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White Jabon (*Anthocephalus cadamba*) and Red Jabon (*Anthocephalus macrophyllus*) for Community Land Rehabilitation: Improving Local Propagation Efforts

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Abstract

Native to South and Southeast Asia, white jabon (*Anthocephalus cadamba*) and red jabon (*Anthocephalus macrophyllus*) are ideal choices for plantation and community forestry. Fast-growing and resistance to pests, the wood of these species have multiple uses. The species are preferred by local communities due to their adaptability and economic profitability. However, a lack of propagation technology appropriate for rural communities limits the domestication of jabon species. The research aimed to identify the best practices for seed germination and seedlings growth under rural conditions. The study used a completely randomized design, testing five treatments for germination media and nine treatments for growing media. Each treatment was replicated three times. All media tested were well-drained, of light texture, fertile, and can be easily produced by farmers by mixing appropriate portions of soils, sand and organic matter. The best soil media for germinating jabon seed is pure soil medium (100%) with the number of germinants equally 634 per 0.5 gram of seed, followed by the mixed soil-sand medium (1:1), which produced 514 germinants per 0.5 grams of seed. The best soil medium for height growth, diameter growth, and total dry weight of jabon seedlings was the mixed soil, cow-manure compost, and husk charcoal medium (3:1:1). These media can be produced under rural conditions with material easily available and improve local propagation of jabon species. Results are widely applicable.

Keywords: seed extraction, seed germination, nursery media, seedlings growth, cow-manure compost, tree domestication, small-scale forestry

1. Introduction

White jabon (*Anthocephalus cadamba* Miq., syn. *A. chinensis* Lamk. A. Rich. Ex Walp.) is a native forest species of South and Southeast Asia from India across to China and south to Australia (Soerianegara & Lemmens, 1993; Orwa, Mutua, Kindt, Jamnadass, & Simons, 2009). The native range of red jabon [*Anthocephalus macrophyllus* (Roxb.) Havil] is restricted to Sulawesi and the Moluccas islands (Fox, 1971). The two species may be considered synonymous (Krisnawati, Kallio, & Kanninen, 2011); but differences in appearances and growth are recognized by both foresters and farmers. These species exhibit the following characteristics: fast growth, straight cylindrical boles and small-diameter self-pruning branches. Jabon timber is suitable for multiple uses, such as plywood, light construction materials, flooring, beams and rafters, boxes and crates, tea chests, packing cases, shuttering, ceiling boards, toys, wooden shoes, bobbins, yokes, carvings, matches, chopsticks and pencils (Soerianegara & Lemmens, 1993).

Anthocephalus cadamba was widely planted in timber plantations in the 1930s in Sabah, Malaysia; and Java and East Kalimantan, Indonesia (Slik, 2006; Fox, 1971). It is common in India, was recommended for West Africa (Fox, 1971), and has been successful grown in Costa Rica, Puerto Rico, Venezuela, Taiwan, Surinam, and South Africa (Orwa *et al*., 2009; Krisnawati *et al*., 2011). In Indonesia it has been cultivated in West Java, East Java, South Kalimantan, East Kalimantan, Sumatra, Sulawesi, West Nusa Tenggara, and Papua (Martawijaya, Kartasujana, Mandang, Prawira, & Kadir, 1989). Although previously planted in commercial plantations, jabon species were not identified as priorities for farmers or communities in the early tree domestication diagnostic work of Southeast Asia (Roshetko & Evans, 1999; Gunasena & Roshetko, 2000). These fast-growing tree species are now favored by local communities due to their adaptability and economic profitability. They are seen as ideal investment choices for timber plantations or community forestry. Trees may reach a height of 45 m with a stem diameter of 100–160 cm with a small buttress of up to 2 m. (Soerianegara & Lemmens, 1993). Jabon can be harvested in 5 years when diameters reach 30-40 cm (Mansur & Tuheteru, 2010). Additionally, these species are easy to grow and more resistant to pests compared to other fast-growing species recommended for plantation and community forestry, such as sengon (*Paraserianthes falcataria*) and gmelina (*Gmelina arborea*).

