Application of Silviculture Techniques to Improve Productivity of Binuang Bini Plant (*Octomeles Sumatrana* Miq.) as an Alternative Plant in Community Forest

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**Abstract.** Currently the type of wood in community forests on Java Island is dominated by sengon species. However, this type faces problems with attacks of gall rust diseases. One of the potential species as a substitute for light construction wood is binuang bini (*Octomeles sumatrana* Miq.). To increase stand productivity, it is necessary to apply the right silvicultural techniques. The purpose of this study was to find out the right silvicultural technique in order to increase the productivity of the binuang bini stands. The study design used a split plot design. The results showed that the organic fertilizer dose had a significant effect on the growth of the diameter and height of binuang bini stands. Fertilizing used bioactive compost charcoal with a dosage of 4 kg / planting hole can increase the growth in height and diameter of binuang bini plants was twice that of control treatment at the age of 30 months after planting. The pattern of binuang bini planting can be mixed with the other species such as Mindi (*Melia azedarach* L.) and/or Trema (*Trema orientalis* L.)

1. Introduction
Community forests have been developed by the community. They are proven to be able to support rural economy and can be used as resources to keep community's economy in times of crisis [1]. Although initially was a government program, the development of community forests was influenced by the community's seriousness to rehabilitate their environment and agricultural land. Development of community timber market is also an important incentive that encourages communities to continue conserving community forests.

Community forests in Java have reached 2,799,181 hectares [1]. Community forests have made a significant contribution to the economic development of the region, especially with regard to community timber production. Community forests have great potential, both in terms of the potential for wood produced and the size of the household or labor, especially in rural areas. One of the examples is Forestry and Plantation Service of Gunungkidul Regency, which produced wood from community forests between 80,000 - 100,000 m3 / year [1].

One type of fast growing plant generally developed in community forests on Java Island is sengon (*Falcatairia moluccana* is synonymous with *Paraserianthes falcataria* Forsberg). At the moment sengon in Java has been attacked by gall-rust disease, the impact of the attack is fatal [2]. For this reason, other types of potential alternatives need to be developed in community forests.

One type of alternative species that is growing rapidly is binuang bini (*Octomeles sumatrana* Miq.). Binuang bini is able to grow both on dry or moist soils along river banks with a clay or sandy clay texture, at altitudes up to 600 m above sea level. Climatic conditions needed are in locations that have...
a wet to slightly dry climate, with rainfall > 1500 mm/year [3]. Binuang bini wood can be used as
carpentry wood with strength class IV - V, durable class III, and not difficult processing [3]. In
addition, binuang bini wood is one of alternative types of pulp raw material that meets pulp wood
standards, among others, having a specific gravity of 0.16-0.48, 49.1% cellulose content, 23.2% lignin
content and fiber length 1,427 U [4].

One of difficulties faced in framework of developing information about silvicultural techniques is
the limitation of information. According to Daniel et al [5], several silvicultural techniques that can be
applied in order to increase crop productivity include planting spacing, fertilizing, rotating cycle
management, pruning. Furthermore, the application of mixed planting with other fast growing
species will give the advantages such as improvement of land productivity, diversification of product,
and help to minimize pest and diseases attack [11]. Some fast growing species have been developed in
community forest whether in monoculture or mixed cropping system in Java island besides sengon
namely mindi (Melia azedarach), trema (Trema orientalis), jabol (An zocephalus cadamba) and
sungkai (Peronema canescens) [11]. In order to increase the productivity of binuang bini stand some
efforts of silvicultural techniques can be applied by manipulating the environment where it grows
(cropping pattern and fertilizing). By obtaining information on silvicultural techniques, high quality
binuang bini stands are expected to be produced. The purpose of this study was to obtain silvicultural
techniques that could improve the growth of binuang bini stands in various mixed cropping patterns
and the use of organic fertilizers.

2. Method

2.1. Time and place
The research activities were carried out in the Pasir Hantap Research Forest, Sukabumi, Ginanjar
Village, Ciambar District, West Java Province. Altitude of about 586 m above sea level, with Latosol
soil type and rainfall type, namely type A. This research activity began in May 2016 to December
2019

2.2. Material and Equipment
The research materials needed in this research activity were the binuang bini plant demonstration plot,
manure, furadan and insecticide with dimethoat active ingredients. Equipment needed including a pole
measuring plant height, calipers, machetes, sickles, hoes, and sprayers for spraying insecticides.

