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Integrated disease management of chickpea wilt caused by *Fusarium oxysporum* f. sp. *ciceri* using biological, botanical and chemical approaches

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Abstract

Chickpea (*Cicer arietinum* L.) (2n=16) is one of the founder crops of modern agriculture. It belongs to Leguminaceae family and is a major source of food and animal-feed. It is not merely another pulse crop in India — it is, by most practical measures, the most important pulse crop. In recent years there has been concern about gradual decline in per capita availability of pulses. An important reason for this miserable situation in the country is mainly due to the attack of the soil borne pathogens. Wilt of chickpea stands out for its sheer persistence and the severity of losses it can inflict, ranging from 10–15% annually under typical conditions to outright crop failure during especially favorable disease years. The biology of this pathogen complicates every management decision. Wilt is caused by *Fusarium oxysporum* f. sp. *Ciceri*, it is both seed-borne and soil-borne; it produces chlamydospores that survive in soil for upwards of six years without a chickpea host. Field study was conducted to test nine integrated management strategies to manage the wilt disease of chickpea. The results thus revealed that all treatment significantly reduced the percent disease incidence, increase the yield and test weight. The lowest percent disease incidence (7.79%) was recorded in (T₉) soil drenching with Propiconazole followed by (8.89%) in (T₄) Seed treatment with Thiram (@1.5g/kg) + Soil application of *Trichoderma harzianum*[1×10⁷ CFU@10 g m⁻²]. The highest percent disease incidence (16.04%) was recorded in (T₅) Soil application of Mustard cake @ 0.2 kg m⁻² + *Trichoderma harzianum*@1 g m⁻² followed by 15.12% in (T₂) Soil application of *Trichoderma harzianum*[1×10⁷ CFU@10 g m⁻²] + FYM (@ 2.5 kgm⁻²), compared to control (31.02%).

Keywords: Chickpea wilt, integrated management of wilt, *Fusarium oxysporum* f. sp. *ciceri*, *Trichoderma*

Introduction

Chickpea (*Cicer arietinum* L.) (2n=16) is among the founder crops of modern agriculture. It belongs to Leguminaceae family and is a major source of food and animal-feed. It is not merely another pulse crop in India it is, by most practical measures, the most important pulse crop. India accounts for 71% of global chickpea acreage and 65% of production, yet its per-hectare productivity sits at a modest 1,012 kg, well below the yields achieved in China or Israel (Food and Agriculture Organization, 2025) This gap is not accidental. It is the aggregation of many small defeats diseases that chip away at both yield and quality year after year. Roughly 172 pathogens were documented on chickpea worldwide (Nene *et al.*, 1996) [6] some of them of importance are *Ascochyta rabiei*, *Fusarium oxysporum* f. sp. *ciceri*, *Uromyces cicerisarietini*, bean leaf roll virus, *Rhizoctonia bataticola*, *Botrytis cinerea*, *Sclerotinia sclerotiorum* and cucumber mosaic virus (Nene, 1980) [5]. In recent years there has been concern about gradual decline in per capita availability of pulses. An important reason for this miserable situation in the country is mainly due to the attack of the soil borne pathogens. According to Sarwar *et al.*, (2012) [8] wilt is a major restrictive factor to chickpea production. Wilt of chickpea is caused by *Fusarium oxysporum* f. sp. *ciceri* (hereafter FOC) stands out for its sheer persistence and the severity of losses it can inflict, ranging from 10–15% annually under typical conditions to outright crop failure during especially favorable disease years (Muche *et al.*, 2022) [3]. This disease was first reported in India by Butler in 1918 but its etiology was correctly determined by Padwick in 1940. *Fusarium* belongs to Division Ascomycota, Order Hypocerales, Family Nectriaceae. Genus *Fusarium*. It is widely

distributed throughout the country and is responsible for heavy reduction in crop yield (Haware *et al.*, 1986) [2]. The losses due to chickpea wilt disease mostly depend upon the favourable environmental, soil factors, amount of viable inoculums present and susceptible host (Navas-Cortes *et al.*, 2000) [4]. Wilt reduces chickpea production both by decreasing seed yield and seed weight. Early wilting is reported to cause more yield loss (77-94%) than late wilting (24-65%), but seeds from late wilted plants are lighter, rougher, and dull. The biology of this pathogen complicates every management decision. FOC is both seed-borne and soil-borne; it produces chlamydospores that survive in soil for upwards of six years without a chickpea host. It colonizes the roots of several rotation crops, pigeonpea, lentil, pea as a symptomless carrier, and it can be found on weed species including *Cyperus rotundus* and *Tribulus terrestris*. Soil temperatures between 24.8 and 28.5 °C, combined with soil moisture above 25% of water-holding capacity, create an environment in which the pathogen thrives. Once established in a field, it is, for all practical purposes, permanent.

