Original Research Article

Effect of *Pseudomonas fluorescens*, organic amendments and botanicals against *Fusarium culmorum* on Black Turmeric (*Curcuma caesia*)

Abstract

Rhizome rot of black turmeric caused by *Fusarium culmorum* is one of the devastating soil-borne disease. An experiment was conducted to evaluate the effect of Pseudomonas fluorescens, organic amendments and botanicals against *Fusarium culmorum* on black turmeric. An experiment was conducted in pot condition at the courtyard of department of Plant Pathology, SHUATS, Prayagraj, using Farm yard manure (FYM), Spent mushroom compost (SMC), Mustard cake, and Neem cake as soil treatment and *Pseudomonas fluorescens* as rhizome treatment respectively against *Fusarium culmorum* of Black Turmeric, during *kharif* season 2022. It was carried out in Randomized Block design (RBD) with four (4) replications. Results revealed that, in the soil application, i.e, the combinations of all the treatments (T_9) recorded minimum disease incidence (16.35 %) which was significant over other treatments and control (T_0) (44.27%).Also to evaluate the radial growth(mm) of *Fusarium culmorum* on black turmeric, seven botanicals from Manipur viz., *Ageratina adenophora*, *Bidens pilosa*, *Centella asiatica*, *Plantago major*, *Strobilenthes crispus*, *Saurauia napaulensis*, *Artemesia vulgaris*, at 10% and 30 % were investigated *in vitro*. The antagonistic effect of botanicals was assayed *in vitro*, which was found effective in the inhibition of mycelial growth (78.5 %) in *Ageratina adenophora* followed by *Artmesia vulgaris* (75.3 %), *Saurauia napaulensis* (72.3 %), *Strobilenthes crispus* (69.5 %), *Plantago major* (65.6%), *Centella asiatica* (61.9%) and least by *Bidens pilosa* (56.3 %) at 30 % concentration.

Italics

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Keywords: Rhizome rot, *Fusarium culmorum*, Botanicals, *In vitro*, Black Turmeric.

INTRODUCTION

Curcuma belongs to family Zingiberaceae, which comprises over 70 species of rhizomatous herbs. *Curcuma caesia* (Roxb.) is also known as Kali Haldi. Black turmeric is a perennial herb with bluish-black rhizome. Black turmeric is one of the important species in the Curcuma genus, which has been used by various tribal communities for a long time before curing multiple diseases due to its medicinal therapeutic properties. The rhizome of Black Turmeric is aromatic due to the presence of volatile oil components, and the colour is much darker blue than in *C. aeruginosa*. Total thirty significant components found in *Curcuma caesia* plant such as representing 97.48% of the volatile oil, with camphor (28.3%), ar-turmerone (12.3%), (Z)-β-ocimene (8.2%), ar-cur cumene (6.8%), 1,8-cineole (5.3%), β-element (4.8%), borneol (4.4%), bornyl acetate (3.3%) and γ-cur cumene (2.82%) as the major constituents (**Vinod *et al.*,2022).**

Black turmeric is native to North-East, and Central India. It flourishes well in moist deciduous forest areas with rich humid and clayey soils. In India, it is found in Chhattisgarh, Madhya Pradesh, Odisha, Uttar Pradesh and West Bengal (**Nadkarni, 1976).**

Fusarium spp. Causes severe significant economic losses in the agricultural area worldwide due to difficulties in managing diseases caused by species of this genus. Fusarium genus, viz the species *F. oxysporum*, *F. solani*, *F. incarnatum*, and *F. musae*, causes postharvest diseases in fruits such as orange, muskmelon, banana, and kiwifruit **(Wonglom and Sunpapao, 2020).**

The first report on *Fusarium culmorum* as the causal agent of stalk rot on maize plants in China. Also, this fungus has been reported to cause maize ear rot in China and produce mycotoxins. (**Leslie and Summerell,2006).** The occurrence of maize stalk and ear rot caused by *Fusarium culmorum* should be monitored because of the potential risk for crop loss and mycotoxin contamination (**Xia *et al.*,2022).**

