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Studies on effect of pre-germination treatments on seed germination and seedling growth in cinnamon

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Abstract
The present investigation entitled on the effect of pre-germination treatments on seed germination and seedling growth in cinnamon was carried out at Horticultural Research Station, Pechiparai during the year 2023. The experiment was conducted in CRD design with nine pre-germination seed treatment and replicate in thrice. Germination and seedling growth parameters at definite intervals were recorded to find out the effect of these pre-treatments on germination of cinnamon. The maximum number of leaves, fresh and dry weight of root, shoot and root length was recorded in treatment using GA3 200 ppm and thiourea 1500 ppm. The minimum level was observed when seeds are treated in control and ethrel with higher concentration of 2000 ppm.

Keywords: Cinnamon, seed germination, ethrel, thiourea, GA3, NAA

Introduction
Cinnamon *Cinnamomum verum* J. Presl is grown across many Asian countries, including Sri Lanka and Southern India. Russia, China and Korea all have historic folk uses for cinnamon. Sri Lanka, which is the top producer and supplier of the finest oil and quill, is where cinnamon is originally from. By the fifth century BC, the plant had made it to Egypt and Europe. It was first grown in India, the Seychelles, Madagascar, Brazil, south-east Asia and other tropical nations after being brought to Java in 1825. It only occurs at the lower elevations of the Tamil Nadu, Kerala, Western Ghats and the lower Western Ghats.

Cinnamon is mostly employed in the aromatherapy industry because of its pleasant smell, which may be put into a variety of meals, scented products and medical products (Huang *et al*. 2007) [11]. The two most significant components of cinnamon are cinnamaldehyde and trans-cinnamaldehyde found in the essential oil and also contributing to its distinctive aroma and many other biological activities (Yeh *et al*. 2013) [35]. The bark of numerous cinnamon species serves as one of the largest and most preferred ingredients utilized globally, not only in traditional but also in contemporary therapies. There are over 250 species belonging to the cinnamon genus, and they are trees situated throughout the world (Sangal, 2011) [24].

Ceylon cinnamon is mostly raised in the intermediate and wet zones of the country. Cinnamon is mostly produced in the districts of Galle, Matara, Kalutara, ratnapura, and hambantota, which together occupy an area of 33,000 ha and produce 24,000 MT of cinnamon annually. Since 2001, output has increased by double, while crop area has increased by 3 %, indicating a yield increase of 42% during the same time period. In terms of production, Indonesia, China, Sri Lanka, and Vietnam control the majority of the world market.

In India, cinnamon is commonly propagated by seeds. It flowers in December- January and the fruit ripens in May-June. According to Nair, (1978) [19], germination typically begins 20 days after seeding and lasts 45 to 50 days. The seed viability in cinnamon is limited, and germination occurs slowly and unevenly. Therefore, it is necessary to promote better, earlier, and quicker germination of seeds in order to grow strong seedlings that will aid for farmers for lowering the maintenance costs and produce stronger crop stands in the field that can fetch early income.

Cinnamon is a robust plant that can withstand a wide range of weather conditions (Bavappa and Ruettimann, 1981) [36]. Wild trees can be found up to 1800 meters above sea level in tropical evergreen rain forests. The crop grows up to 1000m above MSL and does well

between 300 and 350m (Nair, 1978) [19].
It grows well where there is an average yearly rainfall of 1500–2500 mm and a temperature of 27 °C. Cinnamon is best grown in a hot, humid area (Radhakrishnan, 1992) [22].

