Original Research Article

Effect of watering schedules on seed germination of two major agroforestry species *Dalbergia sissoo* and *Gmelina arborea*

ABSTRACT

Aims: Water is an important natural resource supporting life and growth of plants heavily relies on water availability throughout its life cycle. Moisture stress is a major limiting factor in forest crops leading to unsuccessful seed germination. This study investigates the impact of moisture stress on the seed germination of two important agroforestry species *Dalbergia sissoo* and *Gmelina arborea* through manipulating watering schedules after sowing seeds.
Study design: Two independent experiments for*Dalbergia sissoo* and*Gmelina arborea* were designed in a Completely Randomized Block Design (CRBD) with six treatments and three replications for each treatment
Placeof Study: Faculty of Forestry, Birsa Agricultural University, Ranchi.
Methodology: The complete experiment was carried inside a temporary polyhouse where the experimental materials were exposed to the six different watering schedule treatments.The first irrigation for all the treatments were started at the same time. The data recorded during the experiment were subjected to analysis of variance (ANOVA) for statistical significance and difference among treatments were determined by Duncan's Multiple range test at (*P*=.05) level.
Results: Significant differences were observed among the treatments and the results show that with increasing level of moisture stress, the germination performance in both species is highly reduced both in terms of germination percentage and germination energy.
Conclusion: Daily watering to the seeds can help to achieve maximum and early seed germination as evident from data of germination energy with maximum values recorded for the treatments with daily watering schedule.

Keywords:agroforestry, irrigation, moisture stress, seed germination

1. INTRODUCTION

Seed is the primary input for carrying out afforestation, reforestation and plantation in any area and seed germination plays the most crucial role in determining the success rate of the programme. Temperature and availability of water are two major locality factors which governs the germination of seeds and early seedling growth. Soil water supply is an important determinant environmental factor controlling seed germination percentage [1]. Reduced water potential in soil will lead to delayed seed germination and non-availability of water beyond a certain extent completely prevents seed germination [2]. Without satisfactory seed germination the yield is affected drastically and hence it is considered as the most important phase in plantation forestry [3]. That is why it is very much necessary to study the effect of water stress on germination of a species before plantation to ensure its success. Stimulating artificial water stress under control conditions with different variations is one of the most used techniques to study effect of water stress on seed germination [4], [5].

Dalbergia sissoo Roxb. belongs to the plant family Leguminosae. The genus *Dalbergia* contains around 300 species distributed throughout the tropics and subtropics. The

species produces outstanding quality of timber which fetches high commercial value. Apart from timber, it is used as multipurpose tree which provides fuelwood and charcoal, fodder, green manure, honey and several traditional medicines. This makes this species one of the most widely cultivated and economically important forest trees in Asia. *Dalbergia* also plays a vital role in soil and water conservation and it is an excellent choice for plantation during reclamation of eroded soils. *Gmelina arborea* Roxb. belongs to the family Verbenaceae and commonly known as Gamhar. It is a deciduous tree which grows in best under well drained soils. In recent years, the cultivation of *Gmelina* is flourishing in plantation forestry round the globe due to its fast-growing nature. *Gmelina* is an excellent candidate for agroforestry producing good quality timber especially for paper and pulp industries, fruits and fodder. The species is capable of producing a good yield in a short rotation of only 5 to 6 years, under intensive irrigation and use of fertilizers.

D. sissoo and *G. arborea* can easily be propagated by direct sowing, planting out nursery raised seedlings or stump plantation. However, the availability of nursery seedlings for raising adequate quantities for large-scale plantation or afforestation programmes is still a major hindrance in India. Sufficient and continuous availability of water during early stages of plantation, like germination stage, is one of major limiting factors for successful plantation. Timely irrigation is one of the perfect solutions for establishing these trees as plantation crops. Hence, this study has been taken up to understand the effects of different watering schedules on seed germination performance and other growth parameters of the two major fast- growing agroforestry species under nursery condition.

2. MATERIALS AND METHODS

2.1 Experimental Location:

The experiment was conducted at nursery of Faculty of Forestry, Birsa Agricultural University, Patratu Road, Ranchi. The experimental site is situated at a distance of half km from main building of Birsa Agricultural University with an average altitude of 625m above MSL. The site is almost plain with mild slope towards northern side.