Use of chemical compounds has causes great impact on the environmental and health hazard. Therefore, plantbased pesticides appears as an important alternative to synthetic chemical as they do not pose threat to natural environment, human and animal health. Plants contribute 75% of molecular medicines either directly or indirectly (**David *et al.*,2020).** *Lantana camara* is a rich source of bioactive compounds viz, flavones, isoflavones, flavonoids, anthocyanins. Antifungal activities of *L. camara* extracts lyses the cell and alter the membrane integrity. The leaves extract significantly inhibit the radial growth of *Rhizoctonia solani*, *Fusarium oxysporum*. Spraying of leaf extract drastically reduced the plant mortality **(Girish, 2019).**

MATERIALS AND METHODS

The present investigation on **Effect of *Pseudomonas fluorescens*, organic amendments of botanicals against *Fusarium culmorum* on Black Turmeric (*Curcuma caesia*)** has been carried out on collection of disease samples, isolation, identification of rhizome rot through the use of plant products and organic amendments.

Collection of disease samples

The infected plants showing typical symptoms were collected from the field for Identification. The affected rhizomes appear soft and shrunken.

Symptoms

Early symptoms appeared as leaf yellowing, slight wilting and stunting. Foliar yellowing and drying up of foliage which are the normal symptoms of maturity of the crops. When the infected rhizomes are cut open, the infected zones typically appear as dull brown and dark.

Plate I: Infected rhizomes and leaves

Application of organic amendments

Organic amendments such as farm yard manure (FYM) @ 30g/pot, spent mushroom compost (SMC) @ 30g/pot, neem cake (NC) @10g/pot, mustard cake (MC) @10g/pot, NC+FYM @ 5g+10g/pot, MC+FYM @ 5g+10g/pot, NC+SMC @ 5g+15g/pot, MC+SMC @ 5g+15g/pot, FYM@ 5g+SMC@5g+NC@3g+MC@3g/pot were used during experiment. Fourty pots filled with sterilized soil were used for experiment. These organic amendments are applied to soil one week before sowing.

Seeding of rhizomes

The healthy rhizomes were used for planting in the prepared pots. Black Turmeric rhizomes are treated with *Pseudomonas fluorescens* @0.01g in 1litre of water for 24 hrs before planting.

Isolation of *Fusarium culmorum* (Shaker and Alhamadany, 2015):

Washed the collected plant samples (rhizome) with water, cut off to the part with the symptom of 2mm, surface sterilized with the mercuric chloride (0.1%) for 5-10 seconds, then washed with sterilized distilled water thrice to remove any mercuric chloride traces and dried by sterilized filter paper and then transferred to the petri plates with potato dextrose agar media (1 pieces for each plate) and incubated in incubator for 7days at $25^0 \pm 1^0$C.

Identification and morphological characteristics of *Fusarium culmorum*:

Purified fungal isolates by transfer from the end of the isolated fungal culture by sterile needle the fungal mounted on slide, stained with lactophenol and cotton blue and examined under microscope diagnosis based on morphological characteristics of colonies and sclerocial bodies. Morphological identification is based on the shape of the macroconidia formed on sporodochia on carnation leaf agar. The conidiophores are branched monophialides, short and wide. The macroconidia are relatively short and stout with an apical cell blunt or slightly papillate; the basal cell is foot-shaped or just notched. Macroconidia are thick-walled and curved, usually 3–5 septate. Microconidia are absent. Oval to globose chlamydospores are formed, intercalary in the hyphae, solitary, in chains or in clumps; they are also formed from macroconidia (**Leslie and Summerell.,2006).**

Identification of the pathogen species was confirmed from Indian Type Culture Collection (ITCC), Division of Plant Pathology, ICAR-Indian Agricultural Research Institute. Further it was molecular characterized by simple sequencing method**.>BTR-1 *Fusarium culmorum* genes for ITS1**

