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EVALUATION OF *TRICHODERMA* AND BIORATIONALS FOR MANAGEMENT OF FUSARIUM WILT OF CHICKPEA UNDER GREENHOUSE CONDITIONS

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ABSTRACT

Fusarium wilt of chickpea caused by *Fusarium oxysporum* f. sp. *ciceri* (*Foc*) is a ubiquitous soil borne plant pathogen affecting the crop across the world, specifically in the tropical region of India where chickpea is largely grown. The present study was undertaken to evaluate the efficacy of *Trichoderma* isolates and selected biorationals, applied alone and in combination, for the management of chickpea wilt under greenhouse conditions. Treatments were assessed for seed germination, growth parameters, vigour index, and disease incidence. Except for pathogen control, Beejaraksha 6% alone, and its combinations with *Trichoderma*, all treatments recorded seed germination on par with the absolute control. Beejaraksha 6% reduced seed germination and root growth, whereas Panchagavya 10% + *Trichoderma* isolate T 19001 recorded 100% germination and maximum root length (8.40 cm), comparable to the absolute control. Shoot length was generally unaffected in integrated treatments, except in Beejaraksha combinations with T 19001 and T 19012. The highest vigour index was observed in Panchagavya 10% + T 19001 (3040.00), showing a 7.02% increase over the absolute control. Disease incidence was significantly reduced in Panchagavya 10% + T 19001 (13.33%) compared to the pathogen check (76.92%). The efficacy of *Trichoderma* in reducing the disease was decreased by integrating with beejamrutha 10% or beejaraksha 6%. The results indicate that integration of Panchagavya with *Trichoderma* offers an effective and eco-friendly strategy for managing Fusarium wilt of chickpea under greenhouse conditions.

***Key words*:** Beejamrutha, Beejaraksha, Disease incidence, *Foc*, Panchagavya, *Trichoderma*

Introduction

Chickpea (*Cicer arietinum* L.) is one of the oldest cultivated legumes and the third most important *Rabi* pulse crop globally after dry beans and peas, with its origin in south-eastern Turkey (Ladizinsky, 1975). It is predominantly grown under rainfed conditions in the dry regions of the Indian subcontinent, which contributes nearly 90% of global chickpea production (Saxena, 1990; Juan *et al.*, 2000). Chickpea serves as an economical source of high-quality protein and enhances soil fertility through biological nitrogen fixation, making it an important component of sustainable agriculture (Singh, 1997; Asfaw *et al.*, 1994). Chickpea productivity is severely constrained by fungal diseases, with nearly 172 pathogens reported worldwide, the highest diversity being in India (Nene *et al.*, 1996). Among these, Fusarium wilt caused by *Fusarium oxysporum* f. sp. *ciceri* is the most destructive and widespread disease, reported from over 33 chickpea-growing countries, causing yield losses ranging from 10–15% and up to 100% under favorable conditions (Singh and Dahiya, 1973; Cortes *et al.*, 2000; Warda *et al.*, 2017).

The high pathogenic variability of the wilt pathogen limits the du*Rabi*lity of host resistance, while excessive use of fungicides leads to environmental pollution and resistance development (Nimalkar *et al.*, 2006). Hence,

eco-friendly management strategies involving biorationals and biological control agents have gained importance in managing soil-borne diseases (Biswas and Sen, 2000; Rudresh *et al.*, 2005). Among these, *Trichoderma* spp. are widely used due to their antagonistic activity, competitive saprophytic ability, and plant growth-promoting effects, although considerable isolate variability exists (Upadhyay and Mukhopadhyay, 1986; Angulo *et al.*, 2012). Therefore, the present investigation was undertaken to evaluate the efficacy of selected biorationals and *Trichoderma* isolates against *F. oxysporum* f. sp. *ciceri* under greenhouse conditions.