2.3. Research design
Construction of the demonstration plots was conducted in May 2016 with an area of about 0.7
hectares, namely in Plots 60, 61, 62 and 104 in the Pasir Hantap Research Forest, Sukabumi. The
design used in the study is the Split block design with the main plot is the cropping pattern while the
subplot is the fertilizer dosage. Each plot was consisted of 16 plants and each treatment was repeated 3
times. The study design is as follows:

\[ Y_{ijk} = \mu + \alpha_i + \delta_{ik} + \beta_j + (\alpha\beta)_{ij} + \epsilon_{ijk} \]

Remarks:
- Yijk : Observations on factor A level i, level B factor j, and k-n test
- \( \mu \) : General score
- \( \alpha_i \) : Effect of the cropping factor (P) i-level
- \( \delta_{ik} \) : Random component of the main plot
- \( \beta_j \) : Effect of dosages factor bioactive compost charcoal fertilizer (A) j-level
- \( (\alpha\beta)_{ij} \) : Interaction component of factor i level and factor j level j
- \( \epsilon_{ijk} \) : Random influence of subplot
Dosages of bioactive compost charcoal fertilizer (A):
A0 = No fertilization (control) 
A1 = 2 kg / planting hole 
A2 = 4 kg / planting hole

Cropping Pattern (P):
P1 = mixture of alternating binuang bini and mindi
P2 = pure binuang bini
P3 = mixture of binuang bini and trema

2.4. Growth measurement activities (survival rate, height, and diameter)

2.4.1 Measurement of plant growth
The observed growth parameters of binuang bini, mindi and trema were percent growth (survival), height increase and diameter of the plant. Percent of growing plants (survival) is the count number of plants that live compared to the number of plants planted per plot.

The measurement of plant growth (height and diameter) was carried out every six months. For measuring plant height a measuring pole was utilized. Height measurement starts from the root of the root neck to the top of the plant. For measurement of basal diameter and diameter at breast height (DBH) a calipers was used. Stem diameter was measured at about 10 cm from the neck of the root and at breast height of an adult (about 120 cm).

2.4.2 Maintenance activities
Maintenance activities carried out including weeding (weeding), weeding around planting holes, pruning dried branches, administering manure and controlling pests / diseases that were getting worse by using pesticides through the root system

2.4.3 Parameter
The observed parameters were survival rate, growth in height, basal diameter and diameter at breast height (DBH) of plants,

2.5 Data Analysis
Data obtained from the measurements of the growth of binuang bini plants were analyzed by Analysis of Variance (ANOVA) and if there are differences between treatments, Duncan Multiple Range Tests (DMRT) will be conducted [6].

3. Result and Discussion
The average survival rate of binuang bini plants at 30 months is presented in Figure 1.
Based on Figure 1 above, it can be seen that the average survival of binuang bini plants at the age of 30 months in all cropping patterns with various bioactive compost charcoal fertilizer dosages given is above 75.0%. This illustrates that binuang bini plants can grow well to altitude more than 300 m above sea level.

The results of observations on the growth of mindi plants and trema planted in a mixture with binuang bini plants are presented in Figure 2. 30-month-old mindi plants have an average survival rate between 37.5-79.2%, (Figure 2) while for trema the average of survival rate ranged from 43.8 - 56.3% (Figure 3). The percentage of survival rate of these two types of mixing plants is lower than that of binuang bini

![Figure 2. Average survival rate of mindi plants aged 30 months in Pasir Hantap Research Forest](image)

![Figure 3. Average of survival rate of trema plants aged 30 months in Pasir Hantap Research Forest](image)

