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Full Length Research Article

Growth Performance of Selected Bamboos in Secondary Forest and Riparian Ecosystems under Different Silvicultural Treatments

Lorena Pioquinto-Laguardia[1,2,*], Ireneo Latunio Lit Jr.[3], Merdelyn Caasi Lit[4]

[1] Department of Forest Biological Sciences, College of Forestry and Natural Resources, University of the Philippines Los Baños, Laguna, Philippines
[2] Department of Environmental Science and Ecotourism, Nueva Vizcaya State University, Nueva Vizcaya, Philippines
[3] Environmental Biology Division, Institute of Biological Sciences, University of the Philippines Los Baños, Laguna, Philippines
[4] Entomology Laboratory, Institute of Plant Breeding College of Agriculture and Food Science, University of the Philippines Los Baños, Laguna, Philippines
[*] Corresponding Author. E-mail address: lplaguardia@nvsu.edu.ph

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ABSTRACT

This study was conducted in Nueva Vizcaya to evaluate the growth performance of two economically important erect bamboo species, *Bambusa vulgaris* and *Bambusa spinosa*, in secondary forest and riparian ecosystems under different silvicultural treatments. A factorial experiment was arranged in a Randomized Complete Block Design (RCBD) with three silvicultural treatments and three sampling plots. Each sampling plot contained 36 plantlets (18 *B. spinosa* and 18 *B. vulgaris*) for both ecosystem types. The field study lasted six months, with data collected biweekly. Growth parameters measured included percent survival, average height (cm), average diameter (mm), and number of shoots. Data were analyzed using repeated measures ANOVA in MINITAB and summarized with Excel pivot tables. The results revealed significant effects of silvicultural treatments and plot location on growth parameters. *B. vulgaris* exhibited more shoots than *B. spinosa* in the secondary forest. Ring weeding and cultivation (C2) resulted in a significantly higher number of shoots (1.85), followed by ring weeding with no cultivation (1.83), albeit fewer and shorter than those under no weeding and cultivation (1.72). Silvicultural management showed no significant correlation with other variables. A positive correlation between light intensity and growth was observed, with the highest correlation occurring at 4 pm. This pioneering study provides baseline data for monitoring the growth and performance of these bamboo species across distinct ecosystems. By offering comprehensive insights into their growth patterns and adaptability, the findings could inform sustainable management practices and conservation strategies for bamboo resources under varying environmental conditions.

1. Introduction

Deforestation is considered the most serious environmental problem in the Philippines (Gabriel 2023). It means the loss of valuable environmental services such as natural biodiversity, watershed functions, carbon sequestration, and sources of timber and non-timber forest products (Gabriel 2023; Nasution et al. 2024; Shinohara et al. 2019; Upadhaya et al. 2016). Therefore, the government and civil society must exert huge efforts to rehabilitate and reforest the country's denuded uplands and riparian areas.

Past reforestation efforts in the country emphasize the fast-growing exotic species due to their immediate benefits. However, this approach has garnered criticism due to the long-term ecological consequences associated with introducing non-native species. The use of native species such as *Bambusa vulgaris* Schrad. ex J.C.Wendl. and *B. spinosa* Roxb. ex-Buch. -Ham. (cf. Pelser et al. 2022; = *B. blumeana* Schult. & Schult.f. offers numerous advantages for ecological restoration. These species enhance biodiversity, improve soil health, support local economies, and better adapt to the environment. Emphasizing the use of native species in rehabilitation efforts is not only for the communities that rely on these resources. Therefore, a shift toward incorporating native species into restoration strategies is essential for achieving sustainable environment management (Satriagasa et al. 2024).

Bamboo is regarded as one of the most versatile and valuable plants in the Philippines due to its numerous benefits (Van Goethem et al. 2015). In the Cagayan Valley region, it has been utilized for various purposes, including as a source of food, medicine (Baddu and Ouano 2018; Nongdam et al. 2014; Saddoy et al. 2024), and materials for housing, handicrafts, and furniture (Mabborang et al. 2022). In addition, bamboo has also been utilized for decorative purposes, serving as a landscaping element and as a reforestation species to aid in erosion control and stabilizing riverbanks (Aguinsatan et al. 2019).

