Research article

Growth Performance of *Trema orientalis* L. (Blume) Ulm. Seedlings in Response to Mineral Nutrient Omission

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Received 31 December 2020 Accepted 18 May 2021 (*Corresponding Author)

Abstract The Philippine forest land is among the top threatened biodiversity areas in the world and one of the major causes is deforestation. In rainforestation, a reforestation approach developed by Visayas State University (VSU) where pioneer tree species are planted first to copy the natural flow of forest succession. Studies on early successional tree species are limited, especially on determining the growth performance as affected by nutrient deficiency. The study was conducted under screen house condition at the Terrestrial Ecosystems Division (TED), Institute of Tropical Ecology and Environmental Management (ITEEM), VSU, Philippines. This study aimed at evaluating the effect of nutrient omission on morphological and physiological growth of *Trema orientalis* L. (Blume) Ulm at seedling stage. The experimental design was randomized complete block design, with 7 treatments and 3 replications with 35 seedlings in each replication which constituted a total of 735 seedlings. The root collar increment, plant height increment, number of leaves, leaf area, dry biomass and root shoot ratio were evaluated. After six months of fertilizer application, results showed that there was an increasing influence ($p \leq 0.01$) to the root collar diameter increment, plant height increment, number of leaves and leaf area specially in –Ca treatment. The biomass production and root-shoot ratio was significantly affected ($p \leq 0.01$) in control and –N treatments. Stunted growth and reduced leaf were exhibited in seedlings planted at -N and control treatments. Furthermore, the result showed that the omission of calcium has positive effects ($p \leq 0.01$) while omitting nitrogen showed negative effects ($p \leq 0.01$) on the morphology and physiology of *Trema orientalis*. Therefore, the omission of macronutrients at early seedling stage of *Trema orientalis* growth has positively ($p \leq 0.01$) and negatively ($p \leq 0.01$) affected the growth performance of the study plant.

Keywords biomass production, growth performance**,** nutrient omission, rainforestation

INTRODUCTION

Forest has a vital role in the environment and climate change since it functions as a carbon sink. According to World Wildlife Fund (2018), without forest areas, excessive carbon would contribute to the carbon present in the atmosphere and enhances the greenhouse effect. The tropics and the

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subtropics experienced the greatest loss in forest cover mainly due to extensive forestry land uses where forests are converted into crop production areas (Hansen et al., 2013). The Philippine forest land is among the top threatened biodiversity areas in the world (Apan et al., 2017). The country depends on the forest for timber and other resources which leads to irresponsible logging activities, swidden agriculture and mining (Perez et al., 2020). Deforestation also affects the country's resistance to natural disasters such as landslides and flush floods. A solution to this problem is by restoring forest covers through planting of native trees. The value of the forest has become more important considering the threats brought by climate change, as forests' mitigate the effects by retaining water, carbon sequestration and so on (FAO and UNEP, 2020). Rainforestation promotes the importance of native species as it promotes biodiversity rehabilitation, conservation of remaining primary forests and natural resources, and the development of a closed canopy and high diversity forest farming system (Milan and Ceniza, 2009). Regeneration of forest largely depends on the survival and growth rates of native species that are planted or have arrived on their own (D'Antonio and Meyerson, 2002). Rainforestation provides environmental and economic benefits as well as enrichment of biodiversity. It also improves chemical properties of soil and provides higher net income because of the availability of resources (Neidel et al., 2012).

In a disturbed and damaged ecosystem, the early successional tree species together with other pioneer plants are the first to grow because they can adjust to poor soil conditions and adverse environmental situations (Natividad, 2016). In reforestation, pioneer tree species are planted first to copy the natural flow of forest succession which creates diverse forest and variations (Neidel et al., 2012). Soils in the tropics are fragile and the overuse of soil leads to unproductiveness and affects the growth of plants (Pessaraklim, 1999). Just like other tropical countries, the Philippines is also affected by land degradation which is a major ecological problem (Asio and Milan, 2002). Land degradation is mainly due to anthropogenic activities that can lead to loss of soil nutrient, organic matter content, addition of heavy metals, compacted and polluted soils and increased of the pH level of the soil (Asio et al., 2009).

