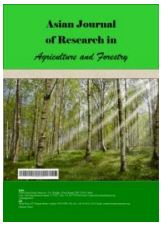

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Effect of Coconut Water on Pre-Sowing Treatments Additive on Seed Germination and Initial Seedlings Growth Performance of Kamagong (*Diospyros discolor*)

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Authors' contributions

This work was carried out in collaboration between both authors. Author MGO designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Author RLL managed the analyses, organization and editing of the study. Both authors read and approved the final manuscript.

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ABSTRACT

Mabolo (*Diospyros discolor*), which is an indigenous species locally known as Kamagong, is popularly called "iron-wood". With over-exploitation, these species are now threatened and are becoming extinct. Hence, it is the only way to conserved and save this economically valuable species by using nursery techniques with appropriate pre-sowing treatments. Therefore, the present study was attempted to evaluate the effect of coconut water on pre-sowing treatments additive on seed germination and initial growth performance of Kamagong (*D. discolor*). The seeds were extracted and subjected to the following treatments for 12 hours: Soaking in 100% water which is the control (T1), soaking with 50% of coconut water and 50% water (T2), and soaking in 100% coconut water (T3). The results showed that T3 had the highest germination mean value (78.33%), mean seedling height (11.80 cm) and mean number of leaves (2.04). By contrast, T2

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(50% coconut water + 50% water) obtained the least germination mean value (76.67%), mean seedling height (11.63 cm) and mean number of leaves (2.00). However, there were no significant differences in the germination percentage, seedling height and number of leaves among all treatments at ($p \leq 0.05$). The seeds subjected to T2 and T3 were significantly ($p \leq 0.05$) better than seeds subjected to T1, having a mean root collar diameter (RCD) value of 3.98 mm, 3.75 mm and 3.48 mm, respectively. In terms of leaf measurements, the seedlings subjected to T2 and T3 had the highest leaf width value of 5.18 cm and 4.97 cm, respectively, whereas the seedlings subjected to T1 had the significantly lowest leaf width of 4.88 cm. Moreover, there was no significant effect among all treatments in terms of leaf and root length. Furthermore, it was observed in the study that fungal pathogens should also be taken into account as the pathogens are associated with the reduction of the germination percentage of the *D. discolor* seeds. Also, the study found out that seeds treated with 50% and 100% coconut water positively influenced the germination and initial seedling growth performance of *D. discolor*.

Keywords: Mabolo; pre-sowing treatment; coconut water; collar diameter; germination percentage; fungal pathogens.

1. INTRODUCTION

Mabolo (*Diospyros discolor*) is an evergreen forest tree that belongs to the Ebenaceae (Ebony) family. In the Philippines, it is commonly identified by its wood locally known as Kamagong. Being an iron-like and nearly unbreakable, Kamagong is popularly called “iron-wood”. The wood is very nice to be used as a material for wooden craft because the wood is reddish brown to black and has a smooth strong and hard texture [1]. It is also widely used for the manufacture of luxurious furniture, sculpture or carvings, fans, spiked items, decorative tools, brushes, wind instruments and also for building construction such as house poles and bridges [2]. The species is indigenous to the low and medium altitude forests of the Philippine from the island of Luzon to the southernmost of the Sulu Islands [3]. It is commonly cultivated for its fruit and even more as a shade tree for roadsides [3]. Some species are now heavily threatened due to their over-exploitation, and may soon become extinct in the wild. Thus, special attention should be paid to the tree’s autecology (study of interaction between individuals and its environment) and relevant information for its sustainability and conservation.

The seed is a key element in plant production that it exercises a very great influence on the success and failures of both natural and artificial regeneration [4]. Seed germination, in turn, is the critical stage for species survival [5]. Hence, pre-germination treatments are necessary to speed up seed germination, increase germination percentage and shorten the germination period required to reach optimum rate [6]. Application of plant growth regulators or nutrients during pre-soaking, priming and other pre-sowing treatments in many crops have improved seedling survival rate and growth performance that results in overall plant growth and productivity [7]. Among the different natural sources used, extracts of plants and their endogenous growth regulators such as coconut water are gaining lots of attraction [8]. Coconut water is the locally available natural plant products and can be used to improve the germination rate and is the cheapest source of nutrients, freely accessible and environmentally friendly. Some of the most significant and useful components in coconut water are cytokinins, (e.g., kinetin trans-zeatin, which are a class of phytohormones) [9]. The other one is indole-3-acetic acid (IAA), which is the primary auxin in plants and other components like sugars, alcohols, lipids, amino acids, nitrogenous compounds, organic acids and enzymes [10]. This hormone (IAA) plays different functional roles in plant and human systems due to their distinct chemical composition. Coconut water with its several hormones may facilitate the germination rate of seedlings [11] and if proven to effectively facilitate the performance of *D. discolor* seeds in the nursery, then it will be a wonderful development.