Community interest in cultivating jabon for livelihood support and land rehabilitation is high, but unfortunately this is not balanced with adequate skill and knowledge of silviculture practices, especially seedling propagation techniques. The failure of some community-based jabon production efforts in Southeast Sulawesi resulted from a lack of knowledge regarding seed germination and seedling propagation. Accordingly, this study was implemented to identify the best soil media for red and white jabon 1) seed germination; and 2) seedling growth. Emphasis was placed on soil media which could be made from farm waste material commonly available around rural communities.

2. Materials and Methods

The research was conducted in a greenhouse of SEAMEO BIOTROP Bogor for four months from March until June 2013. To provide good quality seed for the research, ripe fruit of red and white jabon were collected from natural stands in Kolaka district, Southeast Sulawesi. Seed extraction was conducted using the wet method described by Nurhasybi *et al.,* (2010). The fruits were put in a wet sack for one week and then kneaded to loosen and remove the flesh. Seed were separated from the flesh, mucus and other debris using a 35 mesh sieve. Due to limited seed availability, germination was tested only with red jabon. However, seedling growth was tested for both red jabon and white jabon. Five germination and nine seedling growth media were tested to identify soil media that promoted good germination and seedling growth; and could be readily produced under rural conditions. Pure soil (100%) was used as the control in both studies. Completely randomized designs were used in both studies. Seedlings were watered two times a day to maintain moist soil conditions. Plant nutrients were not added, in order to replicate farmers' actual conditions.

2.1 Germination Media

Five germination media treatments were tested, with each treatment replicated three times (in separate germination trays). The treatments were: (G1) soil (100%); (G2) mixed soil and sand (1:1); (G3) mixed soil, husk charcoal, and compost (1:1:1); (G4) sand (100%); and (G5) mixed soil and husk charcoal (1:1). For each replication, 0.5 gram of red jabon seed was mixed with five spoons of sand and sown evenly across the tray. To maintain high humidity, the boxes were covered with transparent plastic. The parameter measured in this test was the number of seeds germinated one month after sowing.

2.2 Seedling Growth Media

One month after germination, germinants (± 2 cm height with a pair of leaves) were transplanted into nursery bags. Nine growth media treatments were tested. Each treatment was replicated three times, with each replication consisting of ten seedlings. The treatments were: (M1) soil 100%; (M2) mixed soil and husk charcoal (2:1); (M3) mixed soil, cow-manure compost, husk charcoal (3:1:1); (M4) mixed soil, straw-mushroom growth medium waste (2:1); (M5) mixed soil, oyster-mushroom growth medium waste (2:1); (M6) mixed soil, vermi compost (2:1); (M7) mixed soil, straw-mushroom medium, husk charcoal (3:1:1); (M8) mixed soil, cow-manure compost (3:1); and (M9) mixed soil, plant compost (2:1). The parameters observed in this test were: (i) height growth; (ii) diameter growth; and (iii) total dry weight (TDW).

2.3 Growth Measurements

After transplanting germinants into nursery bags, height and diameter growth of jabon seedlings were measured weekly for three months. After the final height and diameter growth measurement, the seedlings were harvested to obtain total dry weight. Dry weight was determined by weighing of plants after being dried in an over for 48 hours at 70^{o} C under 1 atmosphere of pressure. Duncan's multiple range test was used to compare growth data (heigh growth, diameter growth, and dry weight).

2.4 Weighted Scores of Seedling Growth

In order to identify the best overall treatment for combined seedling growth (height growth, diameter growth, and total dry weight) of jabon seedlings, a weighted scoring method was used (Malczewski 1999). The score of each treatment was determined as n – ri + 1, and then normalized by Σ (n – rp + 1). The complete weighting/scoring formulate was:

$$Wi = (n - ri + 1)/\Sigma (n - rp + 1), \text{ where:} \quad (1)$$

$$Wi = \text{normal score of } i^{th} \text{ treatment } (i = 1, 2, 3, \ldots n) \quad (2)$$

$$n = \text{total number of treatments observed} \quad (3)$$

$$rp = p^{th} \text{ treatment } (p = 1, 2, 3, \ldots n) \quad (4)$$

$$ri = i^{th} \text{ rank of treatment} \quad (5)$$

Since the number of the parameters was more than one, the total normal score was formulated as:

$$Wi_{tot} = \Sigma W_{ij} = W_{i1} + W_{i2} + W_{i3} + \ldots, \text{ where:} \quad (1)$$

$$Wij = \text{normal score the -}i^{th} \text{ treatment of -}j^{th} \text{ parameter.} \quad (2)$$

