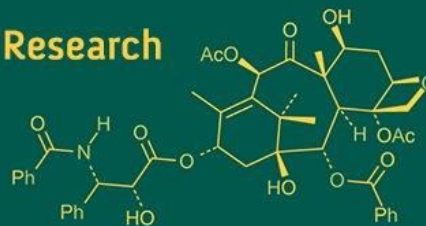
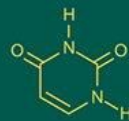
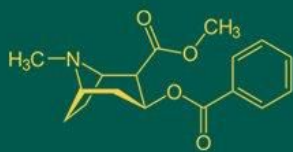


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Evaluation of bio efficacy of *Pseudomonas fluorescens* against soil borne plant pathogen

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Abstract

In the present study, the *in vitro* antagonistic potential of *Pseudomonas fluorescens* seven isolates was evaluated against major soil-borne pathogens including *Fusarium oxysporum* f. sp. *ciceri*, *Rhizoctonia bataticola*, *Rhizoctonia solani*, and *Sclerotium rolfsii*. Bioefficacy was evaluated by dual culture assay were conducted on three media King's B (KB), Potato Dextrose Agar (PDA), and a 1:1 combination of KB and PDA. The mixed KB+PDA medium consistently showed greater pathogen suppression compared to either KB or PDA alone. Among the isolates, Pf 2 exhibited the strongest antagonistic activity. Against *F. oxysporum* f. sp. *ciceri*, Pf 2 achieved inhibition levels of 79.84% on KB+PDA, 76.21% on KB, and 59.46% on PDA, while Pf 7 was the least effective across all media. For *R. bataticola*, Pf 2 recorded 73.78% inhibition on KB+PDA, whereas Pf 1 showed 63.88% inhibition on KB and Pf 2 achieved 47.03% on PDA. In the case of *R. solani*, Pf 2 suppressed growth by 77.52% on KB+PDA, 73.92% on KB, and 40.74% on PDA. Against *S. rolfsii*, Pf 2 demonstrated 81.60% inhibition on KB+PDA, 65.38% on KB, and 52.22% on PDA. Overall, isolates Pf 1 through Pf 5 displayed promising biocontrol potential, while Pf 6 and Pf 7 were comparatively less effective.

Keywords: *Pseudomonas fluorescens*, Dual culture, *Fusarium oxysporum* f.sp *ciceri*, *Rhizoctonia bataticola*, *Rhizoctonia solani*, *Sclerotium rolfsii*

Introduction

Biological control, or biocontrol, involves the use of organisms to directly or indirectly suppress the spread of pathogens and reduce disease severity. Plant-associated microbes play a crucial dual role by enhancing tolerance to both biotic and abiotic stresses, while also promoting plant growth (Welbaum *et al.* 2004; Munees and Kibret 2013) ^[1, 12]. Globally, plant diseases remain a leading cause of crop yield losses (Savary *et al.* 2019) ^[13]. Among soil borne pathogens, *Fusarium* spp. *Sclerotium* spp and *Rhizoctonia* spp. cause extensive losses to this crop in both, open field cultivation as well as under protected cultivation system (Panth *et al.* 2020) ^[14]. Employing biocontrol agents offers a sustainable alternative to chemical treatments, boosting disease resistance and minimizing chemical dependency.

Pseudomonas fluorescens is a Gram-negative, rod-shaped bacterium that inhabits soil and plant rhizospheres, and it has been widely recognized as an effective biocontrol agent in agriculture. Its activity is attributed to the production of diverse secondary metabolites such as 2,4-diacetylphloroglucinol (DAPG), pyoluteorin, phenazines, and hydrogen cyanide, which directly inhibit pathogenic fungi and bacteria (Kumar *et al.* 2023) ^[15]. In addition, it secretes siderophores that chelate iron, depriving pathogens of this essential nutrient, and produces lytic enzymes like chitinases and proteases that degrade pathogen cell walls. Beyond direct antagonism, *P. fluorescens* enhances plant defense through induced systemic resistance (ISR), activating jasmonic acid and ethylene-mediated pathways that strengthen the plant's immune response. Its ability to colonize the rhizosphere rapidly also allows it to outcompete pathogens for space and nutrients, further reducing disease incidence (Haas and Defago 2005) ^[16].

Practical applications include suppression of soil-borne diseases such as *Fusarium wilt*, *Rhizoctonia root rot*, *Pythium damping-off*, and *Sclerotinia stem rot*, as well as bacterial wilt caused by *Ralstonia solanacearum*. Seed treatments and soil inoculations with *P. fluorescens* not only protect crops but also promote plant growth by improving nutrient uptake and root

development. While its effectiveness can vary depending on environmental conditions and microbial competition, it remains a powerful eco-friendly alternative to chemical pesticides, contributing to sustainable farming systems (Aishwarya, *et al* 2004)^[17].

The harmful impact of chemical-based plant protection methods has led to a growing shift toward organic and sustainable farming practices. The use of chemical pesticides to manage soil-borne diseases poses serious risks to both the environment and human health, while also disrupting beneficial soil microorganisms.

