# Growth and yield of porang in agroforestry system with pruning and organic fertilizer treatment

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**Abstract.** Temperature increases due to climate change reduce agricultural production, so adaptation through agroforestry cultivation systems is needed. This study aims to examine the effect of pruning and organic fertilizer on the growth and yield of porang in an agroforestry system. The research used a Randomized Block Design with a split plot pattern with two factors, namely pruning as the main plot and the type of organic fertilizer as a subplot. Pruning treatment with two levels: no pruning and 25% pruning. Organic fertilizer treatment with four levels: chemical fertilizer NPK (40-60-45) kg.ha$^{-1}$, organic fertilizer corncob, organic fertilizer *Indigofera tinscotoria* extraction waste, and organic fertilizer goat manure at a dose of 20 t.ha-1. The treatment was repeated three time. There was an interaction between pruning treatment and fertilizer type on the growth and yield of porang. The combination of no pruning and organic fertilizer from Indigofera tinctoria extraction waste resulted in the highest growth and yield, with tuber weight reaching 74.06 g. Organic Indigofera tinctoria fertilizer can increase the growth and productivity of porang in sengon agroforestry systems.

## 1 Introduction

Climate change is a pressing global challenge and has a significant impact on agricultural productivity. Rising temperatures cause various adverse effects on crop yields, necessitating innovative planting systems that can help mitigate climate change-related challenges [1]. Adaptive cultivation systems can minimize the adverse impacts of climate change through agroforestry systems that integrate trees with annual crops, thereby increasing resilience to extreme climates and increasing land productivity [2]. Agroforestry systems can support carbon sequestration, enabling climate change adaptation and mitigation efforts. Furthermore, tree canopy in agroforestry systems can absorb and reflect some solar radiation, thereby reducing temperatures beneath the tree stands [3]. Several studies have shown that

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agroforestry systems can reduce average air temperatures by 2-5°C and soil temperatures by 3-6°C. One plant that can be cultivated in agroforestry systems is porang (*Amorphophallus muelleri*). This is because porang, as a C3 plant, has high photosynthetic efficiency under moderate temperatures and light intensity [4].

Porang is a tuber plant that serves as an alternative food source in several countries, including Indonesia. Porang contains high levels of glucomannan, making it highly economically valuable and suitable for cultivation on marginal land [5]. This has driven high demand for porang. However, Indonesia faces challenges in increasing porang production, primarily driven by the decreasing availability of optimal agricultural land. Adopting an agroforestry system can improve porang cultivation by utilizing suboptimal land, such as under tree canopies. Porang has the resilience and adaptability to grow in shady environments. Agroforestry system management strategies, including tree pruning and organic fertilization, can support porang growth and yield. This is because low light and fertility are challenges in agroforestry systems. Low light intensity causes a decrease in photosynthetic efficiency, resulting in a 41.5% decrease in crop yields in agroforestry systems compared to monoculture [6]. Based on research by [7] shade from trees causes a 77% decrease in crop yield compared to full light conditions. Decreased light availability is a limiting factor in agroforestry systems, affecting plant performance, so tree pruning is a management strategy to mitigate light limitations.

Managing tree height and canopy structure can influence light interception, resulting in better resource availability for plants under the canopy. Litter and tree root biomass in agroforestry systems can increase organic matter content, thus contributing to soil quality [8]. However, nutrient competition between trees and plants can lead to decreased soil fertility over time. Organic fertilizers can improve soil fertility by increasing organic matter content, improving soil structure, and stimulating microbial activity. Research has shown that animal manure can increase nitrogen and tuber biomass in porang cultivation [9]. Combining pruning with organic fertilization creates synergistic opportunities. The study aimed to examine the effects of pruning and organic fertilizer on the growth and yield of porang in agroforestry systems.

## 2 Materials and Methods

The research was conducted in the community sengon forest of Bakaran Hamlet, Sukosari Village, Jumantono District, Karanganyar Regency with coordinates 7°38'09.1"S 110°57'04.9"E. The research was conducted at an altitude of 178 meters above sea level (masl). The research location has a light intensity of 67913 lux, However, the light intensity decreases under the sengon tree without pruning 62% and with pruning 67%. The research used a Randomized Block Design with a split plot pattern with two factors, namely pruning as the main plot and the type of organic fertilizer as a subplot. The pruning treatment consisted of two levels, namely, without pruning and pruning 25%. The fertilizer type treatment consisted of four levels, namely chemical fertilizer 200 $kg.ha^{-1}$, organic fertilizer corn cob, organic fertilizer Indigofera tinctoria extraction waste, and goat manure fertilizer, each dose of 20 $tons.ha^{-1}$.

The study used Madiun 1 variety porang tubers, NPK chemical fertilizer, goat manure organic fertilizer, Indigofera tinctoria organic fertilizer, and corn cob organic fertilizer. The observation variables were plant height, number of leaves, leaf area index, fresh weight of plant, and fresh weight of the tuber. Observations of plant height, number of leaves, fresh weight of plant, and fresh weight of the tuber were conducted twenty-four weeks after planting. Meanwhile, the leaf area index was observed at sixteen weeks after planting. The observation data were analyzed using analysis of variance at a 5% level and continued with further testing using Duncan's Multiple Range Test at a 5% level.

