Effect of mycosilvi and soil ameliorant to change aluminium concentration by *Albizia chinensis* in silica sand post mining soil medium

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Abstract. This study aimed to analyze the concentration change of Aluminum in the soil with addition of MycoSilvi and soil ameliorant in silica sand post mining soil media. There are three types of MycoSilvi, single or combination, added with soil ameliorant which tested on *Albizia chinensis* (Osbeck) Merrill. The experimental design used was a factorial design with two factors, MycoSilvi (M) consisting of four levels (M0 = without MycoSilvi; M1 = MycoSilvi type 1; M2 = MycoSilvi type 2; and M3 = MycoSilvi type 3) and soil Ameliorant (LC) consisting of four levels (L0C0 = without soil ameliorant; L1C0 = lime; L0C1 = compost; L1C1 = lime and compost). Data analysis used analysis of variance (ANOVA). The results showed that the combination of MycoSilvi and soil ameliorant decreased aluminum concentration from 7.70 to 0.10 cmol(+)kg⁻¹ and increased pH from 3.20 to 5.67 were positively correlated with total biomass. Significant changes were shown in MycoSilvi type 3 with the addition of lime and compost (M3L1C1). Application of MycoSilvi type 3 (M3L0C0) gave equivalent response with application of lime (M0L1C0) to increased dry biomass, so that lime can be replaced with MycoSilvi type 3 (M3L0C0) to promote plant growth, especially biomass of plant.

1. Introduction

Aluminum is one of the micronutrients needed by plants, and if it is excessive in the soil it will be toxic which limits plant growth and productivity. One of the causes of the high concentration of Aluminum in the soil is mining activities carried out openly. The silica sand mining system is open mining by cleaning the entire soil surface from vegetation, top soil cleaning and then moving it to a predetermined location for reuse in reclamation activities after which the next layer of soil is excavated to obtain mining materials [1]. This series of activities causes land to be degraded, unproductive and marginal.

Silica sand post mining site, PT Holcim Indonesia Tbk in Sukabumi, West Java has low nutrients, very acidic soil pH (3.20), high Aluminum concentration (7.70 cmol(+)kg⁻¹). Soil is acidic because the element phosphate (P) is bound by Al so that the P content available to plants is very low even though the total P content is very high. Soil conditions that are poor in nutrients and organic matter make it
difficult for macro and microbiological soil that is useful for plant growth to live and develop. The loss of natural vegetation will also change the surrounding ecosystem and if left unchecked it will become unused land.

One of the actions to overcome these problems is to first make efforts to improve the chemical and biological properties of the soil through soil biotechnology inputs so that later it can be replanted. Soil biotechnology inputs can be in the form of addition of MycoSilvi and soil ameliorant. MycoSilvi is inoculum product of AMF biofertilizer enriched with Mycorrhizal Helper Bacteria (MHBs). AMF plays a role in increasing the rate of nutrient transfer in plant roots, increasing resistance to biotic and abiotic stresses [2] such as root pathogens, water stress [3–6] and heavy metal concentrations [7–9], preventing the loss of nutrients from the soil [10], improve soil chemical properties [11] and soil aggregates [12], increase phosphorus uptake [13] and nitrogen uptake [14]. In addition, AMF also plays a role in increasing plant biomass [15,16] and is resistant to root diseases [17].

Soil ameliorant which is a soil improvement agent plays a role in improving aggregate stability, increasing water absorption, increasing soil cation exchange capacity, as a source of plant nutrients, and being able to provide carbon for soil microorganism life so that it becomes optimum [18].

Previously, MycoSilvi was applied to Accacia decurrens seedlings on ultisol marginal soil media and the results showed an increase in the rate of photosynthesis and growth of Accacia decurrens seedlings by 100% [19] and [20] showed an increase biomass of Falcataria moluccana, Samanea saman and Cassia siamea (995.93%; 667.86%; 1447.62%) with treated of MycoSilvi and soil ameliorant.

The relationship between MycoSilvi application and plant growth in various post-mining soils has been studied, but studies on changes in Aluminum concentration are still very limited. Therefore, in this study, it is expected to examine changes in Aluminum concentration by combining the number of AMF species in MycoSilvi products, including Glomus mosseae, Acaulospora sp. and Gigaspora margarita.

