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Changes in Teak Germination and Seedling Growth Induced by Pre-Sowing Seed Treatment with Electromagnetic Field and Microwave Radiation

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The effect of teak (*Tectona grandis* Linn. f) drupes treatment with electromagnetic field and microwave radiation on germination and seedling growth were studied.
Study Design: Completely randomized block design.
Place and Duration of Study: Division of Seed Science and Technology, Central Institute for Cotton Research, Coimbatore, Tamil Nadu and Seed Science and Technology laboratory, Anbil Dharmalingam Agricultural College and Research Institute, TNAU, Tiruchirappalli, Tamil Nadu.
Methodology: Teak drupes have been exposed to the electromagnetic field of 750^{nt} 5 hrs. per day for 15 days, 1500^{nt} 5 hrs. per day for 15 days and 750 + 1500^{nt} each 5 hrs. per day for 15 days and microwave radiation of 2450 MHz for 10, 20, 30, 40, 50 and 60 sec. The treated and control drupes were placed for germination in the sand filled earthen pots.

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Results: At 28 days after sowing the results revealed that electromagnetic treatment 1500^{nt} 5 hrs. per day for 15 days recorded highest germination of 28.4 %, number of seedlings/100 drupes (32), minimum days required for initial emergence (13 days), root length of 8.3 cm, shoot length of 7.1 cm, dry matter production (49 mg) and vigour index (437). Microwave radiation of 2450 MHz for 30 sec recorded highest germination of 25.2 %, number of seedlings/100 drupes (30), minimum days required for initial emergence (12 days), root length of 8.5 cm, dry matter production (47 mg) and vigour index (373).

Conclusion: It is concluded that, electromagnetic field and microwave radiation treatments may be considered as an alternative method to enhance germination of fresh teak drupes.

Keywords: Teak drupes; pre-sowing seed treatments; germination; vigour index.

1. INTRODUCTION

Teak (*Tectona grandis* L.) is timber producing deciduous tree belonging to family Verbenaceae. It is widely cultivated tropical timber tree in the Asian, African and American continents and many pacific and Atlantic islands. Natural teak forest cover about 29million ha and planted teak covers 4.35 – 6. 89 million ha [1]. Teak seed germination is inhibited by seed emptiness, fewer viable seeds, seed dormancy, and other factors [2]. Many authors had worked on different pre-sowing seed treatments to break dormancy and improve germination in teak [3-7]. Difficulties for establishing large scale plantations of teak because of poor and protracted germination. The nature of barriers which prevent germination in teak drupes can be physiological (presence of germination inhibitors in felty mesocarp and true seed), physical (thick and hard endocarp) and morphological (immature embryo in true seeds) which results in low germination [8]. This delayed and irregular germination of seeds in the nursery is a serious constraint for teak for efficient nursery management and plantation establishment. Therefore, it is essential to determine pre-sowing treatments to ensure early and successful germination in teak.

Pre-sowing seed treatment by electromagnetic fields (EMF) is recognized as an innovative tool for seed germination enhancement and early seedling growth [9-11]. Moreover, it has been reported that the pre-sowing application of electromagnetic field may have positive effects on germination and growth rate that it can be very important for the seeds having low germination capacity. Several studies have reported the positive effects of electromagnetic fields on seed germination. For instance, magnetic field applied to tree seeds was found to increase the rate of germination and the subsequent seedling growth of Sessile oak [12], *Pinus brutia* [13], Red oak [14], Scots pine [15], Norway spruce [16], Smirnov's rhododendron and Black mulberry [17] Oriental beech [18] and *Quercus suber* [19].

Microwave radiation has a positive effect in accelerating seed germination [20-22]. However, regardless of the data concerning the effect of microwaves on plants that have been obtained, little is known as to whether pretreatment of seeds with microwave causes a change in the inner energy of seeds, stimulating enzyme activities, leading to an improvement of the metabolism, and enhancing the intensity of biophoton emission, which is regarded as an index of cell metabolism [23,24]. Microwave radiation at 2450 MHz leads to a significant increase in germination and reduction in germination time for seeds of *Douglas Fir* [25], while similar effects with several types of pine and spruce seeds [26]. Thus, the aim of this study is to determine the effects of electromagnetic field and microwave radiation on the germination and seedling vigour of fresh teak drupes.

2. MATERIALS AND METHODS

2.1 Seed Collection

The experiment was conducted at the Anbil Dharmalingam Agricultural College and Research Institute, TNAU, Tiruchirappalli, Tamil Nadu, during January 2022. Teak drupes (fruit with seeds) were collected from 10 randomly selected plus trees in the top slip seed production area (74^{0}34'E 15^{0}07'N 750 m MSL) and bulked. The bulked drupes were properly dried and cleaned by removing shriveled and insect-damaged drupes. Finally, 9 mm – 12 mm size drupes alone were used as study materials in this experiment.

