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Growth Evaluation of Kemenyan Durame (*Styrax benzoin* Dryand.) Seedlings under Different Shading Levels and NPK Doses

(*Evaluasi Pertumbuhan Semai Kemenyan Durame (Styrax benzoin Dryand.) pada Berbagai Tingkat Naungan dan Dosis NPK*)

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ABSTRACT

Styrax benzoin Dryand. is a resin-producing tree species with considerable economic value, and the availability of good-quality seedlings is essential for supporting its cultivation and conservation. This study aimed to evaluate the early growth response of S. benzoin seedlings under different shading conditions and NPK fertilizer doses in a nursery. The study was conducted at the Silviculture Laboratory Nursery, Faculty of Forestry and Tropical Environment, Mulawarman University, Samarinda, East Kalimantan, from February to May 2025. The observed variables included seedling survival, height increment, stem diameter increment, leaf number, leaf area, and seedling quality index. The results showed that shading condition had a more consistent influence on seedling performance than NPK fertilizer dose. Seedlings maintained under a double-layer shade net with approximately 33% light intensity showed better overall performance in survival performance, vegetative growth, canopy development, and seedling quality index. Statistical analysis indicated that NPK fertilizer dose did not significantly affect the observed growth and quality variables, whereas shading condition significantly affected seedling growth and quality. These findings suggest that shade regulation is an important consideration in the early nursery management of S. benzoin seedlings. Maintaining young seedlings under moderate shade may be more beneficial than relying on increased NPK fertilizer dose alone. Further studies with longer observation periods and broader treatment validation are recommended to refine operational nursery protocols for this economically important resin-producing species.

KEYWORDS*: *Styrax benzoin, seedling growth, nursery, shading, NPK fertilizer

INTISARI

Styrax benzoin Dryand. atau kemenyan durame merupakan jenis pohon penghasil resin yang memiliki nilai ekonomi penting, sehingga ketersediaan semai berkualitas diperlukan untuk mendukung upaya budidaya dan konservasinya. Penelitian ini bertujuan mengevaluasi respons pertumbuhan awal semai S. benzoin pada beberapa kondisi naungan dan

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dosis pupuk NPK di persemaian. Penelitian dilaksanakan di Persemaian Laboratorium Silvikultur, Fakultas Kehutanan dan Lingkungan Tropis, Universitas Mulawarman, Samarinda, Kalimantan Timur, pada Februari hingga Mei 2025. Variabel yang diamati meliputi persentase hidup semai, pertambahan tinggi, pertambahan diameter, jumlah daun, luas daun, dan indeks kualitas bibit. Hasil penelitian menunjukkan bahwa kondisi naungan memberikan pengaruh yang lebih konsisten terhadap performa semai dibandingkan dosis pupuk NPK. Semai yang dipelihara di bawah naungan dua lapis dengan intensitas cahaya sekitar 33% menunjukkan performa yang lebih baik dalam kecenderungan hidup, pertumbuhan vegetatif, perkembangan tajuk, dan indeks kualitas bibit. Analisis statistik menunjukkan bahwa dosis pupuk NPK tidak berpengaruh nyata terhadap variabel pertumbuhan dan kualitas bibit yang diamati, sedangkan kondisi naungan berpengaruh nyata terhadap pertumbuhan dan kualitas semai. Temuan ini menunjukkan bahwa pengaturan naungan merupakan aspek penting dalam pengelolaan persemaian awal S. benzoin. Pemeliharaan semai muda pada kondisi naungan sedang dapat lebih bermanfaat dibandingkan peningkatan dosis pupuk NPK semata. Studi lanjutan dengan rancangan percobaan yang lebih kuat, pengujian kombinasi perlakuan yang lebih jelas, dan periode pengamatan yang lebih panjang diperlukan untuk menyempurnakan rekomendasi pengelolaan persemaian jenis ini.

KATA KUNCI: Styrax benzoin, pertumbuhan semai, persemaian, naungan, pupuk NPK.

INTRODUCTION

Styrax benzoin Dryand. (kemenyan durame) is an important resin-producing tree species and one of Indonesia's valuable aromatic non-timber forest products. *Benzoin* resin has long been used for fragrance, ritual, medicinal, and industrial applications, while benzoin-based agroforestry systems also contribute to rural livelihoods and customary land-use practices in Indonesia. Recent studies have also highlighted the relevance of *Styrax* cultivation for sustaining customary management systems and supporting long-term land-use planning in resin-producing landscapes. However, seedling production remains an important constraint because seed dormancy and ineffective sowing materials may limit the establishment of kemenyan durame plantations. Therefore, the availability of healthy and high-quality planting material is an essential component for supporting both conservation and cultivation strategies for *S. benzoin* (Harada *et al*., 2022; Rahmawaty *et al*., 2023; Susilowati *et al*., 2025).

