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Enhancement of *Gmelina arborea* Roxb and *Nauclea orientalis* Linn Growth with Root Pruning and Bio-Stimulants

(Perbaikan Pertumbuhan Gmelina arborea Roxb *dan Nauclea orientalis* Linn *dengan Pemangkasan Akar dan pemberian Biostimulan)*

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ABSTRACT

A lack of seedling maintenance could lead to decreases in the quality of their growth. Stunted root systems could lead to future disruptions in nutrient absorption. In this research, the root system was improved by applying root pruning to improve the growth of new lateral roots. Furthermore, liquid fertilizer was added to further increase plant growth. This study aims to examine the influence of root pruning and bio-stimulants towards the growth of the saplings gmelina (Gmelina arborea Roxb*) and canary wood (Nauclea orientalis* Linn*), both of which had stunted growth in their permanent nursery in Dramaga Bogor, Indonesia. Factorial design with two analysis factors was used in this study. These were root pruning (0% and 30%) and bio-stimulants (0% and 2%). The combination of 0% root pruning and 2% bio-stimulants increased G. arborea growth (diameter, total dry weight, and number of leaves) and N. orientalis growth (height, diameter, and total dry weight). The combination of 30% root pruning and 0% bio-stimulants showed a significant influence on the number of G. arborea leaves. The combination of 30% root pruning and 2% bio-stimulants affected the leaf colour change of G. arborea and increased both of the saplings root growth. In all treatments, G. arborea and N. orientalis saplings had a seedling quality index value in the range of 0.2 – 1.1.*

***Keywords**: bio-stimulants, Gmelina arborea, nauclea orientalis, root pruning, seedlings*

ABSTRAK

Kurangnya kegiatan pemeliharaan dalam persemaian dapat menyebabkan penurunan kualitas bibit bahkan dapat menyebabkan kematian bibit. Salah satu penyebab kematian bibit adalah akar tidak dapat berkembang dengan baik sehingga fungsinya sebagai alat absorpsi unsur hara akan terganggu. Pada penelitian ini, pemangkasan akar dilakukan untuk memperbaiki sistem perakaran dan meningkatkan pertumbuhan akar lateral baru. Oleh sebab itu, penambahan pupuk cair juga dilakukan untuk meningkatkan pertumbuhan tanaman. Penelitian ini bertujuan menguji pengaruh kombinasi pemangkasan akar dan pemberian biostimulan terhadap pertumbuhan bibit gmelina (Gmelina arborea Roxb*) dan gempol (Nauclea orientalis* Linn*) yang keduanya mengalami stagnasi di persemaian permanen Dramaga Bogor. Penelitian dilakukan menggunakan rancangan acak lengkap faktorial, dengan 2 faktor yaitu pemangkasan akar dan pemberian biostimulan. Pemangkasan akar terdiri atas 2 taraf yaitu 0% dan 30%. Pemberian biostimulan terdiri dari 2 taraf*

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yaitu 0% dan 2%. Pemberian biostimulan 2% dapat meningkatkan pertumbuhan G. arborea (diameter, berat kering total, dan jumlah daun) dan meningkatkan pertumbuhan N. orientalis (tinggi, diameter, dan berat kering total). Pemangkasan akar 30% menunjukkan pengaruh yang signifikan terhadap penambahan jumlah daun G. arborea. Sedangkan kombinasi pemangkasan akar dan pemberian biostimulan mempengaruhi perubahan warna daun pada G. arborea dan meningkatkan pertumbuhan akar pada kedua bibit. Pada semua perlakuan, bibit G. arborea dan N. orientalis memiliki nilai indeks kualitas bibit pada kisaran 0,2 – 1,1.