The bamboo is an ancient woody grass widely distributed in tropical, subtropical, and mild temperate zones. It is known for being the fastest-growing plant on earth (Ahmad et al. 2021; Ritonga et al. 2024; Roxas 2012; Terefe et al. 2019). It builds important and diversified habitats with different specificities according to the nature of the species and the general ecological conditions. This plant is mature and ready for use within 3–5 years (Darwis and Iswanto 2018). It has the advantages of a short growth cycle, self-reproduction, and a low maintenance and regeneration cost compared to wood.

Silvicultural management plays an important role in determining the growth performance of bamboo species, including *B. vulgaris* and *B. spinosa*. The practices employed in silvicultural management can significantly influence various growth parameters, such as height, diameter, root development, and overall health of bamboo plantlets. Understanding the impact of these management practices is essential for optimizing bamboo cultivation, particularly in secondary forest and riparian ecosystems (Jihad et al. 2021). The data gathered in the study may serve as baseline information on the response of two erect bamboo species (*B. vulgaris* and *B. spinosa*), particularly their plantlets, in terms of growth performance in secondary forest and riparian ecosystems under three different silvicultural management treatments. This initiative will enhance awareness of the importance and benefits of bamboo and its potential role as an indicator species in ecosystems.

The study evaluated the growth performance of the two erect bamboo species (*B. vulgaris* and *B. spinosa*) in secondary forest and riparian ecosystems. The field study lasted six months, and data collection was done every other week. The study's main objectives were to determine the growth performance of two erect bamboo species grown in secondary forest and riparian ecosystems under three different silvicultural treatments in Bagabag, Nueva Vizcaya, Philippines. The assessment was conducted on the growth performance of the two erect bamboos grown in secondary forest and riparian ecosystems using percent survival and bamboo growth (height, diameter, and number of shoots.

