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IMPACT OF SEED VIGOR AND WATER STRESS ON THE GROWTH AND SURVIVAL OF FALCATA (*FALCATARIA FALCATA* (L.) GREUTER & R. RANKIN) SEEDLINGS

JOSEPH C PAQUIT

Department of Forest Biological Sciences, College of Forestry and Environmental Science, Central Mindanao University, Maramag, Bukidnon, 8714 Philippines

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Abstract

The impact of seed vigor and water stress on the early growth and survival of *Falcataria falcata* (L.) Greuter & R. Rankin seedlings were thoroughly investigated. A total of one hundred seedlings were subjected to a growth test in a 2 × 5 factorial experiment following a Completely Randomized Design (CRD). The results revealed significant differences ($p < 0.01$) in mean height, leaf number, leaf area, and % survival across the various treatments. It was observed that T1 and T6, which received daily watering, exhibited the highest mean height, measuring 5.6 and 5.2 cm, respectively. T1 and T6 also displayed significantly higher mean leaf numbers, with 14 and 13 leaves, respectively, and more significant mean leaf areas of 184.30 mm^2 and 181.45 mm^2. Furthermore, the % survival rate remained at 100% after ten weeks for treatments T1, T2, T6, and T7. Notably, seed vigor and its interaction with watering frequency did not significantly impact the previously mentioned parameters. The study recommends a daily watering frequency of 10 ml for optimal growth of *F. falcata*.

Introduction

The primary method of propagating plants is through seeds, especially those that are challenging to propagate through asexual means. Despite extensive research, a macro-somatic propagation protocol for *Falcataria falcata* still needs to be available. A few authors have reported initial success in micropropagating *F. falcata* but practical and cost-related constraints have limited its widespread adoption. Additionally, previous micropropagation studies utilized seedling explants rather than cuttings from mature mother trees, limiting the production of clones with superior traits. Consequently, due to these limitations in asexual propagation, regenerating *F. falcata* using seeds remains one of the most viable options.

It is common for seeds to possess various characteristics, including size, weight, and shape. Previous studies have indicated that these traits can impact seed vigor, particularly their ability to germinate quickly. Leffler and Williams (1983) found that seed size, density, and degree of seed filling can significantly affect seed and seedling performance, with larger, high-density seeds demonstrating the highest vigor. Early studies by Wanjura *et al.* (1969) also indicated that seedlings that emerged rapidly showed more remarkable survival and higher relative yields than those that emerged eight or 12 days after planting. Consequently, seed vigor notably influences seedling vigor (Snider *et al.* 2014). However, assessing seed vigor based on physical properties can be challenging in plants with naturally tiny seeds. Therefore, conducting a germination test to evaluate the speed of germination or emergence may be the most suitable approach to assess seed vigor in *F. falcata*.

It is well-established that the developmental conditions, maturation, storage, and aging of seeds significantly impact seed vigor. When faced with challenging germination conditions, seeds

*Author for correspondence: <jcpaquit@cmu.edu.ph>.

with high vigor will display clear growth advantages (Li *et al.* 2022). This study examines the relationship between seed vigor and the early growth of *F. falcata* seedlings. Additionally, it explores the connection between seed vigor and the seedlings' tolerance to water stress. The hypothesis posits that highly vigorous seeds produce seedlings that have better tolerance to water stress.

Materials and Methods

The experiment was set up at Central Mindanao University (CMU) and the seeds were obtained from the Mindanao Tree Seed Center of the Forest and Wetland Research Development & Extension Center in Bislig, Surigao del Sur.

The experiment was laid out in a 2x5 factorial arranged in a Completely Randomized Design (CRD) with ten replications. Factor A was the two seed vigor classes (High and Low), while Factor B was the four watering stress treatments (control **-** (7x a week), 5x a week, 3x a week, 1x a week, and 0x a week or no watering. A total of 100 experimental plots were observed in this study, composed of 10 treatments, each with 10 replications, and the observation period covered 10 weeks. The randomization was conducted by drawing lots, where labels for each plot were written on paper, cut out, and then randomly drawn from 1 to 100 in a 10x10 layout.