AGGGATCATTACCGAGTTTACAACTCCCAAACCCCTGTGAACATACCTTATGTTGCCTCGGCGG
ATCAGCCCGCGCCCCGTAAAAAGGGACGGCCCGCCGCAGGAACCTTAAACTCTGTTTTTAGTGG
AACTTCTGAGTATAAAAAACAAATAAATCAAAACTTTCAACAACGGATCTCTTGGTTCTGGCAT
CGATGAAGAACGCAGCAAAATGCGATAAGTAATGTGAATTGCAGAATTCATGAATCATCGAATC
TTTGAACGCACATTGCGCCCGCCAGTATTCTGGCGGGCATGCCTGTTCGAGCGTCATTTCAACC
CTCAAGCCCAGCTTGGTGTTGGGAGCTGCAGTCCTGCTGCACTCCCCAAATACATTGGCGGTCA
CGTCGAGCTTCCATAGCGTAGTAATTTACATATCGTTACTGGTAATCGTCGCGGCCACGCCGTA
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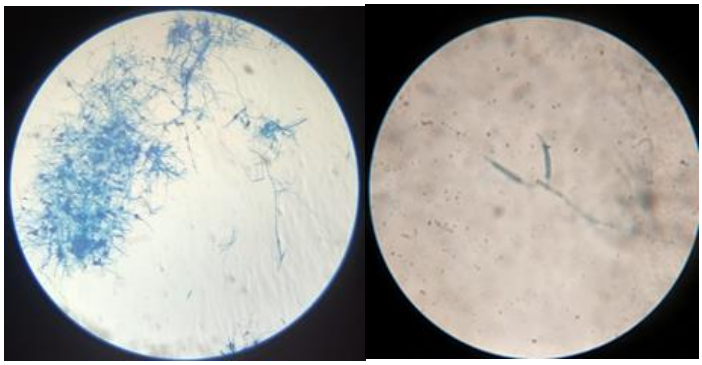


Plate II: Microscopic view of *Fusarium culmorum*

Maintenance of Culture:

The cultures of the fungus were sub-cultured on petri plates and PDA slants and kept in laboratory at 28± °C for 7 days. Such mother culture were preserved at 4°C in refrigerator. Further, these cultures were sub-cultured once in a month and used for future purpose.

Plate III: Pure culture of *Fusarium culmorum* in petriplates and slants

Preparation of botanical extracts:

Plant parts such as leaves, shoot, flowers and roots of all botanicals were washed in running tap water and finally by sterile water and air dried for one day to eliminate surface moisture. The dried leaves were then blended into powder. The powdered samples were packed in plastic bags, marked and sealed in air tide on according method of **David *et al.*,(2020).**

●Aqueous extracts

For making aqueous extract of all botanicals at 10% and 30% concentration, the powdered botanicals were soaked in sterile distilled water. The soaked botanicals powder were first filtered with muslin cloth, then with whatman filter paper and further centrifuged at 1500rpm for 20 minutes. The clean suspended solution was transferred into 100ml conical flask and then sterilized in autoclave at 15lbs pressure for 20 minutes and kept as stock solution. Further each botanicals stock solution were used at two concentration, and it was tested on the radial growth of *Fusarium culmorum* at 24, 48, 72 hrs after inoculation on according method of **Odey *et al.*,(2012).**

Poison food technique

The antifungal activity of plant extract were tested against the pathogen in the laboratory. The experiment was carried out in a completely randomized design (RBD) by poisoned food technique. A requisite amount of the filtrate was mixed in PDA just before pouring to get the desired concentrations of 10 and 30% and gently shaken for thorough mixing of the extract. The PDA plates containing the plant extracts were inoculated aseptically with the pathogen by transferring 5 mm diameter agar disc from the fresh cultures. Three replications are maintained for each treatment. The basal medium (PDA) without any phytoextract served as the control. All the inoculated Petri dishes were incubated at 25±1°C. The radial growth(mm) of the test fungus was measured in all the treatments and compared with the control.

The per cent inhibition of fungal growth was estimated using following formula (**Vincent, 1927):**