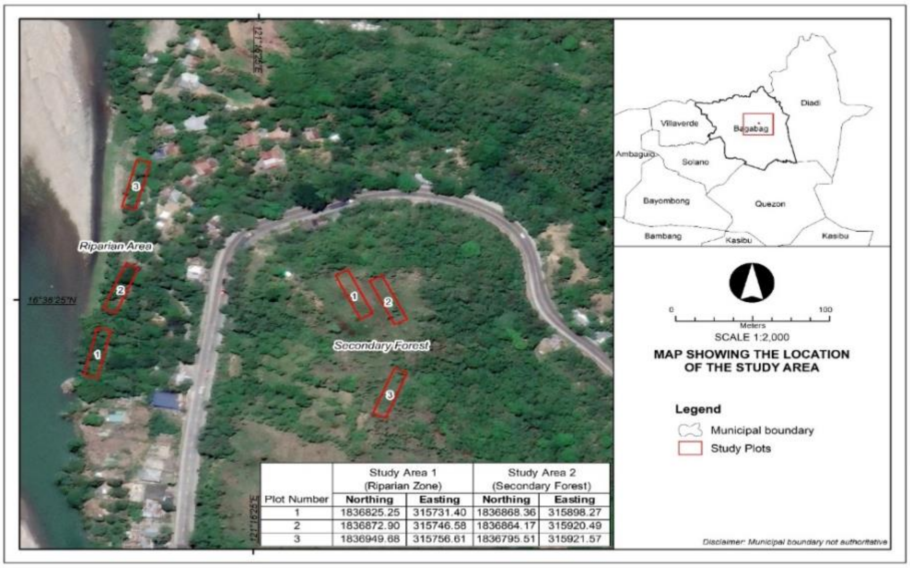
2. Materials and Methods

2.1. Experimental Designs and Layout of the Study

The factorial study was laid out in a Randomized Complete Block Design (RCBD with three silvicultural treatments and three sampling plots. Each sampling plot had 36 plantlets (18 *B. spinosa* and 18 *B. vulgaris*) for both areas of study. Three factors were considered in study A (area of the study): A1 represented the riparian area, and A2 represented the secondary forest. The bamboo species (B), wherein B1 symbolized *Bambusa vulgaris* and B2 *Bambusa spinosa*. The silvicultural treatment is represented by (C), C1- ring weeding, no cultivation, C2- ring weeding and ring cultivation, and C3- no weeding, no cultivation. This study applied specific silvicultural treatments to evaluate their effects on the growth of *B. vulgaris* and *Bambusa spinosa* in secondary forest and riparian ecosystems. The treatments included ring weeding with no cultivation, ring weeding with ring cultivation and a control (no intervention).

Ring weeding involves removing weeds around bamboo plantlets in circular areas, usually 30–50 cm from the stem. This practice helps reduce competition for sunlight, water, and nutrients. On the other hand, ring cultivation combines ring weeding with light tilling of the soil around the bamboo plantlets, also within a 30–50 cm radius, to improve soil conditions for the plants. Lastly, the control treatment involves no weeding or cultivation, allowing the bamboo to grow naturally without human intervention. This approach helps assess the growth performance of the bamboo under unmanaged conditions. These treatments are designed to provide insights into how different management practices affect the growth of bamboo species in various environments.

Nueva Vizcaya has a predominantly mountainous topography featuring steep mountains, rolling hills, valleys, and plains (JICA-DENR 2004). The Cordillera Mountains border it to the west, the Sierra Madre Mountains to the east, and the Caraballo Mountains to the south (Cruz et al. 2018). **Fig. 1** presents the map of the study area. This study was conducted at Purok 6, Kinacao, Baretbet, Nueva Vizcaya (Latitude: 16°36'23.034"N, Longitude: 121°16'21.27"E) (**Fig. 1**). Bagabag, Nueva Vizcaya, has a Type III climate, characterized by a short dry season and an absence of a distinct peak rainfall period (Basconcillo et al. 2016). The study period spanned from June 2021 to February 2022, with data analyzed using MINITAB's repeated measures ANOVA and summarized in Excel pivot tables.



Plot Number	Study Area 1 (Riparian Zone)		Study Area 2 (Secondary Forest)	
	Northing	Easting	Northing	Easting
1	1836825.25	315731.40	1836868.36	315898.27
2	1836872.90	315746.58	1836864.17	315920.49
3	1836949.68	315756.61	1836795.51	315921.57

Fig. 1. Map of the study site.

2.2. Selection and Procurement of Plants/ Planting Material

B. vulgaris and *B. spinosa* plantlets were obtained from the small-scale farmer (Ballesteros Nursery) at Diadi, Nueva Vizcaya. Two species of bamboo plantlets have been selected because both bamboo species are locally found in the area and have uniform ages. These were brought to the greenhouse in Bagabag and acclimatized for over a month. Acclimatization is how an organism adjusts to changes in its environment. Since the bamboo plantlets were acquired from different areas, it was necessary to harden them off by gradually exposing them to outdoor conditions before planting them in the field. Factors influencing acclimatization include gradual exposure to the new temperature range, humidity level changes, and light intensity and duration variations.

The acclimatized bamboo plantlets were then transplanted into larger and individual polyethylene bags measuring 15.24 cm × 15.24 cm × 17.78 cm filled with 1 kg of soil media. The soil media used for planting consisted of a well-draining soil mix that included a combination of sandy loam and organic compost (vermicompost). This mixture provided good aeration and moisture retention, which is essential for healthy root development. The compost added nutrients to the soil, enhancing its fertility and supporting plant growth.

2.3. Site Preparation, Field Layout, Protection, and Maintenance

The site was cleared of weeds and unwanted vegetation. A strip where the plantlets planted are cleared. The spacing was set to 2 m × 2 m to have uniform spacing for secondary forest and riparian areas, and the planting holes are approximately 40 cm × 40 cm and about 40 cm deep. Dug and prepared before transplanting in the field and marked with stakes.