The production of high-quality seedlings is a critical stage in forest plant establishment because nursery attributes such as height, stem diameter, biomass distribution, and seedling quality index (SQI) are closely linked to early field performance. In nursery systems, seedling traits are strongly

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influenced by light conditions. Light provides the energy required for photosynthesis and also acts as an environmental signal that regulates seedling morphology, and physiological adjustment. Previous studies on woody seedlings have shown that nursery light conditions can substantially influence seedling quality and subsequent transplant performance, with moderate shading often improves growth or reduces stress during early establishment. However, the optimum shading level may vary among species (Grossnickle & MacDonald, 2018; Guimarães *et al*., 2024).

Nutrient management is another important component of seedling production. Previous work on woody seedlings has used compound NPK fertilizer with a dose range of 0-5 g seedling^{-1}, but the response of *S. benzoin* seedlings to comparable nursery doses remains insufficiently documented (Puri *et al*., 2025). However, recent synthesis of tropical tree seedling studies indicates that responses to nutrient addition are often variable among species, growing environments, and nutrient combinations, meaning that fertilization does not always produce uniform gains in seedling growth. Accordingly, fertilizer dosage should be interpreted in relation to nursery light conditions, as both factors may jointly influence seedling growth and quality (Cárate Tandalla *et al*., 2024; Santiago *et al*., 2012; Wu *et al*., 2025; Zhou, 2023).

For *S. benzoin*, previous studies have addressed several aspects of its cultivation and establishment. Purwanto *et al*. (2023) examined seed morphology, germination, growing media, seedling growth, and seedling quality index (SQI), while Rahmawaty *et al*. (2023) focused on land characteristics and land suitability for *Styrax* sp. cultivation. In practical nursery protocols, shading is also an important cultural treatment because it regulates seedling light exposure and may influence seedling growth and quality in a species-specific manner (Li *et al*., 2025). Nevertheless, information on the early nursery response of *S. benzoin* seedlings to different shading conditions and NPK fertilizer doses remains limited. This gap is important because nursery management for resin-producing tree species should be based on species-specific responses rather than on generalized silvicultural assumptions. Therefore, this study aimed to evaluate the early growth response of *S. benzoin* seedlings under different shading conditions and NPK fertilizer doses in the nursery, using survival percentage, height increment, stem diameter increment, leaf number, leaf area, and seedling quality index (SQI) as the main growth indicators (Li *et al*., 2025; Purwanto *et al*., 2023; Rahmawaty *et al*., 2023).

MATERIALS AND METHODS

Study site and nursery conditions

This study was conducted at the Silviculture Laboratory Nursery, Faculty of Forestry and Tropical Environment, Mulawarman University, Samarinda, East Kalimantan, Indonesia, located at approximately 0°28′23.37″ S and 117°09′11.98″ E, at an elevation of approximately 10 m above sea level. The study was carried out from February to May 2025, covering a four-month observation

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period. The nursery evaluation focused on *Styrax benzoin* Dryand. seedlings maintained under different shading conditions and NPK fertilizer doses. Seedling growth measurements were conducted daily during the observation period, while microclimatic observations were recorded to describe air temperature, relative humidity, and light intensity under each shading condition.

Plant materials and nursery management

Three-month-old *Styrax benzoin* Dryand. seedlings were used as plant materials in this study. Prior to treatment assignment, seedlings were selected based on uniform age, healthy visual appearance, and the absence of visible disease symptoms . The selected seedlings were transplanted into 20 cm × 20 cm polybags containing a growing medium composed of sterilized soil, rice husk charcoal, and poultry manure at a ratio of 7:2:1. The same growing medium composition was used for all seedlings, and the medium was thoroughly mixed before filling the polybags to minimize variation in baseline nutrient conditions. Poultry manure was therefore treated as a uniform basal component of the growing medium, while NPK fertilizer was applied as the experimental fertilizer treatment. After transplanting, the seedlings were allowed to acclimatize before the start of the observation period. Throughout the nursery period, seedlings were generally watered twice daily, in the morning and afternoon. However, watering was adjusted according to rainfall and substrate moisture; when the growing medium remained sufficiently moist after rainfall, additional watering was not applied. Water was applied until the growing medium was evenly moist without causing waterlogging. The same watering practice was applied across all treatment combinations to minimize variation among experimental units.