Meanwhile, the propagation of *D. discolor* can be performed via seeds or grafting [3]. However, it is usually performed through seeds, which provides genetic variability and late onset of production [12]. The magnitude of these conditions may, however, vary depending on physiological characteristics of seeds, which are classified as orthodox or recalcitrant [13]. No cultivated stocks are available for reforestation or enrichment plantation and no propagation techniques are

recommended yet for germination improvement [14] particularly seed germination of *D. discolor* species. In order to increase germination rate and to save this economically valuable species from being extinct, nursery techniques with appropriate pre-sowing treatments is the only way to be applied [15]. There are some studies conducted on the effects of coconut water by Overbeek et al. [11] on *Centroema* species, Nasib, et al. [16] on *Codieaum variegatum*, Kanna et al. [17] on selected *Albizia* species, Setiawati et al. [18] on *Dendrobium Whom leng*, Abdullahil [19] on *Calanthe* hybrids and Dunsin et al. [20] on Cucumber but researches or information about pre-sowing effects on germination and initial seedling growth performance of *D. discolor* is very limited. It is hypothesized that coconut water, having a number of plant growth promoters, mineral nutrients and vitamins in a naturally balanced composition, may promote the growth and development of plants. This implied on the need for more information regarding the techniques to hasten the germination rate of native species. Thus, the present work was carried out to evaluate the influence of coconut water as an additive for improving the germination and initial seedling growth performance of the native *D. discolor.*

1.1 Objectives

i. To determine the effective pre-sowing treatment that will influence seed germination and initial seedling growth performance of *D. discolor*.
ii. To determine possible factors affecting the germination percentage of *D. discolor* seeds.
iii. To evaluate if coconut water can be utilized as an alternative additive on the germination and initial seedling growth performance of *D. discolor* seeds.

2. MATERIALS AND METHODS

2.1 Location of Seed Collection and Experimental Site

Seeds used in the study were obtained from the College of Forestry and Natural Resources, University of the Philippines-Los Baños (UPLB), Los Baños, Laguna, Philippines. The study was carried out to determine the effect of coconut water on the germination and initial seedling growth performance of *D. discolor* seeds at the IRNR Nursery, UPLB, Los Baños, Laguna (121°14'10.91" E, 14°9'13.68" N) as shown in Fig. 1. The municipalities lies on the northern slopes of the long dormant volcano Mount Makiling and is known among tourists for its hot spring resorts. It has an elevation of 109 meters above sea level and the climate type of the area is tropical monsoon climate with mean temperatures above 18 °C (64 °F) in every month of the year. The area is characterized by dry season.

The study was conducted from September 2019 to November 2019 for ten (10) weeks.

2.2 Experimental Design and Treatments

There were three (3) treatments in the study of which *D. discolor* seeds were soaked for a period of 12 hours in different treatments as follows: T1, 100% water (control); T2, 50% coconut water + 50% water; and T3, 100% coconut water, respectively. A 3x 3 completely randomized design (CRD) with three (3) replicates was used, with each treatment having one hundred (100) seeds making a total of nine hundred (900) seeds used for the whole treatment. Seeds were sown on the second day of September 2019 into the well-prepared germination bed and were properly labelled. Coconut water was collected at the public market within the locality.

After the pre-sowing treatment, seeds were rinsed with distilled water and air-dried for thirty (30) minutes before they were sown in a germination baskets filled with sterilized soil. Meanwhile, each treatment had three (3) plots with each plot containing one hundred (100) *D. discolor* seeds that were treated and randomly assigned according to treatment group as shown in Fig. 2. Plot placement on treatment partitions were done by drawing lots. Then, seeds were sown on their respective treatment plots. In addition, all nursery practices and management techniques were carried out and regular watering was done as per requirement to maintain adequate moisture necessary for germination and seedling growth.

2.2.1 Data collection

Germination was recorded daily until the cease of emerging germinated seeds. The seed was considered germinated by a visible protrusion of split seed coat with the cotyledons, hypocotyls, and epicotyl on the surface of the soil. Daily germination percentages were summed up to obtain a cumulative germination for each

treatment [21]. However, in the present study, germination percentage was obtained on a weekly basis. After the completion of seed germination experiment, the growth performance of the seedlings was monitored to assess the pre-sowing treatment effects on initial seedling growth performance of seedlings. Fifteen (15) seedlings were randomly selected for the measurement of seedling height, root collar diameter (RCD), number of leaves, leaf measurements (length and width) and root length. Initial seedling height, leaf measurements and root length were measured using a 30 cm ruler. A digital caliper, calibrated in millimeter (mm) was used to measure seedling root collar diameter and the number of leaves were determined by visual counting. Also, germination percentage was calculated by dividing the total number of seeds that germinated in each treatment by the number of seeds sown (excluding dead seeds) and multiplied by 100 according to Maguire [22].