2. Materials and methods
Soil sample of silica sand post mining came from the mining area of PT Holcim Indonesia Tbk., Sukabumi, West Java (S 06°55'18.1" and E 106°47'10.8") taken from a depth of 0-20 cm. The materials used in this research are silica sand post-mining soil; MycoSilvi inoculum type Glomus sp.; Gigaspora sp., Acaulospora sp.; seeds of A. chinensis; compost; dolomite lime, zeolite. The tools used in this research are GPS, autoclave, analytical scale, heat-resistant plastic, polybag (15 cm x 12 cm), sprayer, oven, label, and digital camera.

Albizia chinensis seeds are soaked in hot water (80°C) for 15 minutes, then soaked again in cold water for approximately 24 hours. The soaked seeds are then drained. Filling the sprouts with zeolite, then spraying it with water before sprinkling the sengon seeds on top. Seeds were then sown in zeolite germination media. The seeds that have been germinated are watered every morning and evening. Sprouts will appear cotyledons at the age of 1-2 weeks after sowing. Sengon seedlings are ready to be weaned at the age of 2 weeks after sowing [21].

Growing media taken from post-mining land silica sand, sieved and cleaned from the roots and then put in a plastic anti-heat sterilized using an autoclave for 1 hour at a temperature of 121°C with the primary objective to turn off unwanted microorganisms that factor influential in the study is only the factor of the treatment given.

Soil ameliorant that has been sterilized will then be added with ameliorant in the form of dolomite lime and compost. The weight of the soil used is 400 grams/polybag with a size of 15 cm x 12 cm. The media is then added with compost until it reaches 5% of the weight of the soil or as much as 20 grams/polybag. The dose of lime used is 2.078 grams/polybag.

Seeds that are ready to wean are selected that are homogeneous in both height and health, then planted in the prepared planting media. MycoSilvi inoculation will be done by placing 5 grams. MycoSilvi
equivalent to 50 spores per polybag in the area around the roots, then covered with soil media. Parameters to be observed were soil chemical properties, Aluminum concentration before and after treatment, total biomass and root shoot ratio.

The experiment was designed in a completely randomized design with a factorial pattern using split plot design consisting of 2 factors, namely: Factor 1 MycoSilvi inoculation with 4 levels, namely (M0 = without MycoSilvi; M1 = MycoSilvi type 1; M2 = MycoSilvi type 2; and M3 = MycoSilvi type 3) and soil ameliorant (LC) consisting of four levels (L0C0 = without soil ameliorant; L1C0 = lime; L0C1 = compost; L1C1 = lime and compost). The experiment used polybag culture which was repeated 5 times. All data were analyzed by analysis of variance (ANOVA).

3. Results and discussion

3.1. Characteristics of media

Table 1. Results of analysis of chemical properties of silica sand post-mining.

| Chemical properties | Analysis results | Criteria* |
|---------------------|------------------|-----------|
| pH (H₂O)            | 3.20             | Very acidic |
| C-organic (%)       | 4.21             | High      |
| N-total (%)         | 0.19             | Very low  |
| P-available (ppm)   | 13.78            | High      |
| P-total (ppm)       | 278.04           | High      |
| Ca (cmol/kg)        | 2.87             | Low       |
| Mg (cmol/kg)        | 0.85             | Low       |
| K (cmol/kg)         | 0.09             | Very low  |
| Na (cmol/kg)        | 0.11             | Low       |
| KTK (cmol/kg)       | 15.28            | Low       |
| Al (cmol/kg)        | 7.70             | High      |
| Pasir (%)           | 27.70            |           |
| Debu (%)            | 31.49            |           |
| Liat (%)            | 40.81            |           |

Source * [22]

Silica sand post-mining soil of PT Holcim Indonesia Tbk. in Sukabumi, West Java, has a low nutrient content, acidic soil (pH<5) and high concentration of Aluminium (7.70 cmol(+)/kg) so that it is toxic for plant growth and develop. Nutrients content such as total N, Ca, Mg, K, Na is also low so that plants cannot grow properly. This soil also has a low CEC and base saturation. The actual and potential pH values which are classified as low cause the accumulation of Aluminium. The accumulation of aluminium will inhibit plant growth, even though aluminum is one of the micro nutrients needed by plants in small amounts so that if it is excessive it will be toxic to plants. Al³⁺ will bind P to aluminium phosphate (AlPO₄) so that P is not available to plants. In addition, the Al³⁺ will also bind to other elements, namely Ca, K, and Mg so that these elements are not available to plants [23]. The results of the analysis of the chemical properties of the compost used in the study are presented in Table 2.
Table 2. The results of the analysis of the chemical properties of the compost.

| Chemical properties | Analysis result | Criteria* |
|---------------------|-----------------|-----------|
| pH                  | 7.71            | Slightly alkaline |
| C-organic (%)       | 48.79           | Very high |
| N (%)               | 0.58            | High      |
| P (%)               | 2.90            | Very high |
| K (%)               | 1.00            | High      |
| Ratio C/N (%)       | 83.43           | Very high |

Source* [22].