***Kata kunci**: bibit, biostimulan, Gmelina arborea, nauclea orientalis, pemangkasan akar*

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INTRODUCTION

Gmelia arborea Roxb is a member of the *Lamiaceae*_family. This is a large deciduous tree with a straight trunk. This species occurs in a variety of forest habitats, including tropical semi-evergreen, sub-montane, very moist teak forests, sal and dry teak forests (Orwa *et al*., 2009). *Gmelina* leaves are large, heart-shaped and serrated. Soil fertility can be increased by having leaves which fall off easily. The root system of *G. arborea* plants is sufficiently strong to pierce the soil, and its roots disseminate to support optimal *G. arborea* development in the field (Kosasih and Danu, 2013). *Nauclea orientalis* Linn varies from a medium-sized to tall, well-formed tree and is a member of the *Rubiaceae* family. It is a water-loving forest species or plants that is able to tolerate flooding (Goonatilake *et al*., 2015). Generally, *N. orientalis* is a pioneer species (Orwa *et al*., 2009). *G. arborea* and *N. orientalis* wood are usually used for light construction materials, pulp and plywood (Rachmawati *et al*., 2002 and Kosasih *et al*., 2011). Both are categorized as fast-growing tree species, widely planted for wood materials. Therefore, the nursery should be nurtured for environmental sustainability.

Poor maintenance of the seedlings in the nursery could lead to a decrease in quality during growth, which can cause seed death due to improper root development. This leads to the plant having slow growth and stagnation (Setiadi, 2009). Transplanted exceed time planting (expiry seeds) could induce the obstacle of plant growth (stagnation), which was caused by a lack of nutrient and narrow space of growth in soil media (Firmansyah *et al*., 2009). For this reason, the root system would be disturbed (Setiadi and Fauzi, 2014). An ideal environment would support root system development, giving the potential for measuring and assessing seed quality (Pourmajidian *et al*., 2009). One effort to improve root systems was by applying root pruning to saplings (Tripepi, 2009).

The reasons for pruning roots in nursery stock production was to stimulate a dense and compact root system for a high root to shoot ratio, confine the root system to facilitate

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digging (keep in smaller volume), avoid future root problems (circling or kinked roots in containers), and to limit the rate of bud growth for plants growing too fast (Tripepi, 2009). Root pruning was one of the methods to improve the growth of new lateral roots. Small stocks were pruned before being planted in pots or the field. This procedure helps to improve root size and shape, as well as to stimulate new root growth and formation. The response of plants to root pruning varied between species. Root pruning could increase the height and diameter of pine seeds but did not affect *Gnetum gnemon* L. saplings growth (Wulandari and Supriyanto 2013). However, if root pruning was combined with the provision of organic fertilizer, that served to increase root growth, it could increase plant growth. Similar results were obtained in a study conducted by previous researchers, where a combination of root pruning, root stimulation and fertilization gave the best response for height, diameter, and the number of *Albizia chinensis* (Osbeck) Merr. seedling leaves (Handayani, 2014).

Fertilization is the process of adding materials to the soil with the intention of improving and increasing soil fertility. Plant growth can be increased by fertilizer applied properly (Kusumawati, 2021). Fertilizer was available in liquid form which was easier for absorption by root plants. The dose of liquid organic fertilizer should be considered when being applied to plants. Excessive doses of liquid organic fertilizer can cause wilting symptoms in plants (Rahmi and Jumiati, 2007). Bio-stimulants are useful for providing nutrients as well as improving soil properties because bio-stimulants can activate microbes in the soil. The proper dosage of bio-stimulants on planted media can increase the growth of planted seeds. Generally, because the bio-stimulants are a liquid organic fertilizer, the soil and plants were not damaged (Irwansyah, 2015). The bio-stimulants consisted of 95% organic inert, macro and micro nutrients, amino acids, organic acids, enzymes and microbial potential (Setiadi, 2009). The essential macro and micro nutrient elements were N, P, K, S, Ca, Mg, B, Mo, Cu, Fe, Mn, and other organic materials. Liquid organic fertilizer had shown it could improve the physical, chemical and biological properties of the soil. At the same time, it could boost crop production and quality.

The previous research showed that *Gmelina arborea* and *Tectona grandis* L.f. seedlings had a good response to bio-stimulants over a 3 months period (Irwansyah, 2015). Bio-stimulants could activate soil microbes and add macro and micro nutrients; thus, it was useful to stimulate the emergence of new roots after pruning plant roots. Therefore, it was necessary to make efforts to improve the growth of stagnant forest plantation seedlings by root pruning and bio-stimulants.

