The effects of rooting media, IBA, and clones on rooting ability of Teak’s shoot cutting

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Abstract. Clonal forestry of teak in the community forest could increase the forest productivity where the shoot cutting was one of the vegetative propagation methods to propagate and maintain the superior clone of teak. However, the major problem on the shoot cutting of teak was the difference in rooting ability among rooting media, IBA (Indolebutyric Acid) and selected superior of teak clone. The research was conducted on split-split plot design with 10 individual as replication on each treatment. The main plot was two rooting media (cocopeat:rice husk 2:1/A; and soil:sand:compost 3:2:1/B). The subplot was IBA hormone concentration (0 ppm, 50 ppm, 100 ppm, 150 ppm) and the sub-sub plot was 11 clones of teak. The result showed that the rooting ability of teak was affected by all of treatments and interaction among them (P < 0.05), except for the interaction between IBA dosage and clone (P >0.05). The primary and secondary root length showed that clone and interaction between media and clone were significantly different (P < 0.05), while the media was only significantly different for secondary root length (P < 0.05). However, the number of primary and secondary root was not affected by the treatments (P>0.05). Moreover, the best result of rooting ability of teak for rooting media, IBA and was the cocopeat:rice husk (70.53%), IBA 150 ppm (53.18%) and clone WG2 (85%), respectively. It suggested that the seedling production of superior teak through the shoot cutting method depended on the rooting media, IBA concentration, and the specific of teak clone.

1. Introduction
Teak (Tectona grandis Linn.f) is a large deciduous tree and has gained a worldwide reputation on account of attractiveness and durability of its wood, so it has been clustered as one of the most valuable tropical timbers. This makes teak as the most promising species for plantations in the tropics. Teak has been successfully established in agroforestry and enrichment systems especially in Java, thus it has reached an area of 1 million hectares [1]. However, the availability of timber teak resources are far below the needs on both timber productivity and quality. It is caused by using unselected and untested seed in teak plantation. Significant benefits can be derived by using tested and improved plant materials which performing good growth of both genotype and phenotype. The best phenotype and genotype will be inherited to the next generation if it is vegetatively propagated.

Vegetative propagation techniques, especially the clonal option is the best choice for many species [2, 3] including teak [4-6]. Clonal test has been established using 102 numbers of teak clones at 14th compartment Wanagama 1, Gunungkidul [7]. There were 20 best clones performing the height, diameter and good ability to survive at the shallow soil solum. Eleven numbers of twenty teak clones
(D15, F16, A19, F35, E6, F31, A10, WG1, WG2, A51 and F71) were established in the hedge orchard in order to provide a source of seeds for planting operations. There were many vegetative propagation techniques, one of them was cutting the tip [8]. However, vegetative propagation technique still facing obstacles such as the difficulty of the root formation for some specific clones[9], although some research of the combination of rooting media and IBA hormone concentrations has been done [10-13]. So far, study about various clones can be rooted easily were very limited performed. Recent study was conducted in India using two kinds of teak clones [14]. This study aims to understand both individual and interactive effects of clones, IBA treatments and rooting medium on adventitious root formation cuttings of teak. It was a new research needed to complete the silvicultural information especially in vegetative propagation techniques by cuttings on various teak clones. In general, this result will support clonal forestry establishment in Java by adding new clones to avoid the pest and diseases outbreak happened in monoclonal forest.

2. Materials and methods

2.1. Plant materials

The research was conducted in the forest nursery at Wanagama 1, Faculty of Forestry, Universitas Gadjah Mada. The design of the research was the split-split plot design with 10 individuals as replication for each treatment. The main plot was rooting media that were 3 rooting media 2:1 mixture of coco peat: rice husk and a 3:2:1 mixture of top soil: sand: compost. The sub plot was 4 concentration of IBA that was 0 ppm, and 50 ppm, 100 ppm and 150 ppm. Furthermore, the sub-sub plot was 10 clones of teak that was D15, F16, A19, F35, E6, F31, A10, WG1, WG2, A51 and F71. The variable of our research were survival ability, sprouting ability (the number of leaves per cutting, rooting percentage, the number and root length of primary root and secondary root per cutting, above and belowground biomass.