The nursery treatments consisted of three shading conditions and four NPK fertilizer doses. The shading conditions included no shade (approximately 100% light intensity), single-layer shade net (approximately 46% light intensity), and double-layer shade net (approximately 33% light intensity), respectively. Light intensity under each shade condition was measured to describe the differences in the light environment among seedling groups (Li *et al*., 2025). NPK fertilizer (16-16-16) was applied at four dosage levels, namely 0 g, 1 g, 3 g, and 5 g seedling^{-1}. Fertilizer was applied twice, at the beginning of the observation period and one month after the first application, by placing the fertilizer around the planting medium while avoiding direct contact with the seedling stem. The study involved 360 seedlings arranged into 12 shading x NPK treatment combinations, with three replications and 10 seedlings in each experimental unit. The complete treatment combinations are presented in **Table 1**.

Table 1. Treatment combinations of shading conditions and NPK fertilizer doses used in the study

Treatment code	Shading condition	Relative light intensity	NPK dose
S0N0	No shade	100%	0 g seedling^{-1}
S0N1	No shade	100%	1 g seedling^{-1}
S0N3	No shade	100%	3 g seedling^{-1}
S0N5	No shade	100%	5 g seedling^{-1}
S1N0	Single-layer shade net	46%	0 g seedling^{-1}
S1N1	Single-layer shade net	46%	1 g seedling^{-1}

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Treatment code	Shading condition	Relative light intensity	NPK dose
S1N3	Single-layer shade net	46%	3 g seedling^{-1}
S1N5	Single-layer shade net	46%	5 g seedling^{-1}
S2N0	Double-layer shade net	33%	0 g seedling^{-1}
S2N1	Double-layer shade net	33%	1 g seedling^{-1}
S2N3	Double-layer shade net	33%	3 g seedling^{-1}
S2N5	Double-layer shade net	33%	5 g seedling^{-1}

Note: S0 = no shade, S1 = single-layer shade net, S2 = double-layer shade net; N0, N1, N3, and N5 represent 0, 1, 3, and 5 g NPK seedling $^{-1}$, respectively.

Observed variables

The observed variables included seedling survival percentage, height increment, stem diameter increment, leaf number, leaf area, and seedling quality index (SQI). Seedling survival percentage was calculated as the number of living seedlings at the end of the observation period divided by the initial number of seedlings in each experimental unit, multiplied by 100. Seedling height was measured from the base of the stem to the shoot tip using a ruler, while stem diameter was measured at the stem base using a microcaliper. Height and diameter increments were calculated as the difference between the final and initial measurements and expressed as monthly increments. Leaf number was counted manually based on the number of fully expanded leaves, while leaf area was measured using a leaf area meter and expressed in cm^2. Seedling quality index (SQI) was calculated following Dickson *et al*. (1960) as an integrative indicator of seedling quality. The calculation was based on seedling height, stem diameter, total seedling dry biomass, shoot dry biomass, and root dry biomass. For biomass measurement, seedlings were separated into shoot and root components, oven-dried to constant weight, and weighed using an analytical balance. Supporting microclimatic variables, including air temperature, relative humidity and light intensity were recorded to describe the nursery environment under each shading condition (Dickson *et al*., 1960; Grossnickle & MacDonald, 2018; Guimarães *et al*., 2024).

Data compilation and analytical approach

All seedling growth and microclimatic data were compiled and organized according to shading condition, NPK fertilizer dose. The experimental unit was used as the basis for data summarization to avoid pseudo-replication, with each treatment combination represented by three replications. For each observed variable, including survival percentage, height increment, stem diameter increment, leaf number, leaf area, and seedling quality index, mean values were calculated for each experimental unit before further analysis.

The effects of shading condition and NPK fertilizer dose were evaluated using analysis of variance (ANOVA) under randomized complete block design, with NPK fertilizer dose treated as the main treatment factor and shading intensity treated as the blocking factor. When significant effects were detected, mean comparisons were performed using the least significant difference (LSD) test at a 5% significance level. All statistical analyses were performed using R software version 4.5.3

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through the RStudio interface. The analysis was conducted to determine whether seedling responses were mainly influenced by shading condition and NPK fertilizer dose for each observed variable.

