Optimization of maize (Zea mays L) cultivation in post tin mining land

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Abstract: Post tin mining land can be used as agriculture land with ameliorant application and plant spacing modification. This research aimed to study the ameliorant type and plant spacing that affects the growth and yield of maize in post tin mining land. This research was conducted in Post-Tin mining land, Bangka, from February to May 2020. This research used Factorial Randomized Block Design with two factors and three replications. The first factor was ameliorant application consisted of Topsoil (K1), N, P, K + Topsoil (K2), Block compost of cassava peel waste + Topsoil (K3). The second factor was plant spacing (30 cm x 80 cm (J1); 50 cm x 60 cm (J2); 70 cm x 40 cm (J3)). The result showed that ameliorant application gave a significant effect on the growth and yield of maize parameters in post tin mining land. Plant spacing gave the best effect on cop production/ha, dry seed weight, and dry seed production/ha. NPK + Topsoil ameliorant with 30 cm x 80 cm plant spacing gave the best interaction on leaves number, cop diameter, and dry seed weight of maize in post tin mining land.

1. Introduction

Post tin mining land is one of the marginal lands in Bangka Belitung Province and has the potential to be used as agricultural land. The mining area of PT Timah reaches 473,401 ha consisting of 288,729 ha on land and 184,672 ha at sea [1]. Utilization of tin mining land as agricultural land has various obstacles such as acidic soil reaction, poor C-Organic content and Cation Exchange Capacity (CEC), poor macronutrients, and alkaline cation (K, Ca, Mg and Na) [2]. The tin mining area is also dominated by sand, high porosity, low water holding capacity, and nutrient solubilizing [3].

The addition of inorganic and organic ameliorant is one of the efforts that can be done to improve the quality of post tin -mining land as agricultural land. Inorganic ameliorant that can be used is NPK fertilizer as a provider of N, P, and K nutrients in post-mining tin lands with low status [4]. Organic ameliorant that can be utilized is cassava peel waste and topsoil. Cassava peel waste is one of organic waste that can improve soil physical, chemical, and biological properties [5]. Ameliorant of cassava peels waste can apply the innovation of blocks compost technology. Block compost is able to hold the water in the long term, to reduce the heat, to release the nutrient slowly according to the need of the plant [6]. Topsoil application in post-mining land contributed to the revegetation plant effort for rehabilitating the damaged tin mining [7].

Another effort that can be done besides adding ameliorant is to manage the cropping patterns by modifying plant spacing. Plant spacing affects the growth and yield of crop production in post tin mining
land because it is related to the crop competition and space for plants to grow [8]. So that the plant competition for the nutrient and solar radiation in post-tin mining lands can be reduced [9]. The purpose of this study was to determine the type of ameliorant and spacing that affected the growth and yield of maize in post-mining land. Therefore, utilizing post mining land as agricultural land is one of the efforts to promote sustainable rehabilitation and environmental productivity.

2. Materials and Methods

The research was conducted in post tin mining land, Dwi makmur Village, Bangka Regency from February to May 2020. The materials and tools consisted of maize, inorganic fertilizer, block compost of cassava peel waste, topsoil, hoe, meter, chlorophyll meter, digital scale, and calipers. This research used Factorial Randomized Block Design with two factors. The first factor was ameliorant application consisted of (Topsoil (K1), N, P, K+ Topsoil (K2), Block compost of cassava peel waste + Topsoil (K3). The second factor was plant spacing (30 cm x 80 cm (J1); 50 cm x 60 cm (J2); 70 cm x 40 cm (J3)). This research consists of 9 combination treatments with 3 replicates and 7 samples each block. There were 27 experiment units with 20 plants each block.

The procedures included land preparation, ameliorant application, plant spacing arrangement, planting, and harvesting. The first step was land cleared from weeds, then 27 plots made with 3 m x 2 m. The next was an ameliorant application that was done by putting in a planting hole. Inorganic ameliorant was NPK (300 kg/ha urea, 200 kg/ha TSP, and 150 kg/ha KCl). Organic ameliorant was topsoil with 2 kg/hole and block compost of cassava peel waste with 10 tonnes/ha. Plant spacing arrangement was done with three types of plant spacing. The first plant spacing was 30 cm x 80 cm, and then 50 cm x 60 cm, and the last was 70 cm x 40 cm. Planting was done by putting one maize seed each planting hole in different plant spacing with following plant spacing treatment. Watering was done once in a day. Maize was observed and was ready to be harvested when its leaves, stem, and cop turned into yellow and dried.