The management of the disease can be done through cultural, chemical, biological methods and use of resistant varieties. In the absence of resistance / tolerant variety it is difficult to manage the disease caused by soil borne pathogens because of complex soil environment of physical, chemical and biological origin. And yet progress has been made, FOC management does not lie in optimizing any one of the approaches in isolation. It lies in testing them alongside each other, under the same local conditions, and then combining the most effective options into integrated field strategies. Investigation were done to test nine integrated management treatments under field conditions during *rabi* 2020-2021 at the Crop Research Centre, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, U.P

Materials and Methods

The Experiment was conducted at Crop Research centre, SVPUAT, Meerut. Nine treatments were evaluated in a Randomized Block Design with three replications at the Crop Research Centre during *rabi* 2020–2021.

Table 1: Integrated disease management treatments details

S. No.	Treatments	Treatments Details
1.	T ₁	Seed treatment with <i>Trichoderma harzianum</i> [1×10^7 CFU@10 g/kg seed] + <i>Pseudomonas fluorescens</i> (@ 10 g/kg seed)
2.	T ₂	Soil application of <i>Trichoderma harzianum</i> [1×10^7 CFU@10 g/m ²] + FYM (@ 2.5 kg/m ²)
3.	T ₃	Soil application of <i>Trichoderma harzianum</i> [1×10^7 CFU@10 g/m ²] + Press mud (@ 2.5 kg/m ²)
4.	T ₄	Seed treatment with Thiram (@ 1.5g/kg seed) + Soil application of <i>Trichoderma harzianum</i> [1×10^7 CFU@10 g/m ²]
5.	T ₅	Soil application of Mustard Cake (0.2 kg/m ²) + <i>Trichoderma harzianum</i> [1×10^7 CFU@10 g/m ²]
6.	T ₆	Soil application of Neem Cake (0.1 kg/m ²)
7.	T ₇	Soil application of Neem Cake (0.1 kg/m ²) + <i>Trichoderma harzianum</i> [1×10^7 CFU@10 g/m ²]
8.	T ₈	Seed bio-priming with <i>Trichoderma harzianum</i> @ 10g/kg seed
9.	T ₉	Soil drenching with Propiconazole
10.	T ₁₀	Control

Observations recorded

- Percent disease incidence (%)
- Yield (q/ ha)
- Test weight

Statistical analysis

Data of the experiments conducted in the laboratory and field was subjected to statistical analysis. The data were transformed whenever required. The critical difference is calculated at a probability of 5.0% to find out the difference between the treatments.

Results and Discussion

Field experiment were conducted during *rabi* season of 2020-2021 at Crop Research Centre of University. The results in the table no. 2, fig No. 1 and plate 9 revealed that all treatment significantly reduced the percent disease incidence, increased the yield and test weight. The lowest percent disease incidence (7.79%) was recorded in (T₉) Soil drenching with Propiconazole (@ 500 ml/ha after 15 DAS) followed by (8.89%) in (T₄) Seed treatment with Thiram. (@ 1.5g/kg seed) + Soil application of *Trichoderma harzianum* [1×10^7 CFU@10 g/m²]. The highest percent disease incidence (16.04%) was recorded in (T₅) Soil application of Mustard cake @ 0.2 kg/m² + *Trichoderma harzianum* @ 1 g m⁻² followed by 15.12% in (T₂) Soil application of *Trichoderma harzianum* [1×10^7 CFU@10 g/m²] + FYM. (@ 2.5 kg/m²) compared to control (31.02%).

The maximum yield q/ha was recorded (17.98 q/ha) and test weight (g) (192.6 g) in (T₉) Soil drenching with Propiconazole @ 500 ml/ha 15 DAS followed by (16.89q/ha) and test weight (g)(185.7) in (T₄) Seed treatment with Thiram. (@ 1.5g/kg seed)

+ Soil application of *Trichoderma harzianum* [1×10^7 CFU@10 g/m²].