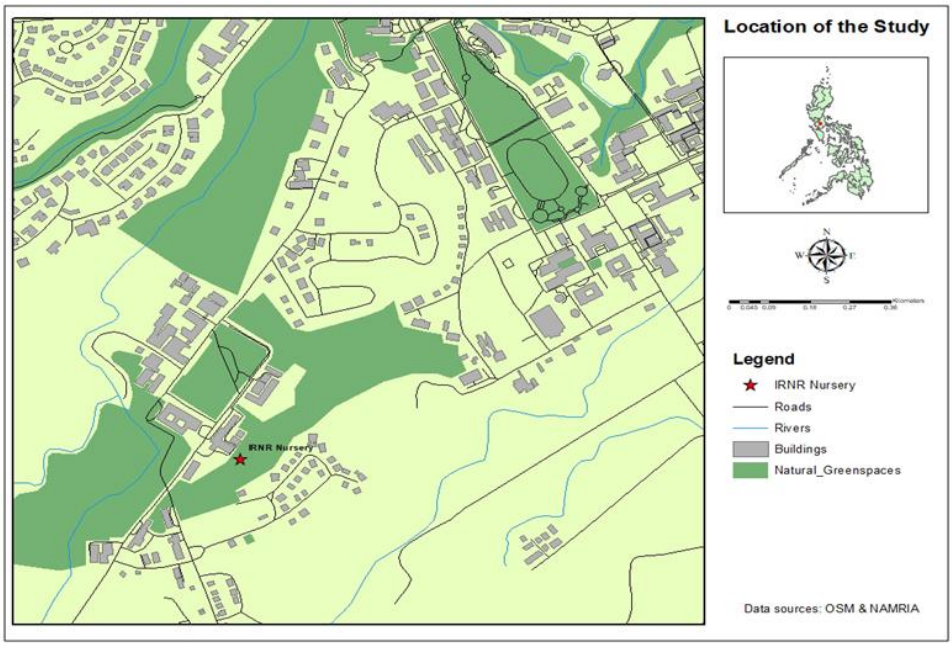

Fig. 1. Location of the study area

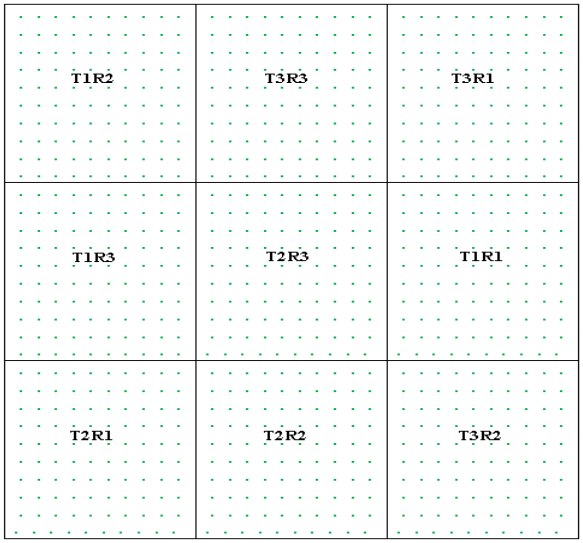

Fig. 2. Experimental design

2.2.2 Factors affecting germination rate of *D. discolour* seeds

2.2.2.1 Seeds infested by pathogens

Physical evaluation of germinating seeds showed that seeds were individually infested with fungus. The frequency of occurrence (PF) for each fungus species was calculated by applying the following formula [23]:

PF% = number of seeds on which a fungus appeared/total number of seeds ×100

2.3 Statistical Analysis

Data collected from the study were subjected to analysis of variance (ANOVA) using SPSS. Duncan's Multiple Range Test (DMRT) was used to determine significant differences among means at 0.05 probability level.

3. RESULTS AND DISCUSSIONS

3.1 Effects of Pre-Sowing Treatments in Seed Germination

The effects of pre-sowing treatments on the germination of *D. discolor* seeds is shown in Table 1. Based on the results, highest germination rate (78.33%) was observed in T3 (78.33%), followed by T1 having a mean value of 77.67%. On the contrary, the least germination rate was recorded in T2, which accounted mean value of 76.67%. However, no significant effect ($p<0.05$) was observed in the germination rates among all treatments.

Table 2 shows the weekly germination percentage obtained for each pre-sowing treatment.