Methodology

Collection of *Pseudomonas fluorescens* isolates

Pseudomonas fluorescens isolates procured from different institute namely Pf 1, Pf 2, Pf 6 procured from NBAIM, Mau. Pf 3 procured from Department of Plant Pathology, PGI, Akola, Pf 4 and Pf 5 Section of Plant Pathology College of Agriculture, Nagpur and Pf 7 from Central Citrus Research Institute, Nagpur.

Collection of soil borne pathogen

Fusarium oxysporum f. sp. *ciceri*, *Rhizoctonia bataticola*, *Rhizoctonia solani*, and *Sclerotium rolfsii* were selected for study which collected from Section of Plant Pathology College of Agriculture, Nagpur.

Maintain a pure culture of micro-organism

The antagonistic activity of each *Pseudomonas fluorescens* isolate was tested against these fungal pathogens. All bacterial were grown on freshly prepared King's B media and fungal cultures on PDA media and incubated at 28 ± 2 °C for 5 to 7 days. Pure cultures were then maintained by sub-culturing onto King's B and PDA slants and stored under refrigeration for future use.

Dual-culture assay in *in vitro*

A dual culture technique was employed to evaluate the antagonistic potential of seven *Pseudomonas fluorescens* isolates against prevalent soil-borne fungal pathogens affecting plants. The interaction between *P. fluorescens* and the fungal pathogens was tested on three media types Potato Dextrose Agar (PDA), King's B medium, and a 1:1 combination of King's B and PDA using Petri dishes. Fresh, pure cultures of *P. fluorescens* and the fungal pathogens were prepared by incubating in King's B for 72 hours and PDA for 4-5 days, respectively. For the antagonism assay, a 4 mm diameter cork borer containing fungal mycelium disc was placed at the centre of the dual media plate under sterile conditions. Each bacterial isolate was then streaked in a square pattern around the fungal disc, maintaining a 3 cm distance from the pathogen. The plates were incubated at 27 ± 2 °C to observe interactions. (Elkahoui *et al* 2012)^[9] (Rathore *et al* 2020) The mycelial inhibition rate was calculated as per by following formula.

$$\text{Per cent Growth inhibition} = \{(C-T)/C\} * 100$$

Results and Discussion

Dual Culture Assay of *Pseudomonas fluorescens* isolates against *Fusarium oxysporum* f. sp. *ciceri* on different media

In the present study, all the seven isolates of *Pseudomonas fluorescens* were allowed individually to interact with *F.*

oxysporum f.sp. *ciceri*, on KB, PDA and KB+PDA media by dual culture assay. Data presented in Table 1 Fig 1 Plate 1. indicated that there is significance difference of seven isolates of *Pseudomonas fluorescens* in inhibiting the growth of *F. oxysporum* f. sp. *ciceri*.

On KB media lowest mycelium growth obtained in by Pf 2 (03.33 mm) followed by Pf 4 (03.66 mm), Pf 3 and Pf 5 (0.5.00 mm) and Pf 1 (06.33). The maximum mycelium growth obtained by Pf 7 (08.00 mm) and Pf 6 (07.33 mm) control consist of 14.00 mm mycelium growth. The highest percent growth inhibition over control found in Pf 2 (76.21) followed by Pf 4 (73.80), Pf 3 and Pf 5 (64.28) and Pf 1 (54.78) Lowest percent inhibition found in Pf 7(42.85) followed by Pf 6 (47.64).

On PDA media lowest mycelium growth obtained in by Pf 2 (35.66 mm) followed by Pf 4 (37.66 mm), Pf 3 and Pf 1 (42.00 mm) and Pf 5 (44.33 mm). The maximum mycelium growth obtained by Pf 7 (63.33mm) and Pf 6 (49.33 mm) control consist of 88.00 mm mycelium growth. The highest percent growth inhibition over control found in Pf 2 (59.46) followed by Pf 4 (57.19), Pf 3 and Pf 1 (52.22) and Pf 5 (49.62) Lowest percent inhibition found in Pf 7(24.67) followed by Pf 6 (43.94).

On KB+PDA media lowest mycelium growth obtained in by Pf 2 (17.33 mm) followed by Pf 4 (22.66mm), Pf 3 (26.00 mm), Pf 1 and Pf 5 (27.00 mm). The maximum mycelium growth obtained by Pf 7 (39.33 mm) Pf 6 (37.33 mm) control consist of 86.00 mm mycelium growth. The highest percent growth inhibition over control found in Pf 2 (79.84) followed by Pf 4 (73.64), Pf 3 (69.76), Pf 1 and Pf 5 (68.60) Lowest percent inhibition found in Pf 7(54.26) followed by Pf 6 (56.59).

In result it found out Pf 1, Pf 2, Pf 3, Pf 4 and Pf 5 effectively control *F. oxysporum* f.sp. *ciceri*, compared to Pf 6 and Pf 7 on KB, PDA and KB+PDA media. On KB medium, *Pseudomonas fluorescens* exhibited robust growth, while the fungal pathogen thrived on PDA. The combined KB+PDA medium supported healthy growth of both the bacterium and the fungus, yielding improved outcomes.

