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RESEARCH ARTICLE

# Application of elicitors to reduce NPK fertilizer in Pakchong grass cultivation on post-tin mining land

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## Abstract

Elicitors in the form of a material made from a solution of grass plants. This study focuses on elicitors as an innovation that supports the reduction of chemical fertilizers. The low nutrient content and sandy soil texture of post-tin mining land can be optimized by cultivating Pakchong grass. This research aimed to determine the growth and yield of Pakchong grass by applying elicitors to reduce NPK fertilizer use. The research was carried out from March 2024 to August 2024. The research location was in Dwi Makmur Village Merawang District, Bangka Regency. This research used an experimental method with a randomized block design (RBD) consisting of 5 treatments and 6 blocks. The treatments were: elicitors alone (P1), elicitors + NPK 25 % (P2), elicitors + NPK 50 % (P3), elicitors + NPK 75 % (P4) and elicitors + NPK 100 % (P5). The research results showed that the provision of elicitors + NPK significantly affected plant height, number of tillers and yield per plot. Applying elicitors in Pakchong grass cultivation on post-tin mining land can reduce NPK use by 50 %. The elicitors from the research area contained phenolic secondary metabolites, which enable plants to absorb nutrients more effectively. The application of elicitors can reduce the metal Pb content in Pakchong grass on post-tin mining land.

**Keywords:** elicitors; NPK fertilizer reduction; Pb content; Pakchong grass; post-tin mining land

## Introduction

There are many post-tin mining lands in the Bangka Belitung Islands. Land damaged by mining requires reclamation and revegetation. As a result, many soils have become dominated by sand and have low nutrient content. Mining activities cause damage to land ecosystems (1). Post-tin mining land has a low pH due to high levels of Al and Fe and low nutrient content and toxic heavy metals (2). Tropical post-tin-mined acid soil (pH 5.34) is dominated by sand particles (88 %), with a very low cation exchange capacity, very low nutrient content (available and total-N, P, K, Ca, Mg) and high toxicities of Zn, Cu, B, Cd and Ti. Soil amendments such as organic paramagnetic humus and compost can improve soil quality by increasing pH, available- P and K and cation exchange capacity, while also maintaining low toxicity. The research shows that post-tin mining land has a sandy texture, with sand content of 66.11 %, clay 4.8 %, dust 29 % and the soil is slightly acidic. The organic matter post-tin mining soil is classified as very low and both the cation exchange rate and base saturation are also very low (4). The lack of nutrients limits optimal land use.

Revegetation by exotic fast-growing pioneer legume species *Pongamia. pinnata* and application of AMF significantly improved some chemical soil properties making them suitable for rehabilitation programs in tropical post-mining areas (3). Critical land such as post-tin mining land can be used as productive land through agricultural cultivation (5). Utilization of post-tin mining land with plant cultivation has been implemented, including the cultivation of sorghum, pineapple and mustard greens (1, 6, 7). However, these plant cultivation efforts have not yet been integrated with livestock. One integrated farming model that can be applied on post-tin mining land is the integration of crops with livestock.

One of the plants that can be cultivated on post-tin mining land is Pakchong grass (*Pennisetum purpureum* cv. Thailand). This plant has good adaptation because it can grow on critical land with minimal nutrients (8). Efforts to utilize post-tin mining land for agricultural purpose can be achieved by planting adaptive types of plants on critical land. Apart from being able to grow on critical land, Pakchong grass is also a plant that can provide animal feed and can grow in post-mining tailings media with the addition of organic materials (10).

Pakchong grass cultivated on post-tin mining land has low nutrient content. Increasing nutrients can be achieved by applying fertilizer. The factor needed to increase plant production and quality is the availability of nutrients through fertilization (11). Fertilization functions as a provider of macro and micronutrients needed by plants. Providing NPK fertilizer can meet the macronutrient needs of plants (12).

Providing NPK fertilizer on post-tin mining land will increase the use of chemical fertilizers. Chemical elicitors are a mitigation strategy for maximize crop yield under abiotic stress.