Compost added to the media contains high to very high nutrients so that it can improve the chemical properties of the research media soil and improve nutrient deficiencies needed by plants. The compost contains a slightly alkaline pH (7.71) so that it can neutralize very acidic soil media. The results of the analysis of the chemical properties of the soil at the end of the research are presented in Table 3.

Table 3. The results of the chemical properties analysis of the soil at the end of the research.

| Treatment       | N (%)* | P (ppm)* | K (cmol/kg)* | Al (cmol/kg)* | pH* |
|-----------------|--------|----------|--------------|---------------|-----|
| M0L0C0          | 0.16 r | 1.75 sr  | 0.18 r       | 5.13 r        | 3.51 sm |
| M0L1C0          | 0.13 r | 1.56 sr  | 0.22 r       | 0.90 sr       | 4.31 sm |
| M0L0C1          | 0.13 r | 9.42 s   | 0.35 r       | 3.13 r        | 3.79 sm |
| M1L0C0          | 0.13 r | 1.38 sr  | 0.23 r       | 5.23 r        | 3.51 sm |
| M1L1C0          | 0.19 r | 1.56 sr  | 0.32 r       | 1.71 sr       | 4.18 sm |
| M1L0C1          | 0.16 r | 9.42 s   | 0.49 s       | 3.84 r        | 3.73 sm |
| M1L1C1          | 0.14 r | 17.25 st | 0.51 s       | 0.20 sr       | 5.14 m  |
| M2L0C0          | 0.13 r | 1.38 sr  | 0.19 r       | 5.63 r        | 3.62 sm |
| M2L1C0          | 0.13 r | 1.56 sr  | 0.21 r       | 1.21 sr       | 4.33 sm |
| M2L0C1          | 0.19 r | 6.24 r   | 0.34 r       | 4.13 r        | 3.72 sm |
| M2L1C1          | 0.13 r | 17.64 st | 0.49 s       | 0.10 sr       | 5.40 m  |
| M3L0C0          | 0.13 r | 0.82 sr  | 0.24 r       | 5.37 r        | 3.64 sm |
| M3L1C0          | 0.13 r | 3.27 sr  | 0.22 r       | 1.22 sr       | 4.25 sm |
| M3L0C1          | 0.12 r | 7.61 s   | 0.38 r       | 4.37 r        | 3.87 sm |
| M3L1C1          | 0.10 r | 17.98 st | 0.47 s       | 0.10 sr       | 5.67 am |

Note: M0: Without MycoSilvi; M1: MycoSilvi Type 1; M2: MycoSilvi Type 2; M3: MycoSilvi Type 3; L0C0: Lime 0 g, Compost 0 g; L1C0: Lime 2,078 g, Compost 0 g; L0C1: Lime 0 g, Compost 20 g; L1C1: Lime 2,078 g, Compost 20 g; sr: Very low, r: Low, s: Medium, st: very high, sm: Very acidic, am: Slightly acidic, m: acidic. Source. *[22].

The results of the final soil analysis after being treated with MycoSilvi and soil ameliorant affected the increase in total N, P-available, K-available and soil pH as well as a decrease in aluminum concentration in the soil media. However, the results of the final soil analysis also showed that the untreated soil (M0L0C0) showed an increase in pH and a decrease in the concentration of Aluminum although it was not so significant compared to that treated with ameliorant soil. This shows that there are other factors that influence the increase in pH and decrease in the concentration of Aluminum, namely the plant factor itself. Contact of roots and soil is the initial formation of the rhizosphere which will change the environmental conditions around the roots due to root exudation in the form of organic acids [2]. The presence of a high concentration of Aluminum causes plant roots to release organic acids continuously which was originally intended to make it easier for roots to penetrate the soil. Organic compounds will bind Aluminum into complex compounds thus limiting the absorption of Aluminum.
into plant roots [24]. The accumulation of organic acids rich in organic carbon will also invite soil microbes to colonize the area around the roots. One of the organic acids released by the roots is a flavonoid compound that initiates the association between Rhizobium and plant roots, especially from the Fabaceae [25]. This association is characterized by the formation of root nodules on plants, the association of plants with Rhizobium will increase the nitrogen content in the soil.