Similar findings of *Pseudomonas fluorescens* effectively control *Fusarium oxysporum* f.sp. *ciceri* were reported by Pandey *et al.* (2022) where out of 20 isolates of *P. fluorescens*, six isolates (Pf4, Pf13, Pf14, Pf18, Pf19, and Pf20) were identified as strong inhibitors against *Fusarium oxysporum* f. sp. *ciceri* (Foc) in dual culture approach, when compared to other bacterial strains of *P. fluorescens*. The antagonistic activity of (Pf 18, Pf 4, Pf 20, Pf 19, Pf13, and Pf 14) was reduced by (80.1, 79.8, 76.4, 73, 72.6, and 70.3) per cent, respectively, as compared to the control. Also Karnewar *et al.* (2022) reported the antifungal activity against *Fusarium oxysporum* f. sp. *ciceri*, the observation showed that treatment *Pseudomonas striata* (T8) was found most effective and showed highest inhibition i.e. 68.51% followed by *Trichoderma harzianum* (T1) and *Bacillus subtilis* (T9) both had the same antagonist i.e. reaction with mycelial growth 30 mm and with per cent mycelial inhibition of 65.62%. And Wavare *et al.* (2017) reported that Among the *Pseudomonas fluorescens*, *Bacillus subtilis* and *Trichoderma harzianum* tested by dual culture technique, *P. fluorescens* suppressed the colonisation of *F. oxysporum* f. sp. *ciceri* by 81.59%. followed by *T. harzianum* 77.30% and *Bacillus subtilis* 74.60%.

Dual Culture Assay of *Pseudomonas fluorescens* isolates against *Rhizoctonia bataticola*

In the present study, all the seven isolates of *Pseudomonas fluorescens* were allowed individually to interact with *Rhizoctonia bataticola*, on KB, PDA and KB+PDA media by dual culture assay. Data presented in Table 2 Fig 2 Plate 2. indicated that there is significance difference of seven isolates of *Pseudomonas fluorescens* in inhibiting the growth of *Rhizoctonia bataticola*.

On KB media mycelium growth obtained in by Pf 1 (13.00 mm) followed by Pf 2 (14.00 mm), Pf 3 (17.66mm), Pf 4 and Pf 5 (20.00), Pf 6 (21.00) and Pf 7 (24.00) control consist of maximum mycelium growth 36.00 mm. The highest percent growth inhibition over control found in Pf 1 (63.88) followed by Pf 2 (61.46), Pf 3 (50.92), Pf 4 and Pf 5 (44.44). Lowest percent inhibition found in Pf 7(33.33) followed by Pf 6 (41.66).

On PDA media minimum mycelium growth obtained in by Pf 1 (47.66 mm) followed by Pf 3 (52.00 mm), Pf 1 (53.00 mm) and Pf 4 (54.00 mm). The maximum mycelium growth obtained by Pf 7 (64.66 mm), Pf 6 (58.00 mm) and Pf 5 (55.33 mm) control consist of 90.00mm mycelium growth. The maximum percent growth inhibition over control found in Pf 2 (47.03) followed by Pf 3 (42.22), Pf 1 (41.11) and Pf 4 (40.00) minimum percent inhibition found in Pf 7(28.14) followed by Pf 6 (35.55) and Pf 5 (38.52).

On KB+PDA media minimum mycelium growth obtained in by Pf 2 (23.33 mm) followed by Pf 4 (26.33 mm), Pf 3 (28.33 mm) and Pf 1 (29.66). Pf 4 (26.33 mm). The maximum mycelium growth obtained by Pf 7 (52.00 mm) followed Pf 6 (49.66 mm) and Pf 5 (31.00) control consist of 89.00 mm mycelium growth. The highest percent growth inhibition over control found in Pf 2 (73.78) followed by Pf 4 (70.41), Pf 3 (68.16), Pf 1 (66.66) and Pf 5 (65.16). Lowest percent inhibition found in Pf 7(41.57) followed by Pf 6 (44.19) over a control.

There is no highly difference in controlling of *Rhizoctonia bataticola* among the isolates of *Pseudomonas fluorescens* on KB and PDA media because poor growth of bacteria take place on PDA and KB media good growth of bacteria and poor growth of fungus, but on KB+ PDA media actual result is revealed and helps to determine best isolate of *Pseudomonas fluorescens*. In result it found out Pf 1, Pf 2, Pf 3 and Pf 4 effectively control *Rhizoctonia bataticola*, compared to Pf 5, Pf 6 and Pf 7 on KB and PDA media. On KB+PDA media Pf 1, Pf 2, Pf 3, Pf 4 and Pf 5 effectively control *Rhizoctonia bataticola*, compared to Pf 6 and Pf 7.

Similar findings of *Pseudomonas fluorescens* effectively control *Rhizoctonia bataticola* were reported by Sangappa and Mallesh (2016) Among the biocontrol agents tested against *Rhizoctonia bataticola*, *Pseudomonas fluorescens* (DAPG+ve)-RP46 was found more effective as compared to other bio-control agents and inhibited maximum mycelia growth (68.95%) of *R. bataticola* followed by *T. harzianum* (Th-R) (61.85%) and *T. viride* (Tv-R) (61.11%) under in vitro condition.

Dual Culture Assay of *Pseudomonas fluorescens* isolates against *Rhizoctonia solani* on different media

In the present study, all the seven isolates of *Pseudomonas fluorescens* were allowed individually to interact with *Rhizoctonia bataticola*, on KB, PDA and KB+PDA media by dual culture assay. Data presented in Table 3 Fig 3 Plate 3. indicated that there is significance difference of seven

isolates of *Pseudomonas fluorescens* in inhibiting the growth of *Rhizoctonia solani*.