$I = C-T / C \times 100$

Where, I = per cent inhibition

C = Colony diameter in control

T = Colony diameter in treatment

RESULT AND DISCUSSION

Disease Intensity of *Fusarium culmorum* in Black Turmeric at different DAS

Perusal of data (table1), revealed that minimum disease intensity was recorded in T_9(FYM + SMC+NC+MC-3.20%) followed by T_8 (NC +SMC-3.90%), T_2(SMC-6.45%), T_7(NC+SMC-9.17%), T_3(NC-10.60%), T_4(MC-11.70%), T_5(NC+FYM-11.92%), T_6(MC+FYM-14.57%), T_1(FYM-14.67%) as compared to untreated checked T_0-Control (21.27%). However, at 75 days, the treatments (T_9,T_8), (T_4,T_5), (T_6,T_1) were found non-significant to each other and statistically at par with each other. At 90 and 105 DAT all the treatments were found significant over control. The results are in agreement with the findings of **Sreegayathri *et al*.,(2018**) soil application of neem cake @ 250 kg ha^{-1} + *Streptomyces reticuli* @ 10 ml/ lit + *Pseudomonas fluorescens* @ 2.5 kg ha^{-1} + *Trichoderma viride* @ 2.5 kg ha^{-1} recorded a significantly lower wilt incidence of 14.4 per cent as against 42.5 per cent in the control, which was found to be 66.1 per cent reduction over control and gall index was also significantly reduced to 1.6 as against 5.0 in control.

Plant growth parameters of Black Turmeric

Plant height (cm)

Perusal of data(table 2), revealed that the maximum plant height (cm) was observed in T_9-(FYM+ SMC+NC+MC-53.25cm) followed T_6(MC +FYM-48.75cm),T_8(NC+SMC-48.25cm), T_2-(SMC-47.50cm), T_5 (NC+FYM-47.50cm), T_7(NC+SMC-47.50cm), T_4-(MC-46.25cm), T_3-(NC-40.00cm), T_1(FYM-37.00cm) as compared to untreated checked T_0-Control (28.75cm).However, at 75 days, the treatments (T_8,T_2,T_5,T_7, T_4), (T_3,T_1), were found non-significant to each other and statistically at par with each other. At 90 and 120 DAT all the treatments were found significant over control. The above results are in agreement with the findings of **Zeeshan *et al*.,(2016)** who observed that button mushroom compost was more effective against height, number of fruits per plant, fresh weight of plant, number of shoots per plant, root length, root weight, and dry plants.

Average number of leaves/plant

Perusal of data (table 3), the maximum number of leaves/plant recorded in treatments T_9(FYM+ SMC+NC @3g+MC-6.00%) followed T_8(NC+SMC-5.75%), T_2(SMC-5.50%), T_7 (NC+SMC-5.50%), T_3(NC-5.25%), T_5(NC+FYM-5.00%),), T_1(FYM-4.75%),T_4(MC -4.75%), T_6(MC+FYM-4.75%), as compared to untreated checked T_0-Control (4.25%).However, at 75 days, the treatments (T_2,T_7), (T_3,T_5), (T_1,T_4,T_6) were found non-significant to each other and statistically at par with each other. At 90 and 105 DAT all the treatments were found significant over control. The above findings are in agreement with **Datta *et al*.,(2017)** who concluded that the application of green leaf manure and application of farm yard manure @ 30 tonnes/ha treatments for dry yield and quality of turmeric. Similar findings by **Umar *et al*., (2013)** observed that the effect of two organic amendments viz: Bitter leaf and Cashew seed kernal used two weeks after germination, indicated superior growth parameters.

Yield component of black turmeric

Weight of rhizomes(g)

The data presented in table-4 at 75 days of sowing, reveals that the highest rhizome weight of black turmeric plants is recorded in T_9(FYM+ SMC+NC+MC-190g) followed T_2(SMC-170g), T4(MC-125g), T_8(NC+SMC-97.25), T_5(NC+FYM-69.50), T_7(NC+SMC-66.25g), T_6(MC+FYM-61.50g), T_3(NC-60g), T_1(FYM-40g), as compared to untreated checked T_0-Control (35.50g). Among the treatments (T_5,T_7), (T_6,T_3) were found non-significant to each other. The results above are in agreement with the similar findings of **Altindal *et al*. (2015)** use spent mushroom compost (SMC) will result in the highest tuber weight and the yield of tuber i,e, 50% from the application of SMC. Similarly, **Mishra and Singh (2019)** observed that the foliar destruction due to leaf spot reduces the yield considerably when the disease starts in its early stages of crop growth.

Table 1: Effect of selected treatments on *Fusarium culmorum* on disease intensity (%) of black turmeric at 75, 90,105 DAT.