An alternative to reducing the use of chemical fertilizers is to provide organic materials. The plant growth and yield can be optimized by providing biosaccharide elicitors (13). Elicitors can help reduce the use of chemical fertilizers. Elicitors are components that provides signals capable of inducing secondary metabolite processes in plant tissue (14). Elicitors act as molecules that activate signal transduction and trigger the activation and expression of genes related to secondary metabolite biosynthesis. Elicitors cause physiological, morphological and phytoalexin accumulation responses (15).

This research aims to support the sustainable development goals (SDGs) program on food security by exploring and enhancing the potential of local resources. It applies adaptive, productive plant cultivation technology through sustainable post-tin mining land use integrated with livestock, aiming to improve the welfare and restore the socio-economic community in Bangka Belitung community. The novelty of the research includes the use of post-tin mining land through an integrated farming system for cultivating Pakchong grass. This study uses weeds around post-tin mining land as material for making elicitors to promote environmentally friendly agriculture. The objectives of the research were to determine the growth and production of Pakchong grass on post-tin mining land.

## Materials and Methods

The research was carried out from March 2024 to August 2024 at Kampoeng Reclamation, Karya Makmur Village, Merawang District, Bangka Regency. The mining locations had been inactive for 20 years. Analysis of the physical, chemical and Pb metal content of the tailings was done in the Soil Laboratory ICBB PT Biodiversitas Bioteknologi Indonesia, Bogor 2024. Analysis of secondary metabolites (Biosaka) and Pb content in plant tissue was done in the Central Laboratory Universitas Padjajaran, Bandung, 2024.

### Experimental design

This research used an experimental method with a randomized block design (RBD) with 5 treatments. The treatments consisted of elicitors and nitrogen (N), phosphorus (P) and potassium (K) fertilizer, namely: elicitors (P1), elicitors + NPK 25 % (P2), elicitors + NPK 50 % (P3), elicitors + NPK 75 % (P4) and elicitors + NPK 100 % (P5). Thus, there were 5 treatment combinations with 6 blocks, giving 30 experimental units.

The materials used were Pakchong grass seeds, elicitor solution, empty palm oil bunches compost and NPK 16:16:16 fertilizer. Treatment of 25 % NPK consisted of 5 g/plant, 50 % NPK of 10 g/plant, 75 % NPK of 15 g/plant and 100 % NPK of 20 g/plant. Fertilization was done by sprinkling fertilizer around the plants. NPK fertilizer was applied twice, namely 4 weeks after planting and 8 weeks after planting.

The land was cleared of weeds using a hoe, then plots measuring 2 m × 2 m were formed, with a distance between plots of 1 m between plots. The next activity was digging planting holes and adding 1000 g of empty palm oil bunches per planting hole (4).

### Preparation of planting

The methodology included land preparation, preparation of planting materials, planting, making elicitors, applying NPK fertilizer and elicitors, maintenance and harvesting.

Making Biosaka began with collecting healthy, fresh and non-slimy leaves from grasses such as babadotan (*Ageratum conyzoides* L.), patikan kebo (*Euphorbia hirta* L.), meniran (*Phyllanthus niruri* L.). One hundred grams of plant material were weighed and mix it with 1 L of water, then kneaded in a bucket for 15-20 min until the water turned green. The juice was strained, then placed in a bottle and close tightly. The solution is left for 7 days to assess Biosaka quality. Successful biosaka was characterized by the absence of sediment in the bottle, no change in color to clear, no foul odor and no gas upon opening the bottle cap. Biosaka application was done by diluting 60 mL of Biosaka into 15 L of water, which was stirred until mixed evenly. Biosaka was applied by spraying it using a hand sprayer. Spraying was done every 14 days until the plants are 3 months old. Biosaka was sprayed on plants at approximately 1 m from the plant.

### Observed parameters

The parameters observed were plant height, number of tillers, yield per plot, secondary metabolites of the Biosaka elicitor solution and heavy metal Pb content in Pakchong grass. The methods included land preparation, preparation of planting materials, planting, making Biosaka, applying NPK fertilizer and Biosaka elicitors, maintenance and harvesting. Biosaka acted as an elicitor component, providing signals capable of inducing secondary metabolite processes in plant tissue.

