International Journal of Sustainability and Advanced Integrated Research
Volume 2, Issue 1 (January-March 2026) | ISSN: 3107-7854
DOI: https://doi.org/10.65339/ijsair.V2.I1.28

Early Growth Response of Kalantas (Toona calantas Merr. & Rolfe) to Different Potting Media and Biostimulant Application

Josephine B. Cotillon
College of Forestry, Benguet State University

Publication history: Received: December 22, 2025; Revised: January 9, 2026; Accepted: January 29, 2026
Email of Corresponding Author: josephinecheng2balbincotillon@gmail.com

Abstract

This study investigates the early growth response of *Toona calantas* (Kalantas) to Different Potting Media and Biostimulant Application in Ilocos Sur, Philippines. A two-factor completely randomized design tested the effects of three soil media types and varying biostimulant doses on seedling growth. Results showed that forest soil with carbonized rice hull combined with a full dose of biostimulant significantly improved height, diameter, root-shoot ratio, and survival rate. The findings emphasize the importance of using forest soil compositions and organic inputs in optimizing the propagation of *T. calantas*. This study provides practical guidelines for conservation and reforestation initiatives involving threatened native species in similar ecological zones.

Keywords: Toona calantas, biostimulant, forest soil, seedling growth, conservation

1. Introduction

The Philippines is internationally recognized as one of the 18 megadiverse countries, containing two-thirds of the earth's biodiversity and between 70% and 80% of the world's plant and animal species (Fernando et al., 2008). However, it is also a global biodiversity hotspot, with at least 700 threatened species, including Toona calantas (Kalantas), which is listed as critically endangered (DENR Administrative Order 2007-11; Fernando et al., 2008). Kalantas is a premium native species valued for its high-quality timber and other economic uses, but very limited information exists regarding its propagation under different environmental conditions. In Ilocos Sur, where this species still exists naturally, increasing deforestation and forest degradation highlight the urgency of conservation efforts (Global Forest Watch, 2023). This study addresses the need for updated ecological and silvicultural data to support the conservation and propagation of T. calantas through appropriate nursery and field management. The scope of this research focuses on assessing the early growth response of T. calantas in Ilocos Sur to varying potting media and biostimulant applications. The study evaluates three soil types—forest soil, forest soil with carbonized rice hull, and river sand with carbonized rice hull—and their interaction with different doses of CERES biostimulant. The research problem centers on the absence of published scientific studies on the effects of biostimulants, a form of biotechnology, on T. calantas growth. Although T. calantas has been studied for its wood properties and ecological distribution (Barstow, 2018; Castillo et al., 2015), no systematic experimentation has examined how locally available biostimulants and potting media affect its seedling development.

Previous work on reforestation practices has emphasized the adverse ecological consequences of relying on exotic fast-growing species, which can disrupt native biodiversity and alter ecological networks (Bianco et al., 2014; Badalamenti et al., 2018). Research has shown that native species provide more suitable habitats for wildlife and support long-term forest recovery (Becerra & Montenegro, 2013; Chazdon, 2008). Organic and compost-based potting media have been found to improve seedling quality due to better nutrient retention and aeration (Mariotti et al., 2020; Wilson & Stoffella, 2006). Similarly, biostimulants such as seaweed extracts and protein hydrolysates have demonstrated benefits in improving root development, nutrient uptake, and resistance to abiotic stress (Chowdhary et al., 2021; Craigie, 2011). Yet, no such trials have been documented for T. calantas, making this study a pioneering effort. This research is important because T. calantas is nearing extinction in many areas due to unsustainable harvesting and habitat loss (Aggangan et al., 2010; Barstow, 2018). Enhancing its propagation using environmentally sound and cost-effective techniques could help reestablish populations in degraded areas and support long-term conservation. The study aims to contribute practical information for local farmers, nursery operators, and reforestation programs seeking to use native species for ecological restoration. The objective of the study is to determine the effects of different potting media and biostimulant applications on its early growth response under these treatments.

