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Integrated disease management of fusarium wilt disease in chickpea (*Cicer arietinum* L.)

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Abstract
Chickpea (*Cicer arietinum* L.), 2n=2x=14, which is a member of the Papilionaceae subfamily of the Leguminoceae family. The experiment was perform in *Rabi* season (2021-2023) at Rama University farm and Randomized Block Design (RBD) was followed. In present study treatment was taken as *Trichoderma viride* (T_1), *Bacillus subtilis* (T_2), *Pseudomonas fluorescens* (T_3), Garlic bulb extract (T_4) @ 5% and 10% concentration, Neem Leaf extract (T_5) @ 5% and 10% concentration, Onion bulb extract(T_6) @ 5% and 10% concentration, Mancozeb (T_7) @ 500 ppm and 1000 ppm, Carbendazim (T_8) @ 500 ppm and 1000 ppm, Untreated Control (T_9) and each treatment had replicated three times. *In vitro* analysis of *Fusarium oxysporum* f. sp. *ciceris* with different treatment after 7 days of inoculation the minimum radial growth was obtained at 1000 ppm concentration of Mancozeb (0.00 mm) and Carbendazim (0.00 mm) followed by *Trichoderma viride* (21.00 mm), *Bacillus subtilis* (24.90 mm), *Pseudomonas fluorescens* (26.60 mm), 10% concentration of Garlic bulb extract (29.70 mm), Neem leaf extract (37.60 mm) and Onion bulb extract (42.50 mm), while the maximum radial growth was seen in the control (83.50 mm). Mancozeb and carbendazim (1000 ppm concentration) showed the highest growth inhibition (100%) followed by *Trichoderma viride* (72.83%), *Bacillus subtilis* (70.12%), *Pseudomonas fluorescens* (67.16%), garlic bulb extract (64.43%), Neem leaf extract (54.97%) and Onion bulb extrac (49.00%). In field the minimum disease incidence was recorded on 60 days after sowing in T_7 (Mancozeb 0.1% concentration) was recorded 86% disease control followed by T_8 (Carbendazim 0.1% concentration) 84.5%, T_1 (*Trichoderma viride* 4g/kg) 80.5%, T_3 *Pseudomonas fluorescens* 4g/kg (79.5%), T_2 (*Bacillus subtilis* 4g/kg) 76.8%, T_4 (Garlic bulb extract 10% concentration) 72.0%, T_5 (Neem leaf extract 10%) 58.0% and T_6 (Onion bulb extract 10% concentration) 49.5%. Similarly the disease incidence was recorded lowest 0% in treatment T_7 (Mancozeb) and T_8 (Carbendazim), followed by T_1 *Trichoderma viride* (6%), T_2 *Bacillus subtilis* (8%), T_3 *Pseudomonas fluorescens* (9%), T_4 Garlic bulb extract (16%), T_5 Neem leaf extract (24%) and T_6 Onion bulb extrac (26%) while highest disease severity recorded in control showing 42% recorded 60 days after sowing.

Keywords: Chickpea wilt, biocontrol, disease incidence, disease severity

Introduction
Chickpea (*Cicer arietinum* L.), 2n=2x=14, which is a member of the Papilionaceae subfamily of the Leguminoceae family. Bengal gram or King of Pulse Crop is another name for chickpea. One of the main pulse crops grown during the *Rabi* season is the chestnut bean. Pulses continue to play a significant role in human diets, particularly among the vast majority of vegetarians in the nation. India, Pakistan, Turkey, Iran, Myanmar, Ethiopia, Mexico, Australia, Syria, Spain, Canada, United States, Bangladesh, Algeria, Malawi, Sudan, and Portugal are among the major producers of chickpeas in the world. The primary origins of the chickpea are in South-West Asia and the Mediterranean region, with Ethiopia serving as the secondary origin. It is a significant pulse crop in the tropical, subtropical, and temperate parts of the world. This pulse is known by a variety of names throughout India, including Chana, Chole, Cholla and Boot, semi-arid regions are where it is cultivated most extensively (Saxena and Johansen (1997) [14].