The immature, empty, or broken seeds were eliminated through water flotation (Krisnawati *et al.* 2011). A hot water pre-treatment was carried out to break the dormancy of *F. falcata* seeds. Three hundred seeds were placed in a white cloth and left to soak overnight (12 hrs) in a liter of hot water in a beaker at 80^{o}C. Following the pre-treatment, the seeds were placed in germination media, which consisted of small plastic containers lined with moist tissue paper. Seed germination was monitored for 1-4 days. Seeds that germinated within 1-2 days, based on the speed of radicle emergence, were separated and labeled as high-vigor seeds.

On the other hand, seeds which germinated within 3-4 days were categorized as low-vigor seeds. As per the experimental design and layout, the germinated seeds were then planted in potting media, comprised of a mixture of garden soil and rice hull obtained from the CMU clonal forest nursery. A transparent plastic covering was placed over the setup to shield the seedlings from rain. A black net was also used to protect the seedlings from direct sunlight. Five watering treatments were administered to the plots: once a day, once every three days, once every five days, once every seven days, and no watering. A uniform amount of water (10 ml) was applied to each experimental plot for the watering treatments. Regular weeding was carried out to ensure that the seedlings were free from competition with other unwanted plants.

Measurement of early seedling growth parameters was performed weekly, including plant height, leaf number, length, and width. Plant height was measured from the collar to the tip of the apical bud using a ruler, and the number of leaves produced was recorded. Leaf area was also calculated using leaf length and width, employing a non-destructive method and a specific equation below.

$$\text{Leaf area} = 0.75 \times (\text{Leaf length} \times \text{Leaf width})$$

The health and survival status of seedlings were also monitored weekly. To examine root parameters, the seedlings were carefully uprooted and washed. Each seedling was cut to separate the shoot and root. The fresh weight was then measured using a digital weighing scale. Subsequently, the shoot and root samples were placed in containers and oven-dried for 24 hrs at 80°C. The samples were then removed for the final measurement of dry weight. The data was analyzed using Analysis of Variance (ANOVA) in RStudio, and Tukey’s Honest Significant Difference was employed for the post hoc test.

Results and Discussion

After a 10-week observation period, it was determined that the differences in mean height, leaf number, leaf area, and % survival among treatments were statistically significant *($p \leq 0.01$)* (Table 1). Increased watering frequency had a significant positive impact on the growth and survival of *F. falcata* seedlings. However, seed vigor and its interaction with different watering frequencies did not significantly affect the parameters mentioned. As an abiotic factor, water can potentially restrict plant development (Ogunrotimi and Kayode 2018).

Table 1. Analysis of variance of data from a 2 × 5 factorial experiment in a CRD.

Sources of variation	Height	Leaf area	Leaf number	% Survival
	P value	P value	P value	P value
Seed vigor	0.15 ^{ns}	0.20^{ns}	0.52^{ns}	0.56^{ns}
Watering frequency	5E-16**	5E-15**	2E-18**	2E-13**
Interaction	0.96 ^{ns}	0.98 ^{ns}	0.98 ^{ns}	0.85 ^{ns}
Error				

** = significant at 1% level, ^{ns} = not significant.

T1 and T6, both receiving daily watering, exhibited the highest mean height. Although the difference between the two treatments was not statistically significant, T1 had a slightly higher mean height (5.6 cm) than T4 (5.2 cm). Watering the plants daily with 10 ml is the optimal watering frequency based on the plant height parameters. As shown in Fig. 1, the mean height of the seedlings decreased as the watering frequency was reduced. This may indicate a slight advantage of high-vigor seeds over low-vigor seeds regarding height difference. Seed vigor can significantly influence seedling vigor (Snider *et al.* 2014). Seedling vigor reflects seedling size and growth rates (Pilon *et al.* 2016). They emphasized the significant impact of proper watering on plant height, highlighting its crucial role in plant growth and development. They noted that water stress can result in stunted growth and decreased plant height. Suazo-López *et al.* (2014) found that adequately watered tomato plants exhibited greater height than water-stressed plants. Similarly, research conducted by Chaves *et al.* (2003) showed that water stress reduced plant height in maize plants. Water facilitates cell expansion in plants by creating turgor pressure as it enters plant cells, thus promoting cell elongation and overall plant height growth.