Materials and Methods

Isolation and identification of pathogen

Fusarium wilt infected plants collected from college farm, Agricultural College, Bapatla used for isolation of the pathogen. To confirm the presence of the pathogen in the collected specimen, the diseased roots were scraped and observed under microscope. Roots of the infected plants were thoroughly washed under tap water. Root bits of infected plant were cut, surface sterilized using 1% sodium hypochlorite for a minute and rinsed in three changes of distilled water to remove the disinfectant. Root bits were blot dried (sterilized blotting paper) before transferring aseptically onto PDA plates and were incubated at 27±1°C in an incubator. Two day old mycelial bits developed on diseased roots were aseptically transferred to glass slides and observations were made to confirm their identity based on morphological characters (conidia and conidiophore). The cultures were identified on the basis of the descriptions given in the monograph on the genus Fusarium (Booth, 1971). The obtained pathogen cultures were sub-cultured on PDA after confirmation.

Isolation and identification of *Trichoderma* sp. from rhizosphere soils

Soil samples were collected from the rhizosphere during survey from different locations in Prakasam district of A.P, India (Amulya *et al.*, 2025). Soil samples were air dried for 24 hours and sieved through a 2 mm sieve. Twenty milligrams of this sieved soil was transferred to a Petriplate and spread uniformly on *Trichoderma* selective medium (TSM) under aseptic conditions. The plates were incubated at 28°C for three to five days. The colonies were allowed to sporulate. Thus obtained *Trichoderma* cultures were sub-cultured on PDA after confirmation. Based on *in-vitro* screening for antagonism, volatile, non volatile metabolites and their compatibility with biorationals, five promising *Trichoderma* isolates (T 19001, T 19007, T 19012, T 19020, T 19023) were selected for greenhouse evaluation.

Preparation of Biorationals

i) **Panchagavya:** Panchagavya was procured from the Zero Budget Natural Farming (ZBNF) farmer in Tenali, whereas beejamrutha and beejaraksha were prepared in the Department of Plant Pathology, Agricultural College, Bapatla.

ii) **Beejamrutha:** Due to the short shelf life of Beejamrutha, a small quantity in reduced proportions was prepared by following the procedure given by Sreenivasa *et al.*, (2009) just before experimentation and used for the experiment. Fresh cow dung of 40 g was tied in muslin cloth and suspended in 160 ml of sterile distilled water overnight. On the next day, the dung bag was squeezed and dipped in water to collect the extract. 40 ml of cow urine, 0.4 g of lime and 0.4 g of bund soil were then added to the extract and stirred well to mix the contents.

iii) **Beejaraksha:** Bund soil of 50 g was mixed with 10 g of turmeric powder. Later, 10 g of Asfoetida powder, 50 g wood ash, 5 ml of cow urine were added, mixed and shade dried for 30 min. Beejaraksha prepared was then preserved in an air tight bottle for future use.

Source of seed

Chickpea seeds of susceptible variety JG-64 obtained from Regional Agricultural Research Station, Nandyal and were used for pot culture studies.

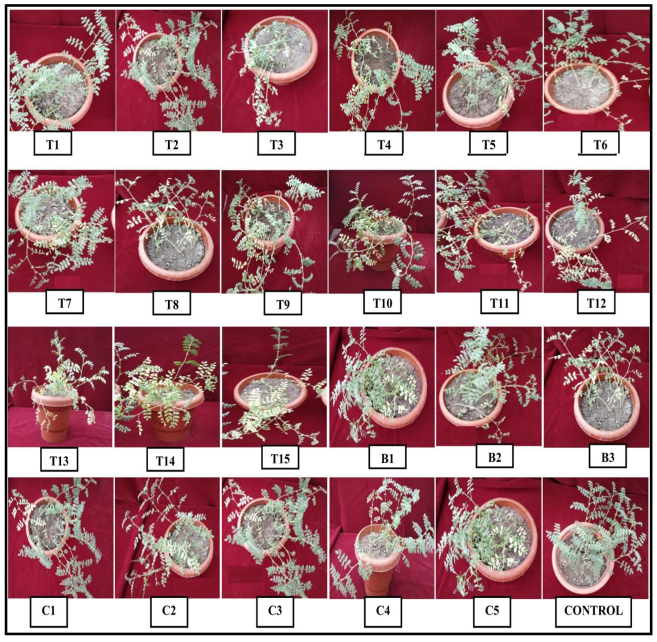

Plate 1: Effect of biorationals and *Trichoderma* isolates on chickpea Fusarium wilt under green house conditions.