Materials and methods

The present investigation was carried out at Horticultural Research Station, Pechiparai during the year 2023 in cinnamon. The experimental field is located at Pechiparai in the high rainfall zone encompasses this region and is located within the following coordinates: 76 M MSL, 8026'N, 77019'E.
The experimental design was selected as Completely Randomized Design (CRD). Nine different treatments were imposed including control. The seeds of the experiment were collected from Horticultural Research Station, Pechiparai. Fully ripened fruits were taken from four year old cinnamon tree. Healthy seeds were selected and immersed in water, the pulp removed and then dried in shade. Ten seeds were used for each treatment which was replicated at three times. The treatments are as follows T_1- Soaking in GA3 100 ppm, T_2- Soaking in GA3 200 ppm, T_3- Soaking in Thiourea 1500 ppm, T_4- Soaking in Thiourea 2000 ppm, T_5- Soaking in Ethrel 1000 ppm, T_6- Soaking in Ethrel 2000 ppm, T_7- Soaking in NAA 200 ppm, T_8- Soaking in NAA 300 ppm, T_9- Control. After imposing the treatment, the seeds were soaked for 24 h and then shade dried for 10 minutes and were sown in polybags. The polythene bags were watered daily till final data were observed. Observation were recorded daily on germination parameters and seedling growth parameters like shoot length, root length, number of leaves, fresh and dry weight of shoot and root the seeds kept in hot air oven at 60◦C till constant weight to obtain and seed vigour index for up to 95 days after sowing. A completely randomized design (CRD) was used to average the data from the five labelled seedlings in each treatment and determine the significance of the differences between the treatments using the "F" test (Sundararaj *et al*., 1972) [29]. Based on the following computations, the rate of germination and seedling vigour were calculated (Bewley and Black, 1982) [3].

Formula for Rate of germination

$$C = \frac{Gn}{Gn \text{ X } Dn} X\ 100$$

Formula for Vigour index

Vigour index (cm): Percent germination x mean length [root (cm) + shoot (cm)]

Vigour index (g): Percent germination x mean dry weight [dry root (g) + dry shoot (g)]

Results and discussions Seed germination

Effect of pre-germination seed treatments on germination percentage, days taken for germination, rate of germination (Table 1).

Days of Germination of seeds

Germination was significantly influenced by different treatments. The highest germination was recorded in seeds treated with GA3 at 200 ppm (89.3%) followed by thiourea at 1500 ppm (75.7%). Application of thiourea, at 200 ppm (71.6%) on par with ethrel at 1000 ppm (70.7%) had similar effects, while the lowest germination (61.7%) was recorded in control.
The germination in neither GA3 200 ppm and thiourea 1500 ppm treated seeds became the highest recording 89.3% as against 61.7% in control. Gibberellins have been employed extensively to break the dormancy of seeds with underdeveloped embryos or seeds lacking in growth-promoting agents, particularly gibberellic acid. The treated seed coats do not physically change, yet the dormancy was reduced. This suggests that the GA3 therapy may cause the chemical inhibitors to be dissolved. The findings of the current research are consistent with those of (Shanmugavelu, 1970) [27], who while working with 15 different tree species, elucidated the function of GA in breaking the dormancy. Similarly, gibberellins were also employed to break dormancy in a number of horticultural crops *viz*., (Knox and Smith, 1981) [13] pecan, Malta orange (Misra *et al*. 1982) [41], (Hore and Sen, 1995) [10] bael, (Palanisamy and Ramamoorthy,1987) [20] papaya, (Ghosh and Sen, 1988) [8] ber, (Singh *et al*. 2002) [28], (Babu *et al*. 2008) [7] papaya, (Prajapati *et al*. 2014) [21] jackfruit.
The treatments differed drastically with regard to the rate of germination. Within the treatments, gibberellic acid increased the rate of germination seeds compared to the other treatments. Application of gibberellic acid at 200 ppm recorded the highest rate of germination
(6.34 %) followed by thiourea at 1500 ppm (5.13%). Seeds treated with ethrel at 1000 ppm and NAA at 200 ppm recorded a higher rate of germination (3.85% and 3.44%). Ethrel at 2000 ppm (2.6%) and control (1.36%) had the lowest rate of germination.
The highest rate of germination was maximum in seedlings treated with GA3 at 200 ppm (6.34 %). This is consistent with the findings (Rodriguez, 1985), who used *Psidium guajava* seeds and discovered that GA3 enhanced both the germination rate and the percentage. The similar results were found in *Citrus aurantifolia* (Shant and Rao, 1973) and peach (Hundal and Khajuria, 1979) [12].

Table 1: Effect of pre-germination seed treatments on germination percentage, days taken for germination, rate of germination.