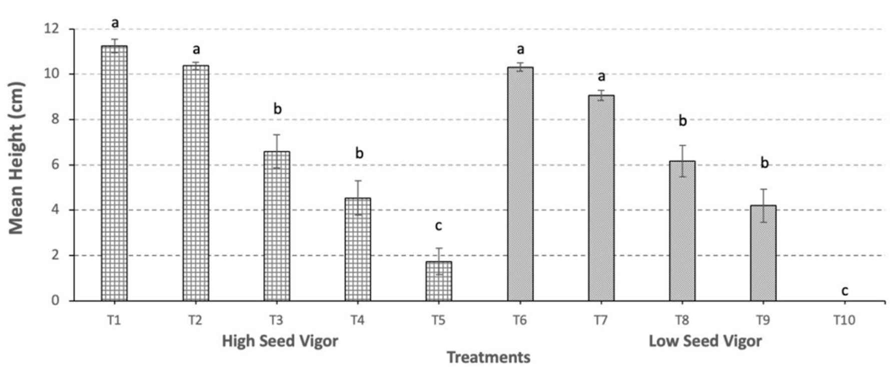

Fig 1. Variation in seedling height among treatments.

Error bars represent SEM. Bars with the same letter are not significantly different at $p \leq 0.01$.

In the experiment, it was observed that treatments T1 (14) and T6 (13) resulted in a higher number of leaves compared to the other treatments (Fig. 2). This indicates that regular watering can increase leaf production in *F. falcata.* Furthermore, the mean leaf area was also higher in T1 (184.30 mm^2) and T6 (181.45 mm^2), providing additional evidence of the positive impact of regular watering on leaf size derived from the length and width of the leaves. The decline in leaf area as the frequency of watering decreases mirrors the trend in leaf number. It was also noted that high-vigor seeds exhibited slightly more significant mean leaf number and area. This observation remained consistent when comparing seeds of varying vigor that received the same watering.

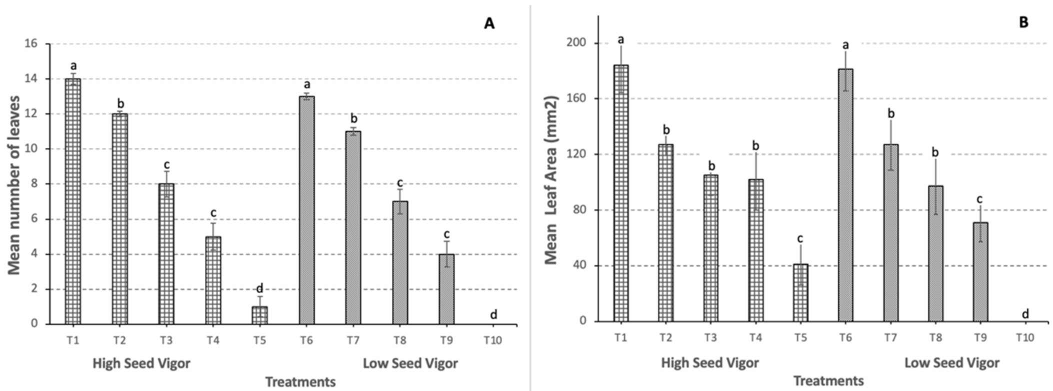

Fig. 2. Variation in leaf number (A) and leaf area (B) among treatments.
Error bars represent SEM. Bars with the same letter are not significantly different at $p \leq 0.01$.