Table 1: Effect of seed treatment with potential *Trichoderma* isolates and biorationals on chickpea seed germination and disease incidence under greenhouse conditions.

Treatments		Seed Germination			Disease Incidence	
Tr.	**Biorational + *Trichoderma* isolate**	**GN**	**DOAC**	**IOPC**	**DI**	**DOPC**
T1	Panchagavya 10% + T 19001	100.00^{a}	0.00	100.00	13.33 (21.14)^{i}	82.67
T2	Panchagavya 10% + T 19007	100.00^{a}	0.00	100.00	20.00 (26.55)^{hi}	74.00
T3	Panchagavya 10% + T 19012	93.33^{abc}	6.67	49.99	35.71 (36.64)^{efg}	53.57
T4	Panchagavya 10% + T 19020	90.00^{abc}	10.00	24.98	40.74 (39.61)^{de}	47.03
T5	Panchagavya 10% + T 19023	96.67^{ab}	3.33	74.99	27.59 (31.57)^{fgh}	64.14
T6	Beejamrutha 10% + T 19001	86.67^{bcd}	13.33	0.00	38.46 (38.28)^{def}	50.00
T7	Beejamrutha 10% + T 19007	90.00^{abc}	10.00	24.98	44.44 (41.79)^{de}	42.22
T8	Beejamrutha 10% + T 19012	93.33^{abc}	6.67	49.99	57.14 (49.11)^{bc}	25.71
T9	Beejamrutha 10% + T 19020	90.00^{abc}	10.00	24.98	66.67 (54.71)^{ab}	13.33
T10	Beejamrutha 10% + T 19023	93.33^{abc}	6.67	49.99	50.00 (44.98)^{cd}	35.00
T11	Beejaraksha 6% + T 19001	73.33^{efg}	26.67	-100.07	68.18 (55.64)^{ab}	11.36
T12	Beejaraksha 6% + T 19007	76.67^{def}	23.33	-75.02	69.57 (56.62)^{a}	9.56
T13	Beejaraksha 6% + T 19012	83.33^{cde}	16.67	-25.06	68.00 (55.60)^{ab}	11.60
T14	Beejaraksha 6% + T 19020	63.33^{g}	36.67	-175.09	73.68 (59.31)^{a}	4.21
T15	Beejaraksha 6% + T 19023	90.00^{abc}	10.00	24.98	70.37 (57.09)^{a}	8.51
C1	T 19001	93.33^{abc}	6.67	49.99	17.86 (24.74)^{hi}	76.78
C2	T 19007	90.00^{abc}	10.00	24.98	22.22 (28.11)^{hi}	71.11
C3	T 19012	96.67^{ab}	3.33	74.99	27.59 (31.58)^{fgh}	64.14
C4	T 19020	96.67^{ab}	3.33	74.99	37.93 (37.96)^{def}	50.69
C5	T 19023	93.33^{abc}	6.67	49.99	25.00 (29.88)^{gh}	67.50
B1	Panchagavya 10%	96.67^{ab}	3.33	74.99	24.14 (29.31)^{gh}	68.62
B2	Beejamrutha 10%	100.00^{a}	0.00	100.00	26.67 (30.98)^{fgh}	65.33
B3	Beejaraksha 6%	70.00^{fg}	30.00	-125.06	57.14 (49.21)^{bc}	25.71
F1	Pathogen check	86.67^{bcd}	13.33		76.92 (61.41)^{a}	
	Absolute control	100.00^{a}			0.00	
	SEm ±	3.63			2.36	
	CV%	7.01			9.88	
	C.D. (0.05)	10.33			6.71	

GN: Germination (%); DOAC: Decrease over Absolute control (%); IOPC: Improvement over Pathogen check (%); DI: Disease incidence (%); DOPC: Decrease over pathogen check (%)

- ve values represent per cent decrease in germination over pathogen check. Values with similar alphabets do not differ significantly.