MATERIAL AND METHODS

The study site was the Nursery of Bogor Agricultural University, West Java. The saplings were planted from February to April 2016 (3 months of observation). Cutting scissors, polybags, calipers, 50 ml and 1000 ml measuring cups, a 100 cm ruler, and labels

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were among the materials used for this research. For the current study, we focused on two fast growing tree species with stagnant growth: gmelina (*Gmelina arborea* Roxb) and canary wood (*Nauclea orientalis* Linn). It uses 6-month-years-old to each sapling which selected from the nursery. Selected plants were removed from the plots a week before treatment. The soil used in this treatment was a mixture of top soil, cocopeat, goat faeces and charcoal husk with a composition of 5:2:2:1 (v/v/v/v) respectively. The growing media which had been mixed was moved into a polybag. In this study, we used bio-stimulants as liquid organic fertilizer obtained from PT Akar Langit Bumi. These bio-stimulants were fermented aerobic or anaerobic organic matter from the urine and faeces of cows to provide nutrients for plants. The bio-stimulants were dissolved in water with 2% concentration (i.e. 1 L bio-stimulants dissolved in 50 L water).

Root pruning treatment consisted of the cutting of the primary and secondary root to 30% of the original length of each root and the leaves approximately cut in half to reduce respiration. Saplings with bio-stimulants treatment were given bio-simulants twice in the first and third week. Sapling plants were given 50 mL of 2% bio-stimulants for each polybag. Factorial design was used in this study with two factor analyses for root pruning and bio-stimulants pouring. There were 0% and 30% level of root pruning factor, and 0% and 2% of bio-stimulants factor, with design as follows:

P_0B_0 = Control

P_0B_1 = Bio-stimulant 2%

P_1B_0 = Root Pruning 30%

P_1B_1 = Root Pruning 30% + Bio-stimulant 2%

The two saplings used in this research are *G. arborea* and *N. orientalis* with 3 replications and each replication consisting of 4 units. The data analysis used in this study is the interaction model for two-factor completely randomized design.

Measuring sapling seed plants

Plant height and diameter were measured every month until the end of the observation (12 weeks). The height was measured using a 100 cm ruler and the diameter was measured with provide markers on saplings using callipers. Total leaves were estimated with calculated from total leaves at the end of the observation (on 12^{th} week) reduced total leaves at the beginning of the observation. At the end of observation, falling or wilting leaves was calculated. To estimate root growth, we compared root condition between control, pruning, and bio-stimulants treatment at the end of the observation. Saplings polybag was opened without damaging the soil media, showing the root growth clearly. The calculation of root shoot ratio was done by measuring biomass on buds and roots of plants at the end of the observation.

The Leaf Color Chart (LCC) was the standard for leaf color determination. The observation was performed at the beginning and the end of research. The LCC is an easy

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to use and inexpensive diagnostic tool for monitoring the relative greenness of a plants leaves as an indicator of the plants nitrogen (N) status. If mean leaf color was an intermediate between 3 and 4, then a standard rate of fertilizer N was applied. If the mean leaf color was higher (for example ≥4), less fertilizer N than the recommended rate was applied. If the mean leaf color was lower (for example ≤3), more fertilizer N than the recommended rate was applied (Bijay-Singh, 2022).

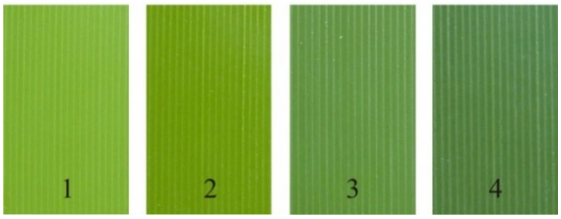

Fig 1. Leaf Color Chart (LCC)

RESULT AND DISCUSSION

Growth is a quantitative term, related only to changes in size and mass. Plant growth is characterized by cell division (increase in quantity) and cell expansion (increase in size) in plants (Gardner *et al.,* 2008). For cells, growth is simply an irreversible increase in volume. For tissue and organs, growth normally reflects an increase in both cell number and cell size. Growth refers to increases in size by cell division and enlargement, and development refers to the differentiation of cells into the various tissue and organs that finally produce a mature plant (Kramer and Kozlowski, 1979). *G. arborea* and *N. orientalis* are sapling plants reproduced in Nursery of Bogor Agricultural University but they exhibit a stagnation in their growth. It might be caused by exceeded the planting period (expiry seeds), thus nutrients in the soil media are insufficient, inducing a decreased rooting system.