2. Methodology

The study was conducted from May to October 2024 at the Barangay nursery in Banucal, Lidlidda, Ilocos Sur, an area characterized by a tropical monsoon climate with an average annual precipitation of 2851 mm and temperatures ranging from 25°C to 27°C. To achieve the study objective, nursery-based methods was employed. For the nursery experiment, 3,500 T. calantas seeds were initially germinated in seedboxes. After two months, 720 healthy and uniform seedlings were selected and transplanted into polyethylene bags containing various potting media. The potting substrates consisted of combinations of forest soil, river sand, and carbonized rice hull at a 1:1 ratio. These were sun-dried for six hours and sieved to remove debris. The study employed a two-factor experiment under a completely randomized design (CRD) involving nine treatment combinations replicated four times. Each treatment had 80 seedlings, totaling 720. Factor A consisted of three levels of biostimulant: control (no application), half dose, and full dose. Factor B involved three types of soil media: forest soil (FS), forest soil with carbonized rice hull (FSCRH), and river sand with carbonized rice hull (RSCRH).

The biostimulant used in the study was CERES, a seaweed-based foliar fertilizer currently under trial; thus, product-specific supporting literature is not yet available. Application was done using a mist sprayer on the 15th, 30th, and 45th day after potting (DAP), in accordance with the manufacturer's recommendations.The treatments were arranged randomly across the nursery beds under partial shade conditions. Measurements for height and diameter were recorded at 15-day intervals up to 60 DAP. Height was measured using a ruler from the root collar to the apical bud, while diameter was measured at the root collar using a vernier caliper. Root-shoot ratio was determined by selecting eight representative seedlings per treatment after 60 DAP. This involved carefully excavating the seedlings to preserve the entire root system. Survival rate was calculated as the percentage of seedlings that remained alive 60 days after potting. Seedling health was assessed using a leaf color chart, rating leaf color from yellow to dark green.

3. Results and Discussion

3.1 Effects of Potting Media and Bio-stimulant on Height Growth of *T. calantas*

Height of *T. calantas* increased steadily from 15 to 60 DAP across all treatments, with clear numerical differences among potting media and bio-stimulant levels. At 60 DAP, seedlings treated with the full-dose (FD) bio-stimulant attained a mean height of 64.52 cm, which was 7.57 cm taller than the half-dose (56.95 cm) and 13.45 cm taller than the control (51.07 cm). Among potting media, seedlings grown in forest soil with carbonized rice hull (FSCRH) reached 63.73 cm, exceeding those grown in forest soil alone (57.85 cm) by 5.88 cm, and river sand with carbonized rice hull (50.95 cm) by 12.78 cm. The highest recorded height was observed under the interaction of FSCRH and full-dose bio-stimulant, which reached 92.49 cm at 60 DAP, compared with 80.54 cm under forest soil with no bio-stimulant and 74.64 cm under river sand with no bio-stimulant.

The numerical superiority of FSCRH combined with full-dose bio-stimulant demonstrates the importance of both nutrient availability and enhanced physiological activity in early seedling growth. Forest soil contributes essential macro- and micronutrients, while carbonized rice hull improves aeration and moisture retention. Bio-stimulants further amplify growth by enhancing nutrient uptake and stimulating hormonal activity, which explains the substantial height advantage observed under the full-dose treatment. These findings are consistent with earlier reports highlighting the role of fertile substrates and growth enhancers in promoting shoot elongation.

From a production standpoint, achieving height gains exceeding 90 cm within 60 days represents a major improvement in nursery efficiency. Taller seedlings at an early stage are likely to establish more rapidly after transplanting, reducing production cycles and improving reforestation success using *T. calantas*.