Soil that was given lime (M0L1C0) was able to slightly increase the N- total and K-available content. Both of these contents are still low category. In contrast to the P-available content which is still in the very low category. Aluminum concentration is already very low category. The soil pH is still very acidic category. This shows that the addition of lime without compost and MycoSilvi, although it has been able to reduce the concentration of Aluminum, has not been able to increase pH so that the availability of N-total, K-available and P-available content is still low.

Soil that was given compost (M0L0C1) was able to slightly increase the content of N-total and K-available. Both of these contents are still in the low category. Contrast with the P-available content which is already in the moderate to high category. Aluminum concentration was low category while the soil pH was still very acidic category. This shows that the addition of lime-free compost and MycoSilvi has been able to reduce the concentration of Aluminum and increase P-available to plants because the compost applied in this study already contains quite high nutrients.

Soil treated with MycoSilvi Type 1 (M1L0C0), type 2 (M2L0C0) and type 3 (M3L0C0) in A. chinensis was able to slightly increase the P-available and K-available content. Both of these contents are still in the very low to low category. The content of N-total in A. chinensis is still in the low category, the concentration of Aluminum is already in the low category, but pH is still very acidic category so that the availability of elements of N-total, K-available and P-available is still low. The research of [26] and [24] stated that mycorrhizal plants can reduce heavy metal content through organic acids exuded through the roots. One of the organic compounds is a phenolic compound which has a tendency to complex compounds form with heavy metals. This complex compound will limit the absorption of heavy metals by plant roots there by reducing the toxicity of heavy metals to mycorrhizal plants. Mansur (2013) also confirmed that AMF also secretes phosphatase enzymes and organic acids, especially oxalate, which help liberate phosphate bound by Al to become available for plants [27]. This is shown by the soil media was given MycoSilvi, there was decrease concentration of Aluminum which correlated with increase soil pH and nutrient content. In addition, plant roots from the Fabaceae can also have symbiosis with Rhizobium that are able to bind nitrogen from the air which plays a role in fertilizing the soil [28]. This was shown in A. chinensis which experienced an increase in nutrient N. The presence of root nodules was an indicator of A. chinensis roots symbiosis with Rhizobium so can increase nutrient N.

Soil that was given MycoSilvi, lime and compost (M1L1C1, M2L1C1, M3L1C1) was able to increase the P-available to very high category. The content of K-available content is in the medium category. N-available is still in the low category. This may be due N fixation by Rhizobium to the reduced in this treatment due to the application of lime and compost. Compost used contains a high element of N (0.58%). Aluminum concentration was already in the very low category and pH was in the acidic category so that the availability of the N-total content in A. chinensis had started to increase. Dolomite lime (CaMg(CO\textsubscript{3})\textsubscript{2}) will be hydrolyzed to produce (OH\textsuperscript{-}), enriching the soil to increase pH which correlates with a decrease in Aluminum concentration. The compost used contains high levels of N, P and K contents and is combined with MycoSilvi which is able to increase solubility and nutrient absorption by expanding the area of root absorption through its external hyphae. The research of [29] reported that Triticum aestivum, Hordeum vulgare and Brassica napus inoculated with AMF were able to increase nutrients, both Nitrogen and Phosphorus, so that plant growth was optimal.
This shows that the addition of MycoSilvi needs to be combined with soil ameliorant to reduce Aluminum concentration and increase soil pH which is positively correlated to the availability of nutrients for plant growth which was previously low and available to plants.

3.2. Growth response

Biomass and shoot root ratio are plant growth parameters observed in this study. Plant biomass is the total amount of organic matter from all plant parts such as roots, stems and leaves. According to [30] plant biomass consists of all materials in plants derived from photosynthesis, absorption of nutrients and water that are processed through a biosynthetic process. Biomass shows the ability of plants to take nutrients from the growing media to support their growth [31]. Plant biomass consists of the total dry weight parameter of plants which is used as one of the growth characteristics for plants due to the accumulation of nutrients, the process of division, enlargement and cell differentiation.

Shoot root ratio is also an indicator of seedling resistance when planted in the field [32]. The shoot root ratio is very influential with the high and low biomass of shoots and root biomass of seedlings. Shoot root ratio describes the balance of seedling growth at the top of the soil with the roots.