3. Results

3.1 Seed Germination Test

The test results showed that the best germination medium for jabon was the 100% soil medium (G1), yielding 634 germinants/0.5 gram of seed weight. The second-best germination medium was the mixed soil and sand (G2) with 514 germinants/0.5 grams of seed weight. The mixed soil, husk charcoal, and compost (G3), sand (G4), and mixed soil and husk charcoal (G5) treatments all produced less than half the number of germinants of the G1 and G2 treatments. Results of the germination test with levels of significance are illustrated in Figure 1.

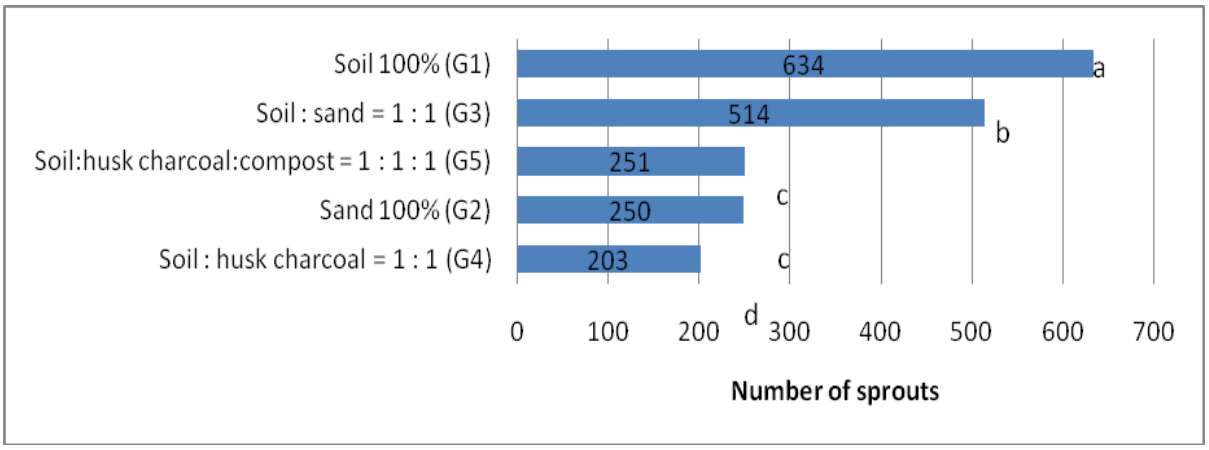

Figure 1. Duncan's multiple range test of red jabon seed germination on several media, one month after sowing (Pr > 0.0001)

3.2 Seedling Growth of Red Jabon

The test results showed the best medium for seedling height growth of red jabon was the mixed soil, composted cow manure, and husk charcoal (M3), with a total height of 12.9 cm, 42% greater than the 100% soil control (M1). Seedlings grown in mixed soil and vermi compost (M6) had a total height of 11.3 cm, 24% greater than the control (M1). Seedlings grown in mixed soil and cow manure (M8) had a total height of 9.7 cm, 7% greater than the control (M1). Seedlings grown in mixed soil, straw mushroom, and husk charcoal (M7) had a total height of 9.7 cm, 4% greater than the control (M1). Total heights of seedlings grown in other media ranged from 8.3 to 5.8 cm and were all less than the control (M1). Height growth data for all nine media with levels of significance are presented in Figure 2.