Plant height measurements were carried out using a meter. Measurements extended from the base of the stem to the tip of the longest leaf. Measurements were based on the 3 tallest Pakchong grass seedlings. Plant height measurements were carried out every 2 weeks until harvest. The number of tillers was calculated by counting the shoots that grew on each cutting seed used. The number of tillers was recorded every 2 weeks until harvest. Pakchong grass harvesting was conducted when the plants were 3 months after planting (MAP). Harvesting was done by cutting at the base of the plant using a machete.

The results for plant height, number of tillers and yield per plot were analyzed using the F test with a confidence level of 95 %. If treatments showed significant effects, a further analysis was conducted using the Duncan's multiple range test (DMRT) with a confidence level of 95 % using DSAASTAT ver.1.021.

## Results and Discussion

### Conditions post-tin mining lands

The results of soil analysis showed that the soil at the research location had a sandy texture, with 96 % sand, 2 % silt and 2 % clay (Table 1). The soil was acidic with a pH of 6.8. The levels of organic matter contained in the soil were organic carbon 0.14 % and total nitrogen 0.02 %. Heavy metal levels in the soil were less than 8 mg/kg, with very low soil cation exchange rates and base saturation.

Post-mining land conditions in the research area were dominated by up to 96 % sand, 2 % silt, 2 % clay and had an acidic pH. The organic matter content was low and the cation exchange capacity was also low. Tin tailings were very porous, coarse in texture (sand), with low water-holding capacity and very low cation exchange capacity (CEC). The soil texture and low soil fertility were considered as the limiting factors for achieving optimum crop production. The levels of organic C, nutrients N, P,

**Table 1.** Results of analysis the physical and chemical properties of soil on former tin mining land

| Variable | Value | Criteria* |
|---|---|---|
| Texture: | | |
| Sand (%) | 96 | |
| Silt (%) | 2 | Sand |
| Clay (%) | 2 | |
| pH $H_2O$ | 6.8 | Acid |
| pH KCl | 4.5 | Acid |
| Organic C (%) | 0.14 | very low |
| Total N (%) | 0.02 | very low |
| Available $P_2O_5$ (mg/kg) | 3.60 | very low |
| Available $K_2O$ (mg/kg) | 2.93 | very low |
| Cation exchange capacity (cmol (+)/Kg) | 1.83 | very low |
| Pb (mg/Kg) | < 8.00 | Normal limits |

***** Laboratory ICBB PT Biodiversitas Bioteknologi Indonesia, Bogor 2024.

K and base saturation were very low and the iron levels were quite high, which had the potential to poison plants (9).

Post-tin mining land dominated by sand fractions caused high permeability and low water retention, so it required extra (16). Organic matter and pH were important for soil quality because they affected the soil's ability to bind and provide nutrients and water for plants (17). Good soil quality maintained and increased plant growth and yield and prevented degradation. The materials used in this research were empty palm oil bunches composted organically. Oil palm frond compost as an organic fertilizer could also improve soil physical properties, such as increasing water and nutrient absorption and improve soil chemical properties so that nutrient availability increased for both macronutrients and micronutrients (18).

## Pb content in Pakchong grass

The results of the analysis of the heavy metal lead (Pb) content in pakchong grass (*P. purpureum)* are presented in Table 2. The elicitors (Biosaka) treatment (P1) had a Pb content of 0.9121 mg/kg. The elicitors + NPK 25 % (P2) treatment had a Pb content of 0.8874 mg/kg. The elicitors + NPK 50 % (P3) treatment had a Pb content of 0.6998 mg/kg. The elicitors + NPK 75 % (P4) treatment had a Pb content of 0.7248 mg/kg. The elicitors + NPK 100 % (P5) treatment had a Pb content of 0.3875 mg/kg. Based on SNI 3148.1 of 2019, the quality requirements for concentrate feed for lactating dairy cows indicate that the Pb content meets SNI quality standards. The Pb content in Pakchong grass plants was at the limit and is safe for consumption by livestock. This is thought to be due to the greater efficiency of Pb uptake in *S. spontaneum* as compared to the increase in absorption efficiency in *P. purpureum* and *H. acutigluma* (10). Pb in post-tin mining land in Bangka was still relatively low and safe for planting because the uptake of Pb levels into grass and tuber plants was still at the limit (19).

