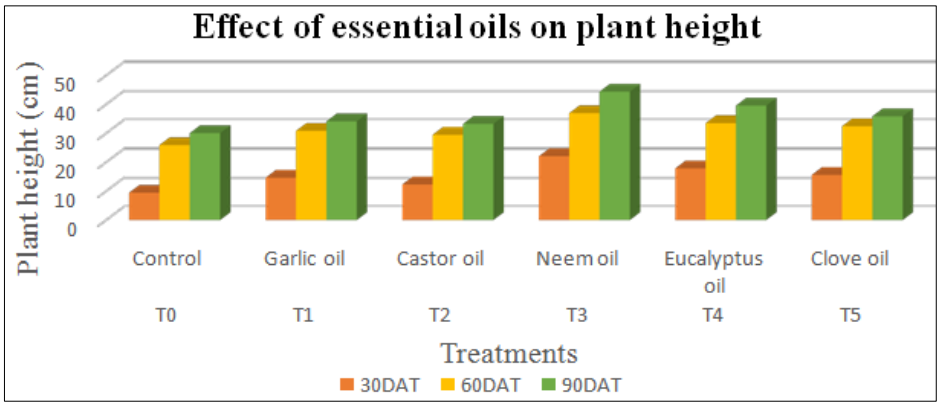

Fig 1: Effect of essential oils on plant height at 30, 60 and 90 DAT of Brinjal

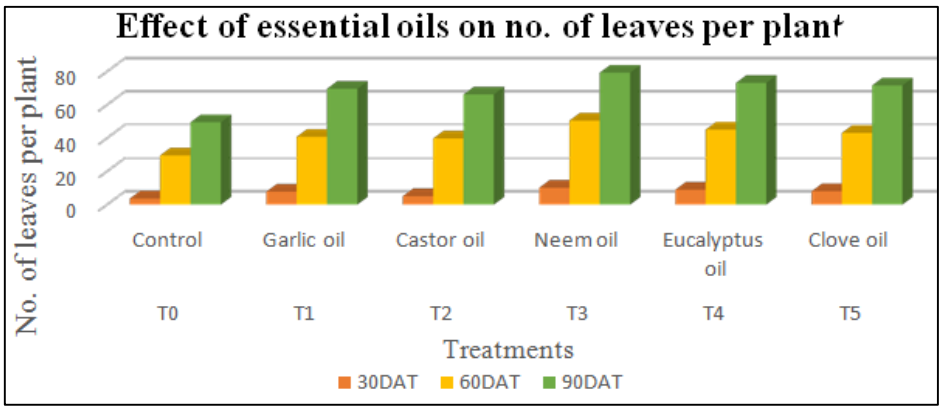

Fig 2: Effect of essential oils on number of leaves at 30, 60 and 90 DAT of brinjal.

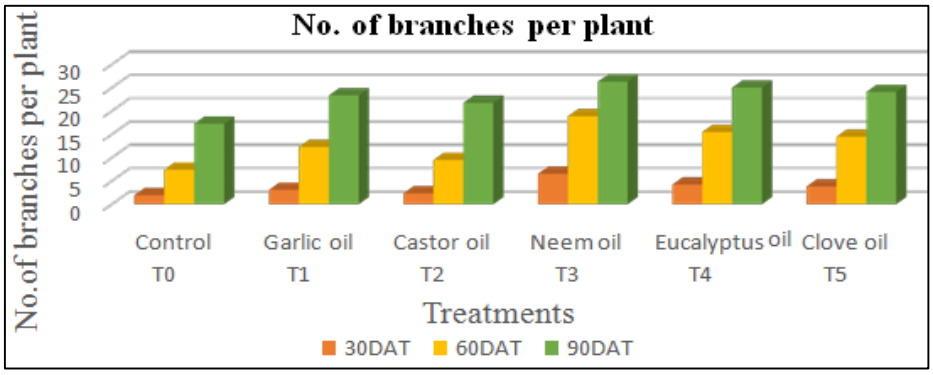

Fig 3: Effect of essential oils on number of branches at 30, 60 and 90 DAT of Brinjal