Trema orientalis is a medium to large sized tree, growing in the average 20 m and attaining diameters of 60 cm at breast height. A tropical tree belonging to family Ulmaceae that grows in poor soil condition and chromite overburdens. This tree is an effective cover to avoid leaching of heavy metals in the presence of mine waste dumps into neighboring environments.

Studies on early successional tree species are limited, especially on determining the growth performance as affected by nutrient deficiency. Thus, this study will focus on early successional species *Trema orientalis* and the effects of mineral nutrient omission, both physiologically and morphologically at seedling stage. The hypothesis for this study is "nutrient element omission will affect the growth performance of *Trema orientalis.*

OBJECTIVES

1. To evaluate the morphological performance of *Trema orientalis* seedlings as affected by nutrient element omission under screen house conditions; and
2. To determine the influence of nutrient element omission on the physiological performance of *Trema orientalis* seedlings.

METHODOLOGY

Location of Study Site and Experimental Design

This study was conducted at the screen house in VSU, Baybay city, Leyte, Philippines. The study site falls under type IV climate wherein rainfall is more or less distributed throughout the year.

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Randomized Complete Block Design (RCBD) was used as the experimental design with 7 treatments and 3 replications for each treatment. Each replication consists of 35 seedlings with a total of 735 seedlings. The treatments were the following: Treatment 1 (T1) – without the application of nutrient solution; Treatment 2 (T2) - nitrogen (-N) was omitted in the solution; Treatment 3 (T3) - phosphorus (-P) was omitted in the solution; Treatment 4 (T4) - potassium (-K) was omitted in the solution; Treatment 5 (T5) - calcium (-Ca) was omitted in the solution; Treatment 6 (T6) - magnesium (-Mg) was omitted in the solution; and Treatment 7 (T7) – complete (N, P, K, Ca &, Mg) nutrient solution.

Data Collection

The first destructive harvesting was done before treatment application. A total of 10 samples in which the roots, stem, and leaves were separated and then measured. After measuring and air drying, the samples were placed in a paper bag and were oven dried at 70 °C for 27 hours (Bande et al., 2013). Then the dried samples were measured using digital analytical balance to acquire the biomass of the roots, stem, and leaves. Six months after treatment application (February 2019) random selection was done and 15 samples were harvested per treatment. The morphology and physiology of the seedlings were initially documented and recorded. This includes the initial root collar diameter (RCD), shoot height, and number of leaves. A correction fluid was used to mark the exact point of the root collar. The root collar diameter was measured using the Vernier caliper (mm). This was done by placing the caliper at the marker and the height was measured using a ruler (cm). The number of leaves was determined through counting of functional leaves. After six months of fertilizer application, second collection of data was done using the same methodology and instruments in their respective parameters.

Data Encoding and Statistical Analysis

Morphological (i.e. root collar diameter, height, and number of leaves) and physiological (i.e. root biomass, stem biomass, and leaf biomass) data were encoded and graphed using MSExcel 2016. Test was done for normality and homogeneity using Statistical Package for Social Sciences (SPSS) version 25. One-way ANOVA was used to determine significant effects of the treatments on root collar diameter increment, shoot height increment, number of leaves, leaf area, dry biomass (i.e., leaves, stem, roots, and total) and root-shoot ratio. Duncan Multiple Range Test (DMRT) and Least Square Differences (LSD) were used to compare treatment means and significant differences of independent variables with significant variations at $p \leq 0.05$.