One kilogram of vermicompost and topsoil is mixed and placed at the basal area near the root zone to help improve the soil's properties and provide plant nutrition before transplanting *B.spinosa* and *B. vulgaris* plantlets in the secondary forest and riparian zone. This soil conditioner, produced from organic matter, enhances soil properties by adding slow-releasing nutrients that are especially beneficial for plant growth. In transplanting, utmost care was observed to ensure that the roots of bamboo plantlets are not disturbed during transplanting. Consider the following practices: proper timing, preparation before transplanting, using the right tools, transplanting techniques, soil preparation, and post-transplant care. **Fig. 2** presents the experimental layout of the study in riparian and secondary forests. This method can reduce root disturbance, helping plants establish their new environment. Paying attention to these techniques supports the plants' recovery from transplant shock and improves their long-term growth. Minimizing root disruption is vital for keeping roots healthy, which is important for nutrient absorption and overall plant strength. Following these best practices leads to better survival rates and productivity for transplanted plants.

Weeding and mulching were conducted before transplanting the bamboo plantlets in the field. Dried leaves and fresh grass cuttings were used as mulch to minimize water loss (Khose et al. 2023). As dried leaves and grass cuttings decompose, they will become organic matter that improves soil structure, enhances moisture retention, and promotes beneficial microbial activity. It will release potassium back into the soil, supporting various plant functions. Temporary fences are added around the plantlets for protection. The transplants were watered regularly or whenever necessary. Thickets and thorny branches of the bamboo from the base up to a meter along the length of the culm were removed regularly, and insect pests and diseases were monitored as well (Blanca 2019). The fire line/fire breaks serve as a buffer zone, created approximately 5 meters along the boundaries by clearing vegetation to prevent the spread of fire into the study areas. This proactive measure is essential for safeguarding the bamboo plantlets and ensuring the success of the plant growth. This fireline was maintained throughout the study but was not included in the silvicultural treatments observed during the data collection.

Plot 1	Plot 2	Plot 3
A1B1C1	A1B2C3	A1B2C1
A1B2C1	A1B1C3	A1B1C1
A1B2C1	A1B1C3	A1B1C1
A1B1C1	A1B2C3	A1B2C1
A1B1C2	A1B1C1	A1B2C2
A1B2C2	A1B2C1	A1B1C2
A1B2C2	A1B1C1	A1B1C2
A1B1C2	A1B2C1	A1B2C2
A1B1C3	A1B2C2	A1B2C3
A1B2C3	A1B1C2	A1B1C3
A1B2C3	A1B1C2	A1B2C3
A1B1C3	A1B2C2	A1B1C3
A1B2C2	A1B2C1	A1B2C2
A1B1C2	A1B1C1	A1B1C2
A1B1C2	A1B1C1	A1B1C2
A1B2C2	A1B2C1	A1B2C2
A1B2C3	A1B2C3	A1B2C3
A1B1C3	A1B1C3	A1B1C3
A1B2C3	A1B1C3	A1B1C3
A1B1C3	A1B2C3	A1B2C3
A1B2C1	A1B2C2	A1B2C1
A1B1C1	A1B1C2	A1B1C1
A1B2C1	A1B1C2	A1B1C1
A1B1C1	A1B2C2	A1B2C1
A1B1C3	A1B2C3	A1B2C3
A1B2C3	A1B1C3	A1B1C3
A1B1C3	A1B1C3	A1B1C3
A1B2C3	A1B2C3	A1B2C3
A1B2C2	A1B1C1	A1B2C2
A1B1C2	A1B2C1	A1B1C2
A1B1C2	A1B2C1	A1B1C2
A1B2C2	A1B1C1	A1B2C2
A1B2C1	A1B1C2	A1B2C1
A1B1C1	A1B2C2	A1B1C1
A1B2C1	A1B2C2	A1B1C1
A1B1C1	A1B1C2	A1B2C1