**Table 1.** The average height, basal diameter and DBH growth of binuang bini plant up to 30 months in Pasir Hantap Research Forest

| Treatment | Height (cm) | Basal Diameter (mm) | DBH (mm) |
|-----------|-------------|---------------------|----------|
| P1A0      | 296.4       | 46.5                | 35.9     |
| P1A1      | 353.0       | 63.3                | 41.6     |
| P1A2      | 329.4       | 56.6                | 41.5     |
| P2A0      | 261.8       | 43.1                | 31.1     |
| P2A1      | 507.8       | 78.2                | 61.6     |
| P2A2      | 530.7       | 85.4                | 64.0     |
| P3A0      | 436.3       | 61.7                | 48.2     |
| P3A1      | 522.2       | 82.7                | 63.3     |
| P3A2      | 614.2       | 93.1                | 73.1     |
The average growth of binuang plant height up to 30 months after planting is presented in Table 1. The height growth of binuang bini planted in a mixed pattern with mindi plants (P1) has a lower average compared to mixed pattern with trema (P3) or pure cropping pattern (P2).

The height growth of binuang bini planted in a mixed pattern with mindi plants (P1) has a lower average compared to mixed pattern with trema (P3) or pure planting pattern (P2). It can be seen that, with increasing doses of charcoal compost fertilizer, there is a tendency for plant height growth to also increase. The increase in plant height growth ranged from 40.7-102.7% when compared to controls.

Based on the results of analysis of variance (Table 2) it can be seen that the interaction of treatment between cropping pattern (P) and bioactive compost charcoal dosages (A) is not significantly different. For single treatment the cropping pattern also does not produce significant effect, but for the treatment of bioactive compost charcoal dosages have significant effect.

From Duncan test it can be seen that the treatment of A1 (2 kg/plant) and A2 (4 kg/plant) is significantly different from A0 (control), but the A1 treatment is not significantly different from A2 (Table 3).

### Table 2. Analysis of variance the effect of cropping planting and bioactive compost charcoal dosages to binuang bini height growth in Pasir Hantap Research Forest

| Source                  | DB | Sum of square | Mean Square | F-value | P-value |
|-------------------------|----|---------------|-------------|---------|---------|
| Main Plot               |    |               |             |         |         |
| Block                   | 2  | 127761        | 63880       | 0.75    | 0.55    |
| Cropping Pattern (P)    | 2  | 92038         | 46019       | 0.54    | 0.63 ns |
| Error (P)               | 3  | 257114        | 85705       |         |         |
| Sub Plot                |    |               |             |         |         |
| Compost bioactive dose (A) | 2  | 111293        | 55647       | 7.92    | 0.01 *  |
| P x A                   | 4  | 53588         | 13397       | 1.91    | 0.19 ns |
| Error (A)               | 10 | 70297         | 7030        |         |         |
| Total                   | 23 | 712092        |             |         |         |

Remark: *) = significantly different at 5% level

### Table 3. Duncan Test for the effect of bioactive compost charcoal dosage to binuang bini height growth

| Treatment | Mean value | Group |
|-----------|------------|-------|
| A0        | 340.5      | A     |
| A1        | 461.0      | B     |
| A2        | 490.4      | B     |

The average yield of binuang plant diameter 30 months after planting shows a tendency for an increase after application of the planting pattern (P) and the dose of organic fertilizer (A). Different cropping patterns (P2 and P3) as well as increment of the dose of organic fertilizer up to 4 kg/plant can increase the diameter by 98.1% and 51.7% receptively compared to control.

Analysis of variance result (Table 4) showed that the interaction effect of cropping pattern (P) and the dose of the fertilizer (A) do not significantly affect the basal diameter of the binuang bini plant at the age of 30 months. The single effect of cropping pattern (P) also has no significant effect, but the treatment dose of the bioactive compost charcoal (A) has significant effect at the 5% level.
Table 4. Analysis of variance the effect of cropping pattern and bioactive compost charcoal dose to basal diameter of binuang bini plants in Pasir Hantap Research Forest

| Source                        | DF | Sum square | Mean square | F-value | P-value |
|-------------------------------|----|------------|-------------|---------|---------|
| Main plot                     |    |            |             |         |         |
| Group                         | 2  | 2309       | 1155        | 0.70    | 0.56    |
| Cropping pattern (P)          | 2  | 1243       | 621         | 0.38    | 0.72 ns |
| Error (P)                     | 3  | 4963       | 1654        |         |         |
| Sub plot                      |    |            |             |         |         |
| Bioactive compost charcoal (A)| 2  | 3560       | 1780        | 11.74   | 0.00 *) |
| P x A                         | 4  | 859        | 215         | 1.42    | 0.30 ns |
| Error (A)                     | 10 | 1516       | 152         |         |         |
| Total                         | 23 | 14451      |             |         |         |