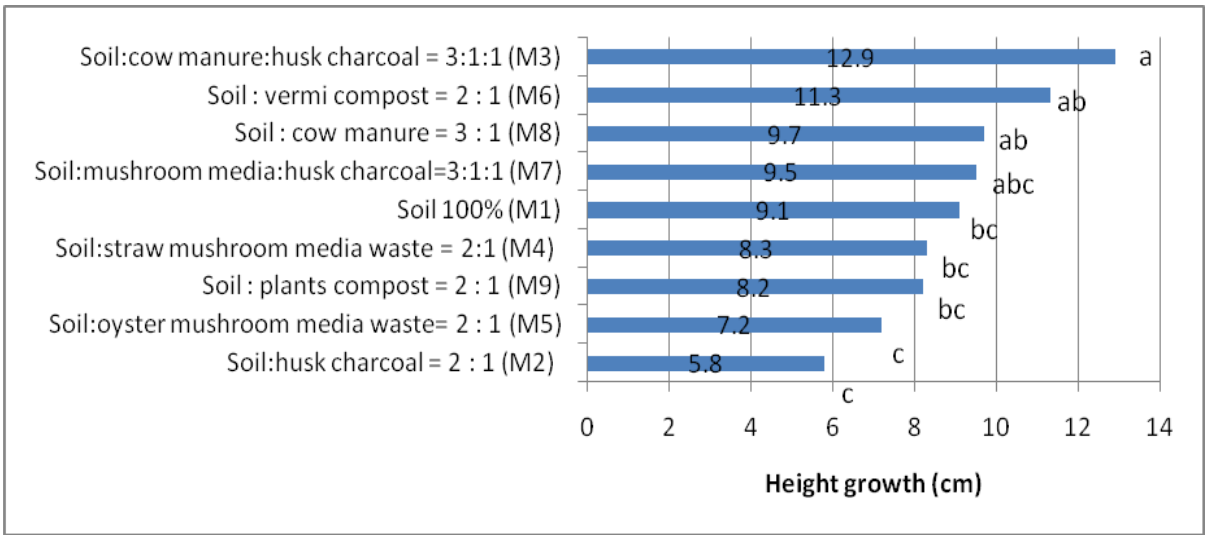

Figure 2. Duncan's multiple range test of the height growth of red jabon in several media (Pr > 0.0232)

The M3 treatment also had the best effect on the other growth parameters of red jabon seedlings; increasing diameter growth by 35% and total dry weight by 216% compared with the control (M1).

Diameter growth and total dry weight of red jabon seedlings for all nine growth media are presented in Table 1. Performance of red jabon seedlings three months after transplanting is shown in Figure 3.

Table 1. Duncan's multiple range test of the diameter growth and total dry weight of red jabon seedlings, three months old

Treatment	Diameter (cm)	Total Dry Weight (gram)
Soil (M1)	0.37 bc	0.950 de
Soil:husk charcoal = 2:1 (M2)	0.30 c	0.867 de
Soil:cow manure:husk charcoal = 3:1:1 (M3)	**0.50 a**	**3.007 a**
Soil:straw mushroom media waste= 2:1 (M4)	0.40 abc	1.157 de
Soil:oyster mushroom media waste= 2:1 (M5)	0.30 c	0.487 e
Soil : vermi compost = 2:1 (M6)	0.40 abc	2.157 bc
Soil:straw mushroom media:husk charcoal = 3:1:1 (M7)	0.37 bc	1.200 de
Soil : cow-manure compost = 3:1 (M8)	0.47 ab	2.430 ab
Soil : plant compost = 2:1 (M9)	0.47 ab	1.587 cd
Pr > F	0.0058	0.0001

Note: Numbers followed by same letter are not significant at Pr > 0.0058 (for diameter) and Pr > 0.0001 (for total dry weight)