Seed Treatment

The seeds were soaked in biorational solution *i.e.*, 10% panchagavya or beejamrutha for 20 min and shade dried. Beejaraksha powder was added @ 6 g per kg of seed and mixed. For *Trichoderma* seed treatment, seeds were mixed with 0.1% carboxy methyl cellulose (CMC) then, the spore suspension of *Trichoderma* was sprinkled, mixed and shade dried. For combinations, the seeds were initially soaked in biorational and shade dried then, they were treated with 0.1 % CMC and sprinkled the *Trichoderma* spore suspension and shade dried. The spore concentration of *Trichoderma* was adjusted to 10^{8} cfu/ml using a haemocytometer (Whitehead, 1957).

Green house evaluation

Foc culture of Bapatla isolate was multiplied on sorghum grains and 50 g of mass culture was thoroughly hand mixed with autoclaved soil separately. The washed and cleaned pots were filled with the *Foc*- soil mixture and incubated for 2 days under glass house conditions. The seeds of chickpea were treated with different combinations of *Trichoderma* and three biorationals served as treatments. Seed treatment with either *Trichoderma* or biorational alone served as controls. Pathogen check with only *Foc* alone added to soil and absolute control without treatment and pathogen served as controls. Each treatment was replicated thrice and seeds treated with respective *Trichoderma* or biorational were sown @ 10 seeds per pot and the pots were watered regularly. Untreated seeds were sown in absolute control and pathogen check. The pots were observed regularly for the development of wilt symptoms and the data on germination, plant stand, number of wilted plants, root length and shoot length were recorded.

Table 2: Effect of seed treatment with potential *Trichoderma* isolates and biorationals on chickpea root length and shoot length under greenhouse conditions.

Treatments		Root length			Shoot length		
Tr.	**Biorational + *Trichoderma* isolate**	**RL**	**DOC**	**IOPC**	**SL**	**DOC**	**IOPC**
T1	Panchagavya 10% + T 19001	8.40^{a}	+ 1.57	96.22	22.00^{a}	+ 10.00	68.42
T2	Panchagavya 10% + T 19007	6.40^{efghi}	22.58	45.63	19.00^{bcd}	5.00	84.21
T3	Panchagavya 10% + T 19012	6.60^{defgh}	20.16	51.45	20.00^{ab}	0.00	100.00
T4	Panchagavya 10% + T 19020	6.20^{ghi}	25.00	39.80	18.67^{bcd}	6.67	78.95
T5	Panchagavya 10% + T 19023	8.13^{ab}	1.61	96.12	19.67^{abc}	1.67	94.74
T6	Beejamrutha 10% + T 19001	7.13^{cde}	13.71	66.99	18.00^{bcd}	10.00	68.42
T7	Beejamrutha 10% + T 19007	6.13^{ghi}	25.81	37.86	20.00^{ab}	0.00	100.00
T8	Beejamrutha 10% + T 19012	7.00^{cdef}	15.32	63.10	17.33^{bcd}	13.33	57.89
T9	Beejamrutha 10% + T 19020	5.70^{ijk}	31.05	25.24	20.00^{ab}	0.00	100.00
T10	Beejamrutha 10% + T 19023	5.06^{kl}	38.79	6.60	18.00^{bcd}	10.00	68.42
T11	Beejaraksha 6% + T 19001	5.00^{kl}	39.52	4.85	16.00^{def}	20.00	36.84
T12	Beejaraksha 6% + T 19007	6.37^{fghi}	22.98	44.66	20.00^{ab}	0.00	100.00
T13	Beejaraksha 6% + T 19012	7.50^{bc}	9.27	77.67	16.67^{cde}	16.67	47.37
T14	Beejaraksha 6% + T 19020	5.90^{hij}	28.63	31.06	18.33^{bcd}	8.33	73.68
T15	Beejaraksha 6% + T 19023	5.27^{jkl}	36.29	12.62	17.67^{bcd}	11.67	63.16
C1	T 19001	7.27^{cd}	12.10	70.87	18.67^{bcd}	6.67	78.95
C2	T 19007	6.87^{cdefg}	16.94	59.22	18.33^{bcd}	8.33	73.68
C3	T 19012	5.97^{hij}	27.82	33.01	18.33^{bcd}	8.33	73.68
C4	T 19020	6.30^{fghi}	23.79	42.72	19.33^{abc}	3.33	89.47
C5	T 19023	6.60^{defgh}	20.16	51.45	18.67^{bcd}	6.67	78.95
B1	Panchagavya 10%	7.00^{cdef}	15.32	63.10	18.67^{bcd}	6.67	78.95
B2	Beejamrutha 10%	6.50^{efgh}	21.37	48.54	17.67^{bcd}	11.67	63.16
B3	Beejaraksha 6%	5.00^{kl}	39.52	4.85	14.33^{ef}	28.33	10.53
F1	Pathogen check	4.83^{l}	41.53		13.67^{f}	31.67	
	Absolute control	8.27^{a}			20.00^{ab}		
	SEm ±	0.23			0.94		
	CV%	6.10			8.87		
	C.D. (0.05)	0.64			2.67		