Visible protrusion of split seed coat with the cotyledons, hypocotyls, and epicotyl on the surface of the soil are indication of seed germination. In T3, *D. discolor* seeds started germination two week after the seeds were sown. A gradual increase was observed and continued to increase up to 78.33% within 10 weeks. However, this mean value was not significantly different ($p<0.05$) from the germination rate of T1 having a mean value of 77.67%. In T2, germination was significantly slowed down ($p<0.5$) from the sixth week and remained constant from nine week up to ten weeks of the study (Fig. 3) as compared to T3 and T1.

The result indicated that T3 had the highest pre-sowing treatment when seeds were soaked within 12 hours before planting. Results of the study showed that coconut water positively influenced seed germination of *D. discolor*. This might be attributed to the fact that coconut water possessed some elements that favoured plant improvement. Similarly, Nasib, et al. [16] reported the same observations though in *Codieaum variegatum* species of seeds and asserted that coconut water could be used as a supplement in many laboratories to improve regeneration of plant cells. Meanwhile, some of the seeds of *D. discolor* soaked in 100% coconut water started germinating two weeks after planting and it is found to be ahead with other seeds subjected to different pre-germination treatments. This is in agreement to the results of Kanna et al. [17], though they used other species of seeds, and revealed that seeds treated with coconut water were germinated ahead than the other treatment without coconut water. Seeds subjected to T1 followed the second highest germination rate. It was reported by Hartmann and Kester [24] that seeds soaked in water helps reduce the time required for germination and improve germination percentage. In addition, higher germination percentage of T1 in the present study might be associated with the less occurrences of fungi attacking the seeds as shown in Table 3 and Fig. 4.

The effects of pre-germination treatment of T2 on the germination of *D. discolor* was the least due to high susceptibility to fungal attacked which was observed during the first five weeks after sowing. This consequently affected the germination percentage as shown in Table 3 and Fig. 4. Though water level was not measured in the study, it was observed that frequent watering negatively affect the *D. discolor* seeds and encouraged manifestation of fungal pathogens, thus reduced the seed germination. This is in agreement with the result of Patane et al. [25] that too much moisture as a result of frequent watering affected the germination of seed negatively. Moreover, despite not included in the study, it was observed that temperature during the sixth weeks of the study is relatively low as there occurred frequent rainy season which add more moisture to the environment and possibly favored the growth of fungal pathogens on the seeds. This is in line with some of the studies, demonstrating that endophyte infection was higher during wet season than dry period and strongly correlated with cumulative precipitation ([26,27,28]). This further dictated

that temperature greatly influenced seed germination as what was observed in the present study. Martins et al. [29] revealed that germination is a process, which is dependent on several factors including temperature being one of the important factors that determine the whole process thus affecting the speed and uniformity of germination. However, germination rate was not significantly different ($p<0.05$) among all treatments.

3.2 Fungal Infestation of *D. discolor* Seeds

Table 3 and Fig. 4 show the number of *D. discolor* seeds infected with fungi. Data for fungal infestation was only recorded from week 1 to week 5 since this was the only period where rapid fungal infestation occurred. Based on the results, it was indicated that T2 consistently affected by fungi and constantly obtained the highest number of *D. discolor* seeds that was affected. This showed that significant difference ($p<0.05$) was observed with T1 and T3 but only at week 1 and week 3, respectively. Among treatments, T3 having a mean value of 11.33% was less attacked by fungi compared to T2 and T1 having 15.33% and 14.67% affected *D. discolor* seeds, respectively.

The decreased germination rate of *D. discolor* seeds by 76.67% was associated with the manifestation of fungal pathogens during the first month of the study. Due to very limited study on *D. discolor*, studies of fungal infestation on other species are used as reference to the effect of fungi on the physiology of seeds during germination. In the study of Khokhar et al. [30], fungus had shown toxic effects on the seedling of cereal as evidenced 90% inhibitions of the seed germination rate of wheat. In the studies of fungal infection on other *Diospyros* species, it was revealed that infection frequency might be affected by the geographical location and dynamic environment of the examined *D. crassiflora* plants ([31,32]). On the other hand, Todd [33] found that infection frequency in endophytes' strongly correlates with microclimate. It has been demonstrated in some studies that endophyte infection is higher during wet season than dry period and strongly correlates with cumulative precipitation ([26,27,28]). Moreover, it was observed during the study that relative humidity was somewhat high at the early stage of germination period on September to October. It was often raining which leads to the manifestation of fungal pathogens. In several studies the cause of black point has been associated with extreme environmental conditions such as heavy rain, high humidity, and extreme temperature during the grain filling duration ([34,35,36,37,38,39,40,41]).

