Study of *Syzygium polyanthum* (Wight) Walp. Growth on the Ex-limestone Mining Soil with Goat Manure and NPK Fertilizer Increment

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Abstract. The limestone mining process causes the former limestone quarry land has low soil fertility characteristics. It is necessary to rehabilitate ex-limestone mine land through revegetation. *Syzygium polyanthum* is a potential tree species for revegetation. This study aimed to analyze the effect of goat manure and NPK addition on the ex-limestone mining soil toward the growth of *S. polyanthum* seedlings and to found the optimal dosage of goat manure and NPK addition. This study used a factorial complete randomized design consisting of two factors, namely goat manure (doses of 0 g, 50 g, 100 g, and 150 g) and NPK (doses of 0 g, 5 g, 10 g, and 15 g). The application of goat manure and NPK on the ex-limestone mining significantly affected the growth of height, diameter, total wet weight, and total dry weight of *S. polyanthum* seedlings, except the root shoot ratio. The best treatment for the addition of goat manure and NPK toward the growth of *S. polyanthum* seedlings on the ex-limestone mining was 150 g goat manure and 5 g NPK.

1. Introduction

Limestone is a type of class C quarry which is widely used in industrial and building processes [1]. The limestone mining process includes land clearing, drilling, blasting, encouraging, and transportation. The impact of this mining activity was the disappearance of the topsoil layer, low organic matter content, low available nutrient content, soil compaction, high pH, and high soil temperatures. Thus, ex-limestone mining land has low physical, chemical, and biological soil fertility characteristics [2].

Soil structure and texture will be damaged when soil cover is lost [1]. Soil structure and texture damage caused the soil to be unable to store and absorb water during the rainy season. Conversely, the soil becomes dense and hard in the dry season. Therefore, it is necessary to rehabilitate ex-limestone mine land through revegetation to improve the damaged soil by mining. Revegetation activities need to be carried out in post-mining areas that had ecosystem disturbance. The selection of the right tree species is one of the main keys to the success of revegetation of mined land. Efforts that can be made to increase the success of revegetation on degraded lands due to mining are by using plants that can adapt and improve the biological, chemical and physical properties of the soil [3].
Syzygium polyanthum is one of the multi-purpose tree species that have the opportunity to be developed in degraded land because it does not require high growing requirements [4]. In addition to selecting types of plants, goat manure and NPK was added to give nutrients to the soil and improve soil properties due to limestone mining. The addition of goat manure and NPK was expected to improve the properties of the ex-limestone mining soil as a medium for plant growth in terms of land revegetation. This study aimed to analyze the effect of goat manure and NPK addition on the ex-limestone mining soil toward the growth of S. polyanthum seedlings and to found the optimal dosage of goat manure and NPK addition. The results of this study were expected to provide benefits in land rehabilitation efforts with the use of suitable species for planting on mining lands.

2. Method

2.1. Time and Place
The study conducted in March - July 2018 in the greenhouse of the Silviculture Laboratory of the Department of Silviculture, Faculty of Forestry, IPB.

2.2. Materials
The tools used were hoes, digital scales, small shovels, polybag (20 cm x 20 cm), sprayer, ruler, calliper, tally sheet, and digital camera. The materials used were three-months S. polyanthum seedlings, goat manure, NPK (15-15-15), and ex-limestone mining soil.

2.3. Procedure
2.3.1. Preparation
The preparation phase included the preparation of planting media and S. polyanthum seedlings. Retrieval of media from the ex-limestone mine was carried out in Ciampea, Bogor. The media prepared consisted of a composition composed of goat manure, NPK fertilizer, and ex-limestone mining soil in a dry air condition. The composition of the dose for control was a medium of ex-limestone mining soil with a dose of 1 kg. After that, goat manure (doses: 0 g, 50 g, 100 g, and 150 g) and NPK (dosage: 0 g, 5 g, 10 g, and 15 g) added.

2.3.2. Planting
The S. polyanthum seedlings that used were from the Dramaga Permanent Nursery. Seedlings transferred into the planting media that prepared in the previous step. Transfer of seedlings was done in the afternoon to reduce the evaporation of the seedlings.

2.3.3. Maintenance
Seedlings that have been planted placed in a greenhouse for three months. Watering was done twice a day, in the morning and evening by considering the condition of the growing media in the polybag.