	Treatments	Disease intensity (%) Mean of four replications		
		75 DAT	90 DAT	105 DAT
T_0	Control	21.27	31.47	44.27
T_1	Farm yard manure (FYM)	14.67	25.62	38.67
T_2	Spent mushroom compost (SMC)	6.45	12.10	25.35
T_3	Neem cake	10.60	20.50	32.07
T_4	Mustard cake	11.70	20.75	32.12
T	Neem cake +FYM	11.92	22.82	32.32
T_6	Mustard cake + FYM	14.57	22.30	32.55
T_7	Neem cake +SMC	9.17	18.32	27.25
T_8	Mustard cake +SMC	3.90	11.50	19.45
T_9	FYM+SMC+ Neem cake+ Mustard cake	3.20	10.15	16.35
C.D. (5%)		2.90	2.71	4.09
SE d±		1.40	1.31	1.98
C.V.		18.52	9.62	9.34

Table 2: Effect of selected treatments on plant height (cm) of black turmeric at 75,90,120 days of sowing:

	Treatments	Plant height (cm) Mean of four replications		
		75 DAS	90 DAS	120 DAS
T_0	Control	28.75	35.00	43.75
T_1	Farm yard manure (FYM)	37.00	50.00	57.50
T_2	Spent mushroom compost (SMC)	46.00	60.00	69.50
T_3	Neem cake	40.00	56.25	63.75
T_4	Mustard cake	42.50	58.75	66.25
T_5	Neem cake +FYM	45.00	60.00	68.75
T_6	Mustard cake + FYM	48.25	61.75	72.50
T_7	Neem cake +SMC	43.00	60.00	67.50
T_8	Mustard cake +SMC	46.25	61.25	71.25
T_9	FYM+SMC+ Neem cake+ Mustard cake	53.25	68.00	78.25
C.D. (5%)		6.06	5.41	5.68
SE d±		2.94	2.62	2.75
C.V.		9.62	6.49	5.91

Table 3: Effect of selected treatments on total number of leaves per plant of black turmeric crops at 75,90,105 days of sowing:

	Treatments	Total no. of leaves/plant Mean of four replications		
		75 DAS	90 DAS	105 DAS
T_0	Control	4.25	4.75	5.50
T_1	Farm yard manure (FYM)	4.75	5.50	6.25
T_2	Spent mushroom compost (SMC)	5.50	6.00	6.25
T_3	Neem cake	5.25	6.00	6.75
T_4	Mustard cake	4.75	5.50	6.00
T_5	Neem cake +FYM	5.00	5.50	6.50
T_6	Mustard cake + FYM	4.75	5.00	6.00
T_7	Neem cake +SMC	5.50	6.00	6.75
T_8	Mustard cake +SMC	5.75	6.25	7.00
T_9	FYM+SMC+ Neem cake+ Mustard cake	6.00	6.50	7.50
C.D. (5%)		0.914	0.913	0.98
SE d±		0.44	0.44	0.44
C.V.		12.11	10.83	10.30

Table 4: Effect of selected treatments on weight of rhizome(g) of black Turmeric:

TREATMENTS	Rhizome weight(g) Mean
T0-Control	35.00
T1-FYM	40.00
T2-SMC	170.00
T3-Neem cake	60.00
T4-Mustard cake	125.00
T5-Neem cake + FYM	69.00
T6-Mustard cake +FYM	61.00
T7-Neem cake +SMC	66.00
T8-Mustard cake+SMC	97.25
T9-FYM+SMC+Neem cake+Mustard cake	190.00
C.D.(5%)	14.45
S.E d (±)	7.00
C.V.	10.83

Evaluation of botanicals against *Fusarium culmorum in vitro*:

The botanicals extracts were screened for their efficacy against *Fusarium culmorum* on PDA amended with their 10% and 30% concentration. The data on the radial growth of the colony(mm) and percent inhibition of mycelial growth recorded have been presented here.