Results on the germination rate in the present study indicated that *D. discolor* seeds were associated with fungi. Such fungus has not been systematically characterized, and moreover, it lacks overall references study about the fungi associated with the seeds of *D. discolor.*

Table 1. Effect of pre-sowing treatment on the germination of *D. discolor* seeds

Pre-sowing treatment	No. of seeds treated and sown in each replicate	No. of seeds infested by fungi (%)	Germination (%)
T1	100	14.67[a]	77.67[a]
T2	100	15.33[a]	76.67[a]
T3	100	11.33[a]	78.33[a]

** Means with the same superscripts in the same column are not significantly different at p<0.05*

Table 2. Effect of pre-sowing treatment on the seeds of *D. discolor* on a weekly basis

Pre-sowing treatment	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10
T1	.33[a]	9.67[a]	59.33[a]	74.33[b]	75.67[a]	76.67[a]	77.00[a]	77.67[a]
T2	.33[a]	54.67[a]	54.67[a]	65.33[a]	73.33[a]	75.67[a]	76.67[a]	76.67[a]
T3	.67[a]	56.00[a]	56.00[a]	75.67[b]	76.33[a]	77.33[a]	77.33[a]	78.33[a]

** Means with the same superscripts in the same column are not significantly different at p<0.05*

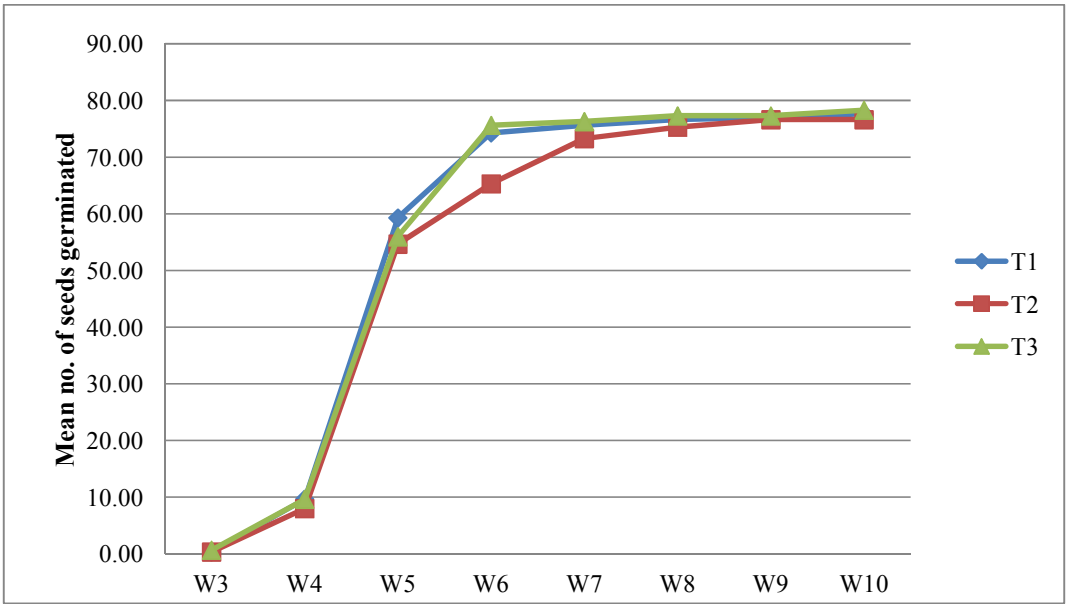

Fig. 3. Trends of germination rate observed in D. discolor seeds

Table 3. Fungal infestation of *D. discolor seeds* per week

Pre-sowing treatment	Week 1	Week 2	Week 3	Week 4	Week 5
T1	1.33[a]	4.33[a]	6.67[a]	10.67[a]	14.67[a]
T2	5.00[b]	6.33[a]	9.00[b]	13.67[a]	15.33[a]
T3	2.66[a]	5.33[a]	6.00[a]	8.33[a]	11.33[a]