# 3 Results and discussion

## 3.1 Plant height

The results showed a significant interaction between pruning treatment and fertilizer type (Table 1). Pruning treatment significantly affected plant height, with the highest plant height in the unpruned treatment, at 30.12 cm. This was due to the very low light intensity in the unpruned treatment, which caused phytochrome to trigger increased auxin hormone activity in stem tissue. Auxin plays a role in cell elongation, so plants respond to light deficiency by increasing the rate of stem elongation as an adaptive measure to obtain higher light intensity [10]. The results showed that plant height in the Indigofera waste extraction fertilizer treatment was significantly different from that in the corncob fertilizer treatment (Table 1). This is supported by the high nitrogen content of Indigofera fertilizer, which stimulates chlorophyll formation, increases photosynthetic activity, and accelerates vegetative growth, including stem elongation [11].

**Table 1.** Effect of pruning and fertilizer type on plant height

| Types of fertilizer | Types of tree Pruning | | Average |
|---|---|---|---|
| | Without tree Pruning | 25% tree pruning | |
| Inorganic fertilizer | 23.90 ab | 23.58 a | 23.74 a |
| Organic corn cob fertilizer | 26.56 abc | 29.85 abc | 28.21 ab |
| *Indigofera tinctoria* organic fertilizer | 39.17 d | 31.17 c | 35.20 c |
| Organic goat manure fertilizer | 30.87 bc | 31.07 bc | 30.97 bc |
| Average | 30.12 b | 28.93 a | + |

Description: Numbers followed by the same letter as in the column and row show no significant difference based on the 5% DMRT, (+) interaction

## 3.2 Number of leaves

The results showed that fertilizer type affected the number of leaves (Table 2). The highest number of leaves was in the *Indigofera tinctoria* fertilizer treatment, at 10.67 leaves. However, comparisons between pruning levels and fertilizer types showed significantly different results. This is because organic fertilizers can increase soil organic matter content, improve soil structure, and cation exchange capacity, thus ensuring more stable long-term nutrient availability for plants, supporting leaf formation and growth. In addition, organic fertilizers can increase the diversity of soil microbes, accelerating the mineralization process of nutrients from fertilizers, allowing plants to access them more effectively compared to inorganic fertilizers [12].

**Table 2.** The effect of pruning and fertilizer type on the number of leaves

| Types of fertilizer | Types of tree Pruning | | Average |
|---|---|---|---|
| | Without tree Pruning | 25% tree pruning | |
| Inorganic fertilizer | 8.50 | 8.00 | 8.25 a |
| Organic corn cob fertilizer | 7.83 | 9.50 | 8.67 a |
| *Indigofera tinctoria* organic fertilizer | 11.00 | 10.33 | 10.67 b |
| Organic goat manure fertilizer | 7.17 | 10.17 | 8.67 a |
| Average | 8.62 | 9.50 | - |

Description: Numbers followed by the same letter as in the column show no significant difference based on the 5% DMRT, (-) without interaction

The number of porang leaves in the *Indigofera tinctoria* fertilizer treatment was significantly different from that in the corncob organic fertilizer treatment. This may be due to the correlation between leaf growth and nitrogen and phosphate uptake by plants. *Indigofera fertilizer* contains 2.84% total nitrogen and 1.54% total phosphorus, which are sufficient for plant growth, triggering an increase in chlorophyll and an increase in the rate of photosynthesis [13]. Leaf number correlates with the leaf area index (Table 6). These results indicate that increasing plant height and leaf number can increase the leaf area index, indicating that vertical plant growth is accompanied by the formation of more leaves, which contribute to total leaf area. More leaves indicate a greater contribution to light absorption and photosynthesis, thus accelerating leaf growth, which strengthens the leaf area index.

### 3.3 Leaf area index

The results showed an interaction between the no-pruning treatment and the type of fertilizer on the leaf area index (Table 3). The combination of the no-pruning treatment with Indigofera tinctoria fertilizer showed the highest leaf area index at 5.96 and was significantly different from the other treatments. The combination of the pruning treatment with inorganic fertilizer showed the lowest leaf area index at 1.87. These results indicate that Indigofera tinctoria organic fertilizer can gradually release nutrients and enrich the soil with organic matter, thereby improving soil structure, water retention, and microbial activity [14]. This encourages sustainable leaf growth and sustainable photosynthetic surface area. Porang plants can obtain optimal light intensity in the no-pruning treatment, thereby increasing the leaf area index. The no-pruning treatment also contributes to improving the composition of the carbon and nitrogen ratio in the soil, which can affect plant productivity. The *Indigofera tinctoria* fertilizer treatment showed the highest leaf area index compared to the other fertilizer treatments. This is supported by the high nitrogen and phosphorus content of Indigofera tinctoria fertilizer, which increases the nitrogen and phosphorus content in the soil, which contributes to plant vegetative growth, including increased leaf area [15]. Furthermore, *Indigofera tinctoria* is a legume that can form a symbiotic relationship with Rhizobium bacteria, fixing atmospheric nitrogen, thereby increasing nitrogen availability in the soil. This process not only reduces dependence on chemical fertilizers but also improves soil health and nutrient availability for other plants.