Perusal in table 5, at 10% concentration, after 24hrs, 48hrs and 72hrs incubation, the least radial growth of *Fusarium culmorum* was observed in T_5-*Ageratina adenophora* (17.4mm), followed by T_2- *Artemesia vulgaris* (23mm), T_7- *Saurauia napaulensis* (25mm), T_3- *Strobilanthes crispus* (27mm), T_4- *Plantago major* (28.4mm), T_6- *Centellla asiatica* (33mm), T_1- *Bidens Pilosa* (37.3mm) and T_0-Untreated (38.3mm). All the botanical treatments were significant over control. The result showed that maximum percentage of inhibition was observed in T_5-*Ageratina adenophora* (54.5%), followed by T_2- *Artemesia vulgaris* (39.6%), T_7- *Saurauia napaulensis* (34.4%), T_3- *Strobilanthes crispus* (29.5%), T_4- *Plantago major* (25.8%), T_6-*Centella asiatica* (13.5%), T_1-*Bidens Pilosa* (2.61) and T_0-Untreated (0.00%).

At 30% concentration,the least radial growth of *Fusarium culmorum* was observed in T_5-*Ageratina adenophora* (2.7mm), followed by T_2- *Artemesia vulgaris* (3.1mm), T_7- *Saurauia napaulensis* (3.5mm), T_3- *Strobilanthes crispus* (3.8mm), T_4- *Plantago major* (4.3mm), T_6-*Centella asiatica* (4.8mm), T_1-*Bidens Pilosa* (5.5mm) and T_0-Untreated (12.6mm). All the botanical treatments were significant over control. The result showed that maximum percentage of inhibition was observed in T_5-*Ageratina adenophora* (78.5%), followed by T_2-*Artemesia vulgaris* (75.3%), T_7- *Saurauia napaulensis* (72.3%), T_3- *Strobilanthes crispus* (69.5%), T_4 - *Plantago major* (65.6%), T_6-*Centella asiatica* (61.9%), T_1 -*Bidens Pilosa* (56.3) and T_0-Untreated (0.00%).

Among all the treatments, at 10% and 30% concentration, the least radial growth(mm) and percentage inhibition of *Fusarium culmorum* was observed in T5-*Ageratina adenophora* (17.4mm) and (2.7mm) and (54.5%) and (78.5%). This is in agreement with the report of earlier studies of **Prakash *et al.*,(2021)** who reported that the anti-fungal activity of *C. asiatica* were tested against *C. albicans, Aspergillus niger,* and *Penicillium* sp. using two methods, disc diffusion method and broth dilution method. *C. asiatica* crude methanol extract was found to be the most effective against fungal activity. **Nasrin *et al.*,(2020)** also found the antifungal activity of *Centella asiatica* against *Aspergillus* sp. One control group and two sample group (1%, 5%) hydrophilic extract of *C. asiatica* has been used. Finally, the study showed that the bioactive compounds of *C. asiatica* are a potential source of preservative that inhibits the growth of fungus. Similarly, **Seepe *et al.*, (2020)** observed the *in vitro* antifungal activity of different medicinal plant extracts individually or in combination against *Fusarium proliferatum, Fusarium solani, Fusarium verticillioides* and *Fusarium graminearum.* The approach of using medicinal plant extracts from renewable plant parts either individually or in combination is sustainable, affordable, environmentally friendly and may be more beneficial in the fight against crop pathogenic diseases, particularly in organic farming.

Table 5: *In vitro* effects of botanicals at 10% conc. on radial growth (mm) of *Fusarium culmorum* at 24 hrs, 48 hrs, and 72 hrs.

Treatment	Mean of Radial growth (mm) at			Mean of Percent inhibition (%) over control at		
	24 hrs	48 hrs	72hrs	24 hrs	48hrs	72 hrs
T0	10.5	34.7	38.3	0.00	0.00	0.00
T1	9.5	31.6	37.3	9.52	8.93	2.61
T2	5.67	21.1	23.1	46.0	39.1	39.6
T3	7.5	24.0	27.0	28.5	30.8	29.5
T4	8.16	25.7	28.4	22.2	25.9	25.8
T5	5.34	14.8	17.4	49.1	57.3	54.5
T6	9.34	26.1	33.1	11.0	24.7	13.5
T7	6.50	22.1	25.1	38.0	36.3	34.4
C.D.(5%)	1.05	1.10	0.56			
C.V.	7.63	2.50	1.11			

Table 6: *In vitro* effects of botanicals at 30% conc. On radial growth (mm) of *Fusarium culmorum* at 24 hrs, 48 hrs, and 72 hrs.