RESULT AND DISCUSSION

Initial seedling condition and nursery setup

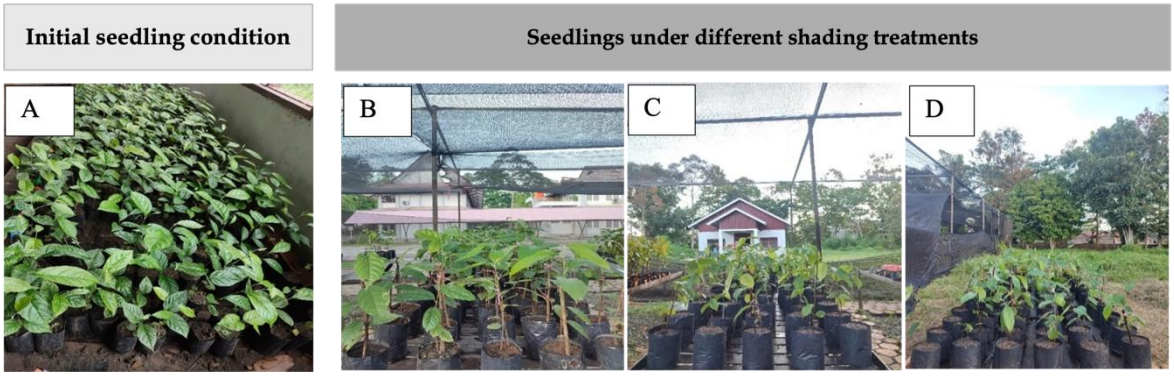


Figure 1. Initial seedling condition and nursery shading treatments of *Styrax benzoin* seedlings: (A) initial seedling condition before treatment evaluation, (B) seedlings under double-layer shade net with approximately 33% light intensity, (C) seedlings under single-layer shade net with approximately 46% light intensity, and (D) seedlings under no shade with approximately 100% light intensity.

At the beginning of the observation period, *Styrax benzoin* Dryand. seedlings were approximately three months old and were selected based on uniform age and healthy visual appearance. The initial mean seedling height, stem diameter, and leaf number were 11.36 cm, 5 mm, and 4 leaves, respectively. Figure 1A shows the initial seedling condition before treatment evaluation, while Figures 1B–D show the visual condition of seedlings under different shading environments during the observation period. The seedlings were maintained under double-layer shade net, single-layer shade net, and no-shade conditions to create different light environments. This visual documentation provides an overview of the initial seedling condition and the nursery setup used to evaluate the effects of shading conditions and NPK fertilizer doses on early seedling performance.

Microclimatic conditions in the nursery

Table 2. Microclimatic conditions under the observed shading treatments in the nursery

Observation month	Air temperature (°C)			Relative humidity (%)		
	No shade (100%)	Single-layer shade (46%)	Double-layer shade (33%)	No shade (100%)	Single-layer shade (46%)	Double-layer shade (33%)
February	31.8	29.9	28.3	67	78	83
March	31.9	30.8	29.6	74	79	84
April	32.3	30.9	30.0	75	79	85
May	33.1	31.6	30.7	75	80	85

Note: Values represent nursery observations conducted from February to May under three shading treatments.

Table 2 shows that the nursery microclimate varied among shading conditions. Air temperature ranged from 28.3 to 33.1 °C, while relative humidity ranged from 67 to 85%. The no-shade treatment tended to show higher air temperature and lower relative humidity, whereas the double-layer shade

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treatment generally maintained lower air temperature and higher relative humidity. The single-layer shade net showed intermediate microclimatic conditions. These results indicate that shading not only reduced incoming light, but also modified the nursery microenvironment by moderating air temperature and relative humidity. In nursery systems, such microclimatic moderation is important because light availability, air temperature, and humidity define the immediate growing environment experienced by seedlings (Li *et al*., 2025).

Seedling survival

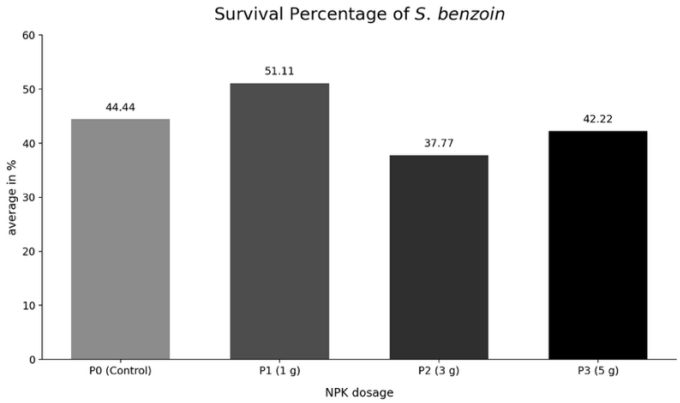


Figure 2. Survival percentage of *Styrax benzoin* seedlings across the NPK fertilizer dose treatments