2.2 Electromagnetic Field

The teak drupes with 10% moisture content were packed in 300 gauge polythene bag and seed samples were exposed under pulsed electromagnetic field for the following field strength and duration with four replications in Biotron devices at division of Seed Science and Technology, Central Institute for Cotton Research, Coimbatore, Tamil Nadu. The drupes were subjected to electromagnetic seed treatment control - T_1, electromagnetic field 750^{nt} 5 hrs. per day for 15 days - T_2, electromagnetic field 1500^{nt} 5 hrs. per day for 15 days- T_3 and electromagnetic field 750 + 1500^{nt} each 5 hrs. per day for 15 days- $T_{4.}$ Drupes without magnetic wavelength exposure were treated as control.

2.3 Microwave Radiation

Teak drupes were exposed to microwave radiation for the following radiation and duration at Seed Science and Technology laboratory, Anbil Dharmalingam Agricultural College and Research Institute, Tiruchirappalli, Tamil Nadu and microwave radiationcontrol - T_1, microwave radiation of 2450 MHz for 10 sec -T_2, microwave radiation of 2450 MHz for 20 sec - T_3, microwave radiation of 2450 MHz for 30 sec - T_4, microwave radiation of 2450 MHz for 40 sec - T_5, microwave radiation of 2450 MHz for 50 sec - T_6 and microwave radiation of 2450 MHz for 60 sec - T_7. Drupes without microwave treatment were treated as control.

The treated (electromagnetic and microwave) (Plate 1) drupes were placed for germination in sand taken in earthen pots (30 cm height and 30 cm upper width) and kept in open sunlight [27]. The experiment was conducted in a completely randomized block design and 10 replications of 30 drupes were used. Percent germination, number of seedlings/100 drupes, time taken for initial emergence, root length (cm), shoot length (cm), dry matter production (mg/seedlings^{-1}) and vigour index were recorded 28 days after sowing [28]. The vigour index were calculated [29] based on the following formula:

Vigour Index = Percent germination X Total seedling length (cm)

2.4 Statistical Analysis

The results were subjected to analysis of variance and tested (t test) for significant differences (p=0.05) as suggested [30]. Percentage values were transformed into arc sine values before statistical analysis.

3. RESULTS AND DISCUSSION

3.1 Electromagnetic Field

The pre-sowing treatments followed in this experiment tended to significantly (0.05%) influence germination, number of seedlings/100 drupes, and seedling emergence. The results revealed that electromagnetic treatment 1500^{nt} 5 hrs. per day for 15 days recorded highest germination of 28.4 percent, number of seedlings/100 drupes (32), minimum days required for initial emergence (13 days), root length of 8.3 cm, shoot length of 7.1 cm, dry matter production (49 mg) and vigour index (437) followed by all other treatment. Control had recorded only 16.5 percent germination (Table 1).

A B

Plate 1. Electromagnetic field (A) and microwave radiation (B) treatment

Table 1. Effect of electromagnetic seed treatments on germination and seedling vigour of fresh teak drupes (28 Days after sowing)

Treatments	Germination (%)	Number of seedlings/ 100 drupes	Days taken for initial emergence	Root length (cm)	Shoot length (cm)	Dry matter production (mg/ seedlings)	Vigour index
T_1 – Control	16.5 (23.5)	19	15	6.1	5.2	39	186
T_2 – Electromagnetic 750 ^{nt} 5 hrs. per day for 15 days	22.3 (27.9)	27	14	7.5	6.3	45	308
T_3 – Electromagnetic 1500 ^{nt} 5 hrs. per day for 15 days	28.4 (31.9)	32	13	8.3	7.1	49	437
T_4 – Electromagnetic 750 + 1500 ^{nt} each 5 hrs. per day for 15 days	26.3 (30.6)	31	14	7.8	6.9	43	387
Mean	23.4 (28.6)	27.2	14.0	7.4	6.3	44.0	330
SEd	0.2724	0.3442	0.2309	0.1246	0.1074	0.7797	5.0179
CD (P=0.05%)	0.5936	0.7500	0.5032	0.2714	0.2340	1.6989	10.9332

(Figures in parentheses indicate arc sine value)

Table 2. Effect of microwave treatments on germination and seedling vigour of fresh teak drupes (28 Days after sowing)

Treatments	Germination (%)	Number of seedlings/ 100 drupes	Days taken for initial emergence	Root length (cm)	Shoot length (cm)	Dry matter production (mg/seedlings)	Vigour index
T_1 – Control	16.5 (23.5)	19	15	6.1	5.2	39	186
T_2 – Microwave radiation of 2450 MHz for 10 sec.	18.5 (25.1)	21	13	6.0	5.8	38	218
T_3 – Microwave radiation of 2450 MHz for 20 sec.	21.3 (27.2)	22	13	6.3	6.2	43	266
T_4 – Microwave radiation of 2450 MHz for 30 sec.	25.2 (30.0)	30	12	8.5	6.3	47	373
T_5 – Microwave radiation of 2450 MHz for 40 sec.	23.5 (28.6)	27	13	7.2	6.5	45	322
T_6 – Microwave radiation of 2450 MHz for 50 sec.	23.0 (28.6)	26	14	7.8	6.2	43	322
T_7 – Microwave radiation of 2450 MHz for 60 sec.	22.1 (27.9)	25	13	6.9	6.0	44	285
Mean	21.4	24.2	13.2	6.9	6.0	42.7	282
SEd	0.255	0.336	0.133	0.090	0.078	0.619	4.764
CD (P=0.05%)	0.531	0.699	0.277	0.188	0.162	1.288	9.908