The results of the variance test of total plant biomass and shoot root ratio were quite influential on the application of MycoSilvi and soil ameliorants. The interaction of MycoSilvi treatment and soil ameliorant showed a very significant effect on plant biomass as well as the shoot root ratio which significantly affected the application of MycoSilvi and soil ameliorant.

Table 4. Effect of MycoSilvi and soil ameliorants on biomass and shoot root ratio for 12 weeks after planting.

| Treatment | Shoot dry biomass (gram) | Root dry biomass (gram) | Total dry biomass (gram) | Shoot root ratio (gram) |
|-----------|--------------------------|-------------------------|--------------------------|-------------------------|
| M0L0C0    | 0.11 ± 0.07e             | 0.09 ± 0.07f            | 0.20 ± 0.14f             | 1.38 ± 0.16b            |
| M1L0C0    | 0.35 ± 0.14e             | 0.21 ± 0.07ef           | 0.56 ± 0.20ef            | 1.64 ± 0.22b            |
| M2L0C0    | 0.51 ± 0.04e             | 0.31 ± 0.03edef         | 0.82 ± 0.06e             | 1.62 ± 0.16b            |
| M3L0C0    | 0.68 ± 0.10de            | 0.40 ± 0.08de           | 1.08 ± 0.16de            | 1.72 ± 0.32b            |
| M0L1C0    | 0.38 ± 0.09ef            | 0.27 ± 0.09def          | 0.65 ± 0.18ef            | 1.42 ± 0.15b            |
| M1L1C0    | 0.92 ± 0.24ed            | 0.51 ± 0.13bed          | 1.43 ± 0.37ed            | 1.81 ± 0.15b            |
| M2L1C0    | 0.97 ± 0.31ed            | 0.52 ± 0.16bed          | 1.70 ± 0.10c             | 1.84 ± 0.07b            |
| M3L1C0    | 1.67 ± 0.28a             | 0.92 ± 0.19a            | 2.59 ± 0.46a             | 1.82 ± 0.09b            |
| M0L0C1    | 0.66 ± 0.02de            | 0.44 ± 0.02de           | 1.06 ± 0.09de            | 1.49 ± 0.11b            |
| M1L0C1    | 0.91 ± 0.52ed            | 0.57 ± 0.27bc           | 1.47 ± 0.79ed            | 1.56 ± 0.22b            |
| M2L0C1    | 1.19 ± 0.21bc            | 0.74 ± 0.20ab           | 1.97 ± 0.33bc            | 1.65 ± 0.23b            |
| M3L0C1    | 1.48 ± 0.37ab            | 0.90 ± 0.40a            | 2.38 ± 0.75ab            | 1.78 ± 0.42b            |
| M0L1C1    | 0.69 ± 0.10de            | 0.43 ± 0.14ade          | 1.12 ± 0.23de            | 1.67 ± 0.25b            |
| M1L1C1    | 1.51 ± 0.34ab            | 0.85 ± 0.15a            | 2.36 ± 0.47ab            | 1.77 ± 0.27b            |
| M2L1C1    | 1.63 ± 0.62a             | 0.97 ± 0.07a            | 2.60 ± 0.63a             | 1.69 ± 0.65b            |
| M3L1C1    | 1.75 ± 0.20a             | 0.81 ± 0.21a            | 2.82 ± 0.48a             | 2.26 ± 0.58a            |

Significancy

| M       | **   | **   | **   |       |
| LC      | **   | **   | **   |       |
| M x LC  | *    | *    | **   |       |
Note: M0: Without MycoSilvi; M1: MycoSilvi type 1; M2: MycoSilvi type 2; M3: MycoSilvi type 3; L0C0: lime 0 g, compost 0 g; L1C0: lime 2,078 g, compost 0 g; L0C1: lime 0 g, compost 20 g; L1C1: lime 2078 g, compost 20 g. The numbers followed by the same letter in the same column show no significant difference based on Duncan's test level 5%.

Soil that was given lime (M0L1C0) increase *A. chinensis* biomass more than the control (M0L0C0). The biomass of *A. chinensis* has increased by 225.00% and the biomass of *P. pinnata* has increased by 48.07%. This is because the added lime is able to increase the soil pH from very acidic to acidic and close to neutral thereby increasing the availability of nutrients for plant growth. [33] stated that liming can reduce P fixation by Al and Fe, stimulate root growth so as to increase nutrient uptake by plants which has an effect on increasing biomass.