**Table 3**. Effect of pruning and fertilizer type on leaf area index

| Types of fertilizer | Types of tree Pruning | | Average |
|---|---|---|---|
| | Without tree Pruning | 25% tree pruning | |
| Inorganic fertilizer | 2.32 ab | 1.87 a | 2.09 a |
| Organic corn cob fertilizer | 3.89 bc | 3.43 abc | 3.66 b |
| *Indigofera tinctoria* organic fertilizer | 5.96 d | 3.18 abc | 4.57 b |
| Organic goat manure fertilizer | 4.10 c | 4.14 c | 4.12 b |
| Average | 4.06 b | 3.15 a | + |

Description: Numbers followed by the same letter as in the column and row show no significant difference based on the 5% DMRT, (+) interaction

### 3.4 Fresh weight of plant

The results showed that pruning treatment and fertilizer type did not affect plant fresh weight (Table 4). Organic fertilizer resulted in higher plant fresh weight. This is because organic fertilizer is able to provide nitrogen, phosphorus, and potassium, which play a role in the synthesis and translocation of photosynthesis products, which subsequently increases plant biomass. Increasing available nitrogen in the soil can encourage plants to produce more chlorophyll, which increases the rate of assimilation. Organic fertilizer affects soil properties and the ability [9].

**Table 4.** Effect of pruning and fertilizer type on fresh plant weight

| Types of fertilizer | Types of tree Pruning | | Average |
|---|---|---|---|
| | Without tree Pruning | 25% tree pruning | |
| Inorganic fertilizer | 41.07 | 20.92 | 30.99 |
| Organic corn cob fertilizer | 42.06 | 54.89 | 48.47 |
| *Indigofera tinctoria* organic fertilizer | 63.36 | 45.43 | 54.39 |
| Organic goat manure fertilizer | 44.91 | 53.63 | 49.27 |
| Average | 47.85 | 43.72 | - |

Description: (-) without interaction

### 3.5 Fresh weight of tubers

The results of the study showed that there was an interaction between pruning treatment and fertilizer type on the fresh weight of the tubers (Table 5). The combination of sengon without pruning with indigofera organic fertilizer showed the highest weight yield of 74.06g. Fertilizer treatment combined with the right level of shade can support optimal growth of porang. Porang can grow optimally at a shade density of at least 40% to a maximum of 60%. The higher the density of a shade, the better the growth of the porang. The treatment without pruning was higher than the 25% pruning (Table 5). According to [4], excessive photorespiration in C3 plants causes the plant to lose photosynthesis results, thereby reducing assimilates that can be used for tuber formation. Organic fertilizer treatment resulted in a higher fresh tuber weight compared to inorganic fertilizer. This is because the organic material in the fertilizer can bind soil particles into good aggregates, improving soil pore size

so that water holding capacity is better. This increases the availability of water useful for the photosynthesis process.

**Table 5.** Effect of pruning and fertilizer type on fresh tuber weight

| Types of fertilizer | Types of tree Pruning | | Average |
|---|---|---|---|
| | Without tree Pruning | 25% tree pruning | |
| Inorganic fertilizer | 35.80 a | 24.93 a | 30.36 a |
| Organic corn cob fertilizer | 55.99 a | 54.20 a | 55.09 bc |
| *Indigofera tinctoria* organic fertilizer | 101.67 b | 46.46 a | 74.06 c |
| Organic goat manure fertilizer | 40.55 a | 55.70 a | 48.12 ab |
| Average | 58.50 b | 45.32 a | + |

Description: Numbers followed by the same letter as in the column and row show no significant difference based on the 5% DMRT, (+) interaction

**Table 6.** Correlation between variables

| | Plant height | Number of leaves | Leaf area index | Fresh plant weight | Fresh tuber weight |
|---|---|---|---|---|---|
| Plant height | 1 | 0.424* | 0.534** | 0.263 | 0.615** |
| Number of leaves | 0.424* | 1 | 0.236 | 0.075 | 0.289 |
| Leaf area index | 0.534** | 0.236 | 1 | 0.549** | 0.739** |
| Fresh plant weight | 0.263 | 0.075 | 0.549** | 1 | 0.715** |
| Fresh tuber weight | 0.615** | 0.289 | 0.739** | 0.715** | 1 |

Description: * = significantly different at the 5% level ($p < 0.05$); ** = very significantly different at the 1% level ($p < 0.01$) based on the Pearson correlation test.

## 4 Conclusion

The combination of no pruning and organic fertilizer from Indigofera tinctoria extraction waste resulted in the best growth and yield, as indicated by the highest plant height, leaf area index, and tuber fresh weight. Organic fertilizer, particularly from Indigofera tinctoria, was more effective than inorganic fertilizers and other organic fertilizers in increasing porang growth and yield. Therefore, the use of Indigofera tinctoria fertilizer without tree pruning is the best combination to support porang cultivation in agroforestry systems.

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