2.2 Experimental material:

The fruits of *Dalbergia sissoo* (pods) and *Gmelina* (drupe) were harvested from the phenotypically superior trees and the respective seeds were extracted. The harvested seeds were then properly sorted, graded and general pre-treatments were given. The seeds were sown in the polybags of size 25cm x 30 cm, filled with a mixture of Sand, Soil and FYM (3:1:1). The complete experiment was carried inside a temporary polyhouse where the polybags were kept and exposed to the six different watering schedule treatments. The first irrigation for all the treatments were started at the same time. The source of watering is provided through sprinklers. The observations were recorded separately for both the species.

2.3 Experimental design:

Two independent experiments E1 (*Dalbergia sissoo*) and E2 (*Gmelina arborea*) were conducted under this study designed in a Completely Randomized Block Design (CRBD) with six treatments and three replications for each treatment (Table 1).

Experiment-1 (E1)

Species*:* *Dalbergia sissoo* (Figure 1)**, Treatments:** T1 to T6

Experiment-2 (E2)

Species: *Gmelina arborea* (Figure 2)**, Treatments:** T1 to T6

Table 1. Details of treatments followed in the study

Treatments	Watering Schedule	Indicating Symbol for *Dalbergia sissoo*	Indicating Symbol for *Gmelina arborea*

T1	Daily Watering	E1T1	E2T1
T2	Watering at every 3 days interval	E1T2	E2T2
T3	Watering at every 6 days interval	E1T3	E2T3
T4	Watering at every 9 days interval	E1T4	E2T4
T5	Watering at every 12 days interval	E1T5	E2T5
T6	Watering at every 15 days interval	E1T6	E2T6

Fig. 1.Seedling emergence *of Gmelina arborea*

Fig. 2.Seedling emergence *of Dalbergia sissoo*

2.4 Experimental parameters:

A. **Commencement of germination after sowing:** The days after which the seeds commenced to germinate after sowing is counted for each experiment.

B. **Completion of germination:** Germination was considered to have completed when the radicles protruded 2 mm from the seed coat. Check for the completion of germination was performed daily for 28 days after sowing (DAS).

C. **Germination percentage:** The germination percentage (GP) for each experiment was calculated with the following formulae:

$$GP = \frac{\text{Total seeds germinated}}{\text{Total seeds sown}} \text{ X } 100$$

D. **Germination energy:** Germination energy is calculated as the total number of seeds germinated up to the day when the rate of germination reached the peak. This parameter is used to calculate the rate and regularity of seed germination at the early stage, which reflects the vitality of the seeds.

Comment [A1]: Where did you inspire?? In literature? Please indicate an author

2.5 Statistical Analysis:

The data recorded during the experiment were subjected to analysis of variance (ANOVA) for statistical significance and difference among treatments were determined by Duncan's Multiple range test at (*P*=.05) level.

3. RESULTS AND DISCUSSIONS

3.1 Experiment-1 (E1):

A. **Commencement of germination after sowing:**
Perusal of data in Table 2 indicates at *P* = .05 [*f* (5, 12) = 3.26, *P* = .04] treatments E1T1, E1T2 and E1T3 are at par with each other and significantly different from treatments E1T4, E1T5 and E1T6 which are also at par with each other (Figure 3).

B. **Completion of germination:** Application of different watering treatments had significant influence on completion of germination of seeds at *P* = .05 [*f* (5, 12) =4.90, *P*=.011]. The statistical analysis (Table 2) revealed that the treatments E1T1 and E1T2 are *at par* with each other and significantly different from the treatments E1T3, E1T4, E1T5 and E1T6 which are also *at par* with each other (Figure 4).

C. **Germination percentage:** The value of germination percentage ranged from 86.06% (E1T1) to 49.87 % (E1T6) for six treatments. The statistical analysis at*P*=.05 [*f* (5, 12) =6.61, *P*=.003] (Table 2) revealed that the treatments E1T1, E1T2 and E1T3 are *at par* with each other. It is also observed that treatments E1T4, E1T5 and E1T6 are also *at par* with each other. It is further observed that treatments E1T1, E1T2, E1T3 are significantly different from the treatments E1T4, E1T5 and E1T6 (Figure 5).

D. **Germination energy**: Impact of moisture stress is significantly noted on the germination energy of *D. sissoo* seed at *P*= .05 for six treatments [*f* (5, 12) =7.68, *P*= .002]. The germination energy is ranged from 47.38 for E1T1 to 7.25 for E1T6. The results obtained from the statistical analysis (Table 2) indicates that the treatments E1T1, E1T2, E1T3 and E1T4 are *at par* with each other. On the other hand, treatments E1T5 and E1T6 are also *at par* with each other. Further observation revealed that treatments E1T1, E1T2, E1T3 and E1T4 significantly different from treatments E1T5 and E1T6 (Figure 6).