Plot 1	Plot 2	Plot 3
A2B1C1	A2B2C3	A2B2C1
A2B2C1	A2B1C3	A2B1C1
A2B2C1	A2B1C3	A2B1C1
A2B1C1	A2B2C3	A2B2C1
A2B1C2	A2B1C1	A2B2C2
A2B2C2	A2B2C1	A2B1C2
A2B2C2	A2B1C1	A2B1C2
A2B1C2	A2B2C1	A2B2C2
A2B1C3	A2B2C2	A2B2C3
A2B2C3	A2B1C2	A2B1C3
A2B2C3	A2B1C2	A2B2C3
A2B1C3	A2B2C2	A2B2C3
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A2B2C1	A2B2C2	A2B2C1
A2B1C1	A2B1C2	A2B1C1
A2B2C1	A2B1C2	A2B1C1
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A2B2C3	A2B2C3	A2B2C3
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A2B1C2	A2B2C1	A2B1C2
A2B1C2	A2B2C1	A2B1C2
A2B2C2	A2B1C1	A2B2C2
A2B2C1	A2B1C2	A2B2C1
A2B1C1	A2B2C2	A2B1C1
A2B2C1	A2B2C2	A2B1C1
A2B1C1	A2B1C2	A2B2C1

Legend:

A (area of the study)
- A1-Riparian
- A2-Secondary Forest

B (Bamboo species)
- B1- *B. vulgaris*
- B2- *B. spinosa*

C (Cultural Treatment)
- C1-Ring weeded, no cultivation (Green)
- C2- Ring weeded and ring cultivation (Yellow)
- C3- No weeding, no cultivation (Control) (Blue)

Fig. 2. The experimental layout of the study is in riparian (a) and secondary forest (b).

2.4. Data Collection

Data collection was conducted every other week. The growth of *B. spinosa* and *B. vulgaris* in secondary forest and riparian ecosystems under the different silvicultural treatments was assessed using percent survival, bamboo growth (culm-height growth, culm-diameter growth, and number of shoots per clump), and light intensity. The formula has been adopted in the study of Getahun et al. (2023). Percent survival is the number of plants that survived after six months from transplanting, computed using the following Equation 1:

$$Survival\ (\%) = \frac{Number\ of\ Seedlings\ Alive}{Number\ of\ Seedlings\ Used} \times 100\% \quad (1)$$

Height (cm) is the average height per clump obtained every other week by measuring from the base to the insertion of the expanded leaf using a meter stick. Diameter (mm) is the average diameter obtained per clump every other week by measuring the base using a caliper. Number of shoots is the number of shoots observed, counted, and recorded. Light intensity is obtained every morning at 7:00 am (0700H), noontime at 12:30 pm (1230H) and afternoon at 4:00 pm (1600H) using a light meter (lux).

3. Results and Discussion

3.1. Percent Survival

Bamboo is a versatile and fast-growing plant (Isukuru 2023; Roxas 2012) extensively studied for its growth and development. One key parameter examined in this study was the percent survival of two bamboo species in different study sites. Studies indicate that several factors affect bamboo growth and survival rates. According to Zhang et al. (2020), environmental conditions such as soil quality, water availability, and light intensity significantly impact bamboo growth. The results showed that optimal light conditions lead to faster growth and higher survival rates, which aligns with the findings of increased growth in areas with more light.

Furthermore, other studies have demonstrated that organic materials like vermicompost or manure can improve soil fertility and promote healthier bamboo growth. For instance, Wang et al. (2019) showed that incorporating organic fertilizers in bamboo cultivation not only boosted growth rates but also enhanced resilience to environmental issues. As shown in **Table 1**, the results revealed a 100% survival rate for *Bambusa vulgaris* and *Bambusa spinosa* planted in the secondary forest. In the riparian area, 34 out of 36 *B. vulgaris* plantlets survived (94.44%), while 32 out of 36 *B. spinosa* plantlets survived (88.89%) after six months of the experimental period. These results indicate that the different silvicultural treatments applied did not affect survival in the secondary forest, while in the riparian area, there was some mortality. This bamboo survival study helped us understand its growth patterns and sustainable management practices for these species. By comparing the findings, it is evident that effective management practices and favorable environmental conditions are key to the survival and growth of bamboo species.