** Means with the same superscripts in the same column are not significantly different at P<0.05*

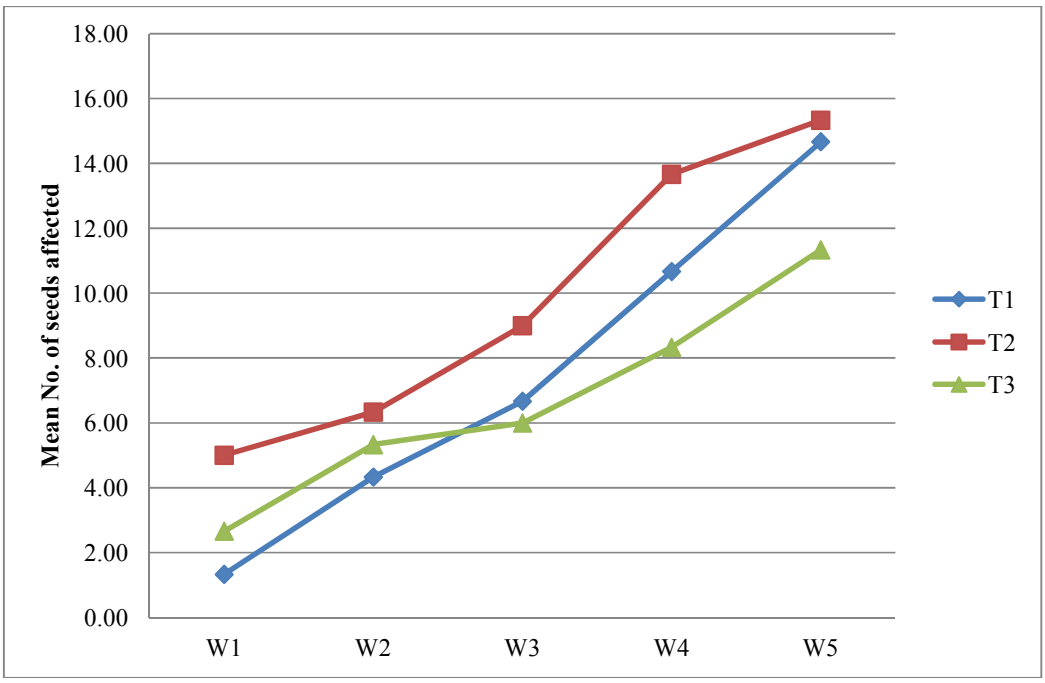

Fig. 4. Trends of fungal infestation in D. discolor seeds on a weekly basis

3.3 Seedling Height

After pre-sowing treatment, seeds subjected to T3 had the highest mean seedling height of 11.80 cm. This was followed by T1 with 11.75 cm and T2 with the lowest mean seedling height of 11.63 cm. However, the analysis of variance (ANOVA) showed that the seedling height is not significantly different ($P<0.05$) among the treatments examined (Table 4).

In the present study, when water, coconut water and their combination, were used as a pre-sowing treatment for the germination of *D. discolor* seeds, they showed comparable effect on the seedling height. Despite there were no significantly differences recognized among the treatments, it was observed that T3 where 100% coconut water was used had showed a slight numeric advantage on the height of seedlings. Overbeek et al. [11] reported that the use of coconut water, containing a variety of nutrients including cytokinins (which regulate growth and development) had resulted in the improved height of plants. Setiawati et al. [18] also reported that coconut water contains growth regulators such as auxin and cytokines that can stimulate the growth of plant seeds. Auxin is capable of stimulating protein synthesis in plant tissues that can lead to increased permeability of cell walls, thus stimulating cell division and elongation that will affect high growth [42]. Auxin is capable of stimulating protein synthesis in plant tissues that can lead to increased permeability of cell walls, thus stimulating cell division and elongation, which will affect high growth [42]. These results are also in consonance with that of Yong et al. [43] who reported that cytokinins stimulate the growth of roots and shoots, which in turn, will increase the height. The cytokinins found in coconut water support cell division, thus promote rapid growth [44]. The slight difference and increase in seedling height of *D. discolor* as observed in this study indicated that coconut water had a positive effect not only on the germination of the seeds but also on the growth and its development. However, more studies should be conducted to understand the detailed effects of coconut water, its mechanism on stimulating germination rate and initial seedling growth performance. In addition, further study should be dealt to determine what level is coconut water can produce significant effect on the germination rate and initial seedling growth performances of *D. discolor*.

3.4 Root Collar Diameter

The results showed that seedlings treated with coconut water (T3) showed positive effects on the diameter of *D. discolor* and were significantly better than seedlings treated with pure water (T1). However, treatments with coconut water as pre-sowing additive did not show any significant effect ($P<0.05$) though it was observed that 50% coconut water had a slight advantage in terms of numerical mean value of seedling collar diameter as shown in Table 4.

Treatment 2 had the highest mean collar diameter of 3.98 mm and 3.75 mm for T3. By contrast, the lowest RCD was observed in T1 with mean value of 3.48 mm. The present study revealed that soaking the seeds of *D. discolor* in coconut water treatment performed significantly better when compared to water treatment alone. In other studies using coconut water, the same results were also obtained. Coconut water was found to be more effective as compared to other plant growth regulators as it had been reported to contain growth promoting factors in the young embryo of plants [45]. Together with auxins, gibberellic acids stimulate cambial activity and in effect, causing the formation of large xylem and phloem cells in woody plants ([46,47,48]).