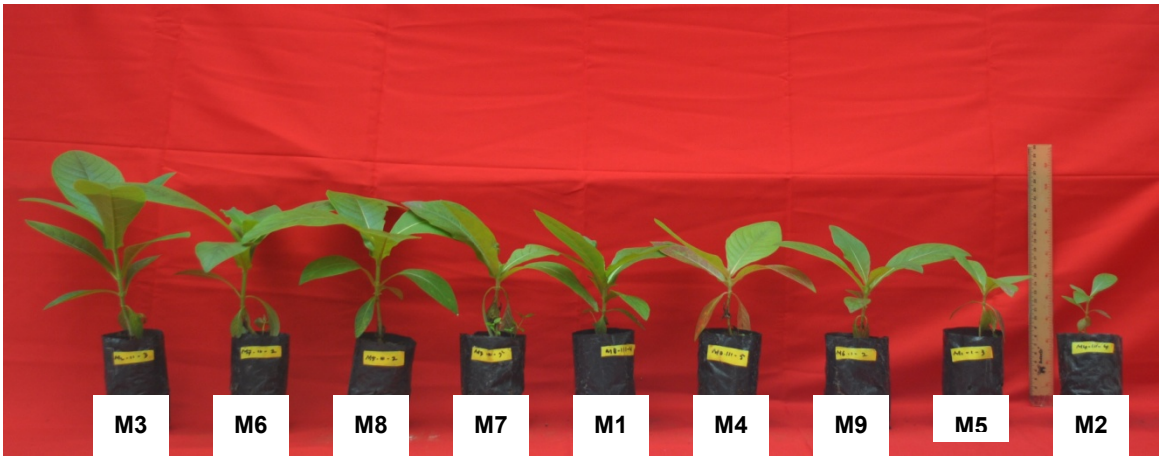

Figure 3. Performance of red jabon seedlings three months old after transplanting

Results of the weighted scoring method indicate that the mixed soil, compost of cow manure, and husk charcoal (M3) is the best treatment for overall growth of red jabon seedlings (Figure 4). The treatment score is 22% greater than the next best medium (M8) and 124% greater than the control (M1).

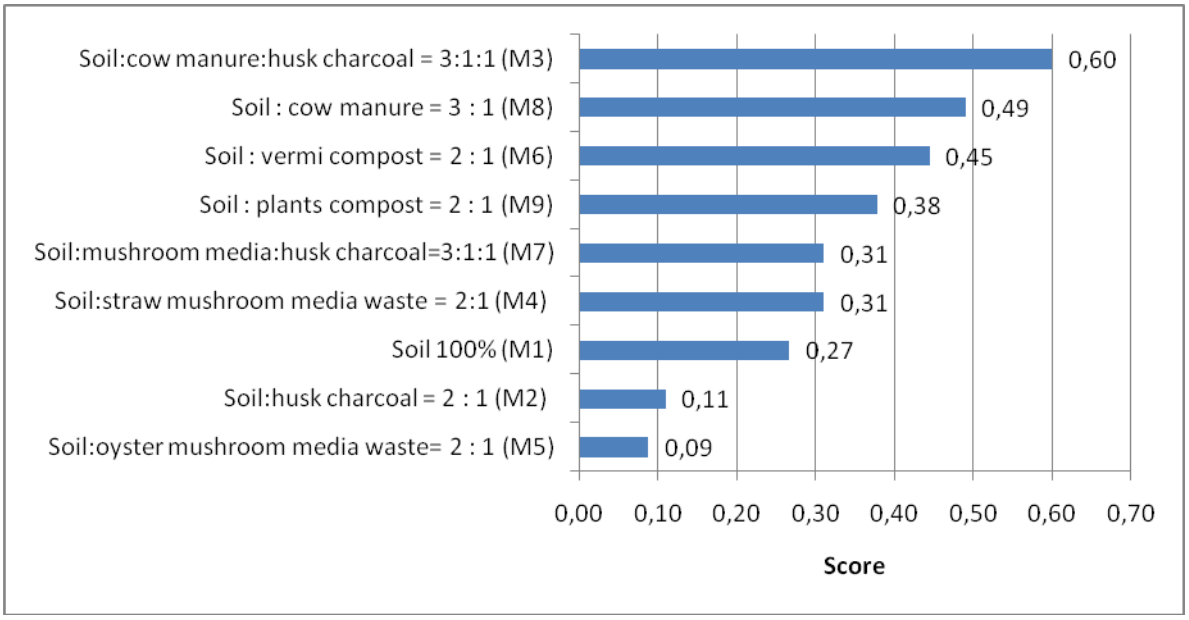

Figure 4. Result of weighted score method for red jabon seedlings in all growth media

3.3 Seedling Growth of White Jabon

The results for growth of white jabon seedlings were similar to those for red jabon seedlings. The best height growth (40.1 cm) and diameter growth (0.55 cm) of white jabon seedlings was in the mixed soil, composted cow manure, and husk charcoal medium (M3). Seedlings in those treatments demonstrated 81% greater height growth and 62% greater diameter growth compared with the control (M1). Height growth data of white jabon in all nine growth media are shown in Figure 5.