The compiled data shown in **Figure 2** indicate that survival percentage varied across the tested NPK doses. The highest value was recorded at P1 (51.11%), followed by P0 (44.44%), P3 (42.22%), and P2 (37.77%). However, the pattern across fertilizer doses was not monotonic, indicating that increasing NPK dose was not consistently associated with better seedling survival. Therefore, the low survival percentage was unlikely to be explained by fertilizer dose alone. The relatively low survival percentage may have been associated with the biological characteristics of young *S. benzoin* seedlings and environmental stress in the nursery. During the observation period, nursery conditions were relatively hot, which may have increased evaporative demand and water loss from seedlings. This condition may have been more critical for young seedlings that were still adapting after transplanting. In addition, the microclimatic pattern suggests that shaded conditions, particularly the double-layer shade net, may have been provided a more buffered growing environment than lighter shade or full-light conditions. Although this pattern should be interpreted cautiously, it is biologically plausible because reduced radiation load and a more buffered microclimate may help lower water stress during early nursery establishment (Li *et al*., 2025).

Height and stem diameter growth

Height and stem diameter growth showed a similar pattern, as shown in **Figure 3**. Across the fertilizer groups, P1 showed the highest mean height increment (1.28 cm month^{-1}) and stem diameter increment (0.36 mm month^{-1}), whereas P2 showed the lowest values (0.99 cm month^{-1} and 0.26 mm month^{-1}, respectively). Nevertheless, these values did not form a clear dosage-response gradient, because the intermediate and higher fertilizer doses did not consistently outperform the control or

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the lower dose. Statistical testing showed that NPK fertilizer dose did not significantly affect height increment or stem diameter increment, whereas shading condition significantly affected both variables. By contrast, the shading data showed a more coherent trend, with seedlings under double-layer shade tending to produce the most favorable height and diameter development. This suggests that, under the nursery conditions observed here, light environment was more consistently associated with early vegetative growth than fertilizer input. Such a pattern agrees with broader seedling-quality literature showing that nursery light regime strongly shapes seedling morphology and early growth performance (Grossnickle & MacDonald, 2018; Guimarães *et al*., 2024).

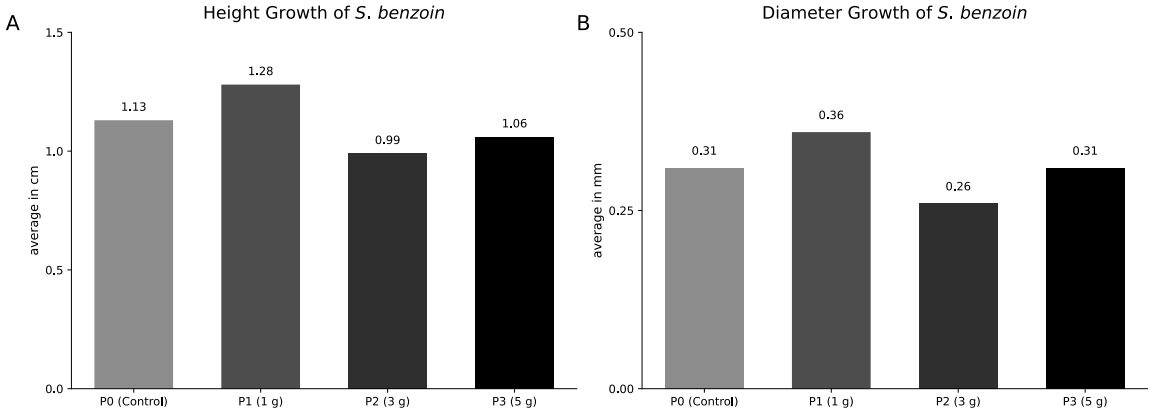


Figure 3. Height growth (A) and stem diameter growth (B) of *Styrax benzoin* seedlings across the NPK fertilizer dose treatments

Leaf number and leaf area

Figure 4 shows that leaf number and leaf area varied across NPK fertilizer dose treatments. For the leaf number, P1 produced the highest mean leaf number (4.41 leaves), while P3 showed the lowest leaf number, with 3.80 leaves. For leaf area, P1 also produced the highest mean value (31.67 cm²), while P2 showed the lowest value (18.33 cm²). These values indicate that P1 tended to produce better canopy development under the fertilizer-dose comparison. However, the fertilizer response remained inconsistent across variables, because the intermediate and higher NPK doses did not consistently produce higher leaf number or larger leaf area.