Treatment 3 also increased collar diameter of the *D. discolor* seedlings and the same results were reported by Setiawati et al. [18]), but in other species of seedlings such as *Dendrobium* species. It was revealed that stem elongation

Table 4. Effect of pre-sowing treatments of *D. discolor* seeds on seedling height, RCD, number of leaves, leaf measurements and roots, 10 months after sowing

Pre-sowing treatments	Seedling height (cm)	RCD (mm)	Number Of leaves	Leaves (cm)		Roots (cm)
				Length	Width	
T1 (100% Water)	11.75[a]	3.48[a]	2.02[a]	7.33[a]	4.88[a]	15.7[a]
T2 (50% Coconut Water and water)	11.63[a]	3.98[b]	2.00[a]	7.74[a]	5.18[b]	15.93[a]
T3 (100% Coconut Water)	11.80[a]	3.75[b]	2.04[a]	7.47[a]	4.97[b]	15.91[a]

** Means with the same superscripts in the same column are not significantly different at p<0.05*

occurs because of the process of cleavage, elongation and enlargement of new cells that occur in apical meristem and stem segment, which causes the plant to grow taller [49]. On the other hand, these authors indicated that cytokinin plays important role in cell division in lateral meristems, and causes the stem and root thickness.

3.5 Number of Leaves and Leaf Measurements

The data revealed that in terms of leaf measurements, treatments with coconut water as pre-germination additive (50% and 100% coconut water) significantly improves ($p<0.05$) leaf width as compared with treatments using pure water only. In addition, results among the treatments were comparable in terms of shoot length. Between treatments with coconut water, either 50% or 100%, showed comparable results to leaf width, shoot length and numbers of leaves of *D. discolor* (Table 4).

Meanwhile, the maximum leaf measurements were observed in T2 with 7.74 cm for leaf length and 5.18 cm for leaf width as compared to 7.33 cm (leaf length) and 4.88 cm (leaf width) for treatments with pure water only. In addition, more leaves were observed in T3 with a mean value of 2.04 as compared to 2.02 in T1. The formation of shoots with coconut water treatment in this study may be due to the presence of cytokinin that has major role in cell division, shoot formation, and activity of shoot meristem [50]. The presence of cytokinin as reported by Davies [51] may also induce bud formation, release of lateral buds from apical dominance. It is moreover serves to stimulate protein synthesis, induce synthesis and chloroplast abundance, causing differentiation in shoot, and contributing to leaf formation [52]. Shoot length can also be affected by the presence of gibberellin in coconut water. This result was also partially reported by Yong et al. [50] that coconut water contain gibberellin combined with low cytokinin concentration was effective in the shoot growth. Coconut water also affected the number of leaves and leaf measurements as compared to water. Abdullahil [19] reported that 50 ml/l of coconut water in media significantly increased shoot, leaf width and leaf area of *Calanthe* hybrids. Similar to the study of Yong et al. [50] reported that addition of coconut water to plant organs produced plantlets that were more active, bigger and more robust than those in the water. Likewise, the addition of coconut water with higher concentrations up to 100% inhibit the growth of the leaves due to the concentration of plant growth regulators (PGR) such as cytokinin, auxins, and gibberellins contained in it will be in supra-optimal concentration thus exceeding the required PGR concentration of the plant tissue. This is in contrast with the present study, as it was observed that at 100% coconut water, more leaves were formed, though no significantly differences were recognized among the treatments. Thus, further study should be conducted to further determine the effects of coconut water on the leaf formation and leaf measurements of *D. discolor*.

3.6 Root Length

The data revealed that root length in treatments with pure water, coconut water and their combination were comparable. The root lengths of *D. discolor* as influenced by various seed treatments are presented in Table 4. The maximum root length (15.93 cm) was observed in T2, though the value was not significantly different ($p<0.05$) from those of other treatments. Shortest roots were observed in T1 with a mean value of 15.70 cm. These results are somewhat similar with Dunsin et al. [20] though the studies used different species such as Cucumber. It was noted that seed priming with fresh coconut water has the highest root length which might be due to increased cell division within the apical meristem of seedling roots from the phytohormones that found in the coconut water [9]. According to Route et al. [42] also reported that cytokines are often used in conjunction with auxin to induce plant roots. Hence, soaking the seeds with coconut water and its combination can be successfully employed to improve the germination and seedling growth performance of *D. discolor.* The results in the present study showed slight influence of coconut water on the root length of *D.discolor* and might be associated to the phytohormones found in coconut water. In the study of Dunsin et al. [20], coconut water was found to be significantly hastened root the development of *Parkia biglobosa* cuttings, specifically the application of coconut water significantly increased the number and percentage of roots due to presence of cytokinins. The influence of cytokinin was further explained by Yong et al. [43] that it helps stimulate the root growth and development of a certain crops via auxin synergist. Cytokinins together with auxins play an essential role in plant morphogenesis by controlling the formation of roots and shoots and moderating their relative