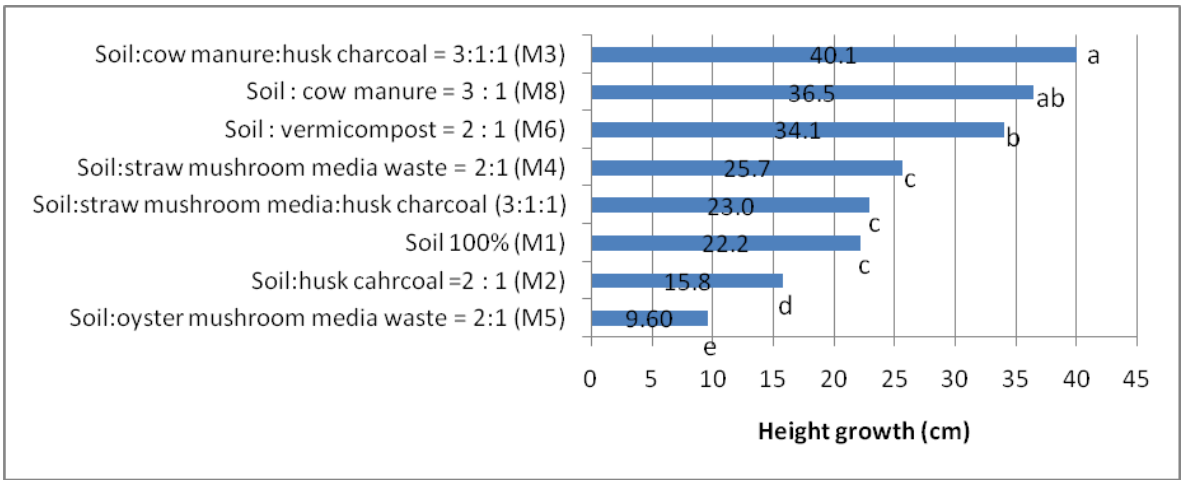

Figure 5. Duncan's multiple range test of the height growth of white jabon on several composition of media (Pr > 0.0001)

The highest total dry weight for white jabon seedlings (3.14 gram) was obtained in mixed soil and compost of cow manure (M8); however, results were not significantly different than the total dry weight (2.88 gram) of seedlings grown in mixed soil, composted cow manure, and husk charcoal (M3). Compared to the control (M1), the mixed soil and composted cow manure (M8) increased total dry weight of seedlings by 298%, while the mixed soil, composted cow manure, and

husk charcoal treatment (M3) increased total dry weight of seedlings by 265%. Diameter growth and total dry weight of white jabon seedlings for all nine growth media are presented in Table 2. Performance of white jabon seedlings three months old after transplanting is shown in Figure 6.

Table 2. Duncan's multiple range test of the diameter growth and total dry weight of white jabon seedlings, three months old

Treatment	Diameter (cm)	Total Dry Weight (gram)
Soil (M1)	0.34 c	0.79 de
Soil:husk charcoal = 2:1 (M2)	0.31 cd	0.64 de
Soil:cow manure:husk charcoal = 3:1:1 (M3)	**0.55 a**	2.88 ab
Soil:straw mushroom media waste= 2:1 (M4)	0.37 c	1.41 c
Soil:oyster mushrrom media waste= 2:1 (M5)	0.27 d	0.47 e
Soil:vermi compost = 2:1 (M6)	0.46 b	2.36 b
Soil:straw mushroom media:husk charcoal = 3:1:1 (M7)	0.36 c	1.15 cd
Soil:composted cow manure = 3:1 (M8)	0.47 b	**3.14 a**
Pr > F	0.0001	0.0001

Note : Numbers followed by same letter are not significant at Pr > 0.0001

Figure 6. Performance of white jabon seedlings three months old after transplanting

As with red jabon, results of the weighted scoring method indicate that the mixed soil, compost of cow manure, and husk charcoal medium (M3) is the best treatment for overall growth of white jabon seedlings (Figure 7). The score of that treatment is 156% greater than the control (M1).