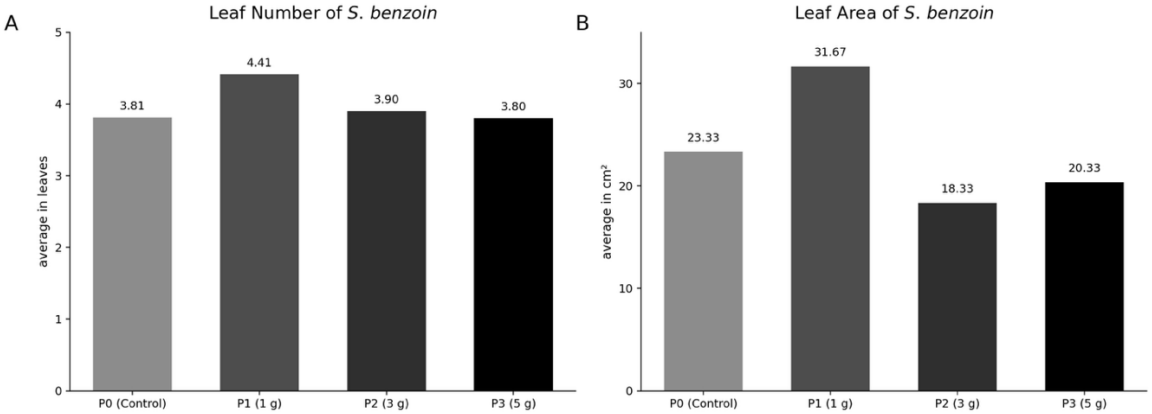


Figure 4. Canopy development of *Styrax benzoin* seedlings across the observed NPK fertilizer dose treatments: (A) Leaf number and (B) leaf area

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Beyond the fertilizer-dose pattern shown in **Figure 4**, the comparison among shading groups in the original analysis indicated that seedlings under double-layer shade showed the highest leaf number and leaf area. Statistical testing showed that NPK fertilizer dose did not significantly affect leaf number or leaf area, whereas shading condition significantly affected both canopy development variables. The highest mean values were observed under double-layer shade with approximately 33% light intensity, reaching 9.38 leaves for leaf number and 42.25 cm² for leaf area. This pattern suggests that leaf development in *S. benzoin* seedlings was closely associated with the light environment in the nursery. This interpretation is biologically reasonable because leaves are the main organs for light interception and photosynthesis, and increased leaf area can represent an adjustment that allows seedlings to capture light more efficiently under shaded condition (Grossnickle & MacDonald, 2018; Li *et al*., 2025).

Seedling quality index

Figure 5 shows that the seedling quality index (SQI) varied among NPK fertilizer dose treatments, with the highest mean value observed in P3 (0.28), followed by P2 (0.22), P1 (0.21), and P0 (0.15). However, statistical testing showed that NPK fertilizer dose did not significantly affect SQI, whereas shading condition significantly affected seedling quality. Nevertheless, this result should not be interpreted as evidence that the highest NPK dose was the best overall treatment, because P3 did not consistently produce the highest values for height, diameter, leaf number, or leaf area.

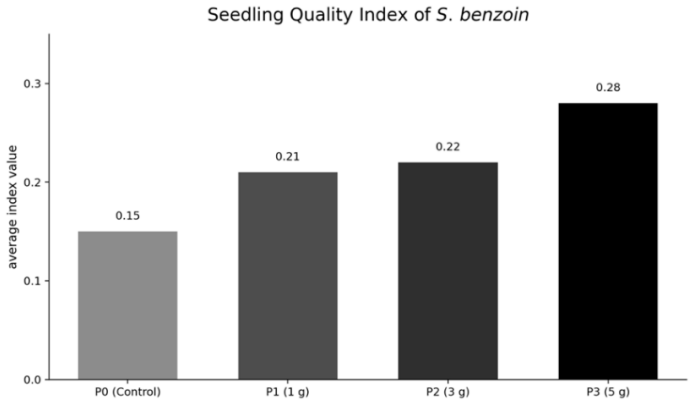


Figure 5. Seedling quality index of *Styrax benzoin* seedlings across the observed NPK fertilizer dose treatments

This apparent contradiction may be explained by the nature of SQI as an integrated index rather than a single growth trait. SQI reflects the balance among seedling height, stem diameter, and dry biomass allocation between shoot and root components. Therefore, seedlings may show a higher SQI when their biomass distribution and morphological balance are relatively better, even if they do not have the highest height or leaf area values. The SQI pattern suggests that the fertilizer response was non-uniform across different growth components. This is not unusual because integrated seedling quality indices are designed to represent multidimensional seedling performance rather than the isolated superiority of a single variable (Dickson *et al*., 1960; Grossnickle & MacDonald, 2018; Guimarães *et al*., 2024).