RL: Root length (cm); DOC: Decrease over control (%); IOPC: Increase over Pathogen check (%); SL: Shoot length (%); IOPC: Increase over Pathogen check (%)

+ indicates per cent increase in shoot length over absolute control; Values with similar alphabets do not differ significantly.

Results and Discussion

Potential *Trichoderma* isolates in Integration with Biorationals under Greenhouse Conditions

The five potential *Trichoderma* isolates, *viz.* T 19001, T 19007, T 19012, T 19020 and T 19023 were assessed for their biocontrol potential, against chickpea wilt, in integration with the three biorationals *viz.* panchagavya, beejamrutha and beejaraksha in pot culture. Five days after sowing, there was 100% germination in Panchagavya 10% + T 19001 or T 19007 isolates and Beejamrutha 10% alone which were on par with absolute control (100%). Further, except in pathogen control alone, and beeejaraksha 6% and its integration with *Trichoderma* isolates, all other isolates and combinations showed germination on par with absolute control. Beejaraksha 6% has decreased the efficacy of *Trichoderma* isolates on chickpea seed germination and *vice-versa*. Beejaraksha 6% has decreased germination by 30.00 % over absolute control and is lower than that in pathogen check (Table 1).

Significant difference was observed among the treatments with respect to disease incidence. Disease incidence was found significantly lower in panchagavya 10% + T 19001 (13.33%) when compared to pathogen check (76.92%). The disease incidence decreased in treatment with panchagavya 10% + T 19001 or T 19007 when compared to their individual *Trichoderma* controls, while in others, the disease incidence was increased over their individual *Trichoderma* or biorationals alone. The efficacy of *Trichoderma* in reducing the disease was decreased by integrating with beejamrutha 10% or beejaraksha 6% (Table 1 and Plate 1).

Table 3: Effect of seed treatment with potential *Trichoderma* isolates and biorationals on chickpea vigour index under green house conditions.