RESULTS AND DISCUSSION

Morphological Performance

Table 1 presents that the root collar diameter increment and shoot height of *Trema orientalis* was significantly ($p \leq 0.01$) affected by the nutrient element omission after six months of treatment application. It is further observed that -Ca treatments had the highest increment in root collar diameter (2.76mm ± 0.09) and shoot height (34.34cm ± 0.70) as compared to the –N and Control (0.92mm ± 0.03) treatments which showed the lowest growth increment of *Trema orientalis* after six months of fertilizer application (Table 4). Nitrogen is important for the formation of protoplasm which is essential for plant growth and development. Thus, omission of Nitrogen will result into stunted growth because cell division is reduced (Uchida, 2000).

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Table 1 Root collar diameter (mm) and shoot height (cm) increments of Anabiong planted under screen house condition six months after treatment application

Treatment	Root collar increment (mm)	Shoot height increment (cm)
Control	0.92 ± 0.08^{d}	8.54 ± 0.76^{d}
-N	1.15 ± 0.08^{c}	7.38 ± 0.76^{d}
-P	2.65 ± 0.08^{a}	25.50 ± 0.76^{b}
-K	2.49 ± 0.08^{b}	26.03 ± 0.76^{b}
-Ca	2.76 ± 0.08^{a}	34.34 ± 0.76^{a}
-Mg	2.41 ± 0.08^{b}	26.61 ± 0.76^{b}
Complete	2.36 ± 0.08^{b}	22.25 ± 0.76^{c}

Note: Values with different superscript letters (a-d) within columns are statistically significant at $p \leq 0.05$. Root Collar Increment n=720, Shoot Height Increment n=727

Similarly, statistical analysis showed that the number of leaves and leaf area of *Trema orientalis* were significantly ($p \leq 0.01$) affected by the nutrient element omission after six months of fertilizer application (Fig. 1). The -N and Control treatments significantly had the least leaves produced after this period and all treatments with Nitrogen produced significantly higher number of leaves. Results indicate that Nitrogen is necessary for the production of photosynthetic plant organ. On the other hand, omission of Calcium resulted to the significant increase ($p \leq 0.01$) in leaf quantity as well as the leaf area of *Trema orientalis* after six months. In view of this observation, it is suggested that Ca maybe regarded not necessary for the production of leaves in *Trema orientalis* under certain growth stage. Results of the current study may also indicate inherent Ca content of the potting medium sufficient enough for the production of leaves.

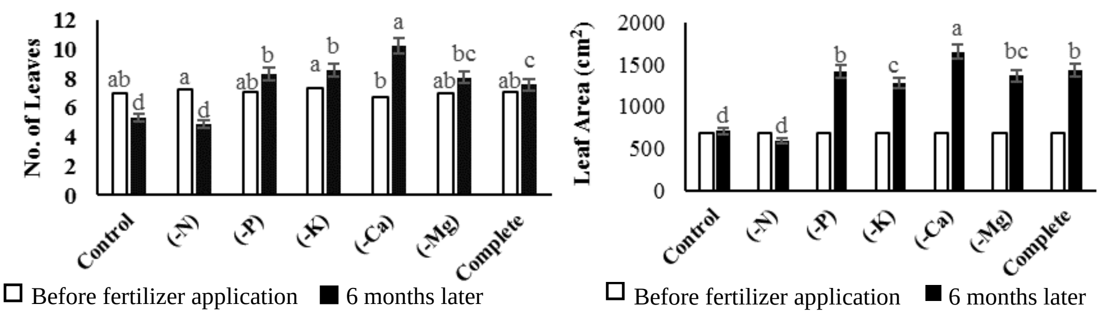

Fig. 1 Number of leaves and leaf area before and after 6 months of fertilizer application

Note: Values with different letter (a-d) designation with the same color are significantly different at $p \leq 0.05$. Number of leaves n=120, Leaf area n=15

Physiological Performance

The dry biomass as shown in Table 2 indicates that the –Ca treatment had the highest total biomass after 6 months of fertilizer application while the –N had the least biomass. -Ca treatment significantly had the highest root, stem and leaf biomass while –N and control treatments had the lowest increase in biomass after 6 months of fertilizer application. Furthermore, it was observed that among the plant organs roots had the most biomass allocation, regardless of what nutrient element was omitted.