Chickpea is cultivated mostly in the Mediterranean basin, the Near East, Central and South Asia, East Africa, South America, North America and more recently, in Australia. The main producers are India, Australia and Pakistan, contributing 67.32%, 6.19% and 5.72%, respectively, to global production. Countries such as Australia, Mexico and Russia are not chickpea consumers but major world exporters (FAO, 2016) [2]. After dried beans and peas, chickpeas are the third most important pulse crop produced globally. 20% of the world's pulse production comes from there. India, Pakistan, and Mexico are among the top nations that produce chickpeas. About 90% of the world's production of chickpeas is produced in six

nations: India, Australia, Turkey, Myanmar, Pakistan, and Ethiopia. According to the Food and Agricultural Organization's (FAO) current projections, global production will be at 16 million metric tonnes in 2021. With a production of around 12 million tonnes, India is the world's top producer in 2021, contributing to about 75% of global output. India is also the world's biggest consumer of chickpeas. As a result, despite accounting for over 75% of global production, the nation came in second. Australia will be the world's greatest exporter of chickpeas in 2022, while Bangladesh will be its largest importer. In India, chickpeas make up around 49% of all the pulses that are produced there. With over 49% of the nation's production, Madhya Pradesh is the sole largest producer. About 17%, 16%, 6% and 5% of the total came from Rajasthan, Maharashtra, Uttar Pradesh, and Andhra Pradesh, respectively. On the other hand, Rajasthan's and Maharashtra's share has steadily increased this year. State examples include Jharkhand and Chhattisgarh are increasing its Chickpea crop production area (FAO, 2021) [3].

An essential *Rabi* crop, chickpeas are typically grown between September and November and harvested in February. Depending on the cultivar, a crop can last 90 to 120 days. While Kabuli varieties mature more slowly than Desi varieties, both have short maturation times. It works best in regions with mid-range temperatures and low to moderate rainfall. The crop is harmed by excessive rains immediately following seeding or during the blossoming period. A severe cold can be seriously damaging. It works best in regions with annual rainfall of 60 to 90 cm. Self-pollinating diploid chickpea (2n=2x=16), has a 740 Mbp genome. Gram is a plentiful source of energy because to its 17-30% protein, 66.5% carbohydrate, and 4.2% fat contents. Each gram of Bengal gram has a caloric content of roughly 352.5 kcal. It is a very good source of vitamins (B1, B2 and Niacin) as well as minerals (Calcium 282 mg/100g, Phosphorus 300 mg/100g, and Iron 7 mg/100g). Compared to animal sources of protein, chickpeas are a cheap source of protein. Compared to other grain legumes, its proteins have a better nutritional value (Gupta and Kapoor, 1980). Since chickpea proteins contain a unique combination of amino acids, they are also more easily digestible. In addition to being plentiful in minerals, vitamins, and carbohydrates, grains also contain significant levels of important amino acids like cysteine, methionine and tryptophan (Singh *et. al*., 1991) [15].

There are a number of biotic and abiotic limitations that contribute to chickpea's low productivity. Drought, heat, salt in the soil, inadequate soil nutrition, etc. are examples of abiotic restrictions. The yield of chickpea is significantly constrained by the biotic factors. It is well recognized that several bacterial, fungal, viral, and insect diseases can damage the crop. Fusarium wilt, Ascochyta blight, Rust, Downy mildew, Cercospora leaf spot, Rhizoctonia dry root rot and collar rot, among other significant fungal diseases, are responsible for yield losses. In the world, more than 50 chickpea pathogens have been identified (Nene *et al*., 1996) [6]. Despite other illnesses, *Fusarium oxysporum* f. sp. *ciceris* Schlechtend Fr. causes wilt disease. The main constraint on chickpea production is *Fusarium oxysporum* f. sp. *ciceris*. Under favourable condition, the wilt infection can damage the crop completely and cause 100% yield loss (Navas-Cortes *et al.*, 2000; Halila and Strange, 1996) [17, 18]. In India annual yield loss due to *Fusarium* wilt were estimated at 10% (Singh and Dahiya 1973; Casas and Díaz, 1985) [19, 20].