(Figures in parentheses indicate arc sine value)

Accordingly, magnetic field treatments applied in this study provided a superiority for the germination of the teak drupes having germination obstacle. Changes occurred in alpha amylase, beta amylase and glutation S-transferase enzymes playing important role in germination of wheat seeds exposed to magnetic field and in satisfying the nutrition requirements of the seeds during germination [31]. Magnetic field leads to certain changes in the intensities of ionic current passing through cell membrane. This interaction leads to osmotic pressure and the cells' capacity of water absorption. Magnetic field affects the ionic current intensity, membrane permeability, ionic concentration at both sides of the membrane, osmotic pressure, and water intake of the seeds. The increase in water intake of the seeds due to magnetic field implementation is explained with increase of the germination rate of the seeds exposed to fixed magnetic field [32]. On the other hand, magnetic treatment could stimulate cell division and cell lengthening, thus increasing the growth of the hypocotyl and root length [33]. Nevertheless, a plethora of reports on magnetic field to increase germination in agricultural crops mung beans [34], chickpea [35], wheat and bean [36], wheat [37], lentil [38], pepper [39], wheat [40], soybean [41] and cumin [42]. Also, enhanced germination of tree seeds of *Albizia procera* and *Leucaena leucocephala* [43], beech [18] and Anatolian pine [44] with magnetic field.

3.2 Microwave Radiation

The results revealed that the significant difference was found among the treatments. Microwave radiation of 2450 MHz for 30 sec. recorded highest germination of 25.2 percent, number of seedlings/100 drupes (30), minimum days required for initial emergence (12 days), root length of 8.5 cm, dry matter production (47 mg) and vigour index (373) followed by all other treatment. Control had recorded only 16.5 percent germination (Table 2) and (Fig 1).

The effects of various exposure times on seed germination, decrease in seed germination is observed in all seed samples with increase in exposure time. Similar trend was obtained in *Acacia spp* [45]. In case of wheat, green gram and bengal gram decrease in trend was observed for vegetative growth and chemical constituents observed with increase in exposure time as compare to control [46]. Magnetic fields on germination of mung bean plants indicated that magnetic field exposure time increases had a lowering the germination percentage [34]. Seeds are subjected to microwave radiation. the microwaves first pass through the cell wall and later are absorbed by the water molecules in the seed. As a result, tissues containing water heat significantly, and cytoplasm collapses the cell wall and leaks out. Furthermore, due to excessive heating, proteins in the seed may denature and lose functionality. Therefore, it is believed that certain seeds subjected to microwave energy were deformed and had a lower germination percentage compared to the control group [47]. In the case of radish seedlings, microwave may reduce the water passage across the cell membrane, closing the aquaporins and causing a reduction of growth in a turgor dependent manner. The increase of growth rate upon irradiation removal was seen during the elongation growth and the cell can partially repair damages occurred at the membrane level [48] (Scialabba and Melati, 1995). It needs in depth study required for electromagnetic field and microwave radiation on dormancy releasing and enhancement of germination and seedling vigour of different age group of teak drupes.

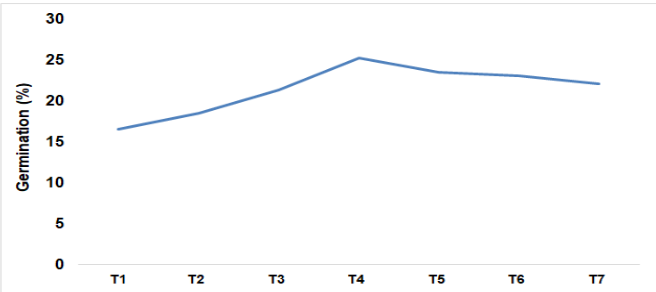

Fig. 1. Effect of microwave radiation on germination of teak

T_1 – Control; T_2 – Microwave radiation of 2450 MHz for 10 sec; T_3 – Microwave radiation of 2450 MHz for 20 sec; T_4 – Microwave radiation of 2450 MHz for 30 sec; T_5 – Microwave radiation of 2450 MHz for 40 sec; T_6 – Microwave radiation of 2450 MHz for 50 sec; T_7 – Microwave radiation of 2450 MHz for 60 sec

4. CONCLUSION

In conclusion, the germination percentage of teak drupes treated with electromagnetic field treatments 1500^{nt} 5 hrs. per day for 15 days were significantly increased 28.4% compared with untreated drupes (16.5%). On the other hand, microwave radiation of 2450 MHz for 30 sec had higher germination of 25.3%. Our results suggest that electromagnetic field and microwave radiation treatments could be used as a physical pre-sowing seed treatment to improve the germination and seedling vigour of fresh teak drupes.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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