Root Shoot Ratio

Overall observation shows that omission of N in the fertilizer solution resulted to the increase in the root-shoot ratio (Fig. 2). This observation confirms the findings of Davidson (1969) in ryegrass that decreasing the availability of N increased root: shoot ratio due to the increased sink strength of the

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roots compared to the shoot sinks. Under the N depletion, soil environment roots tend to increase its length to aid the plant in obtaining more Nitrogen; hence, increasing its root biomass. The observation strongly indicates the importance of these nutrients in translocating photosynthates from shoot for root development.

Table 2 Biomass (g) of the roots, stem and leaves of *Trema orientalis* after six months of treatment application

Treatment	Roots (g)	Stem (g)	Leaves (g)	Total (g)
Control	0.23 ± 0.02^{b}	0.13 ± 0.02^{c}	0.13 ± 0.02^{c}	0.52 ± 0.05^{c}
-N	0.26 ± 0.02^{b}	0.11 ± 0.01^{c}	0.11 ± 0.01^{c}	0.45 ± 0.04^{c}
-P	1.00 ± 0.09^{a}	0.61 ± 0.06^{b}	0.72 ± 0.07^{b}	2.34 ± 0.18^{b}
-K	1.18 ± 0.10^{a}	1.00 ± 0.20^{a}	1.10 ± 0.14^{ab}	3.28 ± 0.41^{a}
-Ca	1.16 ± 0.09^{a}	0.84 ± 0.06^{bc}	0.97 ± 0.07^{ab}	2.98 ± 0.17^{bc}
-Mg	1.06 ± 0.08^{a}	0.77 ± 0.09^{bc}	0.95 ± 0.08^{ab}	2.77 ± 0.24^{bc}
Complete	1.04 ± 0.07^{a}	0.67 ± 0.06^{b}	0.95 ± 0.07^{a}	2.66 ± 0.19^{bc}

Note: Values with different superscript letters (a-c) within columns are statistically significant at $p \leq 0.05$, n=105

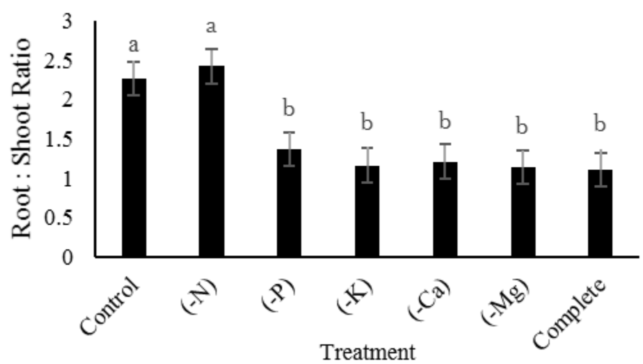

Fig. 2 Root shoot ratio of *Trema orientalis* after six months of fertilizer application

Note: Values with different letter (a-b) designation are significantly different at $p \leq 0.05$ root:shoot ratio n=15

CONCLUSION

Omission of different macronutrient elements has a significant effect ($p \leq 0.01$) on the growth increment of root collar diameter and shoot height, as well as on production of leaves and leaf area that subsequently affected the allocation of biomass in any of the plant parts and the root shoot ratio. This is because the macronutrients have specific functions as involved in the metabolic processes of the plants. Omission of calcium has positive effects on the morphology and physiology of *Trema orientalis*. Furthermore, the consistent low biomass production in -N treatment of the *Trema orientalis* strongly indicates that nitrogen primarily accounts for the growth rate of these plants. Therefore, the omission of macronutrient at the early seedling stage of *Trema orientalis* has positively ($p \leq 0.01$) and negatively ($p \leq 0.01$) affected the growth performance of the study plant.

ACKNOWLEDGEMENTS

We extend our gratitude to the Nature-Life International through ViSCA Forest Reserved CO2 Conservation Project for their generous financial support of the study.

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