Materials and Methods

The present investigation was under taken to ascertain "Integrated disease management of Fusarium wilt in chickpea (*Cicer arietinum* L.)" during the period of October 2021-March 2022 and October 2022- March 2023 at RAMA UNIVERSITY, Faculty of Agricultural science & Allied industries, Mandhana, Kanpur (U.P.). The details of materials used, experimental procedures and method employed during the course of present investigation are presented in this chapter. It also presented climatic and edaphic conditions below.

Treatments Details

T_1: Trichoderma viride @ 500 ppm and 1000 ppm
T_2: Bacillus subtilis @ 500 ppm and 1000 ppm
T_3: Pseudomonas fluorescens @ 500 ppm and 1000 ppm
T_4: Garlic bulb @ 5% and 10% concentration
T_5: Neem Leaf extract @ 5% and 10% concentration
T_6: Onion @ 5% and 10% concentration
T_7: Mancozeb @ 500 ppm and 1000 ppm
T_8: Carbendazim @ 500 ppm and 1000 ppm
T_9: Untreated Control

Chemicals required

The chemicals have been used in the study are Agar-agar, Dextrose, Yeast extract, Beef extract, Sodium chloride, D glucose, $HgCl_2$, Formalin etc.

Cleaning and sterilization of equipment

All glass wares were cleaned with chloric acid before being used, then washed with detergent powder and rinsed with tap water. In an autoclave, the medium was sterilised at 15 lbs, pressure for 20 minutes. Petri plates and glassware were sterilized in a hot air oven for 2 hours at 180 °C. The plastic Petri plates used in the bio-control investigation were disinfected with alcohol. Before being exposed to ultraviolet light for 20 minutes, the isolation chamber was disinfected with alcohol. Other items in the isolation room were sterilised by soaking them in alcohol and then heating them over a flame, such as forceps, inoculation needles, cork borers and lades.

Preparation of culture media

The Fusarium wilt pathogen was isolated, purified *in vitro* Experiment using Potato Dextrose Agar (PDA) medium. Nutrient Agar Medium was used for growing bacteria.

Potato Dextrose Agar (PDA) medium

Composition

Potato Dextrose Agar medium has the following composition like Peeled potato 200g/l, Dextrose 20 g/l, Agar 20 g/l, Distilled water 1000 ml/l and pH 7.(at 25 °C)

Preparation Method

PDA was prepared by the following method and used for the present study. First of all 250 gm potato was washed and the skin was peeled off. The peeled potato was cut into small pieces of size 12 mm. The 200 gm potato cubes were then washed in water. Then it was boiled in 500 ml distilled water for 20 minutes. The potato broth was filtered through a muslin cloth. Agar was also melted in 500 ml of water by heating at the same time. The potato broth was then poured into the melted agar, followed by the addition of dextrose. The final

volume was increased to 1000 ml by adding distilled water. The pH was adjusted to 7.0 then placed in 4-5 conical flasks and sterilized in an autoclave at 15 psi for 20 minutes.

Nutrient Agar (NA) medium

Composition

Nutrient Agar medium has the following composition Peptone 5.0 g/l, Yeastextract 1.5 g/l, Beef extract1.5 g/l, Sodium chloride 5.0g/l, Agar 15.0g/l, Distilled water1000 and pH 7(at 25 °C).

Preparation Method

NA was prepared by the following method and used for the present study, 28 gm of dehydrated powder was mixed with 1000 ml/litres of distilled water in a beaker. The suspension was then brought to boil to thoroughly dissolve the medium. The dissolved medium was then autoclaved for 15 minutes at 15 lbs pressure (121 °C). After completing the autoclaving procedure, the beaker was removed and cooled to around 40-45 °C. Under sterile conditions, the medium was put into sterile Petri plates.