Table 2. Results of germination parameters of *Dalbergia sissoo* in Experiment 1

Treatments	No. of days for commencement of germination	No. of days for completion of germination	Germination percentage	Germination energy
E1T1	8	16.00	86.06	47.38
E1T2	8.33	16.33	81.96	45.78
E1T3	8.33	20.00	78.02	43.37
E1T4	9.33	20.67	62.77	40.94
E1T5	9.67	21.33	55.68	33.53
E1T6	10.33	21.67	49.87	31.78
C.D (at 5%)	***1.58***	***3.55***	***18.15***	***7.25***
S.E.(±m)	***0.51***	***1.14***	***5.83***	***2.33***
C.V. (%)	***9.8***	***10.20***	***14.61***	***9.97***

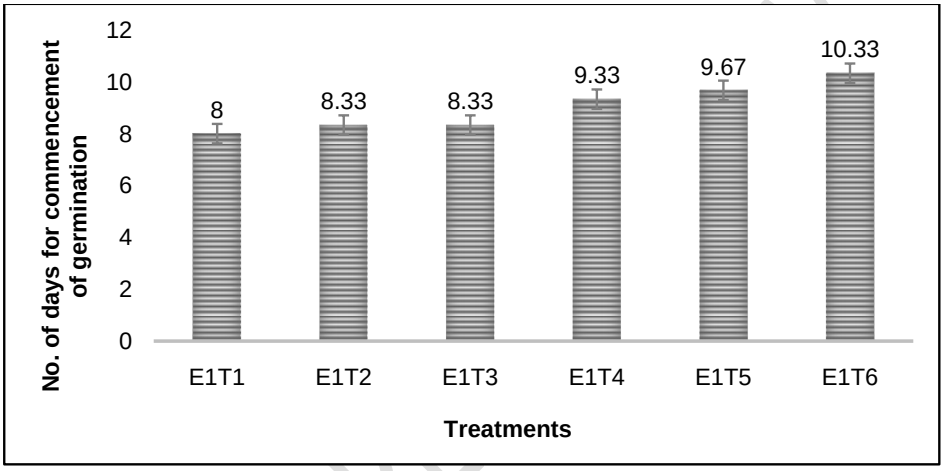

Fig. 3. Effect of different watering schedules on the number of days for commencement of germination in *D. sissoo*

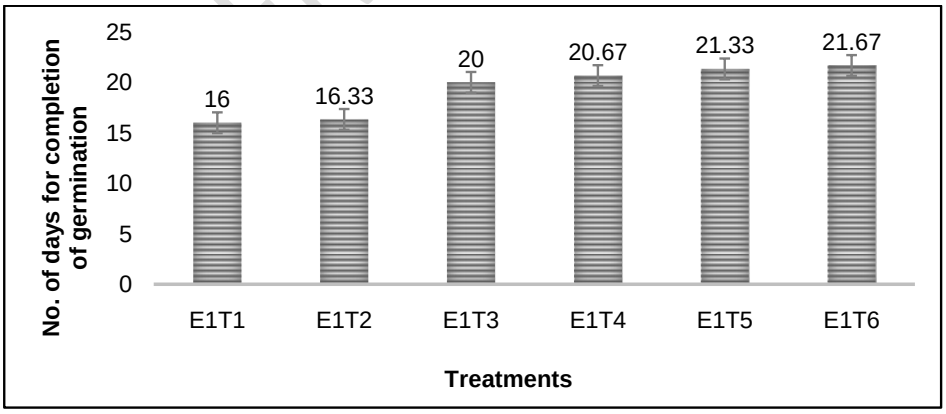

Fig. 4. Effect of different watering schedules on the number of days for completion of germination in *D. sissoo*