On KB media mycelium growth obtained in by Pf 2 (08.33 mm) followed by Pf 4 and Pf 3 quite similar (10.00 and 10.66 mm) and Pf 5, Pf 1 was quite similar (12.00, 12.33 mm) Pf 7 (13.33 mm) and Pf 6 (14.00 mm) control consist of maximum mycelium growth 32.00 mm. The highest percent growth inhibition over control found in Pf 2 (73.96) followed by Pf 4 (68.75), Pf 3 (66.66), Pf 5 (62.50) and Pf 1 (61.46). Lowest percent inhibition found in Pf 6 (56.25) followed by Pf 7 (58.34).

On PDA media mycelium growth obtained in by Pf 2 (53.33 mm) followed by Pf 5 (54.00 mm), Pf 3 (57.00 mm) and Pf 4 (63.33 mm), Pf 1 (64.33 mm), Pf 6 (65.33) and Pf 7(66.00 mm). Control consist of 90.00 mm mycelium growth. The maximum percent growth inhibition over control found in Pf 2 (40.74) followed by Pf 5 (40.00), Pf 3 (36.33) Pf 4 (29.66) minimum percent inhibition found in Pf 7(26.66) followed by Pf 6 (27.41) and Pf 1 (28.52).

On KB+PDA media minimum mycelium growth obtained in by Pf 2 (20.00mm) followed by Pf 4 (25.00 mm), Pf 1 (26.66 mm) and Pf 3 and Pf 5 (28.33). The maximum mycelium growth obtained by Pf 6 (51.66 mm) followed Pf 7 (46.00 mm). Control consist of 89.00 mm mycelium growth. The highest percent growth inhibition over control found in Pf 2 (77.52) followed by Pf 4 (71.91), Pf 1 (70.03), Pf 3 and Pf 5 (68.16). Lowest percent inhibition found in Pf 6 (41.94) followed by Pf 7 (48.31) over a control.

There is no highly difference in controlling of *Rhizoctonia solani* among the isolates of *Pseudomonas fluorescens* on KB and PDA media because poor growth of bacteria take place on PDA and KB media good growth of bacteria and poor growth of fungus, but on KB+ PDA media actual result is revealed and helps to determine best isolate of *Pseudomonas fluorescens*. In result it found out Pf 1, Pf 2, Pf 3 and Pf 4 effectively control *Rhizoctonia solani*, compared to Pf 5, Pf 6 and Pf 7 on KB and PDA media. On KB+PDA media Pf 1, Pf 2, Pf 3, Pf 4 and Pf 5 effectively control *Rhizoctonia solani*, compared to Pf 6 and Pf 7.

Similar findings of *Pseudomonas fluorescens* effectively control *Rhizoctonia solani* were reported by Nagendran *et al.* (2019) [5] Among them, *Pseudomonas fluorescens* strains Tu (Pf)19 and Kk (Pf)24, along with *Bacillus subtilis* strains Tn (Bs)7 and Kk (Bs)19, exhibited the most significant inhibition of both mycelial growth and sclerotial germination of *R. solani*. The isolate Tu (Pf)19 recorded the highest mycelial growth suppression at 75.5%, followed by Kk (Pf)24 with 70% inhibition, when compared to the untreated control. Also Anupriya *et al.*, reported that Among the five isolates tested, Pf1 demonstrated the highest level of pathogen suppression, reducing colony growth by 66.67%, followed closely by Pf3, which achieved a 65.33% inhibition. And Toppo and Tiwari (2015) [7] studied antagonism of fluorescent pseudomonads against *R. solani* in vitro by dual culture and reported that, amongst the 28 isolates, only 3 isolates PKJ25(62.60% inhibition) Pmtcc (55.47%) and PKB27(53.28%) recorded above 50 per cent inhibition of the test pathogen *Rhizoctonia* spp.

Dual Culture Assay of *Pseudomonas fluorescens* isolates against *Sclerotium rolfii* on different media.

In the present study, all the seven isolates of *Pseudomonas fluorescens* were allowed individually to interact with *Sclerotium rolfii* on KB, PDA and KB+PDA media by dual culture assay. Data presented in Table 4, Fig 4 and Plate 4.

indicated that there is significance difference of seven isolates of *Pseudomonas fluorescens* in inhibiting the growth of *Sclerotium rolfii*.

On KB media lowest mycelium growth obtained in by Pf 2, Pf 5 (03.00 mm) followed by Pf 3 (03.33 mm), Pf 4 (03.66 mm). The maximum mycelium growth obtained by Pf 7 (07.33 mm) followed by Pf 6 (06.66 mm) and Pf 1 (05.00 mm). Control consist of 08.66 mm mycelium growth. The highest percent growth inhibition over control found in Pf 2, Pf 5 (65.38) followed by Pf 3 (61.57) and Pf 4 (57.69). Lowest percent inhibition found in Pf 7(15.42) followed by Pf 6 (23.07) and Pf 1 (42.30).