Table 1. Percent survival of the bamboo species in the study sites after six months of observation

Area of the study	Species	Total planted	The number of bamboos survived	Percentage (%)
A1	*B. vulgaris*	36	34	94.44
	B. spinosa	36	32	88.89
A2	*B. vulgaris*	36	36	100
	B. spinosa	36	36	100

3.2. Bamboo Growth

Table 2 shows that *B. vulgaris* had a larger number of culms and bigger diameters than *B. spinosa,* although the two species had equal heights. Ring weeding and cultivation (C2) resulted in significantly larger diameters but fewer shoots and shorter heights than no weeding and cultivation (C3). Producing a bigger diameter is a good indicator of the quality of the bamboo poles; the bigger the diameter, many raw materials will be harvested, and more end products will be produced. On the contrary, treatment C3 (no ring weeding and no cultivation) manifests that both bamboo species can thrive in different areas (Clark et al. 2015). It is a good sign that can be used for reforestation endeavors. Clearing unwanted plants and cultivating soil in the study sites helped grow and develop bamboo species, as shown in the result. Maintenance practices (weeding, watering and other silvicultural treatments) significantly enhanced shoot emergence and production. As the soil was cultivated, more water and soil nutrients penetrated easily to the roots of the two bamboo species. This aligns with the findings of Ahmad et al. (2021) and Dimara et al. (2023), who reported that cleaning, sanitation cutting and applying fertilizers particularly improved shoot and culm production of bamboo.

Based on the study of Bumarlong et al. (1984) and Santos et al. (2023), growth performance showed bamboo is now extensively growing in study areas with stones and rocks exposed through erosion. The study concluded that *B. arundinacea* and *B. blumeana* (*B. spinosa*) have the highest growth performance in soil types. The rhizomes and roots grew in all directions and formed a complex network within a one-meter depth under the ground, preventing soil erosion. Bamboos along riverbanks effectively reduce water flow velocity, with their extensive root systems functioning as natural filters, enabling water to pass while trapping gravel and coarse sediments among their culms (Tardio et al. 2018). They generated sufficient leaf litter and demonstrated resilience, surviving even after forest fires, consistent with the study's findings. Furthermore, vegetation along riverbanks profoundly impacts the physical processes of natural waterways. Plant growth is essential in stabilizing riverbanks (Pertiwi et al. 2021). Moreover, the study of Mulatu and Fetene (2013) confirms that plant management practices resulted in a high number of emerged shoots, low shoot mortality and bigger size culms, which are important attributes of silvicultural management.

Table 2. Comparison of main effects of silvicultural management and species (mean of two areas)

Factor	Level	Number* of shoots	Diameter*	Height*
Silvicultural management	3-Control (no weeding, no cultivation)	1.85^{a}	5.70^{b}	106.86^{a}
	1-Ring weeded, no cultivation	1.83^{a}	5.58^{b}	100.96^{b}
	2-Ring weeded & ring cultivation	1.72^{b}	6.20^{a}	99.34^{b}
Species	1-Kiling (*B. vulgaris*)	1.98^{a}	6.21^{a}	103.05^{a}
	2-Tinik (*B. spinosa*)	1.63^{b}	5.44^{b}	101.73^{a}

Notes: * In a column, factor means followed by a common letter are not significantly different by simultaneous Tukey's test at 5% level.