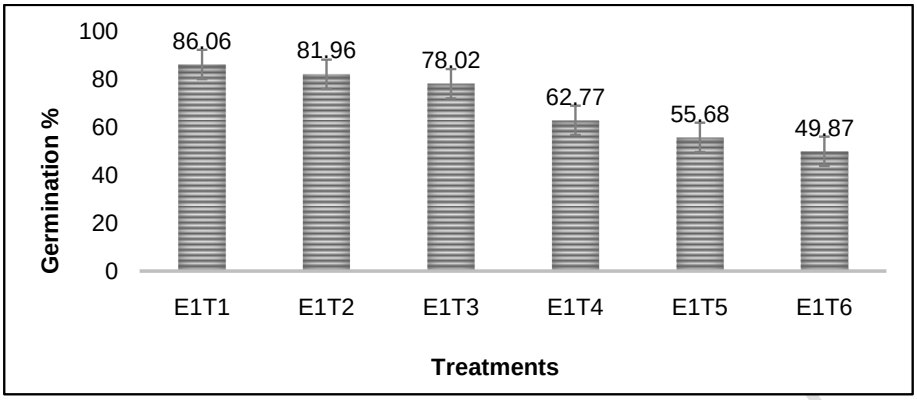

Fig. 5. Effect of different watering schedules on the germination percentage in *D. sissoo*

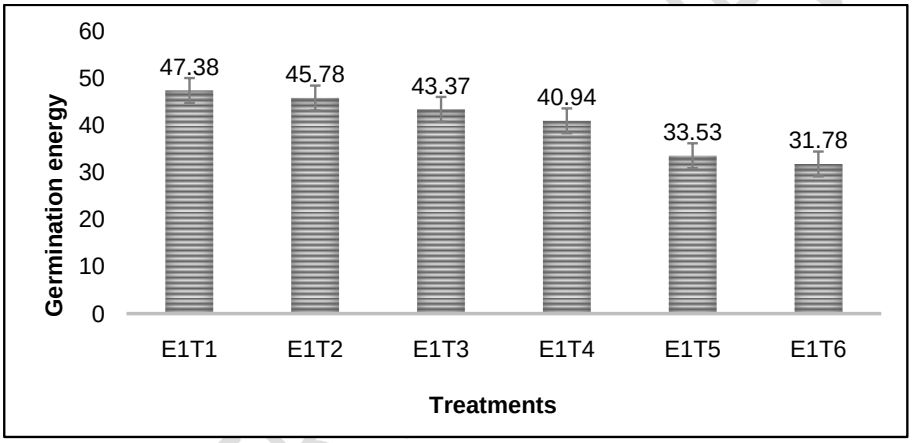

Fig. 6. Effect of different watering schedules on the germination energy in *D. sissoo*

3.2 Experiment-2 (E2):

A. **Commencement of germination after sowing:** Similarly, statistical analysis of the data procured from the experiment carried out on *Gmelina arborea* (Table 3) for commencement of germination of seeds at $P = .05$ [f (5, 12) = 6.28, $P = .004$] revealed that the treatments E2T1, E2T2, E2T3 and E2T4 are *at par* with each other and are statistically significant from the treatments E2T5 and E2T6 (Figure 7).

B. **Completion of germination:** Perusal of data indicated that the application of different watering treatments had significant influence on completion of germination of seeds at $P = .05$ [f (5, 12) =4.49, $P = .015$]. The statistical analysis (Table 3) showed that the treatments E2T1, E2T2, E2T3, and E2T4 are *at par* with each other. It is also observed that treatments E2T5 and E2T6 are also *at par* with each other. It is further observed that the treatments E2T1, E2T2, E2T3, and E2T4 are significantly different from other E2T5 and E2T6 (Figure 8).

C. **Germination percentage:** The germination percentage under the influence of 6 different watering treatments ranged from 73.55 % (E2T1) to 53.13% (E2T6).

The statistical analysis at P = .05 [f (5, 12) =9.45, P=.001] (Table 3) showed that the treatments E2T1, E2T2 and E2T3 are *at par* with each other. It is also observed that treatments E2T4, E2T5 and E2T6 are also *at par* with each other. It is further observed that the treatments E2T1, E2T2 and E2T3 are significantly different from the treatments E2T4, E2T5 and E2T6 (Figure 9).

D. Germination energy: Impact of moisture stress is also significantly noted on the germination energy of *Gmelina arborea*. Germination energy of seeds ranged from 45.78(E2T1) to 7.15 (E2T6) while the statistical analysis results (Table 3) showed the similar trends for six treatments at P = .05 [f (5, 12) =5.75, P = .006] as observed in *Dalbergia sissoo* (Figure 10).