2.2. Statistical analysis

Data were analyzed using the analysis of variance (ANOVA) of split-split plot design to determine the number of leaves per cutting, rooting percentage, the number and root length of primary root and secondary root per cutting, above and belowground biomass. When the effect was significant (p ≤ 0.05), Duncan's Multiple Range Test (DMRT) was used to examine the differences between the treatments [15].

3. Results and discussions

3.1. Effect of rooting media

The result showed that the rooting ability of teak was effected by all of treatments and interaction among them (P < 0.05), except for interaction between IBA hormone concentration and clone (P >0.05). In term of the primary and secondary root length showed that clone and interaction between media and clone were significantly different (P < 0.05), while media was only significantly different for secondary root length (P < 0.05). However, the number of primary and secondary root was not affected by the treatments (P > 0.05) (table 1). Our present result showed that rooting media coco peat: rice husks 2:1 yielded the higher rooting ability (70.53%) than top soil: sand: compost 3:2:1 (23.26%) (Figure 1).
Table 1. Analysis of variance for the effect of rooting media, IBA hormone concentrations, clone types and their interaction on rooting ability, number of primary root, primary root length, number of secondary root, secondary root length, number of leaves, belowground and above biomass of teak cutting.

|   | RA | NPR | PRL | NSR    | SRL   | NLF   | BB   | AB   |
|---|----|-----|-----|--------|-------|-------|------|------|
| Media (M) | 0.0018** | 0.5665ns | 0.1729ns | 0.4742ns | 0.0040** | 0.1244ns | 0.4099ns | 0.0086** |
| Hormone (H) | 0.0318* | 0.3675ns | 0.8492ns | 0.2328ns | 0.5323ns | 0.1703ns | 0.1778ns | 0.4076ns |
| M x H | 0.0604* | 0.3221ns | 0.1657ns | 0.9582ns | 0.4104ns | 0.6785ns | 0.7671ns | 0.5617ns |
| Clone (C) | 0.001** | 0.1107ns | 0.0029** | 0.2271ns | .0001** | 0.2791ns | 0.1782ns | 0.2237ns |
| M x C | 0.0397* | 0.1835ns | 0.0020** | 0.8132ns | .0001** | 0.0225* | 0.4171ns | 0.5613ns |
| H x C | 0.9526ns | 0.2443ns | 0.1204ns | 0.3206ns | 0.1900ns | 0.4621ns | 0.8785ns | 0.5021ns |
| M x H x C | 0.0006** | 0.2712ns | 0.3559ns | 0.2860ns | 0.3218ns | 0.2581ns | 0.0001** | 0.0071** |

* Significant at P < 0.05
** Significant at P < 0.001
ns Not significant

Figure 1. Effects of different rooting media on the rooting ability of teak cuttings

Results showed that rooting media treatment significantly influenced the secondary root length, but has no significant effects on the number of primary and secondary root, and primary root length (table 1). The number of primary root affected the number of secondary root formation. Less number of primary root will increase the number of secondary root. The number of secondary root in line with the secondary root length formation, which is the greater number of secondary root also gave the longer secondary root result (Figure 2). While, the effects of different rooting media on the number of leaves, above and belowground biomass showed in Figure 3.
Figure 2. Effect of rooting media on number of primary root, secondary root and the length of primary and secondary root of teak cuttings. The treatment was followed by different letters indicate significantly different at $P < 0.05$ level.
Figure 3. Effect of rooting media on number of primary root, secondary root and the length of primary and secondary root of teak cuttings. The treatment was followed by different letters indicate significantly different at P < 0.05 level.

The results indicated that rooting media used in this research had no significant impact on number of leaves and belowground biomass. However, it had significant impact on aboveground biomass. Figure 3 showed that top soil: sand: compost always give the number of leaves, above and belowground biomass greater (7.60 g; 0.65 g; 14.97 g) than coco peat: rice husk: 6.43 g; 0.53 g; 13.73 g). Top soil: sand: compost had higher result on above biomass (14.97 g) than coco peat: rice husk (13.73 g). The ability of rooting media in supporting the formation of roots at the cuttings were influenced by the physical media properties (Table 2).

