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Effect of Cycocel (CCC) application on growth, yield, and seed quality of chickpea under terminal heat stress

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Abstract

A field-cum-laboratory experiment was conducted at the Rajasthan Agricultural Research Institute (RARI), Durgapura, Jaipur, during the Rabi 2024 season to evaluate the effects of Cycocel (CCC) on the growth, yield, and seed quality of chickpea under terminal heat stress. Foliar application of Cycocel at 1000 ppm significantly enhanced yield-attributing traits, including the number of pods per plant, 100-seed weight, plot yield, and harvest index, compared with the untreated control. The treatment also accelerated crop maturity, thereby enabling partial escape from terminal heat stress during the reproductive phase. Laboratory evaluation of the harvested seeds further demonstrated significant improvements in germination percentage, seedling length, seedling dry weight, and seed vigor indices (SVI-I and SVI-II), indicating superior seed physiological quality. These findings suggest that the application of Cycocel at 1000 ppm effectively alleviates the detrimental effects of terminal heat stress by improving both crop productivity and seed quality, making it a promising agronomic strategy for enhancing chickpea performance under heat-stressed environments

Keywords: Chickpea, Cycocel (CCC), Terminal heat stress, Seed priming, Growth regulator, Seed quality

Introduction

Chickpea (*Cicer arietinum* L.) is one of the most important pulse crops cultivated in semi-arid and subtropical regions. Its productivity is frequently constrained by terminal heat stress, particularly during flowering and pod development. High temperatures during the reproductive stage accelerate leaf senescence, reduce pollen viability and pod set, shorten the seed-filling period, and ultimately decrease seed yield and quality (Pushpavalli *et al.*, 2020; Kumar *et al.*, 2021) ^[6, 4].

Plant growth regulators have emerged as an effective strategy for improving crop performance under abiotic stress conditions. Among them, Cycocel (CCC) is an anti-gibberellin growth regulator that suppresses excessive vegetative growth, improves assimilate partitioning, and enhances reproductive efficiency. CCC has also been reported to improve photosynthetic efficiency, maintain membrane stability, enhance antioxidant defence, and increase stress tolerance, thereby contributing to improved yield and seed quality under adverse environmental conditions (Hasanuzzaman *et al.*, 2020) ^[2]. Improved source-sink relationships and efficient translocation of photosynthates are important mechanisms for sustaining productivity under terminal heat stress (Benali *et al.*, 2023; Singh and Singh, 2025) ^[1, 7].

Although several studies have reported the beneficial effects of stress management practices in chickpea, information on the use of Cycocel under terminal heat stress, particularly its influence on both field performance and seed quality, remains limited. Therefore, the present investigation was undertaken to evaluate the effect of foliar application of Cycocel @1000 ppm on growth, yield attributes, seed yield, and seed quality of chickpea under terminal heat stress conditions.

Materials and Methods

The experiment was carried out at RARI, Durgapura (SKN Agriculture University, Jobner) during Rabi 2023–24 and 2024–25. Chickpea variety CSJ 515 seeds were sown under field conditions and subjected to terminal heat stress during the reproductive stages with three treatments: T₁ (control), T₂ (seed treated with potash solubilizer at 5 mL/kg seed) and T₃ (Cycocel @ 1000 ppm).

Cycocel at 1000 ppm was applied as a foliar spray at the vegetative and anthesis stages. Observations were recorded for pod number, seed weight, plot yield, and harvest index. Seeds harvested from treated plants were evaluated in the laboratory for germination percentage, seed moisture, seedling length, seedling dry weight, and vigor indices following ISTA (2024) [3] procedures.

Results and Discussion

Effect of Cycocel on growth, yield and seed quality of chickpea under terminal heat stress

The effect of Cycocel (CCC) application on growth, yield attributes and seed quality of chickpea under terminal heat stress is presented in Figure 1. The results revealed that all treatments attained 50% pod formation in 79 days, indicating that Cycocel application had no appreciable effect on the initiation of reproductive development. Plant height was slightly reduced in the Cycocel-treated plants (59.4 cm) compared with the untreated control (61.1 cm), which may be attributed to the growth-retarding effect of chlormequat chloride. Such reduction in vegetative growth is considered beneficial under stress conditions, as it promotes better partitioning of assimilates towards reproductive organs (Pushpavalli *et al.*, 2020; Kumar *et al.*, 2021) [6, 4].