2.3.4. Observation and Data Collection
Data collection was carried out on several parameters, namely height, diameter, total wet weight (TWW), total dry weight (TDW), root shoot ratio (RSR), and soil analysis. Measurement of height and diameter of seedlings done once a week. TWW was measured at the end of the observation by summing the root wet weight and shoot wet weight. Dry weight was measured after the plant parts were dried in an oven at 80 °C for 24 hours. TDW was obtained by summing the root dry weight and shoot dry weight. RSR was calculated based on the comparison of the total shoot dry weight value with the total root dry weight value [5]. Soil analysis was carried out at the beginning and end of the
research at the Laboratory of the Department of Soil and Land Resources at the Faculty of Agriculture, IPB. There were two soil samples, namely control, and treatment that had the best growth.

2.3.5. Experiment Design and Data Analysis
This study used a factorial complete randomized design consisting of two factors and three replications. The first factor was manure with a dose of P0 (0 g), P1 (50 g), P2 (100 g), P3 (150 g). The second factor was NPK fertilizer with doses of N0 (0 g), N5 (5 g), N10 (10 g), N15 (15 g). Data were analyzed using SAS 9.1 portable version. The treatment had a significant effect if \( P \leq 0.05 \). Further tests were carried out using Duncan’s Multiple Range Test.

3. Result and discussion
Growth was an important thing to observe to analyze the adaptability of plants that grow in a growing medium [5]. Table 1 showed the results of variance on the various growth parameters of \( S. \) polyanthum on the ex-limestone mining soil with the addition of goat manure and NPK.

Table 1. The influence of goat manure and NPK addition to \( S. \) polyanthum seedlings growth on the ex-limestone mining soil.

| Parameter | Treatment | Goat Manure | NPK | Goat Manure x NPK |
|-----------|-----------|-------------|-----|-------------------|
| Height    |           | 0.0014*     | 0.0042* | 0.0069*          |
| Diameter  |           | 0.4996tn    | 0.0366* | <.0001*          |
| TWW       |           | 0.0092*     | 0.1430tn | 0.0061*         |
| TDW       |           | 0.0394*     | 0.2169tn | 0.0060*         |
| RSR       |           | 0.3932tn    | 0.5060tn | 0.5105tn       |

The numbers in the table were significant values. * = significantly affected the 95% confidence level with a significant value (Pr < F) 0.05 (\( \alpha \)).

Table 2. The effect of the goat manure and NPK addition on \( S. \) polyanthum height.

| Treatment | Height growth average (cm) | Enhancement (%) |
|-----------|----------------------------|-----------------|
| P3N5      | 17.80 a                    | 142.88          |
| P2N5      | 16.93 ab                   | 130.97          |
| P3N0      | 14.57 abc                  | 98.77           |
| P2N10     | 13.40 abcd                 | 82.81           |
| P3N10     | 13.33 abcd                 | 81.86           |
| P0N5      | 13.30 abcd                 | 81.45           |
| P1N15     | 13.23 abcd                 | 80.49           |
| P0N10     | 11.97 bcde                 | 63.30           |
| P2N0      | 11.70 bcde                 | 59.62           |
| P2N15     | 11.37 bcde                 | 55.12           |
| P1N5      | 9.63 cdef                  | 31.38           |
| P1N0      | 8.83 cdef                  | 20.46           |
| P3N15     | 7.90 def                   | 7.78            |
| P0N15     | 7.70 def                   | 5.05            |
| P0N0      | 7.33 ef                    | 0.00            |
The number followed by the same letter indicated that the treatment was not significantly different at the 95% confidence level.

Table 2 showed that the treatment of P3N5 (150 g goat manure and 5 g NPK) produced the best height growth response. Growth of *S. polyanthum* was influenced mainly by the smooth absorption of nutrients that were directly transported and processed in the leaves in the process of photosynthesis in each plant [6]. Increased plant growth influenced by macro elements that added through fertilization. Manure had complete nutrients, including macronutrients (N, P, and K), micronutrients (Ca, Mg, S, Mn, Co, Bo), and microorganisms. The contribution of NPK fertilizer has supported the availability of macronutrients in the soil in a balanced amount [7]. Table 3 showed the effect of the addition of goat manure and NPK to the growth in *S. polyanthum* seedling diameter.