3.3. Number of New Shoots

The growth and emergence of new shoots in bamboo species, especially in secondary forests, have been studied to highlight ecological importance. Secondary forests typically have a more open canopy, allowing more sunlight to reach the ground- an essential factor for bamboo growth. According to the study of Zhang et al. (2020), bamboo usually emerges during the rainy season when moisture and light levels are high. This leads to a significantly higher number of shoots in secondary forests compared to denser areas like primary forests. Additionally, studies show that the emergence of bamboo shoots is closely linked to seasonal changes. Wang et al. (2019) noted that bamboo shoots tend to emerge at the start of the rainy season when conditions are ideal for growth, especially in secondary forests where moisture levels support shoot development.

The emergence of bamboo shoots from the ground was observed in **Fig. 3**, which grow rapidly and typically reach their maximum height within a few weeks in the two sites. Based on the study of Zhang et al. (2020), bamboo shoots usually emerge during the onset of the rainy season, and very few shoots arise during the dry season when soil moisture is at its lowest, which supports the study's findings. Secondary forest had a significantly newer shoot (mean = 4.02/sampling date) than riparian (mean = 1.93/sampling date) at 5% ($F (1.60) = 14.95$, $p < 0.01$). Sampling dates within areas were not significantly different ($F (28.60) = 1.52$, $p = 0.09$).

3.4. Correlation of the Different Treatments and Ecosystems on the Growth and Development of the Two Bamboos

The simple linear correlation among the different variables is shown in **Table 3**. Silvicultural management is not significantly correlated with all the other variables. The earlier interaction plots indicate that the relationships of silvicultural management with species and sampling dates are non-linear. Plant height, diameter, and number of culms are the species parameters. Species 2 is smaller than Species 1, hence the negative correlations. Growth is dependent on light intensity (Cirtain et al. 2009). Light measurements done three times a day are all positively correlated.

Among these measurements, the one measured at 4:00 pm has the highest correlation coefficients with the growth parameters and area (forest area). Somehow, the growth at 4:00 pm may reflect the combined growth at 7:00 am and 12:30 pm.

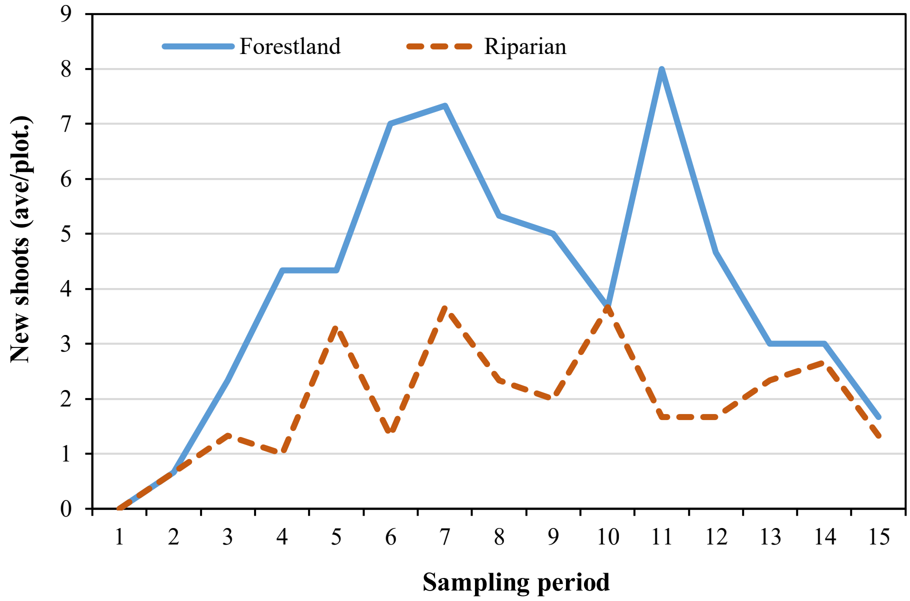

Fig. 3. Number of new shoots by sampling period in secondary forest and riparian areas.

