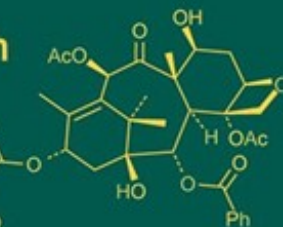
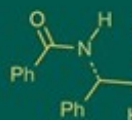
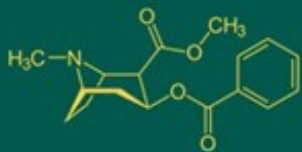


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Effect of pre-sowing seed treatments on seed germination and seedling vigour in cinnamon (*Cinnamomum verum* J. Presl.)

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ABSTRACT

The present investigation entitled "Effect of pre-sowing seed treatments on seed germination and seedling growth in cinnamon (*Cinnamomum verum* J. Presl.)" was conducted during 2024 - 25 at the Main Agricultural and Horticultural Research Station (MAHRS), Iruvakk, Shivamogga, Karnataka. The experiment was laid out in a Randomized Complete Block Design (RCBD) with ten treatments, viz., T_1 (Control), T_2 (GA_3 at 125 ppm), T_3 (GA_3 at 175 ppm), T_4 (GA_3 at 250 ppm), T_5 (Thiourea at 750 ppm), T_6 (Thiourea at 1250 ppm), T_7 (Thiourea at 2500 ppm), T_8 (Ethrel at 400 ppm), T_9 (Ethrel at 1000 ppm) and T_{10} (Ethrel at 1500 ppm), each replicated thrice. The results revealed that pre-sowing treatment with GA_3 at 250 ppm recorded the early germination (14.67 days), minimum days taken for 50 per cent germination (18.00 days), highest germination percentage (96.00%) and maximum rate of germination (5.87). The same treatment also produced the highest shoot length of 3.48, 5.98, 8.18 and 10.33 cm at 30, 45, 60 and 90 DAS, respectively. Among the remaining treatments, GA_3 at 175 ppm and Thiourea at 1250 ppm showed comparatively better performance, whereas Ethrel at 1500 ppm recorded the lowest germination percentage (42.67%), lowest rate of germination (3.00) and the shortest shoot length (6.43 cm) at 90 DAS. Hence, pre-sowing treatment of cinnamon seeds with GA_3 at 250 ppm for 24 h may be recommended for improving seed germination, accelerating seedling establishment and producing vigorous nursery seedlings of cinnamon.

Keywords: Cinnamon, Germination, Protected cultivation, Flowering

Introduction

Cinnamon (*Cinnamomum verum* J. Presl.) is an important perennial tree spice belonging to the family Lauraceae, valued for its aromatic bark, leaves and essential oil. It is widely cultivated in tropical regions and has significant economic importance in the food, pharmaceutical and cosmetic industries (Ravindran *et al.*, 2004; Singh *et al.*, 2021) [1, 2].

Propagation of cinnamon is mainly through seeds; however, the seeds are recalcitrant and exhibit rapid loss of viability, resulting in slow and uneven germination. This affects nursery establishment and the production of healthy seedlings (Hartmann *et al.*, 2018; Baskin *et al.*, 2014) [4, 3]. Pre-sowing seed treatments using plant growth regulators and dormancy-breaking chemicals are effective approaches to improve germination and seedling vigour.

Gibberellic acid (GA_3) promotes germination by stimulating enzyme activity and mobilizing stored food reserves, while thiourea acts as a dormancy-breaking agent by enhancing metabolic activity. Ethrel (ethephon), an ethylene-releasing compound, also influences seed germination and early seedling growth depending on its concentration (Taiz *et al.*, 2015; Abeles *et al.*, 1992) [6, 5].

Previous studies have reported that pre-sowing treatments with GA_3 , thiourea and ethrel significantly improve germination percentage, reduce the time taken for germination and enhance seedling vigour in cinnamon and other crops (Rajan *et al.*, 2023; Bewley *et al.*, 2013) [7, 8]. Therefore, the present study was undertaken to evaluate the effect of different concentrations of GA_3 , thiourea and ethrel on seed germination and seedling growth in cinnamon (*Cinnamomum verum* J. Presl.).