These findings suggest that high-vigor seeds possess a subtle advantage over low-vigor seeds in leaf production. It is worth noting that shoot growth parameters are commonly recognized as key indicators of vigor (Snider *et al.* 2014). The influence of water stress on leaf growth is linked to the plant's adaptation to water scarcity, which reduces transpiration rates (Lu and Neumann 1998). Enukwa (2020) found that a higher watering frequency significantly increased leaf numbers in the two species studied. Dauda *et al.* (2009) reported a considerable effect of watering frequency on the leaf area of Myrobian seedlings. Vandoorne *et al.* (2012) noted that water stress greatly diminished leaf number, total leaf area, and stomatal conductance in *Cichorium intybus* (var. *sativum*). Similarly, Lawlor and Leach (1985) documented a decrease in leaf area during drought. A sufficient supply of water is crucial for maintaining turgidity in leaf cells. Optimal turgidity levels enable leaf cells to expand to their maximum size. Water availability is essential for the production, expansion, and maintenance of plant leaf tissue. An adequate water supply fosters optimal leaf development, while a lack of water can lead to reduced leaf production, smaller leaf sizes, and decreased leaf area.

Treatments 1, 2, 6, and 7 exhibited a 100% survival rate after 10 weeks (Fig. 3). These treatments involved a higher watering frequency compared to the others. Interestingly, all seedlings had similar survival rates after three weeks, but a decline in survival was noticed later on. A sharp decrease in survival was particularly pronounced in T10, where no seedlings survived after four weeks. Additionally, between weeks 2 and 4, wilting was observed in the seedlings of T5 and T10. The death of the seedlings began after three weeks. It has been observed that proper watering significantly increased the survival rate of oak seedlings grown in containers (Oliet *et al.* 2005). Additionally, Mng'omba *et al.* (2011) discovered that the rate and frequency of water application had a notable impact on the survival and growth of *Vangueria infausta* and *Persea* *americana* seedlings. Their study revealed that seedling survival rates were highest when watered once every two days. Adequate watering is critical in fostering a well-established root system, enhancing the seedlings' ability to withstand environmental stresses and improving their survival chances. Conversely, underwatering can lead to seedling dehydration and wilting, potentially resulting in irreversible damage. Furthermore, insufficient moisture can limit root growth and hinder the seedlings' capacity to absorb essential nutrients.

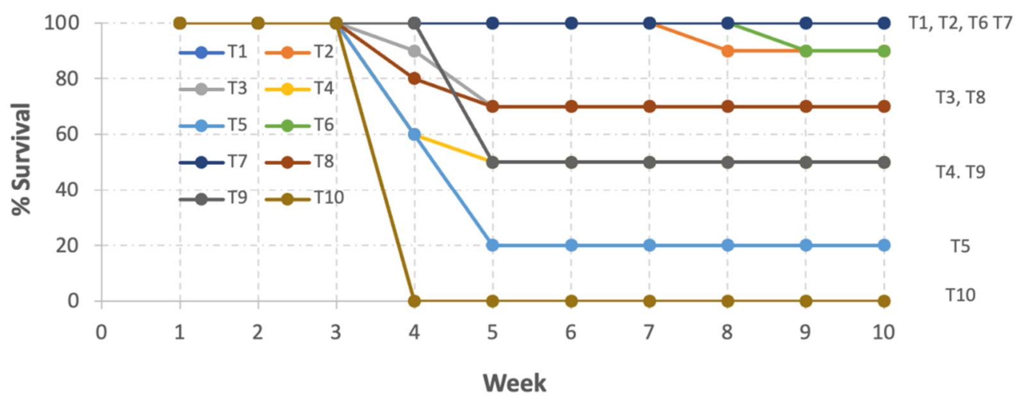

Fig. 3. 10-week trend in the survival rate of *Falcataria falcata* seedlings.

The research revealed significant differences ($p \leq 0.01$) in mean height, leaf number, leaf area, and % survival among treatments. T1 and T6, both receiving daily watering, demonstrated the tallest mean height at 5.6 and 5.2 cm, respectively. Additionally, T1 and T6 produced 14 and 13 leaves, respectively, significantly more than other treatments. Similarly, T1 and T6 had larger leaf areas at 184.30 mm^2 and 181.45 mm^2, respectively. Furthermore, % survival remained 100% after ten weeks for T1, T2, T6, and T5. The study found that seed vigor and its interaction with watering frequency did not significantly impact the parameters above. A watering amount of 10 ml is the recommended rate for *F. falcata.*

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