Table 3. Correlation matrix of the different variables

	Area	Silvicultural	Species	Date	Height	Diameter	Nculms	Light4	Light7
Height	0.112	0.141	-0.129	0.888**	1				
Diameter	0.5**	0.083	-0.378**	0.52**	0.604**	1			
Nculms	0.443**	0.087	-0.313**	0.632**	0.73**	0.739**	1		
Light 4	0.828**	0.111	0.005	0.066	0.17*	0.511**	0.466**	1	
Light 7	0.293**	0.038	0	0.006	0.093	0.205**	0.157*	0.363**	1
Light12	0.143	0.025	0.007	0.099	0.178*	0.142	0.12	0.269**	0.821**

3.5. Light Intensity

In the results, the secondary forest received more light than Riparian Area (**Table 4**), [F (1.78) = 51.79, p <.01)]. In both areas, light at 12:30 pm was most intense and 7 am was the least [F (4.78) = 85.13, p <.01)]. Light is very vital environmental factor aside water and nutrients for the growth and development of the bamboos (Aribal et al. 2022). Based on the study by Kandari et al. (2024), different land cover types provide varying values of microclimate variables, corroborating the study results. The study of Fan et al. (2022) revealed that moderate shading improves the ability of Ma bamboo seedlings to adapt to light conditions. The findings emphasize that modifying the stand structure and ensuring an optimal light environment can enhance cultivation methods and productivity. This study offers valuable guidance for refining bamboo management practices through effective light regulation. The result of this study served as initial information and basis across the mean light intensity in each study site (riparian area and secondary forests). Growth is dependent on light intensity (Miao et al. 2023). Light measurements done three times a day all positively correlate with each other. This study is also a pioneering study in the province of Nueva Vizcaya.

Table 4. Mean light intensity by area and time of day

Area	Time			Area	
	07:00	12:30	04:00	Mean	
Riparian	4133.33	10910.00	6983.10	7342.14	b
Forestland	5395.66	12430.42	11010.97	9612.35	a
Time mean	4764.50	11670.21	8997.03		

4. Conclusions

This study demonstrated the significant influence of various silvicultural treatments on the growth performance of *B.vulgaris* and *B. spinosa* within secondary forest and riparian ecosystems. The specific silvicultural treatments applied included ring weeding with no cultivation, ring cultivation with cultivation and no intervention (control). Each treatment was designed to assess how different management practices impact the growth and survival of bamboo species. Ring weeding with cultivation (C2) resulted in a significantly larger diameter but had fewer shoots and shorter heights compared to the control group (no weeding and cultivation) (C3). A larger diameter indicates the quality of bamboo poles; the bigger the diameter, the more raw materials can be harvested, producing more end products. Conversely, treatment C3 (no ring weeding and cultivation) demonstrates that both bamboo species can thrive in different areas, making it a promising option for reforestation efforts. The survival rate in secondary forests reached 100%, with *B. spinosa* displaying greater diameter and increased shoot production than riparian sites. This suggests that the management practices employed in secondary forests are particularly effective in promoting bamboo growth. Higher light availability in secondary forests was associated with increased growth, particularly for culm diameter and shoot production. Statistical analysis revealed highly significant main effects of silvicultural treatment, species, and sampling dates on growth ($p < 0.01$), underscoring the importance of management practices in influencing outcomes. Light measurements at 1600H displayed the highest positive correlation with growth parameters, indicating light's critical role in bamboo development. This study contributes novel insights into bamboo silviculture in Nueva Vizcaya, highlighting optimal conditions for maximizing growth in both secondary and riparian forest settings. Understanding the effects of specific silvicultural treatments not only contributes to advancing bamboo cultivation practices but also aids in effectively managing natural resources in the Philippines.

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Author Contributions

L.P.L.: Conceptualization, Methodology, Software, Validation, Formal Analysis, Writing – Original Draft Preparation; I.L.L.J.: Conceptualization, Formal Analysis, Investigation, Resources, Data Curation, Writing – Original Draft Preparation; M.C.L.: Conceptualization, Writing – Review and Editing, Visualization, Supervision.

Conflict of Interest

The authors declare no conflict of interest.

Declaration of Generative AI and AI-Assisted Technologies in the Manuscript Preparation

Not applicable.

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