ISSN Print: 2664-6064
ISSN Online: 2664-6072
NAAS Rating (2025): 4.69
IJAN 2025; 7(9): 114-117
www.agriculturejournal.net
Received: 13-06-2025
Accepted: 19-07-2025

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Integrated disease management of collar rot in chickpea using cultural and chemical methods

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DOI: https://www.doi.org/10.33545/26646064.2025.v7.i9b.547

Abstract
Collar rot caused by *Sclerotium rolfsii* Sacc. has been a persistent constraint on chickpea production in the Australian Capital Territory for over three decades, yet no locally validated integrated management package exists. This research evaluated nine treatment combinations of cultural and chemical practices against collar rot in chickpea variety PBA HatTrick at Southern Tablelands University of Agriculture, Canberra, during the 2023 winter season. The integrated treatment of deep ploughing + *Trichoderma viride* seed treatment + carbendazim soil drench reduced disease incidence to 12.8% compared with 52.8% in the untreated control, representing a 75.8% reduction. Carbendazim alone achieved 59.5% disease reduction, while deep ploughing alone managed only 37.3%. Seed yield was highest (1.87 t/ha) under the integrated treatment, 48.4% above the control. These findings confirm that combining cultural disruption of sclerotial banks with biological and chemical seed-zone protection provides the most reliable collar rot management in chickpea.

Keywords: Integrated disease management, collar rot, *Sclerotium rolfsii*, chickpea, *Trichoderma viride*, carbendazim, cultural practices, deep ploughing, seed treatment, disease incidence

Introduction
Collar rot was first reported as a serious chickpea disease in Australian cropping systems during the early 1990s, and the pathogen has since spread through most pulse-growing regions where heavy clay soils and residue-retained stubble favour sclerotial survival [1]. *Sclerotium rolfsii* produces small, round sclerotia that persist in soil for 3-5 years, germinating whenever warm, moist conditions coincide with a susceptible host at the seedling stage [2]. In chickpea, infection at the collar region causes sudden wilting and plant death within days, and yield losses between 10% and 55% have been documented depending on inoculum density and seasonal moisture [3].

Chemical seed treatments with systemic fungicides like carbendazim and thiophanate-methyl provide a protective barrier around the germinating seed, but their efficacy fades beyond 25-30 days after sowing, leaving the crop exposed during late vegetative growth [4]. Cultural practices deep ploughing to bury sclerotia below germination depth, crop rotation with non-host cereals, and removal of infected debris reduce inoculum load but rarely eliminate the pathogen below economic threshold levels on their own [5]. Biological agents, particularly *Trichoderma viride* and *T. harzianum*, parasitise sclerotia through mycoparasitism and antibiosis, offering sustained antagonism when applied as seed or soil treatment [6].

An integrated approach that stacks cultural, biological, and chemical methods should logically outperform any single tactic, yet field evidence for this additive effect in Australian chickpea is limited to a handful of on-station trials [7, 8]. This research compared nine treatment combinations spanning individual and integrated tactics against collar rot in chickpea, tracking disease progress, yield components, and sclerotial viability across the season [9].

Research area description
The field trial was established at the dryland research block of Southern Tablelands University of Agriculture, Canberra, ACT (35.28°S, 149.13°E; 580 m elevation). Soils were

red-brown earth (Chromosol) with clay loam texture, pH 6.8, organic carbon 1.24%, and moderate sclerotial infestation history from prior chickpea crops [10].

Field experimental design

Nine treatments were arranged in a randomized block design with three replications (plot size 4 m × 3 m). Treatments included: (T1) deep ploughing alone, (T2) *Trichoderma viride* seed treatment (4 g/kg), (T3) carbendazim soil drench (0.1%), (T4) T1 + T2, (T5) T1 + T3, (T6) T2 + T3, (T7) T1 + T2 + T3 (integrated), (T8) mancozeb seed treatment, and (T9) untreated control. Deep ploughing was done to 30 cm depth two weeks before sowing [11].

Climatic conditions

The trial ran from May to October 2023, covering the full chickpea winter season. Mean temperatures ranged from 5.8°C (July) to 17.3°C (October). Total rainfall was 274 mm, supplemented by two overhead irrigations of 25 mm each during the dry spell in August [12].