Table 3. Results of germination parameters of *Gmelina arborea* in Experiment 2

Treatments	No. of days for commencement of germination	No. of days for completion of germination	Germination percentage	Germination energy
E2T1	9	16.67	73.55	45.78
E2T2	9.33	17.67	71.89	41.77
E2T3	9.67	18.33	71.40	42.58
E2T4	10.33	18.67	61.14	40.14
E2T5	12	20.67	56.43	33.47
E2T6	13.33	22.00	53.13	31.69
C.D. (at 5%)	***2.12***	***2.91***	***8.95***	***7.15***
S.E.(±m)	***0.68***	***0.93***	***2.87***	***2.3***
C.V. (%)	***11.11***	***8.51***	***7.70***	***10.13***

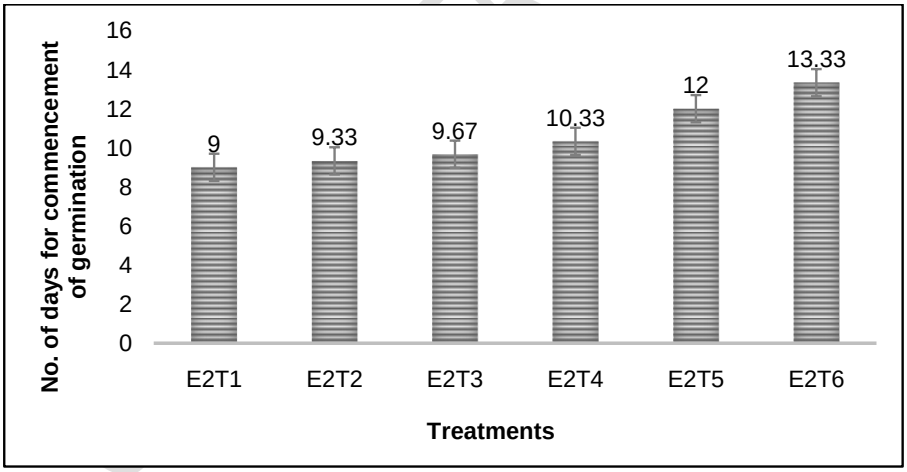

Fig. 7. Effect of different watering schedules on the number of days forcommencement of germination in *G. arborea*

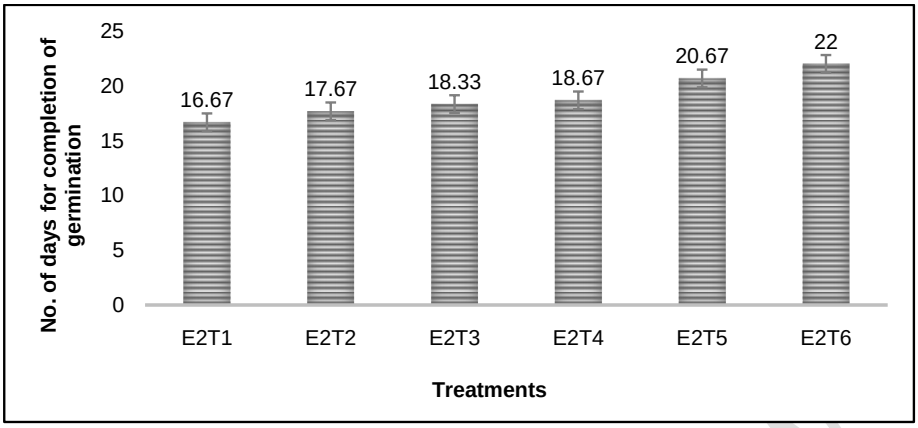

Fig. 8. Effect of different watering schedules on the number of days for completion of germination in *G. arborea*

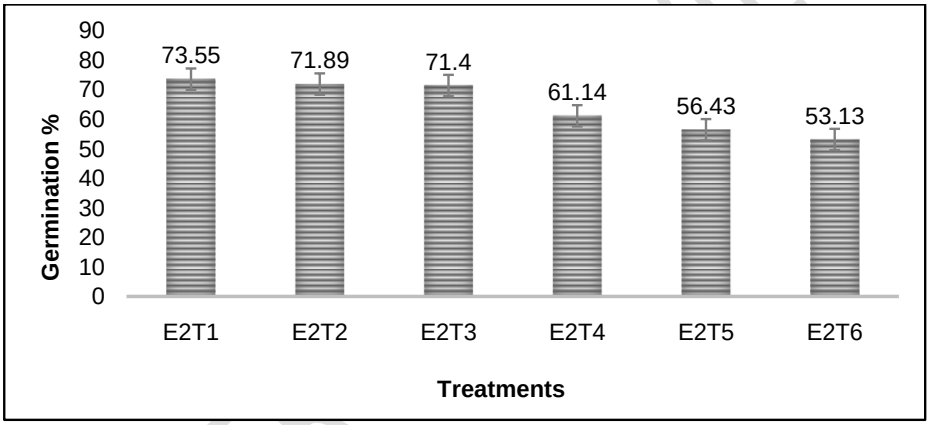

Fig. 9. Effect of different watering schedules on the germination percentage in *G. arborea*