We observed height, diameter, number of leaves, leaf color, root growth, root shoot ratio and seedling quality index of *G. arborea* and *N. orientalis* sapling growth. Twelve weeks of observation show a significant difference in the height of *N. orientalis,* and the diameter, dry shoot and dry total weight and also seedling quality index of *G. arborea* and *N. orientalis*. Interactions between root pruning and bio-stimulants pouring gave a significant difference in the number of leaves of *G. arborea* (Table 1).

Table 1. Recapitulation of data analyze of various saplings growth treated by root pruning and bio-stimulants pouring at 12 weeks.

Variables	Plant species	Root pruning (P)	Bio-stimulants (B)	PxB
Height	*G. arborea*	0.16^{tn}	0.88^{tn}	0.83^{tn}
	N. orientalis	0.40^{tn}	0.01*	0.81^{tn}
Diameter	*G. arborea*	0.99^{tn}	0.00*	0.07^{tn}
	N. orientalis	0.53^{tn}	0.00*	0.75^{tn}
Number of leaves	*G. arborea*	0.04*	0.29^{tn}	0.04*

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	N. orientalis	0.22^{tn}	0.09^{tn}	0.94^{tn}
Shoot dry weight	*G. arborea*	0.45^{tn}	0.00*	0.24^{tn}
	N. orientalis	0.30^{tn}	0.00*	0.89^{tn}
Root dry weight	*G. arborea*	0.49^{tn}	0.07^{tn}	0.49^{tn}
	N. orientalis	0.28^{tn}	0.39^{tn}	0.57^{tn}
Total dry weight	*G. arborea*	1.00^{tn}	0.00*	0.26^{tn}
	N. orientalis	0.22^{tn}	0.01*	0.71^{tn}
Root shoot ratio	*G. arborea*	0.51^{tn}	0.98^{tn}	0.62^{tn}
	N. orientalis	0.36^{tn}	0.22^{tn}	0.49^{tn}
Seedling quality index	*G. arborea*	0.55^{tn}	0.01*	0.33^{tn}
	N. orientalis	0.55^{tn}	0.01*	0.33^{tn}

*= significant values are different at 95% confidence level (Pr>F) 0.05 (α), tn= no significant difference treatment at 95% confidence level

Height and diameter of seedlings

Height of plant occurred in new shoots growth, generally centered on apex (tip) contained in the terminal buds. New buds also appear from any position. In both plants, new bud growth occurred. *G. arborea* buds appeared on the third week, while *N. orientalis* buds appeared on the fourth week. Height and diameter sapling plants with root pruning and bio-stimulants treated are shown in Fig 2. Root pruning with 30% level cutting did affect plant height and diameter, with all saplings responding equally. *G. arborea* saplings treated by bio-stimulants with 2% concentration saw an increase in plant diameter when compared to the control. *Nauclea orientalis* saplings with 2% bio-stimulants saw an increase in height and diameter compared to the control. Increase in height and diameter were approximately 53.25 cm and 6 mm, respectively (it did not show in table).

Table 2. The influence of root pruning and bio-stimulants pouring towards increasing height and diameter of saplings

Variables	Plants species	Root pruning (%)		Bio-stimulants (%)	
		0	30	0	2
Height (cm)	*G. arborea*	17.6^{a}	23.1^{a}	20.1^{a}	20.7^{a}
	N. orientalis	9.7^{a}	11.5^{a}	7.5^{b}	13.7^{a}
Diameter (mm)	*G. arborea*	1.5^{a}	1.5^{a}	1.1^{b}	2.0^{a}
	N. orientalis	1.7^{a}	1.5^{a}	0.9^{b}	2.4^{a}

Numbers in same line and same letters indicate no significant difference treatment at 95% confidence level