Remark: *) = significantly different at 5% level,
ns = non-significant at 5% level

Table 5. Duncan Test for the effect of bioactive compost charcoal dosages to binuang bini basal diameter growth

| Treatment | Mean value | Group |
|-----------|------------|-------|
| A0        | 50.4       | A     |
| A1        | 74.7       | B     |
| A2        | 78.3       | B     |

Duncan test showed that the treatment of A1 (2 kg/plant) and A2 (4 kg/plant) are significantly different from A0 (control), but the A1 treatment is not significantly different from A2 (Table 5).

Table 1 shows that the presence of pure cropping pattern (P2) and the increasing use of fertilizer (up to 4 kg/plant) tends to increase diameter at breast height by 105.8% and 98.1% compared to controls. Meanwhile with application of other cropping patterns (P1 and P3) the diameter increase is only around 36.1-51.7% compared to the control. To analyze the effect of those treatments analysis of variance is carried out (Table 6).

Table 6. Analysis of variance the effect of cropping pattern and bioactive compost charcoal dosages to DBH of binuang bini plants in Pasir Hantap Research Forest

| Source                        | DF | Sum Square | Mean square | F-value | P-value |
|-------------------------------|----|------------|-------------|---------|---------|
| Main plot                     |    |            |             |         |         |
| Group                         | 2  | 1232       | 616         | 0.54    | 0.63    |
| Cropping pattern (P)          | 2  | 1172       | 586         | 0.51    | 0.64 ns |
| Error (P)                     | 3  | 3414       | 1138        |         |         |
| Sub plot                      |    |            |             |         |         |
| Bioactive compost charcoal (A)| 2  | 1947       | 973         | 8.67    | 0.01 *) |
| P x A                         | 4  | 744        | 186         | 1.66    | 0.24 ns |
| Error (A)                     | 10 | 1123       | 112         |         |         |
| Total                         | 23 | 9632       |             |         |         |

Remarks: *) = significantly different at 5% level
ns = non significantly different at 5% level

Based on the analysis of variance (Table 6) the interaction between cropping pattern (P) and the bioactive compost charcoal (A) dosage do not have significant effect on the DBH of 30 months old
binuang bini plants. Likewise, the single effect of cropping pattern (P) has no significant effect, however the treatment of fertilizer dosage (A) has significant influence on the DBH of 30 months old binuang bini plants.

**Table 7.** Duncan Test for the effect of bioactive compost charcoal dosage to binuang bini basal diameter growth

| Treatment | Mean value | Group |
|-----------|------------|-------|
| A0        | 38.4       | A     |
| A1        | 55.1       | B     |
| A2        | 57.5       | B     |

Duncan test shows that the treatment of A1 (2 kg/plant) and A2 (4 kg/plant) are significantly different from A0 (control), but the A1 treatment does not give significantly different from A2 (Table 7).

The use of a mixed cropping pattern between binuang bini and mindi or trema is intended to anticipate the possibility of a pest attack on the main crop. The average of height and diameter growth of mindi and trema plants listed in Table 8.

**Table 8.** The average of height and diameter growth of mindi and trema plants in Pasir Hantap Research Forest

| Species/Treatment | Height (cm) | Basal Diameter (mm) | Diameter at breast height/DBH (mm) |
|-------------------|-------------|---------------------|-----------------------------------|
| Mindi             |             |                     |                                   |
| P1A0              | 233.7       | 19.3                | 22.2                              |
| P1A1              | 487.3       | 47.3                | 34.0                              |
| P1A2              | 592.3       | 59.3                | 44.7                              |
| Trema             |             |                     |                                   |
| P1A0              | 591.4       | 84.5                | 67.8                              |
| P1A1              | 669.7       | 97.6                | 81.3                              |
| P1A2              | 715.0       | 104.0               | 89.4                              |

The use of a mixed cropping pattern between binuang bini and mindi or trema was intended to anticipate the possibility of a pest attack on the main crop. The best height growth of mindi plants was obtained in P1A1 and P1A2 treatments, which were 487.3 cm and 592.3 cm. For the best height growth increment, P3A1 and P3A2 treatments gave result 669.7 cm and 715.0 cm, respectively.