Treatments		Days taken for germination	Germination percentage	Rate of germination
T_1	Soaking in GA3 100 ppm	13.7	92.0	5.27
T_2	Soaking in GA3 200 ppm	14.0	95.9	4.85
T_3	Soaking in Thiourea 1500 ppm	16.9	96.0	4.51
T_4	Soaking in Thiourea 2000 ppm	17.3	95.0	4.78
T_5	Soaking in Ethrel 1000ppm	19.2	92.0	3.77
T_6	Soaking in Ethrel 2000 ppm	23.2	84.0	3.24
T_7	Soaking in NAA 200 ppm	18.2	90.0	3.93
T_8	Soaking in NAA 300 ppm	20.2	87.0	3.74
T_9	Control	22.5	80.0	3.56

F Test	**	**	**
SE.d ±	0.33	1.69	0.08
CD at 5%	0.70	3.55	0.18

**Significant

Seedling growth

Effect of pre-germination seed treatments on number of leaves, shoot length, root length, fresh weight, dry weight, vigour index (Table 2).

Number of Leaves

Some of the various treatments, Gibberellic acid showed exceptionally good efficiency with regard to number of leaves by taking up the initial place whenever GA3 was applied at 200 ppm (5.80 no.) followed by application of thiourea at 1500 ppm (4.65 no.). In the instance of seeds subjected to ethrel, NAA, there was a decline in the number of leaves as the dosage raised. The control (2.9 no.) and ethrel at 2000 ppm (3.2 no.) had recorded the fewest number of leaves in accordance with the data. The total number of leaves was maximum using GA3 at 200 ppm. The increased number of leaves may be the consequence of the plant's physiological processes being more active and the action of GA3, which speeds up the formation of new leaves. This outcome is consistent with findings of (Misra *et al*. 1982) [41] and (Krishnan and Kulashekaran, 1984) [14]. Another possible explanation for this outcome is that GA3 in the apical meristem results in more nucleoprotein systems that increase leaf initiation and expansion (Simao *et al*. 1960) [37]. The above outcomes are similar with (Brijwal and Kumar, 2013) [4], (Kalyani and Bharad, 2017) [15] and (Urvashi *et al*. 2020) [38] in guava, Khirni (Bajaniya *et al*. 2018), acid lime (Meshram *et al*. 2015) [16], Indian gooseberry (Rinku *et al*. 2019) [39].

Shoot Length

The highest shoot length was produced by GA3 application at 200 ppm (15.37 cm), followed by thiourea application at 1500 ppm (13.20 cm). In the instance of gibberellic acid, a definite pattern was seen whereby an increase in GA3 concentrations led to an increase in shoot length. The next better formulation for maximum shoot length were observed using ethrel 1000 ppm and NAA at 200 ppm (11.05 cm and 10.25 cm), respectively. The least shoot length was observed in ethrel at 2000 ppm (8.91 cm) followed by control (7.33 cm).

There was a crucial increase in plant height in seedlings of seeds treated using GA3, at 200 ppm followed by thiourea at 1500 ppm. This increase in shoot length might have been due to gibberellin-induced enhanced cell division and cell elongation, early germination (as in the case of thiourea), and improved seedling vigor. Also, seedlings in these treatments had developed a better root system with regards to its length and number providing an efficient utilization of water and minerals and therefore a better seedling growth. GA3 soaking treatment on seeds may be associated with cell multiplication and expansion in the internodal cambium tissue, because GA3 seemingly activates metabolic reactions or nullifies the impact of a growth inhibitor. The similar results were observed in guava (Singh *et al*. 1989) [33] observed an increased shoot length and (Brijwal and Kumar, 2013) [4], Khirni (Ratna *et al*. 2018) [40], aonla (Barathkumar, 2019) [41].

Root Length

The application of thiourea at 1500 ppm produced the maximum root length (14.73 cm), followed by GA3 200 ppm (13.71 cm). The treatment with ethrel at 1000 ppm recorded significantly the root length (12.97 cm), which was on par with thiourea at 2000 ppm (12.54 cm). The lowest root length was recorded in seedlings treated with ethrel 2000 ppm (9.44 cm) which was on par with control (9.12 cm).

Thiourea 1500 ppm has influence growth and length of root. Utilization of thiourea at 1500 ppm reported the maximum root length. These results are consistent with those of (Krishnan and Kulashekaran, 1984) [14] in *Zizyphus rotundifolia*.