Treatment	Mean of Radial growth (mm) at			Mean of Percent inhibition (%) over control at		
	24 hrs	48 hrs	72hrs	24 hrs	48hrs	72 hrs
T0	7.16	11.00	12.66	0.00	0.00	0.00
T1	2.16	3.16	5.50	69.8	71.2	56.3
T2	0.83	1.83	3.16	88.2	83.2	75.3
T3	1.33	2.50	3.83	81.2	78.7	69.5
T4	1.83	2.33	4.33	79.05	77.2	65.6
T5	0.66	1.66	2.66	90.6	84.8	78.5
T6	1.50	2.83	4.83	74.30	74.1	62.9
T7	1.00	2.00	3.50	86.03	81.8	72.3
C.D.(5%)	0.45	0.48	0.47			
C.V.	12.54	8.06	5.27			

***Fig 1. In vitro* evaluation of botanicals on radial growth(mm) of *Fusarium culmorum* at 10 % concentration.**

T_0 -Control

T_1-*Bidens pilosa*

T_6- *Centella asiatica*

T_4 -*Plantago major*

T_3 -*Strobilanthes crispus*

T_7 -*Saurauia napaulensis*

T_2 -*Artemesia vulgaris*

T_5 -*Ageratina Adenophora*

***Fig 2. In vitro* evaluation of botanicals on radial growth(mm) of *Fusarium culmorum* at 30 % concentration.**

T_0-Control

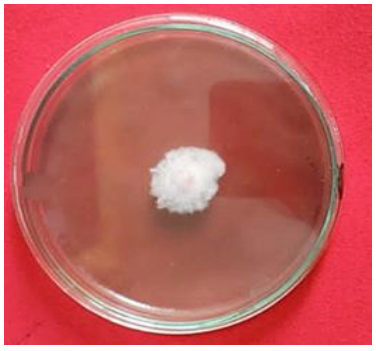
T_1 -*Bidens pilosa*

T_6 -*Centella asiatica*

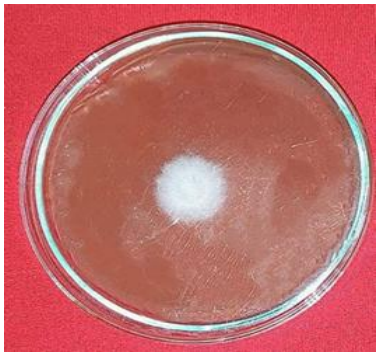
T_4 -*Plantago major*

T_3 -*Strobilanthes crispus*

T_7 -*Saurauia napaulensis*



T_2 -*Artemesia vulgaris*



T_5 -*Ageratina Adenophora*

CONCLUSION

The present study reveals that among the selected treatment, T9(FYM+SMC+NC+MC) significantly reduced the disease intensity of *Fusarium culmorum* at 75, 90 and 105 DAS (3.20%, 10.15%, and 16.35%) respectively as compared to other treatments.The treatments T_9(FYM+SMC+NC+MC) significantly increased the plant height (cm) at 75,90 and 120 DAS (53.25 cm, 68.00 cm and 78.75 cm) respectively as compared to other treatments.T-9(FYM+SMC+NC+MC) significantly increased the number of leaves (%) at 75,90 and 105 DAS (6.00%,6.50% and 7.50%) respectively as compared to other treatments. The treatment T_9(FYM+SMC+NC+MC) significantly increased the weight of rhizome (g) (190g) respectively as compared to other treatments. Among all the treatments, at 10% concentration, after 24hrs, 48hrs and 72hrs incubation, the least radial growth(mm) and percentage inhibition of *Fusarium culmorum* was observed in T5-*Ageratina adenophora* (17.4mm) and (54.5%).At 30% concentration, after 24hrs, 48hrs and 72hrs incubation, the least radial growth and percentage inhibition of *Fusarium culmorum* was observed in T5-*Ageratina adenophora* (2.7mm) and (78.5%). This shows the ecofriendly application of bio-fertilizers in the field of plant protection. Biological control is a promising tool to maintain current level of agricultural production while reducing the release of polluting chemical pesticides to the environment.

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