The parameters in this research were plant height, leaves number, stem diameter, chlorophyll content, root length, tasseling days, cop number, cop length, cop diameter, cop production/ha, dry seed weight, and dry seed production/ha. The data analysis used the F test with a 95% significant level and if the data give a significant effect it will continue by using Duncan’s Multiple Range Test.

3. Result and Discussion

The result of variance analysis showed that ameliorant application gave a significant effect on all parameters except tasseling days. Plant spacing treatment gave no significant effect on all parameters except cop production/ha, dry seed weight, and dry seed production/ha (Table 1).

| Parameters                  | Ameliorant | Plant spacing | Interaction | CV (%) |
|-----------------------------|------------|---------------|-------------|--------|
| Plant height (cm)           | Mean       | Pr >F         | Mean        | Pr >F  | F hit | Pr >F |
|                            | 84.94      | <.0001**      | 0.53        | 0.5995** | 2.44  | 0.0897** | 13.04 |
| Leaves number (strands)     | 70.81      | <.0001**      | 2.98        | 0.0793** | 4.34  | 0.0144*  | 13.89 |
| Stem diameter (cm)          | 12.61      | 0.0005**      | 0.46        | 0.6396** | 0.76  | 0.5649** | 31.74 |
| Chlorophyll content (cci)   | 106.1      | <.0001**      | 1.78        | 0.2002** | 1.18  | 0.3554** | 22.10 |
| Tasseling days (dap)        | 0.37       | 0.6996**      | 0.45        | 0.6454** | 1.04  | 0.4162** | 32.71 |
| Root length (cm)            | 16.09      | 0.0001**      | 0.30        | 0.7445** | 1.60  | 0.2217** | 16.99 |
| Cop number (piece)          | 10.86      | 0.0010**      | 0.37        | 0.6979** | 0.31  | 0.8658** | 35.72 |
| Cop length (cm)             | 30.81      | <.0001**      | 0.42        | 0.6663** | 0.82  | 0.5283** | 27.10 |
| Cop diameter (cm)           | 55.00      | <.0001**      | 0.52        | 0.6031** | 2.99  | 0.0509*  | 23.62 |
| Cop production/ha (tonnes)  | 80.60      | <.0001**      | 3.66        | 0.0490*  | 2.98  | 0.0515** | 36.51 |
| Dry seed weight (g)         | 77.92      | <.0001**      | 5.28        | 0.0174*  | 4.71  | 0.0105*  | 34.67 |
| Dry seed production/ha (tonnes) | 64.79   | <.0001**      | 4.38        | 0.0305*  | 2.88  | 0.0567** | 40.72 |

Notes: CV = Coefficient of variation; ** = Significant at 1% level; * = Significant at 5% level; ns = Not significant; Pr > F = Probability value.
The result of the *Duncan’s Multiple Range Test (DMRT)* test (Table 2 and Table 3), inorganic ameliorant (N, P, and K) + Topsoil produced higher than others on plant height, chlorophyll content, cop length, cop diameter, cop production/ha, dry seed weight and dry seed production/ha. N, P, K nutrients are essential nutrients for the growth and the yield of maize [10]. In addition, N nutrient has a direct role in plant vegetative part formation and plays a major role in chlorophyll synthesis to increase the photosynthesis process [11]. Inorganic ameliorant (N, P, and K) + Topsoil gave the best effect not significantly different from organic ameliorant (block compost of cassava peel waste) + Topsoil on leaves number, stem diameter, root length, and cop number and very significantly different with Topsoil ameliorant.