### Table 3. The effect of the goat manure and NPK addition on *S. polyanthum* diameter.

| Treatment | Diameter growth average (cm) | Enhancement (%) |
|-----------|-----------------------------|-----------------|
| P1N15     | 0.28 a                      | 86.67           |
| P0N5      | 0.27 ab                     | 80.00           |
| P3N10     | 0.25 abc                    | 66.67           |
| P2N10     | 0.24 abcd                   | 60.00           |
| P3N5      | 0.24 abcd                   | 60.00           |
| P2N5      | 0.24 abcd                   | 60.00           |
| P3N0      | 0.22 bcede                  | 46.67           |
| P2N15     | 0.20 cde                    | 33.33           |
| P0N10     | 0.20 cdef                   | 33.33           |
| P0N15     | 0.20 cdef                   | 33.33           |
| P2N0      | 0.19 cdef                   | 26.67           |
| P1N0      | 0.18 cdef                   | 20.00           |
| P1N10     | 0.16 ef                     | 6.67            |
| P1N5      | 0.16 ef                     | 6.67            |
| P0N0      | 0.15 ef                     | 0.00            |
| P3N15     | 0.13 f                      | -13.33          |

The number followed by the same letter indicated that the treatment was not significantly different at the 95% confidence level.

Table 3 showed that the P1N15 treatment (goat manure 50 g and NPK 15 g) produced the best diameter growth response with diameter growth average of 0.28 cm and growth percentage compared to control of 86.67%. The 15 g NPK fertilizer dosage was the best for diameter growth [6]. The effect of NPK was evident because of the presence of nitrogen which stimulated overall seedling growth, specifically stems, branches, and leaves. NPK fertilizer provided nutrients that affect plant quality namely increased plant growth such as height and diameter [7].

The total wet weight had a fundamental relationship with total dry weight because it related to the accumulation of the synthesis of metabolic products used by plant growth [8]. Fertilization aimed to maintain and improve soil fertility by providing substances to the soil that can directly or indirectly develop food materials into food. Appropriate and regular fertilization would increase productivity significantly and profitably compared to no fertilization or irregular fertilization [7].

P3N10 treatment (150 g manure and NPK 10 g) gave the best response with the percentage compared to the control of 112.49% for total wet weight and 136.33% for total dry weight. This treatment was not significantly different from P3N5 (150 g manure and 5 g NPK) with a percentage compared to control of 65.80% for total wet weight and 90.61% for total dry weight. This showed that
both treatments could optimally support the development of *S. polyanthum* seedlings. Table 4 and Table 5 showed the effect of the goat manure and NPK addition on total wet weight and total dry weight of *S. polyanthum* seedlings.

**Table 4.** The effect of the goat manure and NPK addition on *S. polyanthum* TWW.

| Treatment | Total wet weight average (gram) | Enhancement (%) |
|-----------|--------------------------------|-----------------|
| P3N10     | 22.12 a                         | 112.49          |
| P2N10     | 19.85 ab                        | 90.68           |
| P2N5      | 17.51 abc                       | 68.20           |
| P3N5      | 17.26 abc                       | 65.80           |
| P1N15     | 16.56 abcd                      | 59.08           |
| P2N15     | 15.04 abcde                     | 44.48           |
| P0N5      | 14.65 bcde                      | 40.73           |
| P0N10     | 12.86 bcde                      | 23.54           |
| P3N0      | 12.80 bcde                      | 22.96           |
| P2N0      | 12.70 bcde                      | 22.00           |
| P1N0      | 12.35 bcde                      | 18.64           |
| P0N15     | 11.46 cde                       | 10.09           |
| P0N0      | 10.41 cde                       | 0.00            |
| P3N15     | 9.45 de                         | -9.22           |
| P1N5      | 8.16 e                          | -21.61          |
| P1N10     | 7.93 e                          | -23.82          |

The number followed by the same letter indicated that the treatment was not significantly different at the 95% confidence level.

**Table 5.** The effect of the goat manure and NPK addition on *S. polyanthum* TDW.

| Treatment | Total dry weight average (gram) | Enhancement (%) |
|-----------|--------------------------------|-----------------|
| P3N10     | 5.79 a                          | 136.33          |
| P2N10     | 5.16 ab                         | 110.61          |
| P2N5      | 4.93 abc                        | 101.23          |
| P0N5      | 4.92 abc                        | 100.82          |
| P1N15     | 4.75 abcd                       | 93.88           |
| P3N5      | 4.67 abcd                       | 90.61           |
| P2N0      | 3.67 abcd                       | 49.80           |
| P2N15     | 3.46 bcde                       | 41.23           |
| P3N0      | 3.45 bcde                       | 40.82           |
| P1N0      | 3.41 bcde                       | 39.18           |
| P0N10     | 3.13 bcde                       | 27.76           |
| P0N15     | 2.96 bcde                       | 20.82           |
| P3N15     | 2.75 cde                        | 12.25           |
| P0N0      | 2.45 de                         | 0.00            |
| P1N5      | 2.05 e                          | -16.33          |
| P1N10     | 2.01 e                          | -17.96          |