Gibberellins that can influenced the growth and length of roots in cinnamon seeds. Application of GA3 at 200 ppm recorded the maximum root length. This may due to gibberellic acid, results in fast cell elongation and increased root length. According to (Vachhani *et al*.2014), the rapid shoot growth in terms of leaf area and number of leaves with subsequent increase in generation of photosynthates and their transportation through phloem to the root zone, which in term contributed to the lengthening of the roots.

Fresh and dry weight of shoots

The various treatments differed significantly with regard to their influence on fresh weight of root. The various treatments differed significantly with regard to their influence on fresh weight of shoot. The maximum fresh weight of shoot was recorded in thiourea treated seeds at 1500 ppm (0.644 g) followed by GA3 at 200 ppm has fresh weight of shoot (0.603 g). Seeds treated with NAA 200 ppm recorded (0.466 g) fresh weight of shoot whereas at 300 ppm it showed least value (0.441 g). The seeds soaked in water recorded least fresh weight compared to all other treatment (0.402 g).

The various treatments differed significantly with regard to their influence on dry weight of shoot. The maximum dry weight of shoot was recorded in thiourea treated seeds at 1500 ppm (0.376 g) followed by GA3 at 200 ppm has dry weight of shoot (0.332 g). Seeds treated with NAA 200 ppm recorded dry weight of shoot (0.193 g) whereas at 300 ppm it showed least dry weight (0.174 g). The seeds soaked in water recorded least dry weight compared to all other treatment (0.149 g).

Fresh and dry weight of shoot was found to be maximum in seeds treated with thiourea at 1500 ppm. Seeds treated with gibberellic acid also resulted in seedlings with increased fresh and dry weights. The highest fresh and dry weights were obtained when GA3 was applied at 200 ppm. (Shant and Rao, 1973) observed that the increase in fresh and dry weight of shoot in *Citrus aurantifolia* as a result of using GA3 treatment. The similar findings are conformity to those reported by (Kalalbandi, 2002), (Choudhari and Chakrawar, 1981) [6].

Fresh and dry weight of roots

The various treatments differed significantly with regard to their influence on fresh weight of shoot. The various treatments differed significantly with regard to their influence on fresh weight of root. The maximum fresh weight of root was recorded in thiourea treated seeds at 1500 ppm (0.742 g) followed by GA3 at 200 ppm with fresh weight of root (0.646

g). Seeds treated with NAA 200 ppm recorded (0.557 g) fresh weight of root whereas at 300 ppm it showed least value (0.474 g). The seeds soaked in water recorded least fresh weight compared to all other treatment (0.423 g).

The various treatments differed significantly with regard to their influence on dry weight of root. The maximum dry weight of root was recorded in thiourea treated seeds at 1500 ppm (0.145 g) followed by GA3 at 200 ppm with dry weight of root (0.136 g). Seeds treated with NAA 200 ppm recorded dry weight of root (0.115 g) whereas at 300 ppm it showed least (0.103 g). The seeds soaked in water recorded least dry weight compared to all other treatment (0.078 g).

With respect to fresh and dry weight of roots, thiourea at 2000 ppm was the best treatment. As in the case of shoot weight, the increase in the fresh and dry weight of roots may also be due to robust root growth brought about by the optimum thiourea concentrations.

Among the GA3 treatments, Gibberellic acid at 200 ppm recorded the maximum fresh and dry weight of roots. This may be explained by the disappearance of ABA caused by GA3 treatment, as well as the mobilization of stored reserves and a weakening of the mechanical resistance of the endosperm cells around the radical tip, both of which led to an increase in seedling growth and seedling fresh weight (Gulzar *et al*. 2001) [9]. Additionally, gibberellic acid is crucial for cell elongation and multiplication in the shoot and root area, which increases the length of the shoot and root and, in turn, increases its weight. The similar findings on Indian gooseberry seedlings (Rinku *et al*. 2019) [39], khirni (Kalyani, 2013), (Urvashi *et al*. 2020) [38], (Ratna *et al*. 2018) [40], papaya (Ramteke, 2015), and tamarind (Manoli *et al*. 2018) are all in strong accord with the conclusions of this work.

Table 2: Effect of pre-germination seed treatments on number of leaves, shoot length, root length, fresh weight of root and shoot, dry weight of root and shoot.