In the field study, seed treatment with *Trichoderma harzianum* and *Pseudomonas fluorescens* and soil application of organic amendments viz., FYM, Press mud, Neem cake and Mustard cake with biocontrol agents i.e., *T.harzianum*, *P. fluorescens* and soil drenching with Propiconazole were evaluated in possible combinations to assess the integrated effect of treatments on chickpea wilt incidence in the field condition. Field experiment were conducted during *rabi* season 2020-2021 at Crop Research Centre of University. The results revealed that all treatment significantly reduced the percent disease incidence, increase the yield and test weight. The lowest percent disease incidence (7.79%) was recorded in (T₉) soil drenching with Propiconazole followed by (8.89%) in (T₄) Seed treatment with Thiram (@ 1.5 g/kg) + Soil application of *Trichoderma harzianum* [1×10^7 CFU@10 g m⁻²]. The highest percent disease incidence (16.04%) was recorded in (T₅) Soil application of Mustard cake @ 0.2 kg m⁻² + *Trichoderma harzianum* @ 1 g m⁻² followed by 15.12% in (T₂) Soil application of *Trichoderma harzianum* [1×10^7 CFU@10 g m⁻²] + FYM (@ 2.5 kg m⁻²) compared to control (31.02%).

The maximum yield q/ha (17.98 q/ha) and test weight (g) (192.6 g) was recorded in (T₉) soil drenching with Propiconazole @ 500 ml/ha 15 DAS followed by (16.89q/ha) and test weight (g)(185.7) in (T₄) Seed treatment with Thiram (@ 1.5g/kg) + Soil application of *Trichoderma harzianum* [1×10^7 CFU@10 g m⁻²] was recorded in (T₅) Soil application of Mustard cake @ 0.2 kg m⁻² + *T.harzianum* @ 1 g m⁻² compared to control (12.59 q ha⁻¹) and (16.73g). Similarly, Khan *et. al.* (2004) [9] conducted an experiment in New Delhi, India during 2001-02 and 2002-03 to study the effect of treating seed of chickpea (*Cicer arietinum*) BG

256 with commercial formulations (2g/kg seed) of *Trichoderma harzianum* and *Pseudomonas fluorescens*, alone and in combination to control wilt caused by *Fusarium oxysporum* f.sp. *ciceri*. On control plants, wilting was observed and significantly decreased dry weight and the seed yield of chickpea by 20 and 18%, respectively. On chickpea without wilt, treatment with *P. fluorescens* improved the yield by 36% and *T. harzianum* + *P. fluorescens* by 25%. Both bio fungicides suppressed wilt severity, the most effective being *T. harzianum* + *P. fluorescens* (66%). Carbendazim alone reduced wilt incidence by 33% and with *T. harzianum* + *P. fluorescens* by 44%. The soil population of *F. oxysporum* f.sp. *ciceri* (C.F.U./g soil) in untreated plots increased during the first 2 months, but in the bio fungicide/ fungicide treated plots, it gradually and significantly decreased during the 4 months of the crop season. The greatest decrease in the soil population of *F. oxysporum* f.sp. *ciceri* with *T. harzianum* or *T. harzianum* + *P. fluorescens*, followed by *P. fluorescens* and Carbendazim. The rhizosphere population of the bioagents increased significantly in plots where wilt population decreased. The greatest increases in the population of the bioagents was recorded for *T. harzianum* (108-120%), followed by *P.*

fluorescens (65-119%) in the combined treatment, compared with the pre-plant control (December). When the bio agents were applied alone, the population of *T. harzianum* increased by 71-96% and *P. fluorescens* by 46-103%. Nikam *et. al.* (2007) [10] reported chemical seed treatment with Thiram (0.15%) + Carbendazim (0.1%) is proved to be the most effective against *Fusarium oxysporum* f.sp. *ciceri*. *In vitro* evaluation of *Trichoderma* spp. against *F. oxysporum* f. sp. *cicero* revealed the positive cumulative effect of *Trichoderma viride* + *Trichoderma harzianum* + *Trichoderma hamatum* in respect to the percent inhibition of the test fungus. Pot culture studies revealed that the soil applications of *T. viride* @ 2.5kg/ha as the most effective in reducing the incidence of chickpea wilt. Soil amendment with Groundnut cake is proved to be effective against *F. oxysporum* f.sp. *ciceri* followed by neem cake. Thus, chickpea wilt incited by *F. oxysporum* f.sp. *ciceri* being soil borne disease could be managed by the integration of various practices like using resistant varieties, seed treatment with chemicals, seed and soil applications of bio-agents and amendment of soils with oil seed cakes.