#### Table 2. The result of the DMRT test of ameliorant application on the growth of maize in post tin mining land

| Ameliorant               | Plant height (cm) | Leaves number (strands) | Stem diameter (cm) | Chlorophyll content (cci) | Root length (cm) | Tasseling day (DAP) |
|-------------------------|-------------------|-------------------------|--------------------|--------------------------|-----------------|---------------------|
| Topsoil                 | 44.458 c          | 3.921 b                 | 6.284 b            | 4.9544 b                 | 16.102 b        | 50.89               |
| NPK + Topsoil           | 106.716 a         | 8.9289 a                | 13.749 a           | 17.2222 a                | 25.627 a        | 58.00               |
| Block compost + Topsoil | 89.627 b          | 8.4756 a                | 13.211 a           | 5.3644 b                 | 22.727 a        | 55.56               |

Note: Numbers are followed by the same letter in the same column showed no significantly different effect at the Duncan Multiple Range Test (DMRT), α=0.05.

DAP: Day after planting

#### Table 3. The result of DMRT test of ameliorant application on the yield of maize in post tin mining land

| Ameliorant               | Cop number (piece) | Cop length (cm) | Cop diameter (cm) | Cop production/ha (tonnes) | Dry seed weight (g) | Dry seed production/ha (tonnes) |
|-------------------------|--------------------|-----------------|-------------------|----------------------------|---------------------|--------------------------------|
| Topsoil                 | 0.5556 b           | 6.948 c         | 5.940 c           | 0.0967 c                   | 3.186 c             | 0.0419 c                       |
| NPK + Topsoil           | 1.3033 a           | 21.443 a        | 25.264 a          | 2.3611 a                   | 53.512 a            | 1.2374 a                       |
| Block compost + Topsoil | 1.0467 a           | 15.078 b        | 20.673 b          | 0.7444 b                   | 18.993 b            | 0.4039 b                       |

Note: Numbers are followed by the same letter in the same column showed no significantly different effect at the Duncan Multiple Range Test (DMRT), α=0.05.

According to the data (Table 2 and Table 3) N, P, K is the best ameliorant to promote the growth and the yield of maize in post tin mining land because it provides macronutrients for plant development [12]. N, P, K ameliorant increase leaves number, stem diameter, root length, and cop number of maize. Similarly, the ameliorant of block compost of cassava peel increases leaves number, stem diameter, root length, and cop number of maize in post tin mining land. Not only inorganic ameliorant is required for the growth and the yield of the plant but also organic ameliorant. It is similar to the [13] reported that organic ameliorant improves soil structure and nutrient availability.

Management of plant density in marginal land is crucial in order to improve maize production. According to [14], the yield of maize will increase if planted in optimum space. Two tables (Table 4 and Table 5) represent that plant spacing has no significant effect on plant height, leaves number, stem diameter, chlorophyll content, root length, tasseling days, cop number. Although plant spacing not significant to the growth of and the yield of maize in post tin mining land, plant spacing of 30 cm x 80 cm has the highest value on plant height, leaves number, tasseling days, cop number, cop length, and cop diameter are compared to others treatment. Plant spacing treatment (50 cm x 60 cm) gave the highest value on stem diameter and chlorophyll content than other treatments while plant spacing 70 cm x 40 cm gave the highest result on root length. The root system in this research developed well under low plant populations or wide plant spacing. Similarly, the result from [15] reported that plant spacing of 70 cm x 40 cm provided sufficient opportunity for the roots to feed extensively within the nutrient and water
without interrupting and competition. In contrast, the result from [16] reported that denser plant spacing helped maintain a larger root system under a high population.

### Table 4. The result of DMRT test of plant spacing on the growth of maize on post tin mining land

| Plant Spacing          | Plant height (cm) | Leaves number (str, ands) | Stem diameter (cm) | Chlorophyll content (cci) | Root length (cm) | Tasseling day (DAP) |
|------------------------|-------------------|---------------------------|--------------------|---------------------------|------------------|---------------------|
| 30 cm x 80 cm          | 82.64a            | 7.64a                     | 10.22a             | 9.4a                      | 21.78a           | 59.44a              |
| 50 cm x 60 cm          | 80.57a            | 7.17a                     | 11.78a             | 9.95a                     | 20.72a           | 52.56a              |
| 70 cm x 40 cm          | 77.59a            | 6.51a                     | 11.24a             | 8.19a                     | 21.95a           | 52.44a              |

Note: Numbers are followed by the same letter in the same column showed not really different significantly effect at the Duncan Multiple Range Test (DMRT), α=0.05.