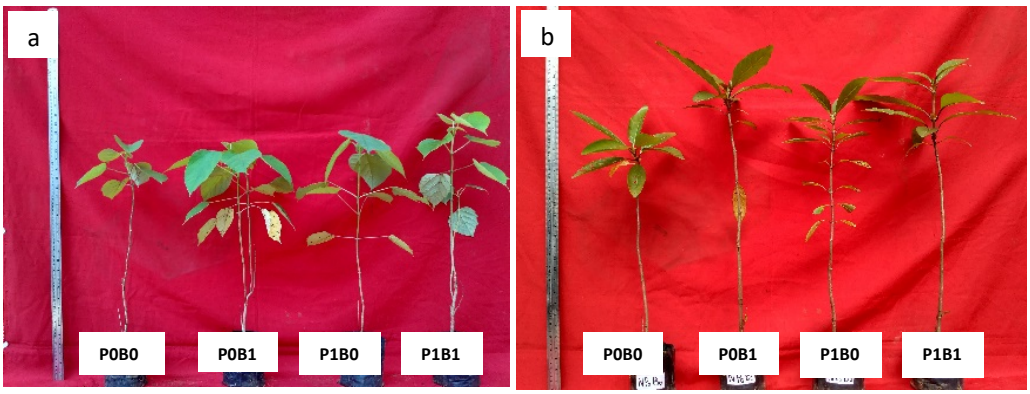

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Fig 2 Sapling plants were treated by root pruning and bio-stimulants: (a) *G. arborea*, (b) *N. orientalis* at 12 weeks observation (P=root pruning; B=bio-stimulants; 0=no treatment; 1=treatment)

Bio-stimulants with 1.67% concentration (1:60) increased height and diameter of *G. gnemon* seedling, and bio-stimulants with more than 1.67% concentration caused burning symptoms of plants (Adisetia, 2015). However, 2% (1:50) bio-stimulants concentration could point out the optimum result height and diameter of *N. orientalis.* This response might be caused by bio-stimulants inducing the rooting system. Liquid organic fertilizer had more advantages compared to solid fertilizer. The advantages of liquid organic fertilizer were that it could overcome nutrient deficiency and provide nutrients quickly (Hadisuwito, 2007). In the previous research, liquid organic fertilizer also increased the height of *A. chinensis* sapling plants (Aurum, 2014).

Shoot, root, and total dry weight of seedlings

Since plants had a high composition of water, and the level of water in a plant depends on the volume of water in its environment (which is very difficult to control), using dry weight as a measure of plant growth tends to be more reliable. Root pruning with 30% level cutting did not give a significant difference towards saplings biomass. Root mass was recommended as a final measurement as the plant must be removed from its growing medium to obtain accurate data. There are a few different methods for measuring root mass depending on the type and structure of the roots.

Bio-stimulants with a 2% concentration treatment improved shoot and total dry weight of saplings. Although, bio-stimulants did not affect root dry weight of plants, when compared to the control (Table 3).

Table 3. The influence of root pruning and bio-stimulants pouring towards increasing shoot, root and total dry weight of saplings

Variables	Plants species	Root pruning (%)		Bio-stimulants (%)	
		0	30	0	2
Shoot dry weight (g)	*G. arborea*	4.9[a]	5.5[a]	3.5[b]	6.8[a]
	N. orientalis	7.7[a]	6.8[a]	4.6[b]	9.9[a]
Root dry weight (g)	*G. arborea*	3.2[a]	2.6[a]	2.0[a]	3.8[a]
	N. orientalis	5.5[a]	7.3[a]	5.7[a]	7.1[a]
Total dry weight (g)	*G. arborea*	8.1[a]	8.1[a]	5.5[b]	10.6[a]
	N. orientalis	12.3[a]	15.1[a]	10.3[b]	17.1[a]

Numbers in same line and same letters indicate no significant difference treatment at 95% confidence level.