Cycocel application significantly improved the yield attributes of chickpea under terminal heat stress. The highest number of pods per plant (56) was recorded with Cycocel @1000 ppm, compared with 51–52 pods plant⁻¹ in the control treatments. Similarly, the number of seeds per pod increased from 1.6 in the control to 1.7 with Cycocel application. Improved pod formation and seed set indicate better reproductive efficiency and enhanced assimilate translocation during the reproductive phase. These findings are in agreement with Benali *et al.* (2023) [1], who reported that maintenance of reproductive growth is essential for improving heat tolerance in chickpea.

Seed yield per plant increased from 12.52 g in the untreated control to 13.58 g in the Cycocel-treated plants. Likewise, 1000-seed weight increased from 153.43 g to 160.55 g, indicating better seed filling under terminal heat stress. The highest plot yield (78.30 kg per 500 m²) was also recorded with Cycocel, compared with 68.44 kg and 69.04 kg in the untreated control and recommended package of practices, respectively. The

improvement in yield was accompanied by an increase in harvest index from 37.8% to 40.10%, suggesting more efficient partitioning of biomass towards seed production. Similar improvements in seed weight and yield under heat stress have been reported by Singh and Singh (2025) [7].

Days to maturity were slightly reduced in the Cycocel-treated plants (128 days) compared with the control (129–130 days), indicating that Cycocel promoted earlier crop maturity. Early maturity is advantageous under terminal heat stress because it enables the crop to escape high-temperature stress during the final stages of seed development. Moreover, the higher benefit ratio observed with Cycocel treatment indicated its economic advantage under stress conditions.

Laboratory evaluation showed that all treatments maintained high germination (>90%), indicating that terminal heat stress did not adversely affect seed viability. However, Cycocel improved several seed quality parameters. The highest germination (91.50%) was recorded with Cycocel @1000 ppm compared with 90.75% in the untreated control. Seedling length increased from 33.8 cm to 36.9 cm, while seedling fresh weight and seedling dry weight increased from 7.17 to 7.40 g and 0.445 to 0.468 mg per 10 seedlings, respectively. These improvements indicate enhanced seed development and greater reserve accumulation during seed maturation.

Seedling vigour was also significantly enhanced by Cycocel application. Seedling Vigour Index-I increased to 3265 compared with 3041–3067 in the control treatments, whereas Seedling Vigour Index-II increased to 42.8 compared with 40.1–40.4 in the controls. The higher vigour indices indicate improved physiological quality of seeds and greater seedling establishment potential. Similar improvements in seed vigour under stress mitigation treatments have been reported by Megha *et al.* (2024) [5] and Yadav *et al.* (2024) [8], while Hasanuzzaman *et al.* (2020) [2] attributed enhanced seedling performance under stress to improved antioxidant defence and membrane stability.

The foliar application of Cycocel @1000 ppm effectively mitigated the adverse effects of terminal heat stress by improving yield components, seed yield, harvest index and seed physiological quality. The combined improvement in productivity, seed vigour and economic returns suggests that Cycocel can be recommended as an effective agronomic practice for chickpea cultivation under terminal heat stress conditions.