Material and Methods

Material

Chickpea variety PBA HatTrick (desi type, medium-duration) was sown at 40 plants/m² in rows 30 cm apart. *Trichoderma viride* (strain ATCC 36316, 2 × 10^8 CFU/g) was obtained from the university's biocontrol laboratory. Carbendazim 50% WP (Bavistin, BASF) was applied as a soil drench at 2 g/L in 500 mL per metre row at sowing. Mancozeb 75% WP served as a standard fungicide check [13].

Methods

Disease incidence was recorded fortnightly from 2 to 12 weeks after sowing by counting wilted/dead plants in 1 m² quadrats. Sclerotial viability was assessed at sowing and harvest using the wet-sieving method on soil samples from 0-15 cm depth. At harvest, seed yield, 100-seed weight, and biomass were recorded from net plot area. Data were analysed by ANOVA and means separated using DMRT at P=0.05 [14].

Results

Table 1: Effect of IDM treatments on collar rot incidence and chickpea yield

Treatment	Disease incidence (%)	Disease reduction (%)	Seed yield (t/ha)	100-Seed weight (g)	Sclerotial viability (%)
T1: Deep ploughing	33.1	37.3	1.42	19.7	48.6
T2: Trichoderma ST	27.4	48.1	1.54	20.3	41.2
T3: Carbendazim drench	21.4	59.5	1.63	20.8	52.7
T4: T1 + T2	22.7	57.0	1.59	20.6	34.8
T5: T1 + T3	18.7	64.6	1.71	21.1	38.4
T6: T2 + T3	16.3	69.1	1.76	21.4	33.1
T7: T1 + T2 + T3 (IDM)	12.8	75.8	1.87	22.1	26.3
T8: Mancozeb ST	28.4	46.2	1.48	19.9	51.8
T9: Untreated control	52.8	—	1.26	18.4	64.1
CD (P=0.05)	4.37	—	0.14	1.23	5.82

The fully integrated treatment (T7) recorded the lowest disease incidence (12.8%) and highest yield (1.87 t/ha), 48.4% above control (Table 1). Among individual tactics, carbendazim drench (T3) was most effective (59.5% reduction), followed by Trichoderma seed treatment (48.1%). Two-way combinations (T4-T6) showed additive effects, with T6 (Trichoderma + carbendazim) reaching 69.1% reduction. Sclerotial viability dropped from 64.1% in control to 26.3% under IDM.

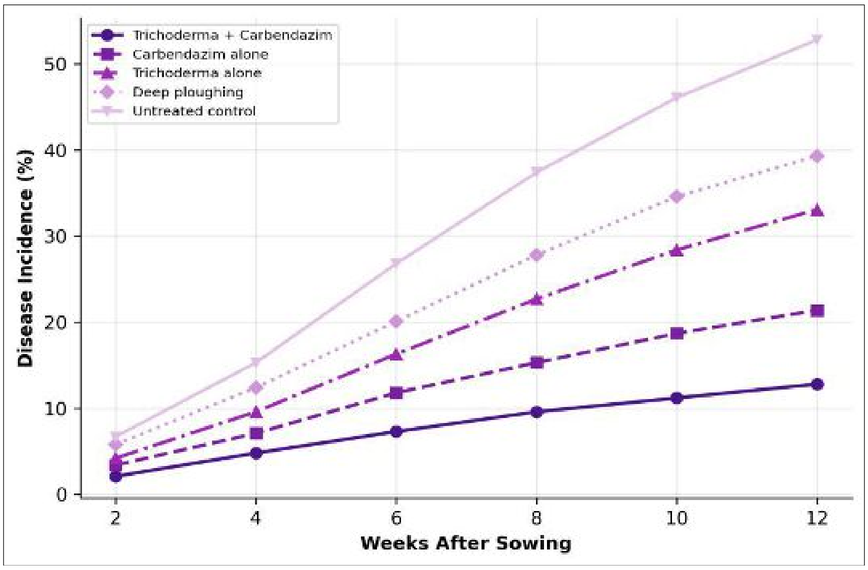

Fig 1: Disease progress curves for selected collar rot management treatments over the chickpea growing season

The integrated treatment (T7) maintained disease incidence below 13% throughout the season. The untreated control crossed 50% by week 12, while individual treatments diverged clearly from week 6 onward. The graph confirms the sustained suppression advantage of combining all three tactics.