Dry weight of plants was a common indicator used to determine seedling growth, because dry weight of plants describes the efficiency of physiological processes in the plants (Wulandari and Susanti, 2012). Shoot dry weight refers to the mass of the above-ground plant parts (stem, leaves, and buds) after water content has been removed. It is a direct measure of photosynthesis allocation to shoot development and indicates overall vegetative growth performance. Total dry weight is a comprehensive indicator of overall

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seedling growth and vigor. Bio-stimulants with 2% concentration increase shoot and total dry weight of sapling plants. This is similar to 1.67% bio-stimulants giving a significant difference to *G. gnemon* shoot dry weight (Adisetia, 2015). Biostimulants are considered to have a positive impact on *G. arborea* and *N. orientalis* seedlings due to the fact that their roots are capable of developing and penetrating the planting medium through the removal seedling from the polybag. Pruning the roots of plants does not cause them excessive stress provided the planting media or environment is very supportive (e.g., adequate water, nutrients, and proper aeration) (Taiz *et al*., 2015). As a result, there is no significant different in dry weight because shoot and root growth remain at its best.

Root growth of seedlings

Soils rarely provide ideal physical condition for root growth. Root growth is generally required for buds and plant growth. Roots have a function as a primary organ for water and mineral absorption and for storage of food reserves. Roots need to grow in order to better support the plant and to better absorb both water and nutrients for the growing plant. Roots are an important factor in helping plants to survive and grow. *G. arborea* and *N. orientalis* root growth was able to penetrate the surface of the media when the polybag was opened (Fig 3).

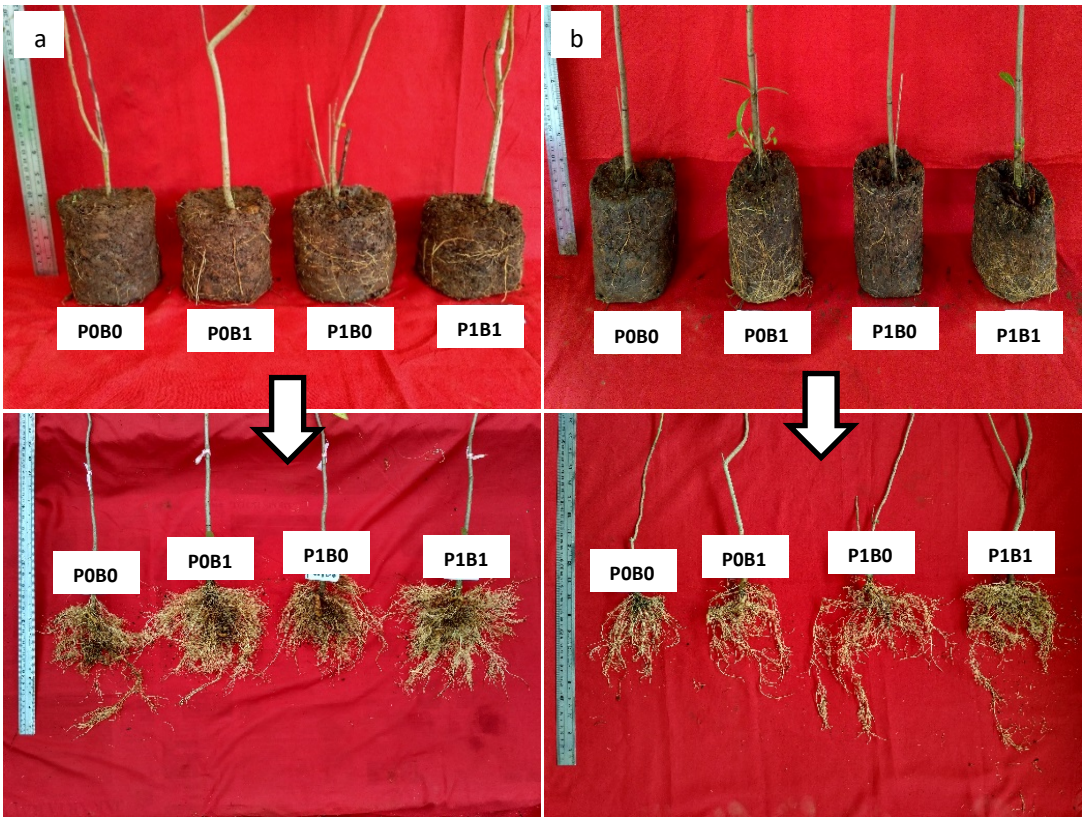

Fig 3. Root plants were treated by root pruning and bio-stimulants: (a) *G. arborea*, (b) *N. orientalis* at 12 weeks observation (P=root pruning; B=bio-stimulants; 0=no treatment; 1=treatment)