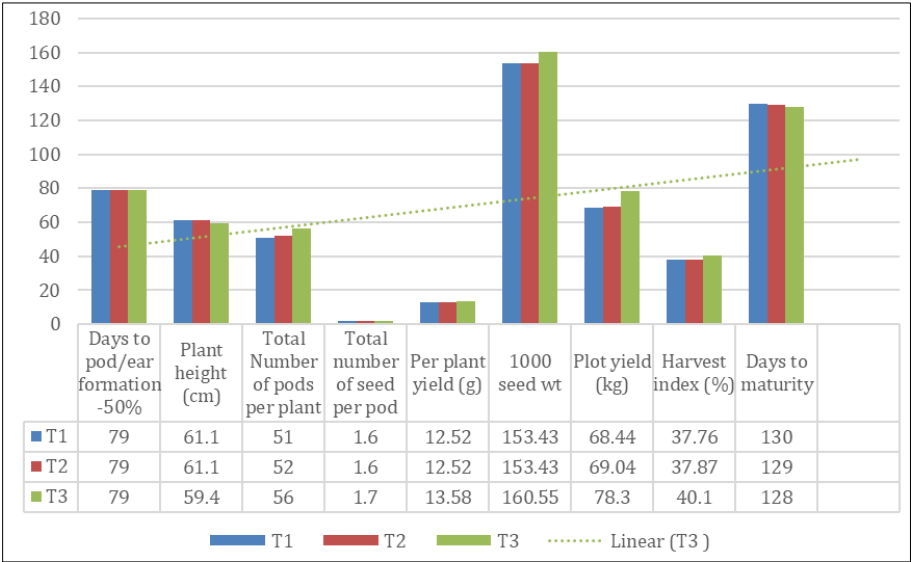


Fig 1: Effect of Cycocel on field performance of chickpea under terminal heat stress.

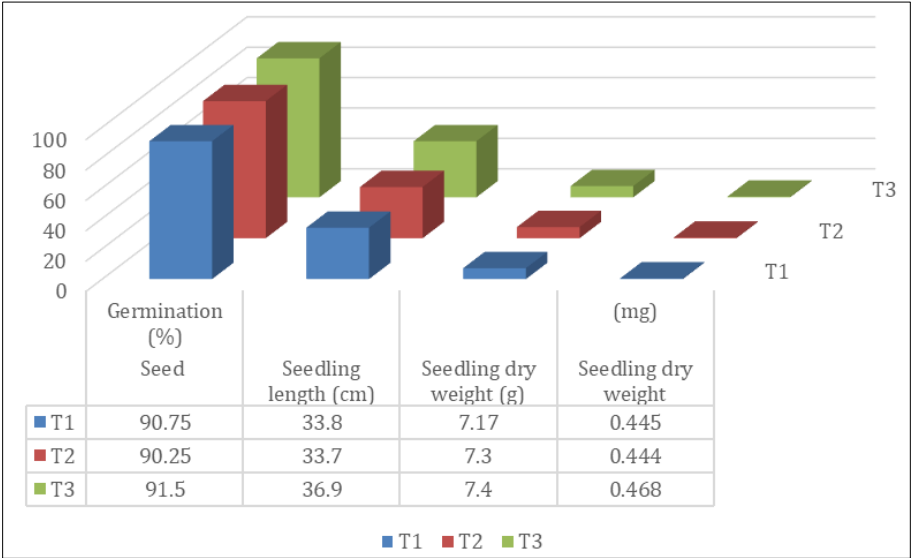


Fig 2: Effect of Cycocel on seed quality parameters of chickpea under laboratory conditions.

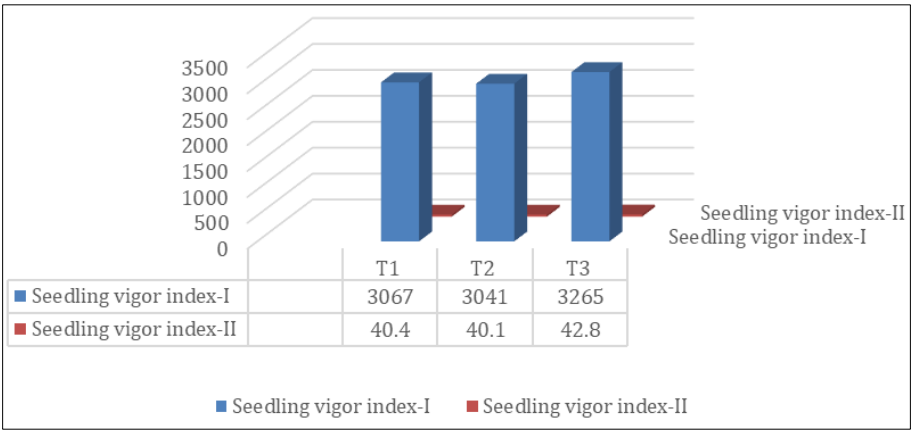


Fig 3: Effect of Cycocel on SVI-I and SVI-II of chickpea under laboratory conditions.

Conclusion

The foliar application of Cycocel (CCC) @1000 ppm effectively alleviated the adverse effects of terminal heat stress in chickpea by improving yield attributes, seed yield, harvest index and seed quality. The treatment also promoted earlier maturity and enhanced seed vigour, indicating that Cycocel can be used as an effective agronomic strategy for improving chickpea productivity under terminal heat stress condition.

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