Table 2. Bulk density, porosity, soil moisture content, and the permeability of the rooting media

| Rooting media | BD (g/cc) | BJ (g/cc) | Porosity | Moisture content (%) | Permeability (cm/hour) |
|---------------|----------|-----------|----------|----------------------|-----------------------|
| A             | 0.28     | 1         | 72.48    | 16.17                | *                     |
| B             | 0.9      | 2.43      | 62.74    | 35.7                 | 3.44                  |

Coco peat: rice husk 2:1 has lower bulk density (0.28 g/cc) than top soil: sand: compost 3:2:1 (0.90 g/cc). Contrary, the lower BD and BJ will increase the rooting media porosity (72.48%). It has the positive impact on rooting ability of cuttings [16]. Media moisture content on coco peat: rice husks was lower (16.17%) than top soil: sand: compost (35.70%). In contrast, media permeability of top soil:
sand: compost was lower (3.44 cm/hour). This value was classified in medium permeability, while the value of media permeability of coco peat: rice husk in this research showed *, meaning that the water passes very quickly and classified in very fast permeability with the number range >25.4 cm/hour [17]. In other words, permeability of the tested media was quite large.

Low rooting ability in the top soil: sand: compost related with poor aeration and media porosity [18]. Based on analysis of variance (table 1) showed that the treatment of the rooting media significantly influenced the secondary root length. Growth of secondary roots on the media coco peat: rice husk associated with better aeration, thus roots will be able to penetrate into the rooting media easily [19]. Figure 2 showed that the number of primary root in line with the number of secondary root. This phenomenon will result a positive effect on cuttings growth related with the effectivity of water and nutrient absorption taken from the rooting media. The result of this research indicated that nutrient content in the vegetative propagation, especially in cuttings after the root initiation phase were necessary. The ability of cuttings to produce leaves and biomass is very important. The presence of nutrients in top soil: sand: compost had a positive impacts on cuttings growth. On the other hand, coco peat: rice husks could not keep enough nutrients required by the cuttings [15].

3.2. Effects of IBA hormone concentration

Various types of hormones affects the rooting ability. Auxin plays an important role in influencing the growth of shoots, stem, root formation and the mean of survival percentage on cuttings [20, 21]. From the analysis of variance (Table 2), IBA hormone concentration had significant effect on rooting ability of teak cuttings.

![Graph showing effects of IBA hormone concentration](image.png)

**Figure 4.** Effects of different IBA hormone concentration on the rooting ability of teak cuttings

The highest rooting ability with a mean value of 53.18% was obtained among whole IBA hormone concentration (Figure 4). Hormones at 150 ppm had the highest mean value (53.18%) for rooting ability, hormones at 100 ppm had 46.51%, hormones at 50 ppm had 46.97% while the control (no hormones) had 40.91%. Table 1 and Figure 5 showed that IBA hormone concentration had not significant effect on the number of primary root and the length of primary and secondary root.
Figure 5. Effect of IBA hormone concentration number of primary root, secondary root and the length of primary and secondary root of teak cuttings. The treatment was not followed by different letters indicate no significant effect at P < 0.05 level.
Figure 6. Effect of IBA hormone concentration on number of leaves, above and belowground biomass of teak cuttings. The treatment was not followed by different letters indicate no significant effect at P < 0.05 level.

Figure 6 showed that IBA hormone concentration in various level had not significant effect on these parameters: the number of leaves and both belowground and aboveground biomass. But, this finding showed that IBA hormone concentration at the highest level (150 ppm) result the optimum yield especially in belowground biomass (0.65 g) compared with IBA hormones concentration treatment at 50 ppm had 0.61 g, at 100 ppm and 0 ppm had 0.54 g. IBA hormone at low concentrations give the lower effect on the ability of cuttings to rooted (< 50%). Therefore, in order to produce cuttings with the higher rooting ability (> 50%), the application of optimal IBA hormones concentration (in this study 150 ppm) is necessary [12, 13, 22-25]. Treatment of IBA hormones will increase both the parameters of number of primary root, primary root length, number of secondary roots and secondary root length compared to the treatment without IBA hormone. This findings from this research agree with [26] who reported that IBA hormone concentration produced better result to the number and the length of root formation. Application of auxin, particularly indole-3-butyric acid (IBA), is one of the most common and effective means to enhance rooting of cultures [27-29]. Cuttings often respond optimally to auxin application during the dedifferentiation phase of adventitious root formation.