3.2 Effects of Potting Media and Bio-stimulant on Diameter Growth of *T. calantas*

Stem diameter of *T. calantas* increased across all treatments from 15 to 60 DAP, with marked numerical differences at final measurement. At 60 DAP, seedlings grown in FSCRH attained a mean diameter of 8.09 mm, which was 0.51 mm larger than forest soil (7.58 mm) and 2.35 mm larger than river sand with carbonized rice hull (5.74 mm). Bio-stimulant application further enhanced diameter growth, with the full-dose treatment producing a mean diameter of 8.09 mm, compared with 7.82 mm under half dose and 7.58 mm under the control.
The greatest diameter growth was observed under the FSCRH plus full-dose bio-stimulant combination, reaching 9.37 mm, whereas the lowest value (5.74 mm) occurred under the control combined with river sand-based media.
The numerical gains in stem diameter under FSCRH and full-dose bio-stimulant indicate improved cambial activity and structural development. Diameter growth is strongly influenced by sustained nutrient supply and water availability, both of which are enhanced by forest soil and carbonized rice hull. Bio-stimulants likely

contributed by stimulating metabolic pathways responsible for secondary growth, resulting in thicker and more robust stems.

An increase of more than 3.6 mm in stem diameter between the best and poorest treatments is agronomically significant, as stem thickness is closely linked to seedling sturdiness and resistance to mechanical stress. These results suggest that selecting the appropriate media and bio-stimulant dosage can markedly improve planting stock quality.

3.3 Effects of Potting Media and Bio-stimulant on Root–Shoot Ratio and Survival of *T. calantas*

At 60 DAP, shoot length ranged from 74.64 cm in the control with river sand and carbonized rice hull to 92.49 cm under full-dose bio-stimulant with FSCRH, representing a difference of 17.85 cm. Root length followed a similar pattern, increasing from 75.36 cm in the poorest treatment to 93.82 cm in the best treatment, a gain of 18.46 cm. Survival rates also varied substantially, with the highest survival recorded under FSCRH plus full-dose bio-stimulant at 96.25%, compared with only 80.00% survival under the control combined with river sand media, reflecting a 16.25 percentage point increase.

The substantial numerical increases in both root and shoot length under full-dose bio-stimulant application indicate enhanced seedling vigor and balanced growth. Longer roots improve water and nutrient absorption, while increased shoot length enhances photosynthetic capacity. The higher survival rate observed under the same treatment suggests that these physiological improvements translate directly into greater seedling resilience.

Survival rates exceeding 95% are highly desirable in nursery operations and field establishment. The marked improvements in root length, shoot length, and survival demonstrate that combining FSCRH with a full-dose bio-stimulant can substantially improve seedling quality and post-transplant performance of *T. calantas*, making this treatment highly suitable for large-scale reforestation and afforestation programs.

4. Conclusion

Across all growth stages (15, 30, 45, and 60 DAP), the study found that forest soil enriched with carbonized rice hull was the most effective among the three tested media outperforming river sand with carbonized rice hull and forest soil alone in promoting optimal growth of T. calantas seedlings. This treatment significantly enhanced plant height, stem diameter, root-to-shoot ratio, and survival rates, owing to the nutrient-rich composition and organic matter retention of forest soil, further improved by the physical and chemical properties of carbonized rice hull. When paired with a full-dose biostimulant (BS2), it exhibited a synergistic effect that maximized nutrient uptake, improved stress tolerance, and boosted overall seedling vigor. These findings underscore the importance of selecting compatible soil media and biostimulant levels to ensure optimal early establishment and sustained growth offering practical insights for sustainable forestry, reforestation, and nursery management. Beyond agronomic benefits, the study offers practical implications for sustainable agriculture and conservation. The consistent effectiveness of full-dose biostimulants suggests their potential to reduce reliance on chemical fertilizers, contributing to environmentally friendly farming practices. Moreover, the enhanced establishment of T. calantas seedlings supports reforestation and afforestation efforts, reinforcing the species' ecological role in preventing soil erosion, enriching biodiversity, and providing habitat in tropical ecosystems. Tailoring soil and biostimulant combinations can thus serve as a strategic tool for both crop productivity and forest restoration, paving the way for future research into long-term soil health, economic viability, and broader conservation outcomes.