Sustainable propagation of cinnamon depends on the production of healthy and vigorous seedlings through efficient nursery management practices. However, cinnamon seeds exhibit slow and uneven germination owing to their recalcitrant nature and rapid loss of viability after harvest. Pre-sowing seed treatments with plant growth regulators and dormancy-breaking chemicals such as gibberellic acid (GA_3), thiourea and ethrel have been reported to enhance germination, improve seedling vigour and promote uniform seedling establishment. Identification of an effective pre-sowing treatment is therefore essential for producing quality planting material and improving nursery success. Therefore, the present investigation entitled "Effect of Pre-sowing

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Seed Treatments on Seed Germination and Seedling Growth in Cinnamon (*Cinnamomum verum* J. Presl.)" was undertaken with the following objectives:

1. To evaluate the effect of different pre-sowing seed treatments with GA₃, thiourea and ethrel on seed germination attributes of cinnamon (*Cinnamomum verum* J. Presl.).
2. To study the influence of different pre-sowing seed treatments with GA₃, thiourea and ethrel on early shoot growth of cinnamon (*Cinnamomum verum* J. Presl.) seedlings.

Materials and Methods

The experiment was conducted at the Main Agricultural and Horticultural Research Station (MAHRS), Iruvakk, Karnataka, India, to evaluate the effect of pre-sowing seed treatments on seed germination and early seedling growth of cinnamon (*Cinnamomum verum* J. Presl.). Fresh, healthy and uniformly matured seeds collected from the Agricultural and Horticultural Research Station (AHRS), Thirthahalli, were used for the study.

The experiment was laid out in a Randomized Complete Block Design (RCBD) with 10 treatments and three replications, comprising 30 seeds per treatment per replication. The treatments consisted of T₁: Control (no soaking), T₂: GA₃ at 125 ppm, T₃: GA₃ at 175 ppm, T₄: GA₃ at 250 ppm, T₅: Thiourea at 750 ppm, T₆: Thiourea at 1250 ppm, T₇: Thiourea at 2500 ppm, T₈: Ethrel at 400 ppm, T₉: Ethrel at 1000 ppm and T₁₀: Ethrel at 1500 ppm. Seeds were soaked in the respective treatment solutions for 24 hr, shade-dried and sown individually in black polyethylene bags (15 × 10 cm) filled with a potting mixture of red soil, sand and well-decomposed farmyard manure in the ratio of 2:1:1.

The polybags were maintained under shade-net condition with regular irrigation and recommended nursery practices. Observations were recorded on days to commencement of germination, days to 50% germination, germination percentage, rate of germination and shoot length at 30, 45, 60 and 90 DAS. The experimental data were analyzed using analysis of variance (ANOVA) appropriate for RCBD, and treatment means were compared using the critical difference (CD) test at the 5% level of significance.

The effect of different pre-sowing seed treatments with GA₃, thiourea and ethrel on seed germination attributes of cinnamon (*Cinnamomum verum* J. Presl.)

Days taken for commencement of germination

The days taken for commencement of germination varied significantly among the different pre-sowing seed treatments (Table 1). The earliest commencement of germination was recorded in GA₃ at 250 ppm (T₄) (14.67 days), which was significantly superior to all other treatments. This was followed by GA₃ at 175 ppm (T₃) (15.47 days), Thiourea at 2500 ppm (T₇) (16.87 days) and Thiourea at 1250 ppm (T₆) (17.82 days). The maximum number of days for commencement of germination was observed in Ethrel at 1500 ppm (T₁₀) (23.83 days), which was statistically on par with the control (T₁) (23.27 days). Among the treatments, GA₃ at 250 ppm (T₄) recorded the earliest commencement of germination (14.67 days), which was significantly superior to all other treatments, followed by GA₃ at 175 ppm (T₃) (15.47 days) and Thiourea at 2500 ppm (T₇) (16.87 days). The maximum number of days taken for commencement of germination (23.83 days) was recorded in Ethrel at 1500 ppm (T₁₀), followed by the control (23.27 days).

The earliest commencement of germination observed in seeds treated with GA₃ at 250 ppm may be attributed to the ability of gibberellic acid to overcome physiological dormancy by stimulating the synthesis of hydrolytic enzymes, particularly α-amylase, which facilitates the mobilization of stored food reserves for embryo growth.

Gibberellins also promote cell elongation, enzyme activity and embryo development, thereby accelerating radicle protrusion and germination. Similar findings have been reported by Hartmann *et al.* (2018) [4], Taiz *et al.* (2015) [6] and Raja Rajan *et al.* (2023) [8].