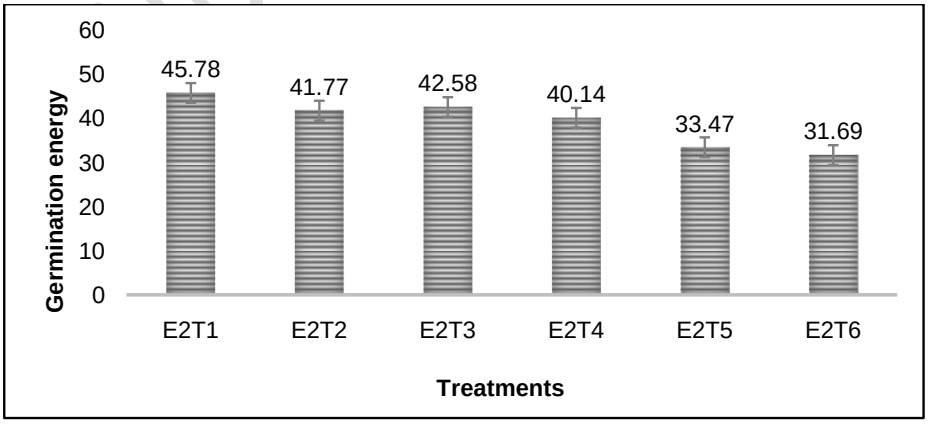

Fig. 10. Effect of different watering schedules on the germination energy in *G. arborea*

The results recorded in the present study clearly indicates that the increase in water stress levels have direct adverse effects on the germination and growth parameters of seeds. The number of days taken for commence germination in both species increases directly with increased level of water stress. Whereas the number of days for completion of germination also significantly increased under water stress treatments. The results are in conformity with the findings of Sevik and Ertiirk[6] on nine species that demonstrated 100% germination of all the species under control treatment (no water stress), while it decreased with increasing water stress. The results also agree with the findings of Khurana and Singh[7] that revealed significant reduction in germination of *Terminaliaarjuna, Terminalia chebula, Acacia nilotica* and *Phyllanthus emblica* under waters stress. Sharma and Prasad [8] also indicated that inadequate soil moisture can reduce germination. The present study also indicates the negative effects of water stress on germination percentage and germination energy in both of the species. Similar trends of decreased germination percentage under water stress were recorded in *Pinus* where 59% germination was recorded for control (no water stress) and 23% germination under water stress condition [6]. Bamigboye and Kayode [9] observed similar trends of decreased germination percentage in *Dioscoreophyllum cumminsii*. Singh and Bishnoi [10] also reported germination percentage varied 90% to 40% from unstressed to severely stressed treatments respectively in *Prosopis cineraria*. Yigit *et al.* [11] showed that the germination percentage for *Dalbergia sissoo* was 93% in the control group, while this rate reduced to 53% under -20 bar of water stress. Boydak *etal*.[12] conducted a study with 6 different origins of *Pinus brutia* seeds where the average germination percentage of the seeds was 84.3% in the control group, but the percentage reduced to 25.2% under -8 bar of water stress level.

4. CONCLUSIONS

In context of the results of the present research, it can be concluded that water stress reduces or delays the emergence of seed and also impacts the germination percentage and germination energy for both the species studied v*iz., Dalbergia sissoo and Gmelina arborea*. Daily watering to the seeds can help to achieve maximum and early seed germination as evident from data of germination energy with maximum values recorded for the treatments E1T1 and E2T1. Increased water stress with prolonged gap in watering schedules leads to the significant delay in seed germination. It is hence evident that water or moisture stress negatively affects all aspects of seed germination. Thus, timely irrigation and proper watering management can be an important tool for successful establishment of crops in the field. This study will prove as the potential base for the similar studies to be taken up with other important fast growing agroforestry species in future.

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