The number followed by the same letter indicated that the treatment was not significantly different at the 95% confidence level.
The quality of seedling growth would be better if it had higher total dry weight value [9] because total dry weight is the biomass from metabolism used for plant growth [10]. Variety studies showed that the administration of goat manure and NPK had no significant effect on the ratio of shoots to the roots of S. polyanthum seedlings. Figure 1 showed the average RSR of S. polyanthum seedlings.

Figure 1. The average root shoot ratio of S. polyanthum seedlings

Seedlings could be said to be good if they had RSR values ranged from 1-3 [11] so that the growth of S. polyanthum seedlings was in optimal conditions in the development of shoots and roots. Treatment with RSR more than 3 showed that S. polyanthum seedling growth was less than optimal because it only dominated the shoot growth. RSR described the condition of nutrients and water in the media that affect the ability of roots to absorb water and nutrients. Large RSR showed that the availability of water and nutrients for plants is relatively optimal. Consequently, the growth of shoots would be more dominant.

Conversely, a small RSR showed that the available water and nutrients were relatively lower. Consequently, root development would become more dominant to increase water and nutrient sorption by plants. RSR was a comparison between the ability of roots to absorb water and nutrients with the extent of photosynthesis and the process of plant respiration at the shoots [12]. Soil laboratory test results showed that the ratio between the best nutrient treatment interaction of 150 g manure and 5 g NPK (P3N5) with the control media of 0 g manure and NP g 0 g (P0N0) had different nutrient percentages. Table 6 showed the results of soil laboratory tests on the S. polyanthum planting media.

| No | Treatment       | Control | Criteria* | Goat Manure and NPK | Criteria* | Difference |
|----|----------------|---------|-----------|---------------------|-----------|------------|
| 1  | pH H₂O         | 7.25    | Neutral   | 7.21                | Neutral   | -0.04      |
| 2  | C-Organic (%)  | 0.08    | Very low  | 5.96                | Very high | +5.88      |
| 3  | N-Total (%)    | 0.03    | Very low  | 0.31                | Medium    | +0.28      |
| 4  | P-Bray-I (ppm) | 6.07    | Low       | 227.56              | Very high | +221.49    |
| 5  | Ca (cmol/kg)   | 57.68   | Very high | 55.73              | Very high | -1.95      |
| 6  | Mg (cmol/kg)   | 0.48    | Low       | 6.72                | High      | +6.24      |
| 7  | K (cmol/kg)    | 0.22    | Low       | 6.34                | Very high | +6.12      |
| 8  | Na (cmol/kg)   | 0.25    | Low       | 0.47                | Medium    | +0.22      |
| 9  | KTK (cmol/kg)  | 24.22   | Medium    | 46.12              | Very high | +21.9      |
|    | Texture (%)    |         |           |                     |           |            |
| 10 | Sand           | 59.88   |           | 47.71              |           | -12.17     |
|    | Dust           | 22.59   |           | 27.10              |           | +4.51      |
Fertilization could improve the properties of soil damaged by mining because it could increase the nutrient content in the soil [14]. Manure was the result of the use of livestock waste in the form of feces of livestock to reduce environmental pollution and could increase plant growth [15]. Manure included in one type of organic fertilizer whose nutrient content was not too high but could improve physical soil properties such as soil permeability, soil porosity, soil structure, water-holding capacity, soil cation, adding nutrients, increasing humus levels, improving soil structure, and encouraging soil microorganisms [7]. Goat manure could improve soil fertility, improve soil structure by stabilizing soil aggregates, aeration, and water holding capacity, and cation exchange capacity. Good soil structure made rooting well developed [16]. The use of NPK compound fertilizer would provide an abundant enough supply of N into the soil so that the administration of NPK fertilizer containing nitrogen would help plant growth [6].

4. Conclusion
The goat manure and NPK addition on the ex-limestone mining soil significantly affected the growth of height, diameter, total wet weight, and total dry weight of *S. polyanthum* seedlings based on the results of variance, except the root shoot ratio. The best treatment for the addition of goat manure and NPK toward the growth of *S. polyanthum* seedlings on the ex-limestone mining soil was 150 g goat manure and 5 g NPK.

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