Husen and Pal [13] and Opuni-Frimpong [30] also discovered that IBA had an important role in an adventitious root formation, increase root quality and root dry weight. The data in this research showed that the number of leaves, aboveground and belowground biomass had a different correlation. The
highest belowground biomass at 150 ppm IBA hormone concentration (0.65 g) had the lowest of number of leaves (6 pieces) and aboveground biomass (14.15 g). It caused by the shoot formation (leaves) sometimes earlier than the root. Carbohydrate content on cuttings material at the time when cuttings treatment were done were still higher, thus that stored carbohydrates are utilized during adventitious root formation in supporting the shoot development and it would affect the value of aboveground biomass higher than belowground biomass [13].

3.3. Effect of type clone
Analysis of variance revealed that different clones resulted in significant differences in the percentage of rooting ability (Table 2).

![Figure 7. Effects of different clone types on the rooting ability of teak cuttings](image)

This study indicated that there were some clones had good ability to rooted (> 70%), but many clones which also had the low capacity to rooted (<70%). Based on clones tested in this research, only WG2 clones showed the high rooting ability up to 85%, while ten other clones had low rooting ability were WG1 (66.25%), F16 (52.92%), F35 (47.92%), E6 (46.25%), F71 (44.17%), A19 (40.83%), D15 (37.08%), F31 (33.75%), A10 (30.83%) and A51 (30.83%) (Figure 7). It affirms that the clones/genotype strongly affect the efficiency of rooting ability. WG2 clone illustrate that it was prospective material to be established in a clonal forestry. Furthermore, type of clones significantly influenced the number and the length of secondary root, but had not significant effect on the number of primary root and primary root length (Figure 8).

![Figure 8. Effects of different clone types on the number of primary root](image)
Figure 8. Effect of clone types on number of primary root, secondary root and the length of primary and secondary root of teak cuttings. The treatment was followed by different letters indicate significant effect at $P < 0.05$ level.
This research showed that clones were not always give the same effects to all variables. This phenomenon showed on the number of primary root, WG1 clones result the highest number of primary root. It had 4 pieces, higher than the others clone. F16 clone had the highest primary root length (15.03 cm), while on the variables of the number of primary root, F16 clone was at the third level. On the number of secondary root, F71 clone got the highest result (14 pieces). The best result on secondary root length was shown by A19 clone (6.97 cm), although it was got the least number of the number of secondary root. The effect of clone types on the number of leaves, above and belowground biomass were shown at Table 2 and Figure 9.

![Figure 9](image-url). Effect of clone types on number of leaves, above and belowground biomass of teak cuttings. The treatment was not followed by different letters indicate no significant effect at $P < 0.05$ level.
Table 2 showed that the different types of clones had not significant effect to the number of leaves, above and belowground biomass. Clone F35 showed the highest number of leaves (8 pieces). Clone WG2 had the highest belowground biomass (0.77 g), and clone F16 had the highest aboveground biomass (14.87 g). Variations of clones in rooting ability in cuttings was first reported by many researchers in different types of plants [12, 14, 31-34]. Only those clones that can be propagated easily will be economically feasible for deployment. Therefore, selection of clones for root ability as well as field performance should be considered as part of clonal forestry program based on rooted cuttings technology [35, 36]. It is evident from these findings that the 3 best clones i.e. WG2, WG1, and especially F16 can be used as the new materials in developing the clonal forestry program. Generally, the number of leaves, above and belowground biomass had in line correlation. Saifuddin [13] in his research get the positive correlation among above and belowground biomass, while higher belowground biomass will increase the above biomass.