On PDA media lowest mycelium growth obtained in by Pf 2 (43.00 mm) followed by Pf 4 (44.33 mm), Pf 5(45.33 mm) and Pf 3 (47.00 mm). The maximum mycelium growth obtained by Pf 7 (58.00 mm), Pf 6 (54.33 mm) and Pf 1 (53.00 mm). Control consist of 90.00 mm mycelium growth. The highest percent growth inhibition over control found in Pf 2 (52.22) followed by Pf 4 (50.74), Pf 5 (49.63) and Pf 3 (47.77). Lowest percent inhibition found in Pf 7(35.55) followed by Pf 6 (39.63) and Pf 1 (41.11).

On KB+PDA media lowest mycelium growth obtained in by Pf 2 (16.00 mm) followed by Pf 4 (23.66 mm), Pf 3, Pf 5 (26.66mm, 26.33 mm), The maximum mycelium growth obtained by Pf 7 (46.66 mm) Pf 6 (42.00 mm) and Pf 1 (31.66 mm). Control consist of 87.00 mm mycelium growth. The highest percent growth inhibition over control found in Pf 2 (81.60) followed by Pf 4 (72.79), Pf 5, Pf 3 (69.73, 69.00). Lowest percent inhibition found in Pf 7(46.35) followed by Pf 6 (51.72) and Pf 1 (63.60)

In result it found out, Pf 2, Pf 3, Pf 4 and Pf 5 effectively control *Sclerotium rolfii*, compared to Pf 1, Pf 6 and Pf 7 on KB, PDA and KB+PDA media. On KB medium, *Pseudomonas fluorescens* exhibited robust growth, while

the fungal pathogen thrived on PDA. The combined KB+PDA medium supported healthy growth of both the bacterium and the fungus, yielding improved outcomes.

Similar findings of *Pseudomonas fluorescens* effectively control *Rhizoctonia solani* were reported by Reddy *et al.* (2021) [6] the bioefficacy of biocontrol against for the management of stem rot of tuberose caused *Sclerotium rolfii* among the isolate *Pseudomonas fluorescens* Pf7 showed the maximum growth inhibition of *S. rolfii* up to 75.94 per cent. This was followed by the isolates Pf9 (74.41) and Pf5 (73.00) in the decreasing order and the least growth inhibition of pathogen (58.52%) was exhibited by the isolates Pf6. and Amrotin *et al.* (2018) [10] evaluated the efficacy of five *Pseudomonas fluorescens* isolates was against *Sclerotium rolfii* and *Rhizoctonia solani*, both obtained from rice fields Among the isolates, P141 exhibited the highest inhibition of *R. solani* with a growth reduction of 65.28%, while P66 showed the greatest effectiveness against *S. rolfii*, achieving 68.33% inhibition.

Conclusion

Dual culture assays were performed against soil-borne pathogens including *Fusarium oxysporum* f.sp. *ciceri*, *Rhizoctonia bataticola*, *Rhizoctonia solani* and *Sclerotium rolfii* using Kings' B (KB), Potato Dextrose Agar (PDA) and a combination of KB + PDA media. The KB + PDA medium demonstrated superior pathogen suppression compared to KB or PDA media alone. Among the isolates, Pf 2 showed the highest antagonistic activity against all soil borne pathogens. Overall, isolates Pf 1 to Pf 5 demonstrated effective biocontrol potential, whereas Pf 6 and Pf 7 were less effective.

Table 1: Dual culture assay of *Pseudomonas fluorescens* isolates against *Fusarium oxysporum* f. sp. *ciceri* on different media

Tr No	Treatment	On KB Media		On PDA Media		On KB + PDA Media	
		Mycelial Growth (mm)	Percent inhibition over control (%)	Mycelial Growth (mm)	Percent inhibition over control (%)	Mycelial Growth (mm)	Percent inhibition over control (%)
1	Pf 1	06.33	54.78	42.00	52.22	27.00	68.6
2	Pf 2	03.33	76.21	35.66	59.46	17.33	79.84
3	Pf 3	05.00	64.28	42.00	52.22	26.00	69.76
4	Pf 4	03.66	73.8	37.66	57.19	22.66	73.64
5	Pf 5	05.00	64.28	44.33	49.62	27.00	68.6
6	Pf 6	07.33	47.64	49.33	43.94	37.33	56.59
7	Pf 7	08.00	42.85	63.33	24.67	39.33	54.26
8	Control	14.000	-	88.00	-	86.00	-
F test		S	-	S	-	S	-
SE (m) ±		0.372	-	0.565	-	0.513	-
CD @ 1%		1.539	-	2.334	-	2.129	-

* Mean of three replication

Table 2: Dual culture assay of *Pseudomonas fluorescens* isolates against *Rhizoctonia bataticola* on different media

Tr No	Treatment	On KB Media		On PDA Media		On KB + PDA Media	
		Mycelial Growth (mm)	Percent inhibition over control (%)	Mycelial Growth (mm)	Percent inhibition over control (%)	Mycelial Growth (mm)	Percent inhibition over control (%)
1	Pf 1	13.00	63.88	53.00	41.11	29.66	66.66
2	Pf 2	14.00	61.46	47.66	47.03	23.33	73.78
3	Pf 3	17.66	50.92	52.00	42.22	28.33	68.16
4	Pf 4	20.00	44.44	54.00	40.00	26.33	70.41
5	Pf 5	20.00	44.44	55.33	38.52	31.00	65.16
6	Pf 6	21.00	41.66	58.00	35.55	49.66	44.19
7	Pf 7	24.00	33.33	64.66	28.14	52.00	41.57
8	Control	36.0	-	90.00	-	89.00	-
F test		S	-	S	-	S	-
SE (m) ±		0.372	-	0.763	-	0.697	-
CD @ 1%		1.539	-	3.154	-	2.879	-