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General implications for nursery management and study limitations

Taken together, the overall results indicate that shading showed a more consistent association with seedling performance than NPK fertilization. This interpretation is supported by the statistical results, which showed that shading condition significantly affected the main growth and quality variables, whereas NPK fertilizer dose did not show a significant effect. In this study, double-layer shading with approximately 33% light intensity repeatedly appeared as the most favorable nursery condition for survival performance, vegetative growth, canopy development, and overall seedling quality. For *S. benzoin*, this pattern is also relevant from a practical standpoint because species-specific nursery handling is still limited, and previous work on kemenyan durame has likewise highlighted the importance of growth and seedling quality assessment for supporting domestication and seedling production (Purwanto *et al*., 2023).

The favorable response under double-layer shade is consistent with the semi-tolerant character of *S. benzoin* seedlings. This species has been described as being able to grow under shaded conditions in its natural tropical forest habitat, where young plants are commonly protected from direct sunlight by the surrounding canopy (Heyne, 1987). In the seedling stage, *S. benzoin* may require protection from excessive radiation and hot nursery conditions (Jayusman, 2014). However, the positive response under approximately 33% light intensity should not be interpreted to mean that darker shade would continuously improve seedling growth. Excessive shade may reduce photosynthetic carbon gain and eventually limit biomass accumulation. Therefore, further testing under lower light intensities would be needed to determine whether growth would continue to increase or begin to decline under heavier shade conditions.

The absence of a clear progressive response to increasing NPK dose should not automatically be viewed as contradictory. Fertilizer effects in tree seedlings are often context-dependent and may vary according to species, substrate condition, baseline nutrient availability, and interactions with the light environment. Experimental evidence from tropical tree seedlings has shown that responses to nitrogen, phosphorus, and potassium addition can differ substantially among species and nutrient combinations, rather than producing a simple uniform increase in growth. In the present dataset, it is therefore reasonable to interpret the NPK results as variable and context-dependent, rather than negative in an absolute sense. A further possibility is that the microenvironment created by shading played a stronger immediate role during early establishment than the added fertilizer doses (Santiago *et al*., 2012; Setyaningsih, 2023).

From a nursery-management perspective, the results suggest that shading management may be the more immediate and reliable intervention for improving the early performance of *S. benzoin* seedlings. In practical terms, maintaining seedlings under double-layer shade during the early nursery phase appears more promising than relying on increased NPK dosage alone. At the same time, the present study should be read within its limits. First, the survival percentages were still relatively low overall, indicating that early nursery establishment remains a sensitive stage for this

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species. Second, the study was limited by the available replication structure and observation period, so the results should be interpreted as practical nursery trends rather than definitive long-term treatment effects. For that reason, future work should use a more rigorously verified experimental data, clearer replication structure, and longer observation periods to confirm whether the same pattern remains stable over time (Grossnickle & MacDonald, 2018; Guimarães *et al*., 2024; Saud *et al*., 2025).

CONCLUSION

This study showed that shading condition had a more consistent influence on the early performance of *Styrax benzoin* seedlings than NPK fertilizer dose. Seedlings maintained under a double-layer shade net (approximately 33% light intensity) tended to show better overall performance in terms of survival, vegetative growth, canopy development, and seedling quality index. The significant response of seedling growth and quality to shading indicates that 33% light intensity can be considered a suitable shade condition for young *S. benzoin* seedlings during the early nursery phase. In contrast, the response pattern to increasing NPK dosage was not uniform across variables, indicating that fertilizer addition did not produce a clear progressive trend under the observed nursery conditions. Among the evaluated nursery treatments, the combination of double-layer shade and low NPK input appears to be a practical option for supporting early vegetative growth, because the 1 g NPK dose showed the best numerical trend for most growth variables while higher fertilizer doses did not provide consistent improvement. These findings highlight the importance of shade regulation during the early nursery phase of *S. benzoin* seedlings. In practical terms, maintaining seedlings under moderate shade may be more beneficial than relying on increased NPK fertilizer dose alone. Further studies using a more robust experimental design are needed to confirm the stability of these patterns and refine nursery recommendations for this species.

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REFERENCES

Cárate Tandalla, D., Homeier, J., & Batáry, P. (2024). Responses of Tropical Tree Seedlings to Nutrient Addition: A Meta-analysis to understand future changes in Tropical Forest Dynamics. Current Forestry Reports, 11(1). https://doi.org/10.1007/s40725-024-00240-6

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p-ISSN : 1978 – 4996
®2026 Jurusan Kehutanan Universitas Pattimura

Dickson, A., Leaf, A. L., & Hosner, J. F. (1960). Quality appraisal of white spruce and white pine seedling stock in nurseries. The Forestry Chronicle, 36(1), 10-13. https://doi.org/10.5558/tfc36010-1

Grossnickle, S. C., & MacDonald, J. E. (2018). Seedling Quality: History, Application, and Plant Attributes. Forests, 9(5), 283. https://doi.org/10.3390/f9050283