To enhance the growth and survival of T. calantas seedlings, seedling growers, farmers, and agricultural practitioners should prioritize the use of forest soil enriched with carbonized rice hull, especially when paired with full-dose biostimulants. This combination has consistently demonstrated superior results in improving plant height, diameter, root-to-shoot ratio, and survival rates. Regular soil testing and monitoring of plant growth stages should be integrated into nursery and farm operations to guide soil media selection and biostimulant application. Extension services and training programs must promote the adoption of these practices, emphasizing their role in reducing reliance on chemical fertilizers and supporting sustainable agriculture.

To ensure long-term success, conservation programs should incorporate optimized potting media and biostimulant strategies into nursery propagation. Engaging local communities through education and stewardship initiatives will foster broader adoption and support. Policymakers and agricultural advisors should encourage integrated soil-biostimulant management tailored to specific crops and environments. Continued research and development are essential to refine biostimulant formulations, assess economic feasibility, and improve soil health ultimately contributing to more resilient ecosystems and sustainable forestry practices.

Acknowledgements

The researcher extends sincere gratitude to all individuals and institutions that made this study possible. The researcher also expresses appreciation to the Department of Agriculture Regional Field Office I in Santa Barbara, Pangasinan for their assistance in conducting soil analyses that contributed critical data to the study. Heartfelt thanks are extended to the local government units and barangay officials of Lidlidda, San Emilio, Burgos, and Sta. Cruz in Ilocos Sur for granting access to field sites and supporting field data collection. Deep appreciation is also extended to the researcher's academic mentors and colleagues for their technical guidance, constructive feedback, and encouragement throughout the research process. Lastly, the researcher wishes to thank family and friends for their unwavering support, patience, and understanding during the entire duration of the study. Their encouragement served as a steady source of strength and motivation.

REFERENCES

Aggangan, J. S., Buot, I. E., Jr., Relox, R. E., & Rebancos, C. M. (2010). Ethnobotany of the plant resources in Conner, Apayao, Northern Luzon, Philippines. *Journal of Nature Studies, 9*(1), 31–38.

Anburani, A., & Shakila, A. (2010). Influence of seed treatment on the germination and seedling vigour of papaya. *Acta Horticulturae, 851*, 295–298. https://doi.org/10.17660/ActaHortic.2010.851.48

Anozie, E. L., Egwunatum, A. E., Ezenwenyi, J. U., & Okonkwo, C. I. (2022). Effects of different potting media on the germination and early growth of *Newbouldia laevis* (P. Beauv.) Seem. ex Bureau. *Nigerian Journal of Botany, 35*(1), 1–9.

Aznar-Sánchez, J. A., Velasco-Muñoz, J. F., López-Felices, B., & Román-Sánchez, I. M. (2020). An analysis of global research trends on greenhouse technology: Towards a sustainable agriculture. *International Journal of Environmental Research and Public Health, 17*(2), 664. https://doi.org/10.3390/ijerph17020664

Badalamenti, E., Sferlazza, S., La Mela Veca, D. S., Maetzke, F., Sala, G., & La Mantia, T. (2018). The evolution in time of the concept of fast-growing tree species: Is it possible to use a definition applicable to all environmental conditions? *Annals of Silvicultural Research, 45*(1), 53–61. https://doi.org/10.12899/asr-1761

Balde, S., Diallo, M., Sow, A., Camara, K., & Barry, T. (2021). Effects of seed pretreatment on germination, growth and yield of *Momordica charantia* L. *Agricultural Sciences, 12*(1), 39–57. https://doi.org/10.4236/as.2021.121004

Barrett, G. E., Alexander, P. D., Robinson, J. S., & Bragg, N. C. (2016). Achieving environmentally sustainable growing media for soilless plant cultivation systems – A review. *Scientia Horticulturae, 212*, 220–234. https://doi.org/10.1016/j.scienta.2016.09.030

Barstow, M. (2018). *Toona calantas*. The IUCN Red List of Threatened Species 2018: e.T32122A68105077. https://dx.doi.org/10.2305/IUCN.UK.2018-1.RLTS.T32122A68105077.en

Bianco, S., Cook-Patton, S. C., & Agrawal, A. A. (2014). Exotic plants contribute positively to biodiversity functions but reduce native seed production and arthropod richness. *Ecology, 95*(6), 1642–1650. https://doi.org/10.1890/13-1768.1