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Root pruning treatment could stimulate new lateral root growth in *G. arborea* and *N. orientalis* until through the soil media, however, new lateral root growth is insufficient to increase stagnation seedling growth. Root pruning also improves the number of *G.arborea* leaves (Table 4). Root pruning increases *G. arborea* and *N. orientalis* growth. This positive response is also found in previous research (Kurniawan, 2014). Reasons to prune roots of nursery stock production are to stimulate a dense, compact root system for a high root to shoot ratio, confine the root system to facilitate digging (keep in smaller volume), avoid future root problems (circling or kinked roots in containers), and limit the rate of shoot growth for fast growing plants (Mattjik and Sumertajaya, 2006). To keep the equilibrium between the roots and the shoots, the plant responds by partially damaging the root tissue through root pruning. Thus, the absorption of water and nutrients is more active in these new roots.

Number and color of leaves

The combination of root pruning with 30% level cutting and bio-stimulants 2% concentration did not affect the number and color of leaves. Meanwhile, the single factor of root pruning with 30% level cutting and bio-stimulants 0% concentration did increase the number of leaves of *G. arborea* saplings. The single factor of 0% root pruning and 2% bio-stimulants also increased the number of leaves of *G. arborea* saplings compared with the control (Table 4). Before and after treatment, the number of leaves increased approximately 7 – 13 leaves per saplings.

Table 4. Interaction between root pruning and bio-stimulants pouring towards increasing number of leaves of saplings

Plants species	Root pruning level (%)	Bio-stimulants (%)	
		0	2
G. arborea	0	4^{b}	8^{a}
	30	9^{a}	8^{a}
N. orientalis	0	3^{a}	5^{a}
	30	5^{a}	7^{a}

Numbers in same line and same letters indicate no significant difference treatment at 95% confidence level

Root pruning and biostimulants treatment affected in addition to seedling growth but also alterations in leaf coloration. Leaves represent a crucial function, particularly as a place for photosynthesis. Generally, *G. arborea* leaves color was dominated by a light yellowish green before treatment. After treatment by 30% root pruning and 2% bio-stimulants concentration, *G. arborea* leaves color was dominated by dark green. Leaf color of *G. arborea* saplings before and after treatment changed from 1 to 4 on the LCC scale, while no treatments affected the leaf color of *N. orientalis* saplings. The leaf color chart (LCC) is important is assessing the sufficiency of nitrogen in plants. Alterations in leaf pigmentation in seedlings signify that the roots are capable of developing adequately to provide efficient nutrition absorption. According to Aurum (2014) variations in leaf color are

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regarded to be a sign that there is an increase in the amount of chlorophyll in plants that are given treatment, so that the photosynthesis process for plant metabolism works more optimally and might encourage development.