Days taken for 50 per cent germination

The days taken for 50 per cent germination differed significantly among the pre-sowing treatments (Table 1). The minimum number of days required for 50 per cent germination was recorded in GA₃ at 250 ppm (T₄) (18.00 days), followed by GA₃ at 175 ppm (T₃) (21.33 days) and GA₃ at 125 ppm (T₂) (24.00 days). Thiourea at 1250 ppm (T₆) required 25.33 days, while Thiourea at 2500 ppm (T₇) took 24.33 days. The maximum number of days for 50 per cent germination was recorded in Ethrel at 1500 ppm (T₁₀) (31.00 days), followed by the control (T₁) (30.33 days).

The reduction in the number of days required for 50 per cent germination with GA₃ at 250 ppm may be attributed to the rapid activation of metabolic and physiological processes associated with germination. Gibberellic acid enhances enzyme activity, promotes reserve mobilization and stimulates embryo growth, thereby ensuring rapid and synchronized germination. The delayed germination observed in ethrel-treated seeds at higher concentrations may be due to its inhibitory effects on early germination processes. These findings are in agreement with Bewley *et al.* (2013) [7], Taiz *et al.* (2015) [6] and Raja Rajan *et al.* (2023) [8].

Germination percentage

The germination percentage was significantly influenced by the different pre-sowing treatments (Table 1). The highest germination percentage was recorded in GA₃ at 250 ppm (T₄) (96.00%), which was significantly superior to all other treatments. This was followed by GA₃ at 175 ppm (T₃) (85.33%) and Thiourea at 1250 ppm (T₆) (80.00%). Moderate germination percentages were recorded with GA₃ at 125 ppm (T₂) (72.00%) and Thiourea at 2500 ppm (T₇) (69.33%). The lowest germination percentage was recorded in Ethrel at 1500 ppm (T₁₀) (42.67%), followed by the control (T₁) (46.67%).

The significantly higher germination percentage recorded with GA₃ at 250 ppm may be attributed to its role in overcoming seed dormancy and enhancing the mobilization of stored carbohydrates, proteins and other metabolites required for embryo growth. Enhanced hydrolytic enzyme activity and improved metabolic efficiency promote rapid and uniform germination, resulting in a higher percentage of seedling emergence. Similar observations have been reported by Hartmann *et al.* (2018) [4], Bewley *et al.* (2013) [7] and Raja Rajan *et al.* (2023) [8].

Rate of germination

The rate of germination differed significantly among the pre-sowing seed treatments (Table 1). GA₃ at 250 ppm (T₄) recorded the highest rate of germination (5.87), followed by GA₃ at 175 ppm (T₃) (5.15) and Thiourea at 1250 ppm (T₆) (4.70). Moderate rates of germination were observed in GA₃ at 125 ppm (T₂) (4.34), Thiourea at 2500 ppm (T₇) (4.22) and Thiourea at 750 ppm (T₅) (3.90). The lowest rate of germination was recorded in Ethrel at 1500 ppm (T₁₀) (3.00), followed by the control (T₁) (3.25).

The higher rate of germination recorded with GA₃ at 250 ppm could be attributed to its stimulatory effect on physiological and biochemical activities associated with seed germination. Gibberellic acid promotes the synthesis of hydrolytic enzymes, increases respiratory activity and enhances nutrient translocation to the developing embryo, resulting in rapid and uniform seedling emergence. Conversely, higher concentrations of ethrel leads to delay in germination and lower the germination rate. Similar findings have been reported by Copeland *et al.* (2001) [9], Hartmann *et al.* (2018) [4] and Raja Rajan *et al.* (2023) [8].

Influence of different pre-sowing seed treatments with GA₃, thiourea and ethrel on early shoot growth of cinnamon (*Cinnamomum verum* J. Presl.) seedlings

The shoot length of cinnamon seedlings was significantly influenced by the different pre-sowing seed treatments at all stages of observation (30, 45, 60 and 90 DAS) (Table 2). At 30 DAS, the maximum shoot length was recorded in GA₃ at 250 ppm (T₄) (3.48 cm), which was significantly superior to all other treatments, followed by GA₃ at 175 ppm (T₃) (3.12 cm) and Thiourea at 1250 ppm (T₆) (2.96 cm). The minimum shoot length was recorded in Ethrel at 1500 ppm (T₁₀) (2.16 cm).