Tr. No.	Treatments (Biorational + *Trichoderma* isolate)	Vigour index	Decrease over control (%)	Increase over pathogen check (%)
T1	Panchagavya 10% + T 19001	3040.00^{a}	+ 7.02	83.78
T2	Panchagavya 10% + T 19007	2540.00^{bcd}	10.14	76.57
T3	Panchagavya 10% + T 19012	2482.67^{bcdef}	12.17	71.88
T4	Panchagavya 10% + T 19020	2238.00^{defg}	20.83	51.88
T5	Panchagavya 10% + T 19023	2687.33^{abc}	4.93	88.61
T6	Beejamrutha 10% + T 19001	2178.22^{defg}	22.94	46.99
T7	Beejamrutha 10% + T 19007	2352.00^{cdefg}	16.79	61.20
T8	Beejamrutha 10% + T 19012	2263.00^{cdefg}	19.94	53.92
T9	Beejamrutha 10% + T 19020	2313.00^{cdefg}	18.17	58.01
T10	Beejamrutha 10% + T 19023	2152.89^{defg}	23.84	44.92
T11	Beejaraksha 6% + T 19001	1539.93^{h}	45.52	- 5.18
T12	Beejaraksha 6% + T 19007	2021.44^{fg}	28.49	34.18
T13	Beejaraksha 6% + T 19012	2013.08^{g}	28.78	33.49
T14	Beejaraksha 6% + T 19020	1534.78^{h}	45.70	- 5.60
T15	Beejaraksha 6% + T 19023	2064.00^{efg}	26.98	37.66
C1	T 19001	2420.44^{bcdefg}	14.37	66.79
C2	T 19007	2268.00^{cdefg}	19.76	54.33
C3	T 19012	2349.00^{cdefg}	16.90	60.95
C4	T 19020	2477.89^{bcde}	12.34	71.49
C5	T 19023	2358.22^{cdefg}	16.57	61.71
B1	Panchagavya 10%	2481.11^{bcdef}	12.22	71.75
B2	Beejamrutha 10%	2416.67^{bcdefg}	14.50	66.49
B3	Beejaraksha 6%	1353.33^{h}	52.12	-20.44
F1	Pathogen check	1603.33^{h}	43.28	
	Absolute control	2826.67^{ab}		
	SEm ±	130.96		
	CV%	10.12		
	C.D. (0.05)	372.28		

Positive values represent per cent increase in vigour index over absolute control; Negative values represent per cent decrease in vigour index over pathogen check; Values with similar alphabets do not differ significantly.

There was found to be a significant variation among root and shoot lengths which were taken after 30 days of sowing. The results showed that the highest root length was observed in Panchagavya 10% + T 19001 with 8.40 cm, (at par with absolute control) having 1.57 % increase in root length over absolute control and 96.22% over pathogen check. There was 96.12% improvement in root length over pathogen check in Panchagavya 10% + T 19023 whereas, 1.61% decrease in root length was observed over absolute control. Root length is drastically reduced in beejamrutha treated seeds, either alone or in integration with *Trichoderma* isolates (Table 2). It may be noted here that beejaraksha when integrated with *Trichoderma* might have affected the population of *Trichoderma* in soil and also the chickpea seed germination and root length.

When observations were recorded on shoot length, after 30 days of sowing in absolute control it was measured 20 cm. In pathogen check, shoot length was only 13.67 cm equivalent to 31.67% decrease over absolute control. Among the biorationals, panchagavya and beejamrutha could result in a shoot length on par with absolute control while beejaraksha significantly lowered shoot length (14.33 cm equivalent to 28.33% reduction over absolute control). When chickpea seeds were treated with individual *Trichoderma* isolates, shoot length was on par with absolute control (Table 4). When biorationals and *Trichoderma* isolates were integrated, shoot length was on par with absolute control except in beejaraksha + T 19001 or T 19012. This indicated that *Trichoderma* isolates *i.e.* T 19007, 19023 could nullify the effect of beejaraksha to some extent. Further, 100% increase in shoot length over pathogen check was observed in panchagavya 10% + T 19012, beejamrutha 10% + T 19007 and beejaraksha 6% + T 19007 (Table 2).