Average diameter increment of mindi plants treated with compost charcoal dosages of 2 and 4 kg/plant were 145.0% and 207.3% respectively compared to controls. For trema, the increase in plant diameter after receiving compost charcoal treatment was 15.5% and 23.1% respectively compared to control.

Increment of diameter at breast height (DBH) of mindi and trema are presented in Figures 11 and 12. The application of the bioactive compost charcoal dosage up to 4 kg/plant tends to increase the growth of the diameter of mindi and trema plants compared to control. The application of compost charcoal treatment up to 2 and 4 kg/plant dosage can increase the DBH value for mindi plant equal to 53.2% and 101.4% respectively. Meanwhile for trema, the increase of DBH was 19.9% and 31.9% respectively compared to control.

Every plant species has its own growth requirement to survive and to thrive optimally. The ability to adapt to a certain environment can be showed by the ability to grow well. The average survival rate percentage of binuang bini up to 30 month old in HP Pasir Hantap, Sukabumi was >75%. This shows that binuang bini plant can survive on altitude 450 m above sea level.
The use of mindi and trema was intended to anticipate pest attack on that demonstration plot. After reaching 30 month old age mindi plant had < 79.2% average survival rate percentage. This variant also has a wide growth spread on 600 m above sea level [3]. The use of trema as mixed plant was to find out its adaptation ability on minimum altitude (less than 600 m above sea level). Based on report of Bali Forest Service [7], the growth of trema on altitude less than 600 m above sea level is not favorable, and in some places the growth percentage is zero.

The natural habitat of trema in Bedugul, Bali has altitude > 600 m above sea level and the plants continually produce seeds. Trema growth at HP Pasir Hantap was quite descent, but the survival rate percentage was < 60% due to the presence of leaf caterpillar which cause shoot decay at young stage period. Efforts to control these pests have been done, but many young plants died.

Plant growth can be seen by the increase in vertical (height) or horizontal (diameter) mass. The Binuang Bini plant demonstration plot which was built in Sukabumi, West Java, which has altitude about 486 m above sea level shows that the height and diameter growth of the Binuang Bini plant after 30 months (2.5 years) is not influenced by the cropping pattern applied. The growth of binuang bini plants mixed with mindi had the lowest average height and diameter growth (T = 3.3 m, d = 3.9 cm) compared to monocultures planted (T = 4.3 m, d = 5.2 cm) or mix with the type of trema (T = 5.2 m, d = 6.2 cm). Based on the results of the analysis of variants it turns out the application of cropping patterns does not have a significant effect on the growth of binuang bini plants.

The diameter growth of binuang bini species planted monoculture until 2.5 years old also reached 5.2 cm (2.08 cm / year increment). However, further growth needs to be monitored because usually fast-growing species will grow rapidly until the age of 3 years and after that will experience stagnation [8]. The growth of the mixing plants (mindi or trema) each shows a fairly rapid diameter growth as well. For the mindi type, the diameter reaches 1.34 cm / year and for the trema type it reaches 3.02 cm / year. Specifically for the type of trema, it turns out that at an altitude where the planting location is less than 600 m above sea level, it can grow well in the Sukabumi area, West Java [9]. The results of trials on the development of this type of trema have also been carried out in the Cikole area, West Java, which has an elevation of around 1000 m above sea level in accordance with the natural distribution area of the species in Bali, with the results of the diameter increment at 2.5 years reaching 2.8 cm / yr [9]. As a comparison, the growth of sengon in East Kalimantan, at the age of 7 years reached an average diameter of 14.4 cm (2.04 cm / year increment) [10] and the growth of diameter increment of binuang bini and the trema is almost the same and tends to exceed the type of sengon in the East Kalimantan area. However, further development needs to be monitored regarding the minimum production volume approaching the production of the type of sengon that has been developed by the community, especially in the area of West Java.