Table 4.6: Integrated disease management of Wilt of Chickpea under field conditions

Treatment	Treatment details	Diseases Incidence (%)	Yield (q/ha)	Test weight (g)
T ₁	Seed treatment with <i>Trichoderma harzianum</i> [1×10^7 CFU@10g kg ⁻¹ seed] + <i>Pseudomonas fluorescens</i> . (@ 10 g kg ⁻¹ seed)	11.23	16.65	179.8
T ₂	Soil application of <i>Trichoderma harzianum</i> [1×10^7 CFU@10 g m ⁻²] + FYM. (@ 2.5 kgm ⁻²)	15.12	15.21	168.4
T ₃	Soil application of <i>Trichoderma harzianum</i> [1×10^7 CFU@10 g m ⁻²] + Press mud. (@2.5 kg m ⁻²)	14.97	15.48	169.8
T ₄	Seed treatment with Thiram. (@1.5g/kg) + Soil application of <i>Trichoderma harzianum</i> [1×10^7 CFU@10 g m ⁻²]	8.89	17.23	185.7
T ₅	Soil application of Mustard Cake (0.2 kg m ⁻²) + <i>Trichoderma harzianum</i> [1×10^7 CFU@10 g m ⁻²]	16.04	15.02	166.7
T ₆	Soil application of Neem Cake. (0.1 kg m ⁻²)	13.92	15.82	172.5
T ₇	Soil application of Neem Cake (0.1 kg m ⁻²) + <i>Trichoderma harzianum</i> [1×10^7 CFU@10 g m ⁻²]	12.41	16.28	175.6
T ₈	Seed bio-priming with <i>Trichoderma harzianum</i> @10g/kg seed	12.03	16.23	174.8
T ₉	Soil drenching with Propiconazole @ 0.1% concentration	7.79	17.98	192.6
T ₁₀	Control	31.02	12.36	152.4
SE(m)		0.091	0.030	0.132
CD		0.514	0.296	0.620

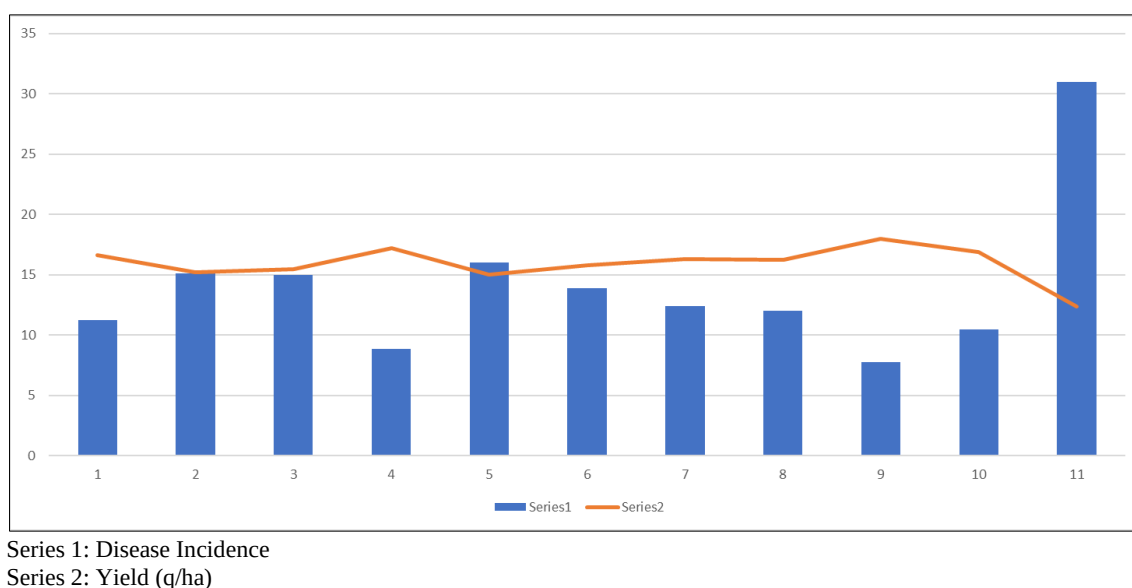


Fig 6: Effect of treatments on Disease incidence of *Fusarium oxysporum* f. sp. *ciceri* and grain yield of chickpea during 2020-2021

Conclusion

This study demonstrates that integrated disease management offers the most viable path forward for controlling chickpea wilt

caused by FOC, a pathogen whose soil-borne persistence effectively precludes eradication. The central conclusion, however, is neither novel nor subtle: effective management of

FOC demands integration — of biological, chemical, and botanical tools, deployed in combinations tailored to local conditions and constrained by the long-term imperative of preserving both soil health and the economic viability of chickpea cultivation

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