**Table 2.** Pb metal content in Pakchong grass plants in tin-mining land

| Treatments | Pb content (mg/Kg) | Criteria* |
|---|---|---|
| Elicitors (P1) | 0.9121 | Low |
| Elicitors + NPK 25 % (P2) | 0.8874 | Low |
| Elicitors + NPK 50 % (P3) | 0.6998 | Low |
| Elicitors + NPK 75 % (P4) | 0.7249 | Low |
| Elicitors + NPK 100 % (P5) | 0.3875 | Low |

Results of analysis in the Labor Central University of Padjadjaran Bandung, 2024.

Research on post-tin mining land showed levels of the heavy metal Pb below 8 mg/Kg. The use of elicitors can reduce NPK fertilizer on pakchong grass on post-tin mining land resulted in Pb metal levels in the range of 0.3875-0.9121 mg/kg, which were within normal limits. Post-tin mining land in the Bangka Belitung Islands had moderate to low heavy metal content and thus can be used as productive land such as agricultural land. The low level of Pb metal absorbed by plants was caused by Pb being broken down by microorganisms in the soil, which was strengthened by substances released by the roots (exudates), namely sugars, alcohols and acids. This exudate is food for microorganisms that break down pollutants and other soil biota. This factor made plants act as metal excluders.

## Plant growth response

The results of the analysis of the differences in growth and yield of Pakchong grass with the application of biosaka showed that there were very significant differences. The elicitors + NPK fertilizer were significantly different among treatments for the observed parameters of plant height, number of tillers and yield per plot (Table 3). The elicitors have a significant influence on the productivity of Pakchong grass on post-tin mining land. The elicitors showed are high levels of secondary metabolites such as phenolics, tannins and saponins.

**Table 3.**The results of the analysis in growth and yield of Pakchong grass on post tin-mining land

| Variable | F count | Probability | CV (%) |
|---|---|---|---|
| Plant height (cm) | 17.95 | 0.0001** | 5,14 |
| Number of tillers | 24.22 | 0.0001** | 9,29 |
| Yield per plot (Kg) | 25.41 | 0.0001** | 12,19 |

****** = very significant at the 0.01 level. **CV**= coefficient of variation (%)

The DMRT further test results showed that the best treatment was the application of elicitors + 50 % NPK (Table 4). The highest mean variables were plant height, number of tillers and yield per plot. Elicitors treatment (P1) showed the lowest average results from treatments P2, P3, P4 and P5. Elicitors treatment without NPK fertilizer has not been able to meet the nutrients needed by Pakchong grass on post-tin mining land.

**Table 4.** DMRT test results of application of elicitors and NPK fertilizer to Pakchong grass on post-tin mining land

| Treatments | Parameter | | |
|---|---|---|---|
| | Plant height (cm) | Number of tillers | Yield per plot (kg) |
| Elicitors (P1) | 197.12d | 5.29b | 6.47c |
| Elicitors + NPK 25 % (P2) | 232.00b | 8.33a | 12.02b |
| Elicitors + NPK 50 % (P3) | 247.41a | 9.08a | 13.97a |
| Elicitors + NPK 75 % (P4) | 208.42cd | 8.17a | 11.30b |
| Elicitors + NPK 100 % (P5) | 221.23bc | 8.20a | 11.87b |

The numbers followed by the same letter in the same column show no significant difference at the 5 % level.

The combination treatment of elicitors + 50 % NPK fertilizer dose gave higher results compared to other treatments. This result suggests that biosaka combined with 50 % NPK fertilizer provides the best outcome. The combining NPK fertilizer with elicitors means that the availability of the nutrients provided can be utilized optimally and efficiently (23). The combination of elicitors and NPK fertilizer influences the vegetative and generative growth of plants (24). The application of Biosaka plays a role in the process of forming secondary metabolites in which plant cells play an active role in absorbing and searching for nutrients (25). Application of elicitors + a 50 % dose of NPK fertilizer can increase the growth of Pakchong grass, so that the NPK is 50 % is sufficient for the growth and yield of Pakchong grass. Elicitors contain chemical compounds that can stimulate physiological and morphological responses, as well as trigger the accumulation of phytoalexins and increase the activation and expression of genes related to the biosynthesis of secondary metabolites, elicitors can also induce resistance in plants (26).