growth [53]. Further, the role of cytokinin is in spurring root growth, especially by stimulating the differentiation of root meristem cells [54], whereas the role of auxin has been reported as the central mediator of organ development by promoting cell division, cell extension, and cell differentiation [55]. Moreover, auxin has been proven to accelerate and improve the rooting percentage of the stem cuttings [56] while cytokinin according to Jonas et al. [57] stimulates water uptake, promote cell division and organ development and auxin has the role in root initiation. Nasri et al. [58] revealed that exogenous auxin applications may have an indirect influence by increasing the translocation rates and sugar movement to stem cuttings and promote root growth. Moreover, Heloir et al. [59] revealed that the physiological changes of rooting are correlated with changes in auxin concentration and the high endogenous auxin concentration is normally associated with a high rooting rate at the beginning of the rooting process ([60,61]).

4. CONCLUSION

Results obtained in the present study emphasized the necessity of treating *D. discolor* seeds before planting in order to enhance its germination rate as well as its seedlings growth and development. Based on the results of the study, it was observed that T2 did significantly better in terms of RCD and leaf measurements, especially the width. T2 also had the highest mean leaf measurements in terms of its shoot length and root length when used as a pre-sowing treatment for *D. discolor* seeds. Moreover, T3 (100% coconut water) had the highest mean germination percentage, seedling height and number of leaves. However, it was not significantly different from other treatments. This proves that seeds subjected with coconut water either 100% or 50% enhanced germination percentage, seedling height, collar diameter, number of leaves, leaf measurements and root length. Though, the soaking of the seeds in water was the cheapest pre-germination treatment that shortened the number of days naturally required for germination to occur, however, water alone had the least mean values on the initial seedling growth performance of the *D. discolor.*

It can be concluded that soaking the seeds in coconut water has the potential effects on hastening and ensuring uniform germination rate. Moreover, either 50% or 100% of coconut water will be used for the fast growth performances of *D. discolor* species. It will be cost effective with greater economic returns not just for farmers who will engage nursery production but also for other plantation and other reforestation projects as it has been proven from the study that coconut water positively influenced the germination and initial seedling growth performance of *D. discolor*. Additionally, phytohormones content and chemical properties of coconut water exerted various roles in the different aspects of plant growth and development of *D. discolor.* Furthermore, fungal pathogens should be also be taken into account as it is proved in the study that the coconut water have reduced the germination percentage of the seeds subjected to 50% coconut water and 50% water (T2). Such fungus has not been systematically characterized, and moreover, it lacks overall references studies about the fungi associated with the seeds of *D. discolor.* Coconut water with its several hormones may facilitate the germination rate of seedlings, and has been proven to effectively influence the performance of *D. discolor* seeds in the nursery. Results indicated that coconut water is effective in improving germination and initial seedling growth performance but it is hoped that the results of the study will provide useful information not just for a large scale plantation but also for the development reforestation and encourage domestication. However, further research and investigations are required to find out its role especially that there is lacking information using different techniques about the species related to its growth and development.

5. RECOMMENDATION

Results of the present study revealed that coconut water can be used as a pre-sowing treatment additive to enhance germination rate and initial seedling growth performance of *D. discolor*. However, due to several limitations of the present study, other parameters were not included such as determination of actual concentration of phytohormones present in the coconut water thus, this study recommended to do further study on the following:

- Identification of hormones and other components related to different stages of maturity of coconut water and its specific mechanisms on the germination rate and seedling growth and development of *D. discolor*.

- Effect of different concentration and duration levels of soaking *D. discolor* seeds to determine if their efficacy could be improved upon.
- Effect of high humidity on the germination and growth performance of *D. discolor.*
- Identification and characterization of fungal pathogens attacking Kamagong seeds during the germination and seedling stage and to what extent or specific weather conditions that fungal attack will occur.
- Effect of high humidity, watering regime and other environmental consideration of coconut water on *D. discolor* seeds as it is associated with fungal pathogens and consequently affected the germination rate of seeds during the first five weeks of the study.
- Intensive survey of fungal infestation of Kamagong seeds, which deserve to be more explored in further investigations to better understand their role and ecology because it might hinder and limit the propagation and production of this kind of species.
- The use of coconut water should be further studied in *D. discolor* and in other species to determined its effectiveness.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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