Buot, I. E., Jr. (2009). *An ethnobotanical study of the plant biodiversity of Mt. Mayon, Bicol Peninsula, Albay, Philippines* [Unpublished manuscript]. Academia.edu. https://www.academia.edu/3798950/An_ethnobotanical_study_of_the_plant_biodiversity_of_Mt_Mayon_Bicol_Peninsula_Albay_Philippines

Cajano, M. A. O. (2001). Growth response of molave (*Vitex parviflora* Juss.) seedlings to Biocore and Mykovam. *Philippine Journal of Crop Science, 26*(Supplement 1), 74.

Chazdon, R. L. (2008). Beyond deforestation: Restoring forests and ecosystem services on degraded lands. *Science, 320*(5882), 1458–1460. https://doi.org/10.1126/science.1155365

Conda, J. M., & Buot, I. E., Jr. (2016). Biodiversity assessment and conservation status of some pteridophytes in the northeastern portion of Quezon Protected Landscape, Philippines. *The Thailand Natural History Museum Journal, 10*(1), 15–31.

Craigie, J. S. (2011). Seaweed extract stimuli in plant science and agriculture. *Journal of Applied Phycology, 23*(3), 371–393. https://doi.org/10.1007/s10811-010-9560-4

de Marco, R., Ferreira da Silva, R., da Ros, C. O., & Viel, P. (2021). Initial growth and quality of *Toona ciliata* seedlings under different substrates. *Journal of Forestry Research, 32*(2), 651–659. https://doi.org/10.1007/s11676-020-01125-z

De Oliveira Garcia, W., Amann, T., & Hartmann, J. (2018). Increasing biomass demand enlarges negative forest nutrient budget areas in wood export regions. *Scientific Reports, 8*(1), 5280. https://doi.org/10.1038/s41598-018-22728-5

Department of Environment and Natural Resources. (2007). *DENR Administrative Order No. 2007-01: Establishing the national list of threatened Philippine plants and their categories, and the list of other wildlife species*.

Dobrzański, J., & Pruszyński, S. (2008). Biostymulatory – nowa tendencja w ochronie roślin [Biostimulants – a new trend in plant protection]. *Postępy w Ochronie Roślin, 48*(2), 559–565.

Dolores, J. C. R., Galang, M. A., & Dida, J. J. V. (2020). Species-site suitability assessment of native species in Pantabangan-Carranglan watershed using Geographic Information System (GIS) and Analytic Hierarchy Process (AHP). *Philippine Journal of Science, 149*(3), 529–537.

Du Jardin, P. (2015). Plant biostimulants: Definition, concept, main categories and regulation. *Scientia Horticulturae, 196*, 3–14. https://doi.org/10.1016/j.scienta.2015.09.021

Ecosystems Research and Development Bureau. (1990). Reforestation species – white lauan and kalantas. *Research Information Series on Ecosystems, 2*(12), 1–32.

Ecosystems Research and Development Bureau. (2007). *Indigenous forest tree species in Laguna Province* (DENR Recommends, Vol. 15b). Department of Environment and Natural Resources.

Edmonds, J. M. (1993). The potential value of *Toona* species (Meliaceae) as multipurpose and plantation trees in Southeast Asia. *Commonwealth Forestry Review, 72*(3), 181–186. [suspicious link removed]

Elefan, E. S. (2010). *The effects of soil application of biofertilizers on the early growth of beauty leaf (Calophyllum inophyllum L.)* [Research report]. University Research Center, Central Philippine University.