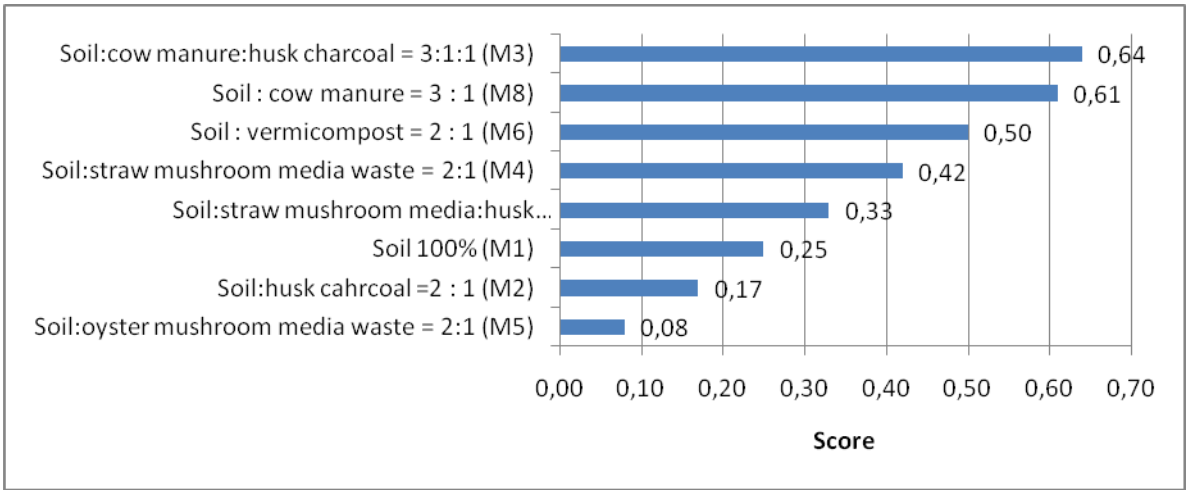

Figure 7. Result of weighted scoring method of white jabon seedlings for all growth media

4. Discussion

Farmers are the dominate land managers in the developing world, producing food, timber and other tree products and environmental services from small landholdings (Tscharntke *et al.*, 2012; Jackson *et al.*, 2010). Smallholder tree farming systems are recognized as contributing significantly to local livelihoods and land rehabilitation efforts (Garrity, 2004; Idol, Haggar, & Cox, 2011; Leakey, 2010). The importance of smallholder systems as a source of forest and tree products will only increase as global forest resources continue to shrink and human populations expand (Roshetko, 2013). The successful establishment of smallholder tree planting systems is partially dependent on the availability of good quality germplasm (seed and seedlings) and adequate propagation techniques and skills (Roshetko, Snelder, Lasco, & van Noordwijk, 2008).

Red jabon and white jabon are ideal choices for timber plantations and community forestry investments because of their fast growth, adaptability to many sites, economic profitability, and utilization variability. Additionally, jabon species have straight cylindrical boles and small self-pruning branches. Those characteristics reduce the need for tree management and are advantageous for smallholder timber production systems (Bertomeu, Roshetko, & Rahayu, 2011). Jabon species have become popular with some communities particularly for diversifying production and utilizing fallow land. However, a lack of propagation and cultivation information has limited the success of farmers' jabon seedling production efforts.

A first step to improve seedling production is to identify nursery media that promote seed germination and seedling growth. Desirable nursery media are well-drained, fertile, free of pests and diseases, and have a light texture. They are usually made by mixing appropriate portions of soils, sand and organic matter. Results of this study demonstrate that the best germination medium for jabon is 100% soil (G1), with the second-best being the mixed soil and sand (G2). The germinants produced by the other three treatments were less than half that of the G1 and G2 treatments. The superior germination rate promoted by the pure soil and the soil-sand media demonstrates that soil supplements are not necessary to enhance seed germination. Thus farmers need not use their limited time, effort and resources to produce special germination medium. The study also identified the best medium to promote seedling growth of both jabon species is the mixed soil, compost of cow manure, and husk charcoal (3 : 1 : 1) (M3). The superior growth promoted by the medium demonstrates that adequate nutrients can be provided by material readily available on farms. These media can be easily produced in rural communities without investment in expensive commercial agricultural inputs. The

use of these media will enhance local propagation efforts with jabon and can be used with other species. These results are relevant to conditions across Indonesia and other tropical countries where tree planting systems hold potential to enhance rural livelihoods and contribute to land rehabilitation. Subsequent efforts to improve the domestication of jabon species are to make the best quality seed available to farmers and test various post-planting seedling management options under farmers' conditions.

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