At 45 DAS, Maximum shoot length was recorded in GA₃ at 250 ppm (T₄) (5.98 cm), followed by GA₃ at 175 ppm (T₃) (5.34 cm) and Thiourea at 1250 ppm (T₆) (5.06 cm), whereas the minimum shoot length was recorded in Ethrel at 1500 ppm (T₁₀) (3.70 cm).

Similarly, at 60 DAS, the maximum shoot length was observed in GA₃ at 250 ppm (T₄) (8.18 cm), followed by GA₃ at 175 ppm (T₃) (7.32 cm) and Thiourea at 1250 ppm (T₆) (6.94 cm). The minimum shoot length was recorded in Ethrel at 1500 ppm (T₁₀) (5.10 cm).

At 90 DAS, the maximum shoot length was recorded in GA₃ at 250 ppm (T₄) (10.33 cm), followed by GA₃ at 175 ppm (T₃) (9.23 cm) and Thiourea at 1250 ppm (T₆) (8.73 cm). The minimum shoot length was observed in Ethrel at 1500 ppm (T₁₀) (6.43 cm), which was statistically on par with the control (T₁) (6.83 cm).

The significantly greater shoot length was observed in seedlings raised from seeds treated with GA₃ at 250 ppm may be attributed to the promotive effect of gibberellic acid on cell division, cell elongation and internodal expansion. Gibberellins stimulate the mobilization of stored food reserves through enhanced hydrolytic enzyme activity, resulting in increased nutrient availability for vigorous shoot growth. The continuous increase in shoot length throughout the observation period indicates the sustained influence of GA₃ on vegetative growth. Thiourea at 1250 ppm also improved shoot growth, possibly by enhancing metabolic activity and breaking dormancy, whereas higher concentrations of ethrel adversely affected seedling growth due to the inhibitory effect of excess ethylene on cell elongation. Similar findings have been reported by Hartmann *et al.* (2018) [4], Taiz *et al.* (2015) [6] and Raja Rajan *et al.* (2023) [8].

Presl.)

Presl.)

Table 1. Effect of pre-sowing seed treatments on seed germination parameters of cinnamon (*Cinnamomum verum* J.

Treatments	Days taken for the commencement of germination	Days taken for 50 per cent germination (%)	Germination percentage (%)	Rate of Germination (%)
T ₁ : Control (no soaking)	23.27	30.33	46.67 (43.08)	3.25
T ₂ : GA ₃ at 125 ppm	18.13	24.00	72.00 (58.06)	4.34
T ₃ : GA ₃ at 175 ppm	15.47	21.33	85.33(67.43)	5.15
T ₄ : GA ₃ at 250 ppm	14.67	18.00	96.00 (78.46)	5.87
T ₅ : Thiourea at 750 ppm	21.10	27.33	58.67 (49.97)	3.90
T ₆ : Thiourea at 1250 ppm	17.82	25.33	80.00 (63.43)	4.70
T ₇ : Thiourea at 2500 ppm	16.87	24.33	69.33 (56.37)	4.22
T ₈ : Ethrel at 400 ppm	22.33	29.33	53.33 (46.91)	3.62
T ₉ : Ethrel at 1000 ppm	21.03	28.33	49.33 (44.61)	3.42
T ₁₀ : Ethrel at 1500 ppm	23.83	31.00	42.67 (40.79)	3.00
S.Em±	0.640	0.610	0.470	0.150
CD @ 5%	1.910	1.800	1.400	0.440

Table 2. Effect of pre-sowing seed treatments on shoot length of cinnamon (*Cinnamomum verum* J. Presl.) seedlings at different growth stages

Treatments	Shoot length (cm)			
	30 DAS	45 DAS	60 DAS	90 DAS
T ₁ : Control (no soaking)	2.30	3.95	5.42	6.83
T ₂ : GA ₃ at 125 ppm	2.82	4.82	6.60	8.33
T ₃ : GA ₃ at 175 ppm	3.12	5.34	7.32	9.23
T ₄ : GA ₃ at 250 ppm	3.48	5.98	8.18	10.33
T ₅ : Thiourea at 750 ppm	2.54	4.36	6.00	7.53
T ₆ : Thiourea at 1250 ppm	2.96	5.06	6.94	8.73
T ₇ : Thiourea at 2500 ppm	2.78	4.76	6.56	8.23
T ₈ : Ethrel at 400 ppm	2.56	4.40	6.08	7.63
T ₉ : Ethrel at 1000 ppm	2.40	4.10	5.68	7.13
T ₁₀ : Ethrel at 1500 ppm	2.16	3.70	5.10	6.43
S.Em±	0.074	0.158	0.185	0.217
CD @ 5%	0.220	0.469	0.550	0.644