* Mean of three replication

Table 3: Dual culture assay of *Pseudomonas fluorescens* isolates against *Rhizoctonia solani* on different media

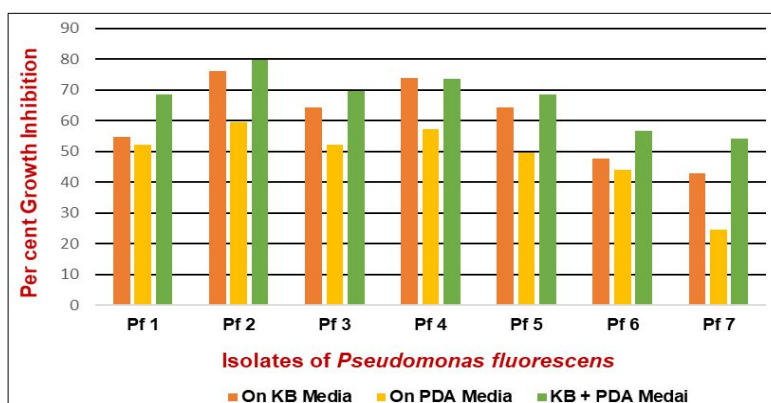
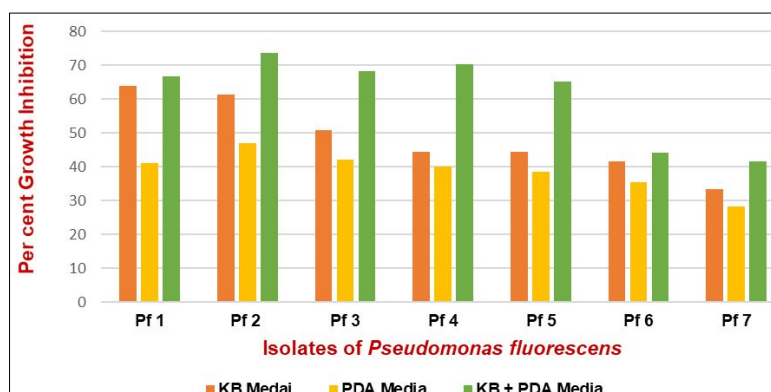
Tr No	Treatment	Dual culture assay of <i>Pseudomonas fluorescens</i> isolates against <i>Rhizoctonia solani</i> on different media					
		On KB Media		On PDA Media		On KB + PDA Media	
		Mycelial Growth (mm)	Percent inhibition over control (%)	Mycelial Growth (mm)	Percent inhibition over control (%)	Mycelial Growth (mm)	Percent inhibition over control (%)
1	Pf 1	12.33	61.46	64.33	28.52	26.66	70.03
2	Pf 2	08.33	73.96	53.33	40.74	20.00	77.52
3	Pf 3	10.66	66.66	57.00	36.33	28.33	68.16
4	Pf 4	10.00	68.75	63.33	29.66	25.00	71.91
5	Pf 5	12.00	62.5	54.00	40.00	28.33	68.16
6	Pf 6	14.00	56.25	65.33	27.41	51.66	41.94
7	Pf 7	13.33	58.34	66.00	26.66	46.00	48.31
8	Control	32.00	-	90.00	-	89.00	-
F test		S	-	S	-	S	-
SE (m) ±		0.701	-	0.311	-	0.513	-
CD @ 1%		2.920	-	1.287	-	2.121	-

* Mean of three replication

Table 4: Dual culture assay of *Pseudomonas fluorescens* Isolates against *Sclerotium rolfsii* on different media

Tr No	Treatment	Dual culture assay of <i>Pseudomonas fluorescens</i> Isolates against <i>Sclerotium rolfsii</i> on different media					
		On KB Media		On PDA Media		On KB + PDA Media	
		Mycelial Growth (mm)	Percent inhibition over control (%)	Mycelial Growth (mm)	Percent inhibition over control (%)	Mycelial Growth (mm)	Percent inhibition over control (%)
1	Pf 1	05.00	42.3	53.00	41.11	31.66	63.60
2	Pf 2	03.00	65.38	43.00	52.22	16.00	81.60
3	Pf 3	03.33	61.57	47.00	47.77	26.66	69.00
4	Pf 4	03.66	57.69	44.33	50.74	23.66	72.79
5	Pf 5	03.00	65.38	45.33	49.63	26.33	69.73
6	Pf 6	06.66	23.07	54.33	39.63	42.00	51.72
7	Pf 7	07.33	15.42	58.00	35.55	46.66	46.35
8	Control	08.66	-	90.00	-	87.00	-
F test		S	-	S	-	S	-
SE (m) ±		0.390	-	0.612	-	0.565	-
CD @ 1%		1.614	-	2.529	-	2.334	-