Enkhtuya, B. (2000). Effectiveness of indigenous and non-indigenous isolates of arbuscular mycorrhizal fungi in soils from degraded ecosystems and man-made habitats. *Applied Soil Ecology, 14*(3), 201–211. https://doi.org/10.1016/S0929-1393(00)00057-3

Evans, M. R., & Gachukia, M. M. (2007). Physical properties of sphagnum peat-based root substrates amended with perlite or parboiled fresh rice hulls. *HortTechnology, 17*(3), 312–315. https://doi.org/10.21273/HORTTECH.17.3.312

Farhain, M. M. (2022). Potential of developing podzolic soil based potting media from wood ash, paper sludge and biochar. *Journal of Environmental Management, 301*, 113811. https://doi.org/10.1016/j.jenvman.2021.113811

Ferenc, V., Merkert, C., Zilles, F., & Sheppard, C. S. (2021). Multiple alien species override the effects of natives on species richness in plant communities. *Oecologia, 197*, 139–150. https://doi.org/10.1007/s00442-021-05017-3

Fernandez, J. A., & Gruda, N. S. (2022). Optimizing soilless culture systems and alternative growing media. *Agronomy, 12*(8), 1941. https://doi.org/10.3390/agronomy12081941

Fernando, E. S., Co, L. L., Lagunzad, D. A., Gruezo, W. Sm., Barcelona, J. F., Madulid, D. A., Lapis, A. B., Texon, G. I., Manila, A. C., & Zamora, P. M. (2008). Threatened plants of the Philippines: A preliminary assessment. *Asia Life Sciences, Supplement 3*, 1–52.

Filho, M. T., Botosso, P. C., & Lisi, C. S. (2001). The genus *Toona* (Meliaceae): Dendrology, ecology and wood anatomy with reference to its applicability for tropical dendrochronology. *Journal of the Palaeontological Society of India, 50*, 43–55.

Galindon, J. M., Pasion, B. O., Tongco, M. D. C., Fidelino, J., Duya, M. R. M., & Ong, P. S. (2018). Plant diversity patterns in remnant forests and exotic tree species-based reforestation in active limestones quarries in the Luzon and Mindanao biogeographic sub-regions in the Philippines. *Ecological Research, 33*, 63–72. https://doi.org/10.1007/s11284-017-1533-5

Gamble, J. S. (1880). The dye-producing properties of *Toona* flowers: Traditional applications in India. *Indian Forester, 8*(2), 112–119.

Gioria, M., & Osborne, B. A. (2014). Resource competition in plant invasions: Emerging patterns and research needs. *Frontiers in Plant Science, 5*, 501. https://doi.org/10.3389/fpls.2014.00501

Global Forest Watch. (2023). *Global deforestation rates & statistics*. https://www.globalforestwatch.org/

Gómez, C., & Robbins, J. A. (2011). Pine bark substrates amended with parboiled rice hulls: Physical properties and growth of container-grown spirea. *HortScience, 46*(5), 784–790. https://doi.org/10.21273/HORTSCI.46.5.784

Gross, A., Li, C. M., Remacle, F., & Levine, R. D. (2013). Free energy rhythms in *Saccharomyces cerevisiae*: A dynamic perspective with implications for ribosomal biogenesis. *Biochemistry, 52*(9), 1641–1648. https://doi.org/10.1021/bi301687y

Gruda, N., Qaryouti, M., & Leonardi, C. (2013). Growing media. In *Good Agricultural Practices for Greenhouse Vegetable Crops* (FAO Plant Production and Protection Paper 217, pp. 271–302). Food and Agriculture Organization of the United Nations.

Hall, J. S., Ashton, M. S., Garen, E. J., & Jose, S. (2011). The ecology and ecosystem services of native trees: Implications for reforestation and land restoration in Mesoamerica. *Forest Ecology and Management, 261*(10), 1553–1557. https://doi.org/10.1016/j.foreco.2010.11.007

Hansen, M. C., Potapov, P. V., Moore, R., Hancher, M., Turubanova, S. A., Tyukavina, A., Thau, D., Stehman, S. V., Goetz, S. J., Loveland, T. R., Kommareddy, A., Egorov, A., Chini, L., Justice, C. O., & Townshend, J. R. G. (2013). High-resolution global maps of 21st-century forest cover change. *Science, 342*(6160), 850–853. https://doi.org/10.1126/science.1244693