Plants cannot absorb nutrients optimally due to the poor conditions of post-tin mining land, which has low nutrient availability. The application of inorganic fertilizer, such as NPK, can increase nutrient availability in post-tin mining land. The application of Biosaka containing elicitors enables plants to absorb nutrients more effectively. This is because elicitors send signals that induce the production of hormones, enzymes and enhance plant cell regeneration. These effects allow plants to grow and develop harmoniously within an ecosystem alongside other organisms (27).

As a result, elicitors help plants that grow on post-tin mining land adapt more easily. Elicitors indirectly play a role in the rehabilitation of post-tin mining land, as plants applied with elicitors can produce secondary metabolites that have function in plant defense and make plants become more adaptive. Plants that can grow adaptively can gradually improve the ecosystem in post-tin mining land and then aid the rehabilitation of post-tin mining land.

### Secondary metabolic biosaka (elicitors)

The laboratory elicitor (Biosaka) solution test results contained phenolic secondary metabolites, tannins, flavonoids, saponins and triterpenoids. Table 5 shows that there are high levels of secondary metabolites such as phenolics, tannins and saponins. Flavonoids, triterpenoids and steroids were at low levels, while the secondary metabolites of alkaloids were not found in the Biosaka solution. Sources of materials used in making elicitors (Biosaka) were taken from post-tin mining land include Babandotan, Patikan Kebo and Meniran. The results showed a positive test for flavonoid, saponin, alkaloid and tannins in all five-leaf samples and a positive triterpenoid test on all grass (11).

**Table 5.** Result analysis secondary metabolic elicitors content

| Secondary metabolites | Test methods | Results (criteria)* |
|---|---|---|
| Fenolik | Reagent $FeCl_3$ 5 % | +++ (lots) |
| Tanin | Reagent FeCl 1 % | +++ (lots) |
| | Reagent HCl + Mg | + (a little) |
| Flavonoid | Reagent $H_2SO_4$ | - (not) |
| | Reagent NaOH 10 % | + (a little) |
| Saponin | Heated | +++ (lots) |
| Triterpenoid | Reagent $H_2SO_4$ + $CH_3COOH$ anhydrite | + (a little) |
| Steroid | Reagent $H_2SO_4$ + $CH_3COOH$ anhydrite | (not) |
| Alkaloid | Reagent Dragendorff | (not) |

*Results of analysis in the Labor Central University of Padjadjaran Jatinangor, 2024.

Elicitors that play a role in secondary metabolites increase plant resistance systems. The elicitor is thought to function by stimulating the plant produces a response and the plant can actively absorb the existing nutrients. Elicitors are also able to protect plants from pests and diseases, allowing plants to maintain health and vigor. The reaction to administering Biosaka elicitors can manifest as increased growth, increased resistance to pests and diseases or accumulation of secondary metabolites. An application of bio-fertilizer may reduce the use of inorganic fertilizer and therefore promote sustainable banana production (28).

This elicitor can increase crop production and quality. Providing elicitors in combination with a 50 % NPK dose can increase plant growth and yield. It is thought that the resistance system produced by plant secondary metabolites allows plants to remain healthy and capable of producing good-quality yield. Providing elicitors and NPK fertilizer to Pakchong grass can optimize the growth and yield of plants on post-tin mining land. Providing elicitors to Pakchong grass on post-tin mining land can reduce NPK use by 50 %. It was possible to reduce the use of inorganic fertilizer to 50 % if compensated with the application of the liquid organic bio-fertilizer (28).

## Conclusion

The application of elicitors significantly reduces the need for NPK fertilizers on post-tin mining land, affecting key parameters such as plant height, number of tillers and yield of Pakchong grass. The application of elicitors with 50 % NPK provided the best growth and yield in Pakchong grass. The application of elicitors also reduced the metal Pb content in Pakchong grass on post-tin mining land.

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## Authors' contributions

TL conducted the research design, outlined the overall study, general coordination and coresponding to the editor. AP performed the field treatment of the research, data collection and drafted the manuscript. DP performed the statistical analysis and reviews. MA performed the manuscript aligment with research design. All authors read and approved the final manuscript.

## Compliance with ethical standards

**Conflict of interest:** Authors do not have any conflict of interest to declare.

**Ethical issues:** None

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