Preparation of slants

To make PDA slants, 2-3 ml media was poured into each culture tube, which was then sealed with non-absorbent cotton and sterilized in autoclave at 15 psi, 121 °C for 15 minutes. Later, tubes were kept slanted on a wooden support and allowed to harden. The slants were kept in the refrigerator.

Collection of wilt infected Chickpea plants

The root and shoot of Fusarium wilt-infected Chickpea plants were collected from the field area of Rama University, Uttar Pradesh. The wilt infected Chickpea roots and stems were carried to the lab in rough dry envelops labeled with the location, variety, date of collection, and other information. The samples were dried in the shade for 24 hours to remove any excess surface moisture. Following drying, the material was incubated in B.O.D envelops and kept at 6-8 °C for isolation and future investigation.

Isolation and purification of the pathogen

The diseased part of the Chickpea sample showing the distinct characteristic of wilt was selected stem was rinsed in tap water first. Using a sterile blade, the cleansed infected areas were sliced into little bits along with some good portions. To eliminate residues of mercuric chloride, the cut pieces were surface sterilized with 0.1 percent $NaOCl_2$ solution within the laminar flow and thoroughly rinsed 3-4 times with sterilized water. Excess moisture was eliminated with the help of sterilized blotting papers. In Petri plates, three to four pieces of diseased plant parts were put at similar distances from each other in aseptic condition. The Petri dishes were placed in a B.O.D. incubator for 7 days at 25 °C. After 24 hours of incubation, the mycelial growth of the fungus was detected on these incubated plates. The fungus was observed once a day till it grew.

Identification of the pathogen

The pathogen was identified on the basis of morphological, cultural and pathogenic behavior. Colour, septation, branching and width of the hyphae were studied with the help of a microscope.

$$\text{Inhibition per cent} = \frac{C-T}{C} X100,$$

Where C= Mycelium growth in control plate, T= mycelium growth in treatment.

$$\text{Disease incidence} = \frac{\text{Number of infected plants}}{\text{Total number of Plants}} X\ 100$$

Result and discussion

Efficacy of botanicals and chemicals against *Fusarium oxysporum* f. sp. *ciceris* on radial growth and per cent inhibition *in vitro.*

The fungicides Mancozeb and Carbendazim (500 ppm), as well as plant extracts from neem leaf (*Azadirachta indica*), garlic bulbs (*Allium sativum*), and onion bulbs (*Allium cepa*) at a concentration of 5%, were evaluated for effectiveness *in vitro* using the food poisoning technique. Similar *in vitro* tests using 10% concentrations of plant extracts, including neem leaf extract, garlic bulb extract, and onion bulb extracts, were done with 1000 ppm concentrations of Mancozeb and Carbendazim.

Evaluation of 5% and 10% of botanical extract and 500 and 100 ppm chemical against *Fusarium oxysporum* f. sp. *ciceris* and bioagents on radial growth (*in vitro*)

Radial growth and growth inhibition after 4 and 7 days of incubation.