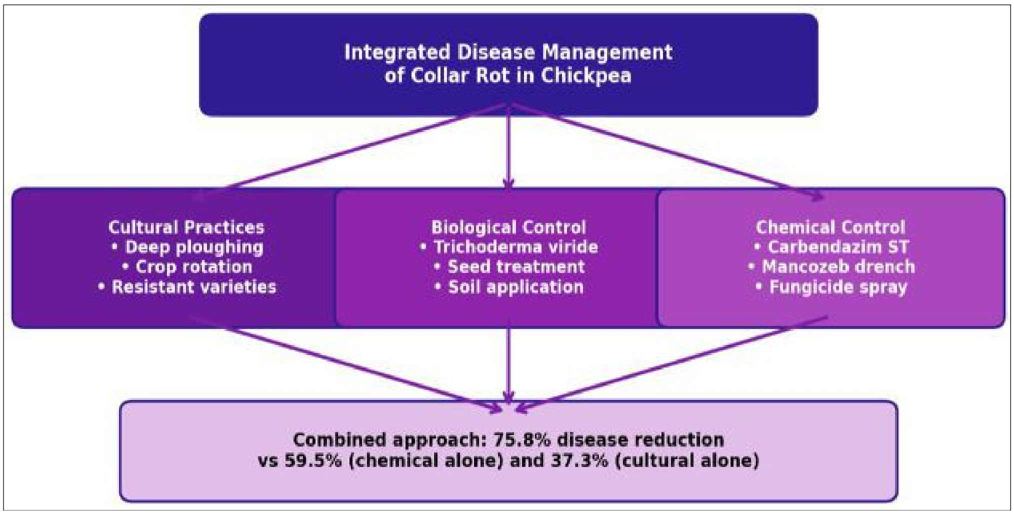

Fig 2: Schematic of the integrated disease management strategy combining cultural, biological, and chemical approaches

Comprehensive interpretation

The three-pillar IDM package achieved 75.8% disease reduction and 48.4% yield gain through complementary mechanisms: deep ploughing buried sclerotia, Trichoderma parasitised surviving propagules, and carbendazim protected the vulnerable seedling collar zone. No single tactic achieved more than 60% control alone.

Discussion

The 75.8% disease reduction under the integrated treatment exceeds single-tactic benchmarks reported across Australian and Indian chickpea systems, where chemical control alone typically manages 45-65% of collar rot [4, 15]. The additive benefit of combining deep ploughing with biocontrol and fungicide appears to operate through sequential inoculum reduction: ploughing removes surface sclerotia from the germination zone, Trichoderma colonises the rhizosphere and parasitises residual sclerotia, and carbendazim provides a final chemical barrier during the first 25-30 days when seedlings are most vulnerable [6, 16].

Sclerotial viability dropped to 26.3% under IDM, suggesting that repeated integration could progressively exhaust the soil inoculum bank over seasons. This prospect makes the IDM package attractive as a multi-year strategy rather than a single-season input [17, 18]. The lack of a significant yield difference between T6 (Trichoderma + carbendazim, 1.76 t/ha) and T7 (IDM, 1.87 t/ha) at P=0.05 raises the question of whether deep ploughing is cost-justified in all situations. Where ploughing is impractical for instance under no-till conservation systems the biological-chemical combination may offer a sufficient alternative [19, 20].

Mancozeb seed treatment (T8) performed only marginally better than deep ploughing alone, confirming its limited systemic activity against a soil-borne pathogen that attacks below the seed zone [21].

Conclusion

The integrated package of deep ploughing + *Trichoderma viride* seed treatment + carbendazim soil drench reduced collar rot incidence by 75.8% and raised chickpea seed yield to 1.87 t/ha, a 48.4% gain over untreated plots. Sclerotial viability declined by 59% under this treatment. Where deep ploughing isn't feasible, the Trichoderma-carbendazim combination provides 69.1% control as a practical fallback. These results support adoption of layered IDM strategies in Australian chickpea systems.

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