The result of the DMRT test (Table 5), plant spacing treatment gave significantly different effects on maize yield in post tin mining land. Plant spacing (30 cm x 80 cm) gave the highest value on cop production/ha, dry seed weight, and dry seed production/ha. Plant spacing of 30 cm x 80 cm gave the highest result not significantly different with a plant spacing of 50 cm x 60 cm and very significantly different with a plant spacing of 70 cm x 40 cm. Wider plant spacing declined the plant competition for nutrient and root development in marginal land like post tin mining land [17]. In addition, there is no competition for sunlight absorption because the position of leaves between plants does not cover each other [18]. Meanwhile denser plant spacing can increase plant competition for nutrients, air, water, sunlight, and limited growing space in marginal land because it is related to the plant density or plant population [19]. A higher plant population will decrease the grain-filling stage because of the root competition in nutrient absorption. This result in line with [20] showed that root reductive activity in all root zones were decreased under narrow plant spacing.

### Table 5. The result of DMRT test of plant spacing on the yield of maize on post tin mining land

| Ameliorant            | Cop number (piece) | Cop length (cm) | Cop diameter (cm) | Cop production/ha (tonnes) | Dry seed weight (g) | Dry seed production/ha (tonnes) |
|-----------------------|--------------------|-----------------|-------------------|-----------------------------|---------------------|-------------------------------|
| 30 cm x 80 cm         | 1.02a              | 15.11a          | 18.22a            | 1.2456 a                    | 32.433 a            | 0.6924 a                      |
| 50 cm x 60 cm         | 0.89a              | 13.53a          | 16.26a            | 1.1733 a                    | 24.069 ab           | 0.6069 ab                     |
| 70 cm x 40 cm         | 1a                 | 14.83a          | 17.39a            | 0.7833 b                    | 19.189 b            | 0.3839 b                      |

Note: Numbers are followed by the same letter in the same column showed not really different significantly effect at the Duncan Multiple Range Test (DMRT), α=0.05.

The result of Duncan’s Multiple Range Test (DMRT) showed that the combination of N, P, K + Topsoil ameliorant with a plant spacing of 30 cm x 80 cm gave the highest result not significantly different with a combination of block compost + Topsoil ameliorant with a plant spacing of 30 cm x 80 cm on leaves number. N, P, K + Topsoil ameliorant with a plant spacing of 30 cm x 80 cm gave the highest leaves number very significantly different with the combination of topsoil ameliorant with a plant spacing of 30 cm x 80 cm of maize in post tin mining land. The combination of N, P, K + Topsoil ameliorant with a plant spacing of 30 cm x 80 cm is significantly different from other treatment on cop diameter and dry seed weight (Table 6.) These results are similar to [21] showed that NPK fertilizer application with optimum plant spacing might have more efficient utilization of sunlight and performed perfectly assimilate translocation leading to a higher yield of seed.
Table 6. The result of the DMRT test at combination treatment of ameliorant application with plant spacing on leaves number, cop diameter, and dry seed weight of maize in post tin mining land.

| Plant spacing | Ameliorant | Leaves number | Cop diameter | Dry seed weight |
|---------------|------------|---------------|--------------|----------------|
|               | Topsoil    | N,P,K + Topsoil | Block compost +Topsoil |
| 30 cm x 80 cm | 3.58Ab     | 10.01Aa       | 9.33Aa       | 0.05Ab         |
| 50 cm x 60 cm | 3.29Ab     | 9.24ABa       | 9.00Aa       | 0.25Ac         |
| 70 cm x 40 cm | 4.10Ab     | 7.54Ba        | 7.10Aab      | 9.25Ab         |

Notes: Numbers are followed by the same letter in the same line or column showed not really different significantly effect at DMRT test, α=0.05. Uppercase notations are read vertically and lowercase letters are read horizontally.

4. Conclusion

N, P, K + Topsoil ameliorant was the best ameliorant to promote the growth and the yield of maize in post tin mining land, and the wider plant spacing is recommended for planting maize in marginal land.

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**Acknowledgment**

The authors are grateful for financial support from the Ministry of Research Technology and Higher Education, the Republic of Indonesia for Applied Research Grant 2019.