The minimum radial growth was obtained at 500 ppm concentration of Mancozeb (0.79 mm) followed by Carbendazim (1.07 mm), *Trichoderma viride* (9.8 mm), *Bacillus subtilis* (11.99 mm), *Pseudomonas fluorescens* (13.40 mm) 5% per cent concentration of Garlic bulb extract (24.00 mm), Neem leaf extract (33.00 mm) and Onion bulb extract (36.00 mm) while the maximum radial growth was observed in control (Table no. 1). The growth inhibition percentage was computed and the results show that Mancozeb (500 ppm concentration) has the highest growth inhibition (98.38%), followed by Carbendazim (97.81%), *Trichoderma viride* (79.45%), *Bacillus subtilis* (75.05%), *Pseudomonas fluorescens* (71.90%) and 5% concentrations of Garlic bulb extract (51.02%), Neem (32.65%) and Onion bulb extract (26.53%) (Table no. 1). In 1000 ppm concentration Mancozeb and Carbendazim showed 100% growth inhibition even after 4 day of inoculation. While other treatments inhibit like 10% concentration of Garlic bulb extract 81.22% (29.70 mm), Neem leaf extract 69.08% (37.60 mm) and onion bulb 50.62% (42.50 mm) as compare to control. After 7 day of inoculation inhibit *Trichoderma viride* 72.83% (21.00 mm), *Bacillus subtilis* 70.12% (24.90 mm), *Pseudomonas fluorescens* 67.16% (26.60 mm), Garlic bulb extract inhibit 64.43% (29.70 mm), Neem leaf extract 54.97% (54.97 mm) and Onion bulb 49.10% (49.10 mm) as compare to control (Table 2). Similar results were obtained in the study conducted by Patra and Biswas (2016), who observed that the percentages of Mancozeb and Carbendazim that inhibited growth at 500 ppm were 92.22% and 78.89%, respectively. The present finding supported by Calistro *et al.* (1997) they used culture filtrates of *T. viride* (T_5) and *T. harzianum* (T_2) were generally more effective in inhibiting *Aspergillusflavus*, *F. moniliforme* and *Fusarium oxysporumciceris* growth then those of the other two aggressive strains. *T. harzianum* (T_1) and *T. viride* (T_6) had little influence on *A. flavus*. Similar findings were made in the experiment conducted by Ghante *et al.* (2018),

who showed that the concentration of carbendazim and mancozeb at which the greatest growth inhibition was observed was 1000 ppm.

Effect of plant extract, bioagent and fungicides on disease incidence and per cent disease control against *fusarium oxysporum* f. sp. *ciceris* (*in vivo*)

The minimum disease incidence was found on 30 days after sowing in T_7 Mancozeb @ 0.1% (10%) followed by T_8 Carbendazim @ 0.1% (12%), T_1 *Trichoderma viride* @ 4g/kg (17.5%), T_3 *Pseudomonas fluorescens* @ 4g/kg (19%), T_2 *Bacillus subtilis* @ 4g/kg (20%), T_4 Garlic bulb extract @ 10% (21.4%), T_5 Neem leaf extract @ 10% (34.6%), T_6 Onion bulb extract @ 10% (44%) and T_9 control (78%). At 45 days after sowing the minimum disease incidence was found in T_7 Mancozeb @ 0.1% (11.8%) followed by T_8 Carbendazim @ 0.1% (14.0%), T_1 *Trichoderma viride* @ 4g/kg (19.0%), T_3 *Pseudomonas fluorescens* @ 4g/kg (20.0%), T_2 *Bacillus subtilis* @ 4g/kg (21.0%), T_4 Garlic bulb extract @ 10% (25%), T_5 Neem leaf extract @ 10% (38.0%), T_6 Onion bulb extract @ 10% (47.2%) and T_9 control (85.6%). Highest disease was recorded in T_9 in which 7%, 14.4% and 22% disease controlled after sowing at 30, 46 and 60 days, subsequently. The minimum disease incidence was found at 60 days after sowing in T_7 Mancozeb @ 0.1% (14%) followed by T_8 Carbendazim @ 0.2% (15.5%), T_1 *Trichoderma viride* @ 4g/kg (19.5%), T_3 *Pseudomonas fluorescens* @ 4g/kg (20.5%), T_2 *Bacillus subtilis* @ 4g/kg (23.2%), T_4 Garlic bulb extract @ 10% (28.0%), T_5 Neem leaf extract @ 10% (40.2%), T_6 Onion bulb extract @ 10% (50.5%) (Table 3). Here Mancozeb and Carbendazim were found superior over all the treatments the same results were found by Khanna *et al.* (2021) [9]. They recorded lowest per cent disease incidence in the plot treated by Mancozeb (10.83%). Sravani *et al.* (2023) [16] also recoded lowest per cent disease incidence in the plot treated by Mancozeb (12.36%) against *Fusarium oxysporum* f. sp. *ciceris*, the causal agent of vascular wilt disease of chickpea and found effective.