* Mean of three replication

**Fig 1:** Dual culture assay of *Pseudomonas fluorescens* isolates against *Fusarium oxysporum* f. sp. *ciceri* on different media**Fig 2:** Dual culture assay of *Pseudomonas fluorescens* isolates against *Rhizoctonia bataticola* on different media

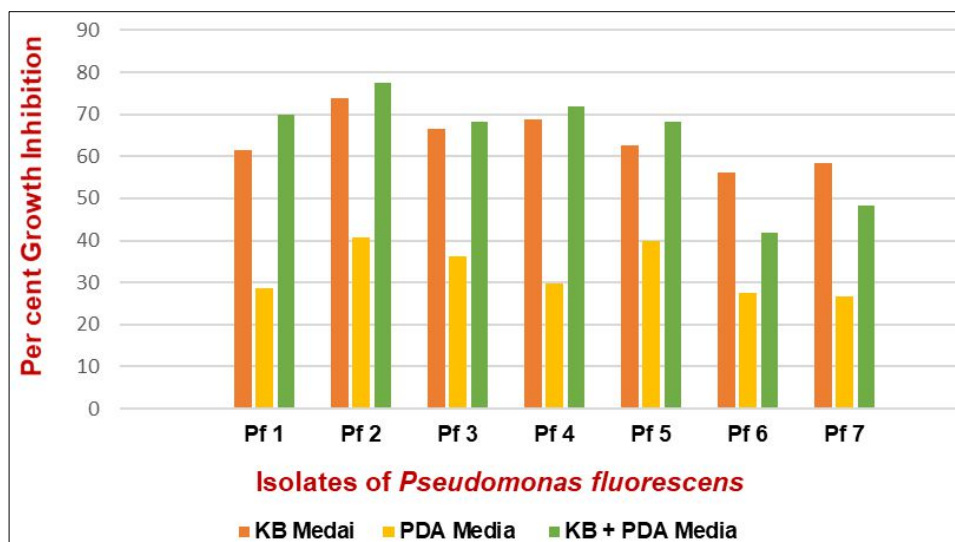


Fig 3: Dual culture assay of *Pseudomonas fluorescens* isolates against *Rhizoctonia solani* on different media

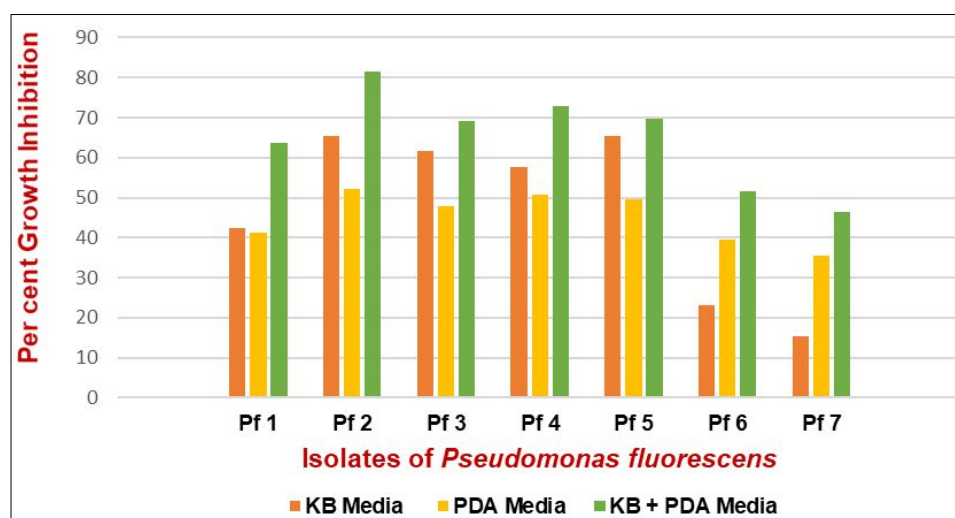


Fig 4: Dual culture assay of *Pseudomonas fluorescens* isolates against *Sclerotium rolfsii* on different media.