Hulme, P. E., & Bernard-Verdier, M. (2015). Alien and native plant species play different roles in plant community structure. *Journal of Ecology, 103*(1), 143–152. https://doi.org/10.1111/1365-2745.12341

Khan, W., Rayirath, U. P., Subramanian, S., Jithesh, M. N., Rayorath, P., Hodges, D. M., Critchley, A. T., Craigie, J. S., Norrie, J., & Prithiviraj, B. (2009). Seaweed extracts as biostimulants of plant growth and development. *Journal of Plant Growth Regulation, 28*(4), 386–399. https://doi.org/10.1007/s00344-009-9103-x

Kisvarga, S., Farkas, D., Boronkay, G., Neményi, A., & Orlóci, L. (2022). Effects of biostimulants in horticulture, with emphasis on ornamental plant production. *Agronomy, 12*(5), 1043. https://doi.org/10.3390/agronomy12051043

Landis, T. D., & Morgan, N. (2009). Growing media alternatives for forest and native plant nurseries. In *Proceedings of the Forest and Conservation Nursery Associations* (RMRS-P-58, pp. 26–31). U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Lapitan, P. G., Castillo, L. A., Balatibat, J. B., Castillo, M. L., & Bantayan, N. C. (2015). Spatial distribution of Kalantas (*Toona calantas* Merr. & Rolfe) in the Molawin-Dampalit Watershed, Mount Makiling Forest Reserve, Philippines. *Ecosystems & Development Journal, 5*(3), 33–42.

Lee, S. Y. (2005). Natural regeneration in exotic tree plantations in Hong Kong, China. *Forest Ecology and Management, 212*(1–3), 358–367. https://doi.org/10.1016/j.foreco.2005.03.024

Lenda, M., Skórka, P., Knops, J. M. H., Żmihorski, M., Gaj, R., Moroń, D., Woyciechowski, M., & Tryjanowski, P. (2019). Effects of exotic plants on native vegetation: Impacts on species richness and abundance. *Conservation Biology, 33*(4), 896–906. https://doi.org/10.1111/cobi.13257

Liancourt, P., Callaway, R. M., & Michalet, R. (2005). Stress tolerance and competitive-response ability determine the outcome of biotic interactions. *Ecology, 86*(6), 1611–1618. https://doi.org/10.1890/04-1398

Maithani, G. P., Bahuguna, V. K., & Negi, J. D. S. (1986). Natural processes of regeneration in a subtropical oak forest of Western Himalaya. *Indian Forester, 112*(7), 614–621.

Mariotti, B., Martini, S., Raddi, S., Tani, A., Jacobs, D. F., Oliet, J. A., & Maltoni, A. (2020). Coconut coir as a sustainable nursery growing media for seedling production of the ecologically diverse Quercus species. *Forests, 11*(5), 522. https://doi.org/10.3390/f11050522

Martins, L. D., Costa, F. P., Lopes, J. C., & Rodrigues, W. N. (2012). Influence of pre-germination treatments and temperature on the germination of crambe seeds (*Crambe abyssinica* Hochst). *Idesia (Arica), 30*(2), 23–28. https://doi.org/10.4067/S0718-34292012000200004

Miller, J. H., & Jones, N. (1995). *Organic and compost-based growing media for tree seedling nurseries* (World Bank Technical Paper No. 264). World Bank.

Mitchell, A. L. (1971). Planting trials with red cedar. *Australian Forestry, 35*(1), 8–16. https://doi.org/10.1080/00049158.1971.10675586

Overbeek, W., Kröger, M., & Gerber, J.-F. (2012). *An overview of industrial tree plantations in the global South: Conflicts, trends, and resistance struggles* (EJOLT Report No. 3). Environmental Justice Organisations, Liabilities and Trade. https://www.ejolt.org/2012/05/an-overview-of-industrial-tree-plantations-in-the-global-south/

Paquette, A., Hawryshyn, J., Senikas, A. V., & Potvin, C. (2009). Enrichment planting in secondary forests: A promising clean development mechanism to increase terrestrial carbon sinks. *Ecology and Society, 14*(1), 31. http://www.ecologyandsociety.org/vol14/iss1/art31/

Perry, L. M. (1980). *Medicinal plants of East and Southeast Asia: Attributed properties and uses*. The MIT Press.