Effect of plant extract, bioagent and fungicids on disease severity against *fusarium oxysporum* f. sp. *cieris* (*in vivo*)

From the table No. 4 it is clear that the seed treatment with Mancozeb 0.1% (T_7) and Carbendazim 0.1% (T_8) are very effective against *F. oxysporum* f. sp. *ciceris*, data pertaining from the table showing 0% disease severity after 30, 45 and 60 of sowing. Other treatments like *Trichoderma viride* (T_1) @ 4g/kg 4%, 5% and 6%, *Bacillus subtilis* (T_2) @ 4g/kg (6%, 7% and 8/%), *Pseudomonas fluorescens* (T_3) @ 4g/kg (7%, 8% and 9%), Garlic bulb extract (T_4) @ 10% (14, 15 and 17%), Neem leaf extract (T_5) @ 10% (22, 24 and 24%), Onion bulb extract (T_6) @ 10% (23%, 25% and 26%) and in plot which was untreated (Control) recorded 34%, 37% and 42%) disease severity after 30, 45 and 60 days of sowing. findings of Moutassem *et al*., (1985) [10] supporting to present study, they recorded data at 30, 45 and 60 day of interval and revealed that in chick pea disease incidence 17%, 25% and 40% respectively. Golakiya *et al.* (2018) [4]. Reported The disease severity in plants under ambient conditions (56.8%) was significantly higher ($P < 0.05$) as compared to EO + CO_2 (42.9%) treatment, but at par with plants exposed to ECO_2 (50%).

Table 1: Effect of plant extracts 5% and fungicides 500 ppm on mycelium growth of *F. oxysporum* f. sp. *ciceris* (*in vitro*)

Sl. No.	Treatments	Dose (%/ppm)	4 days after inoculation		7 days after inoculation	
			Radial growth (mm)	Percent inhibition (%)	Radial growth (mm)	Percent inhibition (%)
1.	T_4= Garlic bulb extract	5%	24.00	51.02	49.60	40.24
2.	T_4= Neem leaf extract	5%	33.00	32.65	59.70	28.07
3.	T_4= Onion bulb extract	5%	36.00	26.53	62.40	24.81
4.	T_4= Mancozeb	500 ppm	0.79	98.38	1.40	98.31
5.	T_4= Carbendazim	500 ppm	1.07	97.81	1.69	97.96
6.	control	-	49.00	0.00	83.00	0.00
	SEm±		0.3788		0.7046	
	CD at 1%		1.6365		3.0438	

Table 2 (a): Effect of plant extracts 10% and fungicides 1000 ppm on mycelium growth of *F. oxysporum* f. sp. *ciceris* (*in vitro*)

Sl. No.	Treatments	Dose (%/ppm)	4 days after inoculation		7 days after inoculation	
			Radial growth (mm)	Percent inhibition (%)	Radial growth (mm)	Percent inhibition (%)
1. 1	Garlic bulb extract	10%	9.05	81.22	29.70	64.43
2. 2	Neem leaf extract	10%	14.90	69.08	37.60	54.97
3. 3	Onion bulb extract	10%	23.80	50.62	42.50	49.10
4. 4	Mancozeb	1000 ppm	0.00	100	0.00	100
5. 5	Carbendazim	1000 ppm	0.00	100	0.00	100
6. 6	control	-	48.20	0.00	83.50	0.00
	SE.m±		0.260		0.4468	
	C.D. at 1%		1.1231		1.9301	

Table 2 (b): Effect biocontrol agents against radial growth of *F. oxysporum* f. sp. *ciceris* using dual culture technique (*in vitro*)

Sl. No.	Treatments	4 days after inoculation		7 days after inoculation	
		Radial growth (mm)	Percent inhibition (%)	Radial growth (mm)	Percent inhibition (%)
1	T_1= *Trichoderma viride*	9.80	79.45	21.00	72.82
2	T_2 = *Bacillus subtilis*	11.90	75.05	24.90	70.12
3	T_3 = *Pseudomonas fluorescens*	13.40	71.90	26.60	67.16
4	Control	47.70	0.00	81.00	0.00
	SEm	0.4306		0.5827	
	C.D. at 1%	1.8601		2.5173	