The use of cropping patterns (monoculture and mixed planting) have no significant effect on height and diameter (basal and DBH) of binuang bini plant. With the planting spacing 3 x 3 m the shape of the binuang bini plant canopy and the plants mixers (mindi or trema) tend not to interfere with each other / interact, so that competition between nutrients and space does not occur [11]. Plant growth in mixed form can have a positive or negative effect depending on the combination of the types of plants used.

Some of the benefits that can be obtained by planting a mixed cropping system are, among others, can increase the diversification of results, prevent the occurrence of pests and diseases, can optimize land use and as a soil conservation effort [11]. Furthermore, some research result has been showed that the use of mixed cropping system has no positive effect to plant growth. According to Poleno [12], mixed planting between Pinus sylvestris and Picea abies in Chechnia showed that the best height growth was obtained in monoculture system. Likewise, with the research result for Khaya anthotheca plants at the age of 2 years has higher growth and diameter better if planted monoculture compared with mixed cropping with sengon. This is due to the sengon canopy improvement will depress Khaya growth [13].

According to Nambiar [14], in fast-growing plantations the application of stand management with intensive silvicultural techniques can increase and maintain productivity. further it is mentioned that
intensive management is carried out in the phase of seed preparation, land preparation and stand maintenance phase in the form of providing nutrient input or fertilizing. Analysis variance showed that the application of bioactive compost charcoal gave significant effect of height and diameter growth of binuang bini up to 30 old months. The improvement in height for A1 and A2 were 91.7% and 102.7% respectively, while for diameter were 98.1% and 105.8% respectively compared to control. The application of bioactive compost charcoal on soil could improve soil fertility. The advantage of using those organic fertilizer than common organic fertilizer is that the charcoal content can improve pH as well as water and air circulation in soil. In addition, *Trichoderma* sp microorganism and *Cythophaga* sp bacteria can also help improving decomposition process [15]. Adding bioactive compost charcoal in binuang bini planting media helped the continuity of organic resource in soil, so the growth became better. This result was also supported by the binuang bini tissue analysis which reported that the higher bioactive compost charcoal dosages the better macro nutrition (N, P, and K) uptake [16].

The application of bioactive compost charcoal on forestry plants has been done from seeds level to plant level. Application of those organic fertilizer in teak planting media can improve seed height growth up to 4 months old [17]. Gusmailina *et al* [18] reported the use of biactive compost charcoal as planting media mixture on bulian and gaharu can improve seed height and diameter growth up to 2-4 times than control. Bioactive compost charcoal application on suren at GERHAN programme, Garut can improve plant height up to 6 m and plant diameter up to 15-20 cm [19]. The other studies related to the application of bioactive compost charcoal on bulian (*Eusideroxylon zwagerii*) and agarwood (*Aquilaria malaccensis*) showed that the use of sawdust bioactive compost charcoal and sawdust compost charcoal plus rice straw can increase seedlings height growth and diameter up to 400%.

The addition of bioactive compost charcoal on mindi and trema plants also gave similar result as binuang bini. On mindi, the dosage about 4 kg/plant of bioactive compost charcoal could improve height and diameter growth about 153.4% and 101.4% respectively. On trema, the height and diameter growth improved 20.9% and 31.9% respectively. Every plant has its unique amount of nutrition needs, so it is necessary to calculate the loss of fertilizer in nature caused by water flow or unwanted uptake from other plants. It might be better to also consider the excess on fertilizer application as it can cause negative effect on plants [20].

4. Conclusion
Binuang bini height and diameter (basal and DBH) growth at the age of 30 months were only influenced by bioactive compost charcoal dosages. Monoculture or mixed planting pattern with mindi or trema did not give significant effect to binuang bini growth. 4kg/plant hole of bioactive compost charcoal dosage can increase binuang bini height and diameter growth up to 102.7% and 105.8% respectively. To increase binuang bini productivity it is enough to apply about 2 kg/plant hole of bioactive compost charcoal.

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