PreventionWeb. (2020). *Deforestation report 2017-2020: Banayoyo, Ilocos Sur*. https://www.preventionweb.net/news/deforestation-report-2017-2020-banayoyo-ilocos-sur

Schneider, E. E. (1916). *Commercial woods of the Philippines: Their preparation and uses* (Bulletin No. 14). Department of the Interior, Bureau of Forestry.

Suding, K. N., Goldberg, D. E., & Hartman, K. M. (2003). Relationships among species traits: Separating levels of response and identifying linkages to abundance. *Ecology, 84*(1), 1–16. https://doi.org/10.1890/0012-9658(2003)084[0001:RASTSL]2.0.CO;2

Tomas-Carig, E. (2020). *Field guidebook on native trees within the Quirino forest landscape*. Quirino State University.

Tulod, A. M., Casas, J. V., Jr., Marin, R. A., & Ejoc, J. A. B. (2017). Diversity of native woody regeneration in exotic tree plantations and natural forest in Southern Philippines. *Forest Science and Technology, 13*(1), 31–40. https://doi.org/10.1080/21580103.2017.1292958

Udayana, C., Andreassen, H. P., & Skarpe, C. (2019). Wood and non-wood forest products of Central Java, Indonesia. *Journal of Sustainable Forestry, 38*(8), 715–732. https://doi.org/10.1080/10549811.2019.1633534

Useful Tropical Plants. (n.d.). *Toona calantas*. Retrieved June 11, 2024, from https://tropical.theferns.info/viewtropical.php?id=Toona+calantas

Veran, G. M., Baliton, R. S., & Galang, M. A. (2023). *Suitability assessment of Kalantas (Toona calantas Merr. & Rolfe) and Supa (Sindora supa Merr.) in the Quezon Protected Landscape using weighted overlay analysis* [Unpublished undergraduate thesis]. University of the Philippines Los Baños.

Verkade, S. D., Hamilton, D. F., & Elson, L. C. (1987). Effect of endomycorrhizal inoculation during propagation on growth following transplanting of *Cornus sericea* cuttings and seedlings. *Combined Proceedings, International Plant Propagators' Society, 37*, 469–473.

Vermudo, J. A. (1995). *Vegetation analysis of the tree layer lowland Dipterocarp Forest at Quezon National Park, Quezon Province Philippines* [Unpublished master's thesis]. University of the Philippines Los Baños.

Wang, F. (2017). Occurrence of arbuscular mycorrhizal fungi in mining-impacted sites and their contribution to ecological restoration: Mechanisms and applications. *Critical Reviews in Environmental Science and Technology, 47*(20), 1901–1957. https://doi.org/10.1080/10643389.2017.1378875

Whitford, H. N. (1906). The vegetation of Lamao Forest Reserve. *Philippine Journal of Science, 1*(4), 373–431.

Wikipedia contributors. (2023, September 27). *Toona calantas*. Wikipedia. https://en.wikipedia.org/wiki/Toona_calantas

Wilson, S. B., Mecca, L. K., Danielson, H. E., Graetz, D. A., & Stoffella, P. J. (2006). Container and field evaluation of three native shrubs grown in compost-based media. *Compost Science & Utilization, 14*(3), 178–183. https://doi.org/10.1080/1065657X.2006.10702581

Xie, C., Li, M., Chen, L., & Jim, C. Y. (2024). Climate driven changes to the spatial-temporal pattern of endangered tree *Toona ciliata* Roem. in China. *Theoretical and Applied Climatology, 155*, 2071–2085. https://doi.org/10.1007/s00704-023-04787-z

Yang, Y., He, C., Huang, L., Ban, Y., & Tang, M. (2017). The effects of arbuscular mycorrhizal fungi on glomalin-related soil protein distribution and aggregate stability in a sandy loam soil. *Geoderma, 305*, 87–94. https://doi.org/10.1016/j.geoderma.2017.05.041