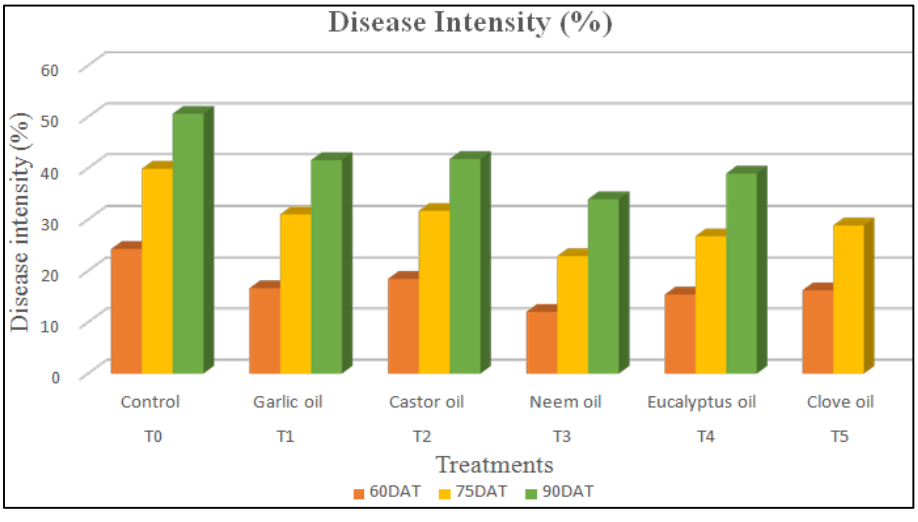

Fig 4: Effect of essential oils on leaf spot disease intensity of brinjal at different days of intervals.

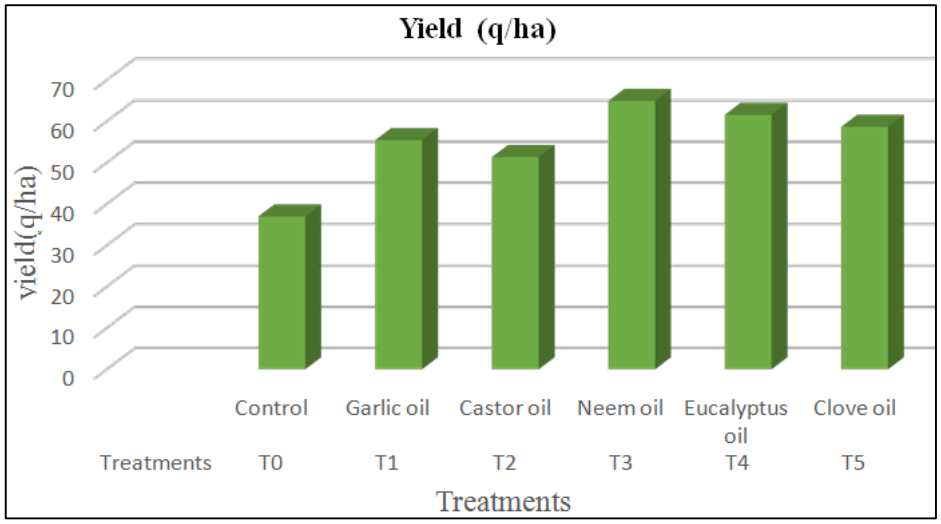

Fig 5: Effect of essential oils on yield (q/ha) of Brinjal

Summary

Observations were recorded at successive stage of plant growth on various parameters such as plant height, number of leaves, number of branches, total number of flowers per plant, total number of fruits per plant, per cent disease intensity and yield and these are recorded. The results obtained were statistically analysed and are summarized as given below:

Plant height at 30,60 and 90 DAT was significantly increased in treatment T3-Neem at (22.03cm), (36.90cm) and (44.33cm) respectively. No. of leaves at 30,60 and 90 DAT was significantly increased in treatment T3- Neem oil (10.13), (50.46) and (79.26) respectively. No. of branches at 30,60 and 90 DAT was significantly increased in treatment T3- Neem oil (6.53), (18.87) and (29.27) respectively.

Total No. of flowers of brinjal was significantly increased in treatment T3- Neem oil (9.33). No. of fruits per plant of brinjal was significantly increased in treatment T3- Neem oil (5.47). Root length (cm) was significantly increased in treatment T3- Neem oil (9.78cm).

Disease intensity (%) at 60, 75 and 90 DAT was significantly increased in treatment T3- Neem oil (12.01%), (22.86%) and (33.94%). Yield (q/ha) was significantly increased in treatment T3- Neem oil (64.92 q/ha).

The results showed that treatment T3 recorded the highest gross returns ₹ 259680/-, net returns ₹ 130826/- with yield 64.92 q/ha and C: B ratio 1:2.01 followed by T4 with yield 61.47 q/ha and C: B ratio 1:1.77. Thus, according to this single trial T3 Neem oil @ (5%) is highly cost benefited when compared with other treatments.

All the treatments used in experiment were found effective to varying extent. All the treatment statistically significant over control and seedling treatment with Neem oil proved to be most effective against *Alternaria alternata*. Reducing the Alternaria leaf spot intensity and also the growth parameters had better development with this treatment. Eucalyptus oil and clove oil were approximately equally effective.

Conclusions

Alternaria leaf spot is a destructive disease that causes higher yield losses in brinjal hence the management of this disease is important. Neem oil @ 5% was found most effective against *Alternaria alternata* causing Alternaria leaf spot of brinjal under field conditions, which recorded minimum disease intensity and maximum yield. Therefore, it may be recommended for the better management of Alternaria leaf spot of brinjal. The findings of the present experiment are limited to one crop season (*Zaid*-2021) under Prayagraj Agro-climatic conditions, as such validate the present findings more such trials should be carried out in future.

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