3.4. The effects of interaction treatment

Effect of various interactions treatment between rooting media and IBA hormone concentration on rooting ability was presented in table 1. It showed that the interaction between them had not significant effects results on the rooting ability of teak cuttings at the P < 0.05 level. The same result shown on the interaction between IBA hormone concentration and clone types. Otherwise, the interaction between rooting media and clone types, and the interaction between rooting media, IBA hormone concentration, and clone types were significantly affected on the rooting ability. The interaction of rooting media and clones which give the best rooting ability on cuttings are presented by coco peat: rice husk+WG2 clone (100%), coco peat: rice husk+WG1 clone (86.67%), coco peat: rice husk+F35 clone (80.83%). The interaction between rooting media, IBA hormone concentration, and clone types which gave the best result were coco peat: rice husk+WG2 clone+50 ppm, 100 ppm, 150 ppm (100%). The value of this research result (100%) showed that coco peat: rice husk rooting media interact with WG2 clone and IBA hormone concentration at the all level will be effective used on cuttings. Beside WG2 clone, WG1 clone combine with coco peat: rice husk and 150 ppm hormone concentration also gave the best rooting ability (100%).

Table 1 presented that the number of primary root and primary root length were not significantly affected by the interaction between rooting media and IBA hormone concentration, the interaction between rooting media and clone types, and the interaction between rooting media, IBA hormone concentration, and clone type. Then the interaction between rooting media and IBA hormone concentration, the interaction between IBA hormone concentration and clone types, and the interaction between rooting media, IBA hormone concentration, and clone type were not significantly affected on the number and length of secondary root. However, the interaction between rooting media and clone type was significantly affected on the number and the length of secondary root. The best three interaction between them showed by coco peat: rice husk+F16 clone (18 pieces), coco peat: rice husk+F16 clone (17 pieces), coco peat: rice husk+WG1 clone (16 pieces). The best three interaction between them and their influence on the secondary root length showed by coco peat: rice husk+A19 clone (10.17 cm), coco peat: rice husk+F16 clone (4.77 cm), coco peat: rice husk+A10 clone (3.59 cm).

Significant influence shown by the interaction between rooting media and clones on the number of leaves can be seen in Table 1. Top soil: sand: compost+F35 clone (9 pieces), top soil: sand: compost+D15clone (8 pieces), coco peat: rice husk+A19clone (8 pieces) were the three best result in the interaction between rooting media and clones. The interaction between rooting media and IBA hormone concentration, the interaction between IBA hormone concentration and clone types, and the interaction between rooting media, IBA hormone concentration, and clone types had not significantly affected on the number of leaves on teak cuttings.

Above and belowground biomass showed significant differences in the level of 95% in the treatment of the interaction between rooting media, IBA hormone concentrations and clones, but not in the interaction between rooting media and IBA hormone concentration, the interaction between rooting
media and clone, the interaction between IBA hormone concentration and clone. The best result on the interaction of rooting media, IBA hormone concentrations and types of clones on root biomass were shown by the treatment top soil: sand: compost+D15+150 ppm IBA hormone concentration (1.6 g), topsoil:sand:compost+A10+50 ppm IBA hormone concentration (1.4 g), coco peat: rice husk+A10+50 ppm IBA hormone concentration (1.37 g). The best interaction between rooting media, IBA hormone concentrations and types of clones that influence above biomass on cuttings shown by top soil: sand: compost+D15+0 ppm IBA hormone concentration (22.1 g), top soil: sand: compost+D15+0 ppm IBA hormone concentration (20.6 g), and top soil:sand:compost+D15+150 ppm IBA hormone concentration (18.9 g).

4. Conclusion
Different rooting media had significant effect on the rooting ability, length of secondary roots, and above and belowground biomass of teak cuttings. Physical properties, especially the porosity on coco peat: rice husk showed the best rooting ability percentage (70.53%). Contrary, rooting media had not significantly effects on the number of primary root, primary root length, number of leaves, and belowground biomass. IBA hormone concentration significantly affect the ability of rooting ability, but did not significantly affect the other observation variables. IBA hormone concentration of 150 ppm gives best results on rooting ability compared with the three other IBA hormone concentration level. Clone types had significantly effect on the rooting ability, primary and secondary root length, but had not significantly affected on the other observation variables. The best 3 clones were able to give the best response were WG2, WG1, and F16 (reaches> 50%). The interaction between those three individual treatment also had significantly effect on the rooting ability. The best interaction showed by coco peat: rice husk rooting media+150 ppm IBA hormone concentration+WG2 clone.

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