Guimarães, Z., Da Silva, D., & Ferreira, M. (2024). Seedling quality and short-term field performance of three Amazonian forest species as affected by site conditions. iForest, 17, 80-89. https://doi.org/10.3832/ifor4317-016

Harada, K., Wiyono, & Munthe, L. (2022). Production and commercialization of benzoin resin: Exploring the value of benzoin resin for local livelihoods in North Sumatra, Indonesia. Trees, Forests and People, 7, 100174. https://doi.org/10.1016/j.tfp.2021.100174

Heyne, K. (1987). Tumbuhan Berguna Indonesia (Vol. 3). Yayasan Sarana Wana Jaya.

Jayusman. (2014). Mengenal Pohon Kemenyan (Styrax spp.): Jenis dengan Spektrum Pemanfaatan Luas yang Belum Dioptimalkan. IPB Press.

Li, Q., Zhang, L., He, J., Li, J., Zhang, H., Li, Y., Gu, Y., Luo, H., Lu, M., Lu, K., & Xiong, L. (2025). Effects of different shade treatments on Melaleuca seedling growth and physiological properties. BMC Plant Biology, 25(1), 203. https://doi.org/10.1186/s12870-025-06218-1

Puri, S. R., Hamzah, H., Handayani, R., Rumondang, J., & Desthaniah, M. (2025). Pengaruh Pemberian Pupuk NPK Terhadap Pertumbuhan Bibit Kaliandra Merah (Calliandra Calothyrsus Meissn) Pada Media Ultisol: The Effect of NPK Fertilizer Application on The Growth of Red Calliandra Seedlings (Calliandra calothyrsus Meissn) on Ultisol Media. Jurnal Silva Tropika, 9(1), 129-139. https://doi.org/10.22437/jurnalsilvatropika.v9i1.44417

Purwanto, Ura', R., Handayani, D., Nuralamin, Azwar, F., Wakhid, N., Siahaan, H., & Tata, M. H. L. (2023). Morfologi Benih, Pertumbuhan, dan Indeks Mutu Bibit Kemenyan Durame (Styrax benzoin Dryand) Pada Berbagai Media Tumbuh. Jurnal Penelitian Hutan Tanaman, 20(2), 91-104. https://doi.org/10.59465/jpht.v20i2.140

Rahmawaty, Ismail, M. H., Rauf, A., Batubara, R., Sitorus, E. W. E., Simamora, Z., & Ginting, E. F. (2023). Land characteristics and land suitability assessment for Styrax sp. In Humbang Hasundutan Regency, North Sumatra, Indonesia. Heliyon, 9(7), e16936. https://doi.org/10.1016/j.heliyon.2023.e16936

Santiago, L. S., Wright, S. J., Harms, K. E., Yavitt, J. B., Korine, C., Garcia, M. N., & Turner, B. L. (2012). Tropical tree seedling growth responses to nitrogen, phosphorus and potassium addition. Journal of Ecology, 100, 309-316. https://doi.org/10.1111/j.1365-2745.2011.01904.x

Saud, O. R., Syarifudin, A., Nugroho, A., Saud, O. R., & Utami, W. S. (2025). Inventarisasi Hama dan Penyakit pada Bibit Lima Jenis Tanaman Buah Tropis di Persemaian Mentawir. MAKILA, 19(2), 383-393. https://doi.org/10.30598/makila.v19i2.22687

Setyaningsih, L. (2023). Ketergantungan Semai Johar (Cassia siamea Lamk) Terhadap Fungi Mikoriza Arbuskula Pada Media Tailing Tambang Emas. MAKILA, 17(2), 238-250. https://doi.org/10.30598/makila.v17i2.11010

Susilowati, A., Rachmat, H. H., Hartini, K. S., Yulita, K. S., Ginting, I. M., & Arrofaha, N. (2025). Seed germination of kemenyan durame (Styrax benzoin Dryander) with various treatments of breaking dormancy. IOP Conference Series: Earth and Environmental Science, 1571(1), 012006. https://doi.org/10.1088/1755-1315/1571/1/012006

Wu, W., Chen, L., Liang, R., Huang, S., & Li, X. (2025). The role of light in regulating plant growth, development and sugar metabolism: A review. Frontiers in Plant Science, 15, 1507628. https://doi.org/10.3389/fpls.2024.1507628

Zhou, L. (2023). Light effects on seedling growth in simulated forest canopy gaps vary across species from different successional stages. Frontiers in Forests and Global Change, 5, 1088291. https://doi.org/10.3389/ffgc.2022.1088291

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