As shoot length or root length alone may not give the correct picture of treatment effects, vigour index due to treatments was also calculated. Vigour index is the sum of shoot length and root length multiplied by germination percentage. The treatment which results in higher vigour index is considered to be the best treatment. Highest vigour index was found in panchagavya 10% + T 19001 (3040.00) with 7.02 % increase over absolute control (2826.67) though both were statistically on par. The vigour index was found to be least in plants treated with beejaraksha 6% alone (1353.33) and its combination with T 19001 (1539.93) or T 19020 (1534.78) which were on par with pathogen check (1603.33). Vigour index was increased in panchagavya 10% when treated with *Trichoderma* isolates in comparison to *Trichoderma* isolates alone (Table 3). The greenhouse experiment confirmed the efficacy of T 19001 in reducing Fusarium wilt incidence in chickpea and identified it as the most promising biocontrol isolate among the *Trichoderma* isolates evaluated. Accordingly, T 19001 was selected for field evaluation during *Rabi* 2018–19 and 2019–20, where the results corroborated the greenhouse findings, with Panchagavya 10% + T 19001 consistently proving most effective in reducing disease incidence (Amulya *et al.*, 2026).

The results obtained were in agreement with Mukhopadhyay (1995) who reported that the seed treatment with bioagents *viz*. *T. harzianum* and *Gliocladium virens* improves plant growth and plant productivity, also helps in protection against a wide range of soil borne pathogens *viz. S. rolfsii, R. solani* and *F. oxysporum*. Saralamma and Vithal Reddy (2003) reported that soil application of *T. harzianum* (H) inoculum against root rot of groundnut caused by *S. rolfsii* was superior in reducing the percentage disease incidence while increased the shoot length (24 cm), root length (17 cm) and yield (1509 kg ha^{-1}).

Panchagavya is a natural and ecofriendly product that helps in plant protection against soil borne pathogens (Dhama *et al.*, 2013). Many workers have reported that organic amendments stimulate antagonistic micro organisms in soil which in turn increase the plant growth (Arjunan *et al.*, 1987; Rao and Sitaramaiah, 2000; Champawat and Sharma, 2003). Naik and Sreenivasa (2009) studied the influence of bacterial isolates in panchagavya which resulted in increased seed germination (99%), seedling length and vigour in wheat. Seed and soil application of *Trichoderma* isolates significantly increased the germination or field emergence and lowest Fusarium wilt disease incidence in chickpea as compared to nontreated control under greenhouse tests (Bhagat and Pan, 2011). There was 92% seed germination of pea when beejamrutha was used as seed treatment in comparison to control (56%) whereas, panchgavya was found to be the most effective (88.9%) in controlling the stalk rot of cauliflower (Chadha *et al.*, 2012).

Population of *F. o.* f. sp. *ciceri* (wilt of chickpea) in soil was reduced when bioagents (*Trichoderma* spp. + *P. fluorescens*) treated seeds were sown in soils amended with organic composts (FYM and vermicompost) by enhancing the disease control potentiality of antagonists (Kala *et al.*, 2016). Lee *et al.*, (2016) reported that *Trichoderma* spp. produced volatile organic compounds in conjunction to enhance plant growth. In their study, they found that tomato biomass increased >99%, plant length and lateral roots also increased by the incorporation of *T. viride*. Amendments of soil with organic materials have tremendous effect on enhancing the chickpea yield as it reduces the incidence of Fusarium wilt up to a considerable level (Patra *et al.*, 2017). Shweta *et al.*, (2019) reported that *Trichoderma* isolates induces lignifications early and completes within 6 days of pathogen (*Foc*) challenge and provide better protection in chickpea. According to Akash *et al.*, (2025), seed biopriming with *Trichoderma* spp. improved germination, plant growth, and biomass in tomato and significantly suppressed Fusarium wilt.

Conclusion

From the present investigation, it is concluded that T 19001 was found to be effective under greenhouse conditions when integrated with panchagavya, by not only increasing germination, root length and shoot length of chickpea, but also significantly reduced the disease incidence (13.33%) compared to the pathogen check (76.92%). Integration of *Trichoderma* with Beejamrutha (10%) or Beejaraksha (6%) reduced its disease suppression efficacy. Thus, Panchagavya (10%) + T 19001 proved to be the most effective treatment, offering an effective and eco-friendly alternative to chemical fungicides for sustainable management of chickpea wilt.

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