Soil treated with MycoSilvi type 3 (M3L0C0) gave a greater increase *A. chinensis* biomass than soil treated with lime alone (M0L1C0). Biomass of *A. chinensis* increased by 440.00%. This indicates that the role of lime to increase plant biomass can be replaced by MycoSilvi type 3 (M3L0C0). Many studies reported that plants inoculated with AMF had better growth and biomass than those not inoculated with AMF [34–37]. In addition, [38] stated that biomass was positively correlated with an increase in chlorophyll content in plants. Mycorrhizal plants experienced an increase in chlorophyll content which was influenced by the increased absorption of P and Mg from the soil. Chlorophyll content is very influential on the photosynthesis process, an increase in chlorophyll content is positively correlated increase in plant biomass [15,16]. *Rhizophagus fasciculatus, Triticum aestivum, Funneliforme mosseae* and *Solanum lycopersicum* with a significant increase shoot, root, and total biomass respectively 36.3%, 28.5%, and 29.7% and increased absorption of phosphorus, nitrogen, and potassium respectively 36.3%, 22.1%, and 18.5% [26].

Soil treated with MycoSilvi type 3 (M3L0C0) was equivalent to soil treated with compost (M0L0C1) in increasing *A. chinensis* biomass by 440.00%. This indicates that the combination of AMF contained in MycoSilvi can replace the role of compost. The more diverse the number of species that were inoculated on the plants, the more positive effects were shown in increasing plant growth and biomass as happened in *A. chinensis*. The same results were shown in the study of [10] nutrient uptake and biomass of *Trifolium* inoculated with 2 types of AMF isolates (*Claroideoglomus claroideum* and *Rhizoglomus irregulare*) were better than those inoculated with only 1 type of AMF (*Funneliformis mosseae*).
Soil that was given lime and compost (M0L1C1) increased *A. chinensis* biomass more than the control (M0L0C0). The biomass of *A. chinensis* increased by 460.00%. Lime and compost are able to reduce Al toxicity and increase soil pH so that it has an impact on increasing plant growth and biomass [39]. Soil treated with MycoSilvi type 3 (M3L0C0) increased *A. chinensis* biomass equivalent to soil given lime and compost (M0L1C1) which is 440.00%. This indicates that the role of MycoSilvi in increasing *A. chinensis* biomass very significant is when planted in marginal media so that the effect is not significantly different from that of soil with lime and compost. In line with the research of [40] that *Argania spinosa* inoculated with AMF gave positive results to the increase in its biomass which was positively correlated to the increase in mycorrhizal colonization in its roots.

Soil that was given MycoSilvi type 3, lime and compost (M3L1C1) increased the biomass of *A. chinensis* more than that given only MycoSilvi or lime and compost (M0L1C1). The biomass of *A. chinensis* increased by 1310.00%. The addition of lime and compost can increase soil pH from very acidic conditions to acidic conditions and increase nutrients content that are useful for plant growth. This increase in nutrient content was due to MycoSilvi containing AMF which was able to expand the field of nutrient uptake. This is in accordance with the research of [20] which showed that the application of MycoSilvi and soil ameliorant in the form of lime and compost was able to increase plant biomass of *F. moluccana* (995.93%), *S. saman* (667.86%) and *C. siamea* (1447.62%) on post-mining silica sand soil that had a pH of Very acidic soil and low nutrient content. [41] reported that AMF species *A. tuberculata* and *Glomus* sp. able to increase shoot and root dry weight which is correlated with decreased absorption of metals toxic.

The combination of MycoSilvi type 3 lime and compost (M3L1C1) treatment resulted in *A. chinensis* biomass was the largest compared to other treatments. *A. chinensis* biomass increased by 1310.00% compared to control. Shoot root ratio of *A. chinensis* ranged from 1.38-2.26 so that if planted in the field it would be more resistant. This is in accordance with [32] that seedlings will be ready to be planted in the field if they have an NPA value of 1-3.

4. Conclusions

The results showed that the addition of a combination of Mycosilvi and soil ameliorant could reduce the aluminum concentration and increase soil pH. The most significant decrease in Aluminum concentration was shown in MycoSilvi type 3 with the addition of lime and compost (M3L1C1) from 7.70 cmol(+)/kg to 0.10 cmol(+)/kg which was positively correlated with an increase in plant biomass. The response of increasing plant biomass on the application of Mycosilvi type 3 (M3L0C0) is equivalent to the application of lime (M0L1C0), so that the role of lime (M0L1C0) can be replaced with Mycosilvi type 3 (M3L0C0) in increasing plant biomass.

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