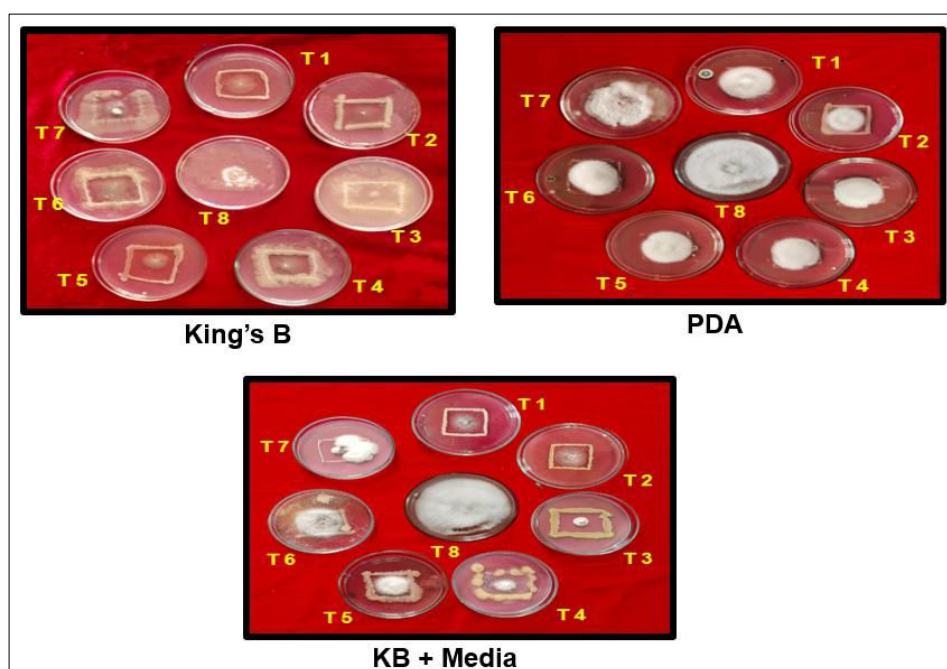


Plate 1: Dual Culture Assay of *Pseudomonas fluorescens* isolates against *Fusarium oxysporum* f. sp. *ciceri*

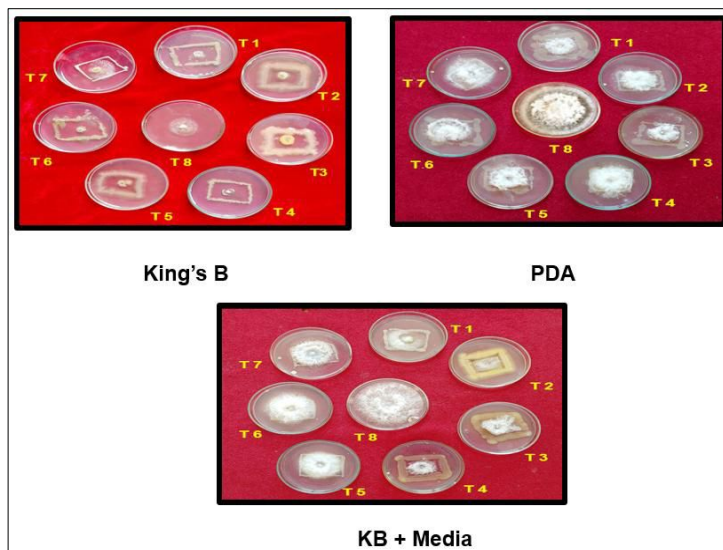


Plate 2: Dual Culture Assay of *Pseudomonas fluorescens* isolates against *Rhizoctonia bataticola* on different media

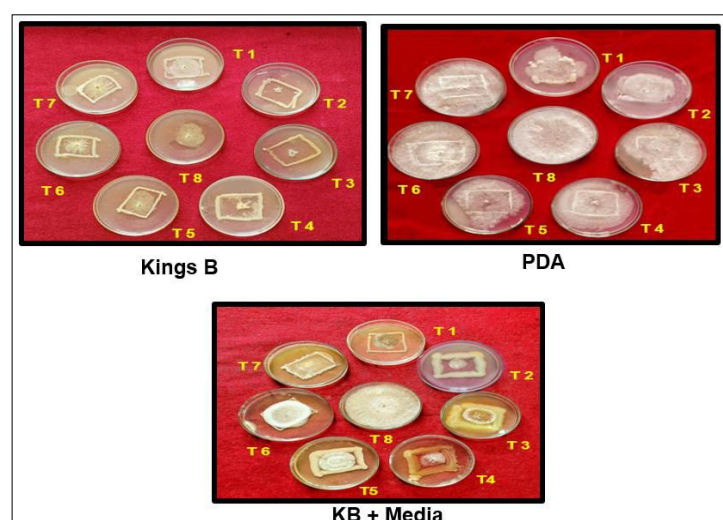


Plate 3: Dual Culture Assay of *Pseudomonas fluorescens* isolates against *Rhizoctonia solani* on different media

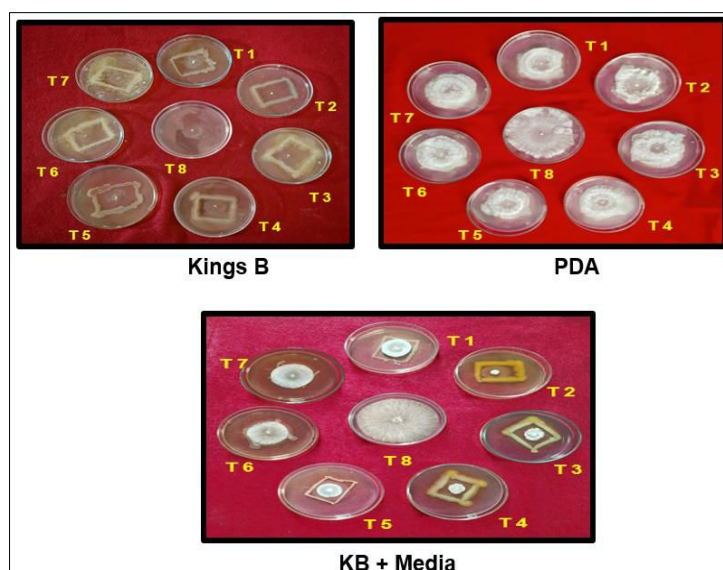


Plate 4: Dual Culture Assay of *Pseudomonas fluorescens* isolates against *Sclerotium rolfsii* on different media

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