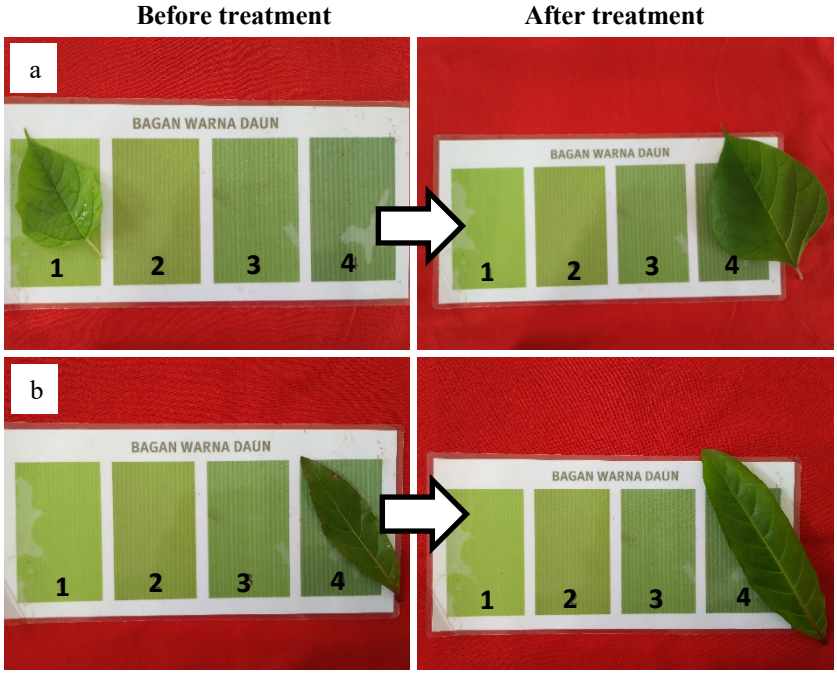

Fig 4. Leaf color change: (a) *G. arborea*, (b) *N. orientalis*, after and before treatment

Root shoot ratio and seedling quality index

Roots allow a plant to absorb water and nutrient from the surrounding soil and healthy root systems are key to healthy plants. Root shoot ratio was one measurement to assess the overall health of plants. Each plant species has a normal root shoot ratio, therefore any variation from this normal level indicates a change in the overall health of the plants.

In all treatments, *G. arborea* and *N. orientalis* had a root shoot ratio value of 0.9-2.8 (Table 6). Thus, treatment did not affect the root shoot ratio value because all of sapling plants were still within a good root shoot ratio and seedling quality index value that was 1 – 3 and 0.2 – 1.1, respectively (Table 6). Treatment also did not affect saplings plants, as all saplings were still within the limits of a good seedling quality index value, that was > 0.09.

Table 6. The influence of root pruning and bio-stimulants pouring towards root shoot ratio and seedling quality index

Variables	Plants species	Root pruning (%)		Bio-stimulants (%)	
		0	30	0	2
Root shoot ratio	*G. arborea*	1.9[a]	2.3[a]	2.1[a]	2.1[a]
	N. orientalis	2.1[a]	1.1[a]	0.9[a]	2.2[a]
Seedling quality index	*G. arborea*	0.9[a]	0.8[a]	0.6[b]	1.1[a]
	N. orientalis	0.9[a]	0.8[a]	0.6[b]	1.1[a]

Numbers in same line and same letters indicate no significant difference treatment at 95% confidence level

Darwo and Sugiarti (2008) state that the root shoot ratio value determines the quality of the seedlings. In the preliminary stages of growth, there is a correlation between the root shoot ratio and plant morphology. This indicates how crucial the plant root system is to the adaptability, water absorption, and recover from plant stagnation processes. *G. arborea* and *N. orientalis* seedlings root shoot ratio values are still in an acceptable range, particularly between 1 – 3 (Barnett, 1984). Wulandari and Susanti (2012) indicate that the Seed Quality Index can be used to determine the resistance of seedlings that will be provided to the field. *G. arborea* and *N. orientalis* seedlings quality index values were unaffected by the application of root pruning and bio-stimulant treatments, it is thought that the four varieties of seedlings will adapt effectively to field environments.

CONCLUSION

This research indicates that good root systems could increase the quality of sapling plants. Root growth influences plants physiological mechanisms in deciduous trees such as *G. arborea* and *N. orientalis*. Growth of *G. arborea* (diameter, total dry weight, and number of leaves) and *N. orientalis* (height, diameter, and total dry weight) is higher with 2% bio-stimulant pouring concentration than when used with other saplings. While 30% root pruning could increase the number of *G. arborea* leaves. The combination of 30% root pruning and 2% bio-stimulant pouring could provide significant influence over leaf color change of *G. arborea* and affect the root growth of *G. arborea* and *N. orientalis*. Consequently, it is essential to enhance nursery management that emphasizes root growth to provide plants with optimal growing space. It is important to consider the timing of transplanting seedlings to prevent their stagnation. The results of this research can be utilized in nurseries that propagate fast growing seedling species, especially *G. arborea* and *N. orientalis* plants, which emphasize seedlings quality. In future research, the clarification of the characteristic species of saplings is important. Each sapling has different responses to treatment. Considerations should be made for the physiology of each plant species.

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