Table 3: Effect of dresser fungicide, botanicals and bio-agents against *F. oxysporum* f. sp. *ciceris* on per cent disease incidence in Chickpea (*in vivo*)

Sl. No.	Treatments	Per cent disease incidence		
		At 30 DAS	At 45 DAS	At 60 DAS
1.	T_1= *Trichoderma viride*@ 4gm/kg	17.5	19.0	19.5
2.	T_2 = *Bacillus subtilis*@ 4gm/kg	20	21.0	23.2
3.	T_3 = *Pseudomonas fluorescens* @4gm/kg	19	20.0	20.5
4.	T_4= Garlic bulb extract @ 10%	21.4	25	28.0
5.	T_5 = Neem Leaf extract @ 10%	34.6	38.0	40.2
6.	T_6 = Onion bulb extract @ 10%	44	47.2	50.5
7.	T_7 = Mancozeb @ 0.05%	10	11.8	14
8.	T_8 = Carbendazim @ 0.05%	12	14.0	15.5
9.	T_9 = Untreated Control	78	85.6	93
	SEm±	0.8173	0.8051	0.7123
	C.D. at 5%	2.4503	2.4137	2.1355

Table 4: Effect of seed dresser fungicides, botanicals and bio-agents against *Fusarium oxysporum* f. sp. *ciceris* on per cent diseases control *in vivo*

Sl. No.	Treatments	Per cent disease control		
		At 30 DAS	At 45 DAS	At 60 DAS
10.	T_1= *Trichoderma viride*@ 4gm/kg	82.5	81.0	80.5
11.	T_2 = *Bacillus subtilis*@ 4gm/kg	80.0	79.0	76.8
12.	T_3 = *Pseudomonas fluorescens* @4gm/kg	81.0	80.0	79.5
13.	T_4= Garlic bulb extract @ 10%	78.6	75.0	72.0
14.	T_5 = Neem Leaf extract @ 10%	65.4	62.0	58.0
15.	T_6 = Onion bulb extract @ 10%	56.0	52.8	49.5
16.	T_7 = Mancozeb @ 0.05%	90.0	88.2	86.0
17.	T_8 = Carbendazim @ 0.05%	88.0	86.0	84.5
18.	T_9 = Untreated Control	7.0	14.4	22.0
	SEm±	1.9373	1.6336	1.3878
	C.D. at 5%	5.8081	4.8975	4.1606

Table 5: Effect of dresser fungicide, botanicals and bio-agents against *F. oxysporum* f. sp. *ciceris* on disease severity in Chickpea (*in vivo*)

Sl. No.	Treatments	Disease severity		
		At 30 DAS	At 45 DAS	At 60 DAS
1.	T_1 =*Trichoderma viride*@ 4gm/kg	4	5	6
2.	T_2 =*Bacillus subtilis*@ 4gm/kg	6	7	8
3.	T_3 =*Pseudomonas fluorescens* @4gm/kg	7	8	9
4.	T_4 =Garlic bulb extract @ 10%	14	15	16
5.	T_5 =Neem Leaf extract @ 10%	22	23	24
6.	T_6 =Onion bulb extract @ 10%	23	25	26
7.	T_7 =Mancozeb @ 0.05%	0	0	0
8.	T_8 =Carbendazim @ 0.05%	0	0	0
9.	T_9 =Untreated Control	34	37	42
	SEm±	0.4578	0.5057	0.4514
	C.D. at 5%	1.3886	1.5339	1.3691

Conclusion

The effect of bio control agents, plant extract and fungicides were evaluated and found that Mancozeb and Carbendazim @ 0.1% are the best among all the treatments for seed dressing, bio control agents like *Trichoderma*, *Bacillus subtilis* and *Pseudomonas fluorescens* are also effective seed dresser against *F. oxysporum* f.sp. *ciceris*. While plant extracts are slightly effective as compare to bio control agents and fungicides.

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