Conclusion

Pre-sowing seed treatments significantly influenced the seed germination and early seedling growth of cinnamon (*Cinnamomum verum* J. Presl.). Among the evaluated treatments, GA₃ at 250 ppm proved to

be the most effective, recording the earliest commencement of germination, minimum days to 50 per cent germination, highest germination percentage, highest rate of germination and maximum shoot length at all stages of growth. GA₃ at 175 ppm and thiourea at 1250 ppm were the next best treatments, whereas higher concentra

tions of ethrel were comparatively less effective. Therefore, pre-sowing treatment of cinnamon seeds with GA₃ at 250 ppm for 24 hr is recommended for improving germination, ensuring uniform seedling

establishment and producing vigorous seedlings under nursery conditions.

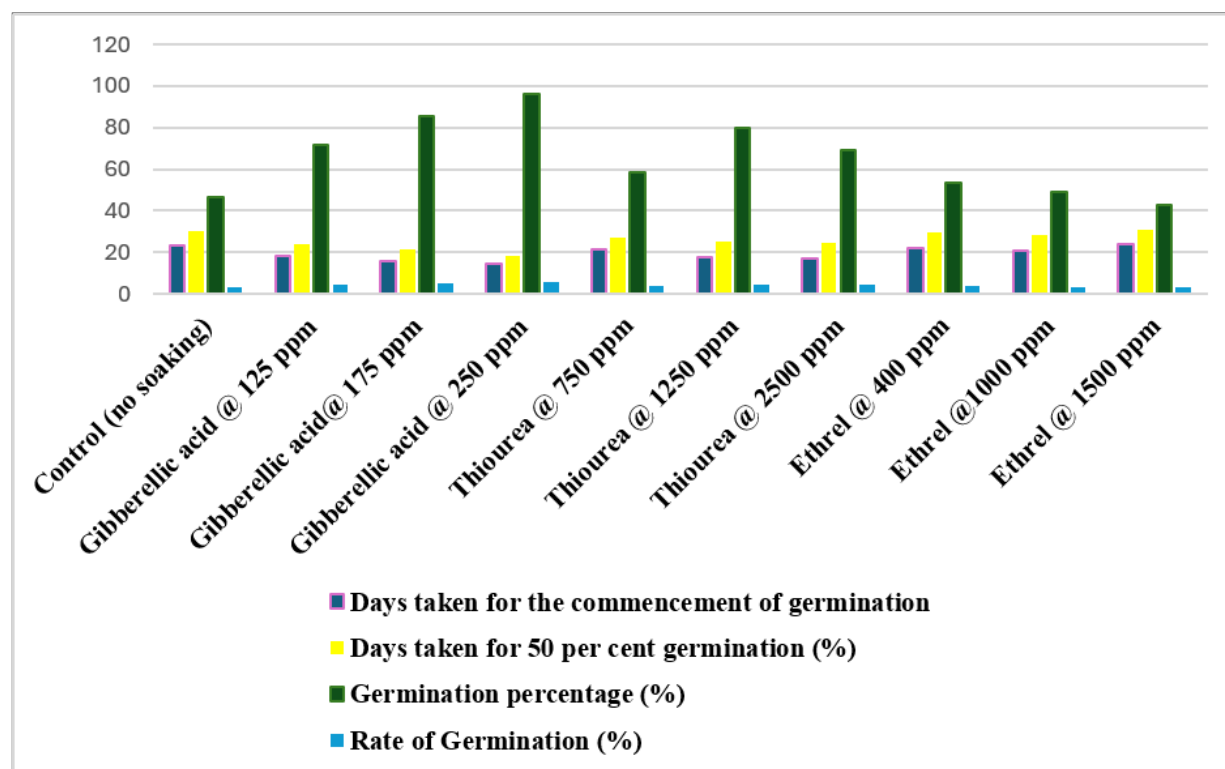


Figure 1. Effect of pre-sowing seed treatments on seed germination parameters of cinnamon (*Cinnamomum verum* J.).

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