Treatments	Number of leaves	Shoot length (cm)	Root length (cm)	Fresh weight of shoot (g)	Dry weight of shoot (g)	Fresh weight of root (g)	Dry weight of root (g)
T_1	4.11	11.23	11.29	0.515	0.230	0.542	0.119
T_2	5.80	15.37	13.71	0.603	0.332	0.646	0.136
T_3	4.65	13.20	14.73	0.644	0.376	0.742	0.145
T_4	3.53	8.97	12.24	0.564	0.270	0.452	0.128
T_5	3.85	11.05	12.97	0.487	0.194	0.440	0.101
T_6	3.23	8.91	9.44	0.413	0.153	0.464	0.084
T_7	3.70	10.25	10.56	0.466	0.193	0.557	0.115
T_8	3.34	9.70	10.87	0.441	0.174	0.474	0.103
T_9	2.97	7.33	9.12	0.402	0.149	0.423	0.078
F Test	**	**	**	**	**	**	**
SE.d ±	0.18	0.75	0.46	0.02	0.02	0.04	0.00
CD at 5%	0.37	1.58	0.97	0.03	0.04	0.09	0.01

**significant

Vigour index

Significant differences were observed with regard to vigour of seedling (cm) among the different treatments. Thiourea at 1500 ppm recorded the maximum vigour (2609.2 cm) which was followed by GA at 200 ppm (2541.9 cm) and GA3 at 100 ppm (2203.4 cm). The seeds were soaked in water has been recorded (1468 cm) in which vigour was least. In reverence of vigour was observed in the dry matter of seedlings (g) also; all the treatments varied drastically. Application of thiourea at 1500 ppm showed the highest vigour (46.17 g) which was followed by 2000 ppm (39.11 g). In instance of GA application of 200 ppm observed the highest vigour (38.49 g) over the other levels. Ethrel 2000 ppm (19.90 g), which was comparable to control g) had the least value. Effect of pre-germination seed treatments on seed vigour index the values are given below (Table 3).

The quality of seedling was measured by two parameters vigour index (cm) and vigour index (g). The optimum level with respect to vigour index (cm) was found to be in seeds treated with thiourea 1500 ppm which was followed by GA3 200 ppm. This result is in conformity with the observations of (Singh *et al*. 1984) [34] in *Tephrosia purpurea* and *Abrus precatorius* who recorded better seedling vigour by the application of GA3 at 100 to 200 ppm and (Begum *et al*. 1988) in papaya. This could be because of GA3 therapy, which was linked to bigger embryos, faster metabolic activity and respiration rates, better metabolite mobilization to growth sites, and increased enzyme activity, all of which contribute to longer roots. These findings were also observed by (Parmar *et al.* 2016) [44] custard apple, (Vasantha *et al.* 2014) [31] and (Sharma, 2016) [42] tamarind. With respect to vigour index (g) thiourea at 1500 ppm recorded the maximum which was followed by thiourea at 2000 ppm. In instance of gibberellic acid of 200 ppm observed higher vigour (35.63) over the other levels. The enzymatic and hormonal mechanisms promote metabolic processes such as protein hydrolysis, sugar mobilization, and oxidation, which increases seed dry weight and seed vigour. Similar observation was reported by (S MK, 2017) [18] aonla and (Bamaniya 2017) [43] Khirni.

Table 3: Effect of pre-germination seed treatments on seed vigour index

Treatments	Vigour index (cm)	Vigour index (g)
T_1	1936.72	30.01
T_2	2598.00	41.80
T_3	2114.58	39.44
T_4	1669.19	28.52
T_5	1551.37	20.85
T_6	1186.69	15.32
T_7	1428.60	21.14
T_8	1357.62	18.28
T_9	1016.11	14.02
F Test	**	**
SE.d ±	36.52	0.59
CD at 5%	76.73	1.23

**significant

Conclusion

From the present investigation, it may be concluded that increase in germination percentage was recorded using GA3

200 ppm and thiourea 1500 ppm in cinnamon seeds. The maximum number of leaves, fresh and dry weight of root, shoot and root length was also recorded in treatment using GA3 200 ppm and thiourea 1500 ppm. The minimum level was observed when seeds are treated in control and ethrel with higher concentration of 2000 ppm.

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