Replacement of KCl with organic fertilizer on cultivation of porang (*Amorphophallus muelleri* Blume) under sonokeling stands

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**Abstract.** KCl fertilization is generally done to increase the productivity of porang tubers, but the continuous use of KCl can degrade soil fertility. Based on this, KCl needs to be replaced with organic fertilizer. This research aimed to determine the effect and replacement of KCl with organic fertilizer which caused the highest porang yield. The research was held in the BKPH Pojok forest area, Grobogan, Central Java in March-July 2020. The research was using one-factor RCBD. This treatment was the replacement of KCl with organic fertilizer with percentage 100:0%, 75:25%, 50:50%, 25:75%, 0:100%, and control in 4 replications. Observation parameters included tuber fresh weight, tuber storage weight, tuber diameter, tuber thickness, and tuber chip weight. The data were processed by using ANOVA 5% and DMRT 5%. The results showed that KCl had a strong influence on the yield of porang which included tuber fresh weight, tuber storage weight, and tuber chip weight, and organic fertilizer was able to replace the role of KCl. The usage of KCl and organic fertilizer was selected based on the yield of the highest tuber diameter and thickness and appeared with the same percentage (50% KCl:50% organic fertilizer).

1. **Introduction**

Porang (*Amorphophallus muelleri* Blume) is a tuber-producing plant that grows well under the shade [1]. This makes porang generally planted under forest stands such as sonokeling (*Dalbergia latifolia*) because the stand serves as a shade to reduce the intensity of light received by plants. Porang tubers contain starch, protein, fiber, fat, oxalic acid, and glucomannan [2]. The Glucomannan compounds are commonly used as raw materials in the pharmacy, food, and cosmetic industries. This makes the demand for porang exports in the form of chips to various countries such as Japan, China, Korea, Australia, Sri Lanka, Italy, and Malaysia to be high reaching 10,000 tons per year [3].

Intensification of porang cultivation activities needs to be done to meet export needs, one of which is through fertilization. Fertilization activities in porang cultivation generally use inorganic fertilizers, such as KCl. K element content in KCl has an important role in the process of formation and translocation of carbohydrates [4]. However, the continuous use of KCl has the potential to decrease soil fertility, including causing the soil to become hard, lowering the soil's ability to store water, and converting soil pH into acid [5].
Based on that, the use of KCl needs to be replaced with organic fertilizer. One type of organic fertilizer that can be used as a substitute for KCl is cow manure. This study aimed to obtain the influence and replacement of KCl with organic fertilizer that causes the highest porang yield.

2. Materials and methods
The research was held during March-July 2020 in the forest area of BKPH Pojok, Kemadohbatur Village, Tawangharjo District, Grobogan Regency with slope of the land about 8-15°. Tools and materials needed in this study include rulers, meters, thermohygrometers, lux meters, scales, knives, KCl, organic fertilizer, marker, name tag and porang plants. This study used a one factor Randomized Complete Block Design (RCBD). This treatment was the replacement of KCl with organic fertilizer with percentage. Treatment consists of 6 levels with each level repeated 4 times. The level of treatment in this study is as follows:
P1 = 100% KCl
P2 = 75% KCl : 25% organic fertilizer
P3 = 50% KCl : 50% organic fertilizer
P4 = 25% KCl : 75% organic fertilizer
P5 = 100% organic fertilizer
P6 = Control

The implementation of the research began with the determination of crop blocks, then continued with the selection of porang plant samples that are still active on growth period, green and upright to be marked using name tag and marker. The next activity was the application of KCl and organic fertilizer following the dose of each treatment level. Every month after the application of the treatment, it followed with agroclimatic and growth observation of porang plants that include plant height, stem circumference, and leaf length. The porang plants are then harvested to observe the parameters of yield that include tuber fresh weight, tuber storage weight, tuber diameter, tuber thickness, and tuber chip weight. Data from the observations are processed with an ANOVA level of 5% and DMRT level of 5%.

3. Result and discussion
3.1. General conditions
The research location is an area with litosol soil types. Litosol soil has physical, chemical, and biological properties that are not good enough for plant growth because it is a relatively young type of soil with a rough texture [6]. This is in accordance with the results of the initial soil analysis of the research location (Table 1).

| Parameter       | Result     | Description |
|-----------------|------------|-------------|
| Total N         | 0.19 %     | Low         |
| Available P     | 7.73 ppm   | Medium      |
| Exchangeable K  | 0.23 me %  | Low         |
| Organic C       | 1.69 %     | Low         |
| Organic matter  | 2.91 %     | Medium      |
| Water content   | 7.12 %     | Low         |
| pH              | 5.67       | Slightly acidic |
| C/N ratio       | 8.89       | Low         |
| Porosity        | 45.11 %    | Medium      |

Source: Analysis result of Chemical Laboratory and Soil Fertility Faculty of Agriculture UNS 2020

Climate conditions at the research location were suitable for the growth of porang. Rainfall in the last ten years has averaged 180 mm/month, which is included in the middle category. Average temperatures ranged from 25.3°-29.9°C in 2017-2020. This temperature is suitable for the growth of porang which needs a temperature about 22°-30°C [7]. Average relative humidity ranged from 67-88%
on 2017-2020. Average light intensity ranged from 35.68-45.48%. The condition of light intensity is suitable for the porang growth which needs shade around 40-60% [8].

This research used a KCl Kujang brand with K2O content of 60%. KCl has a solid granule shape with a reddish white color. Organic fertilizer used in this research was a manure cow that had decomposed with the brand of Rojokoyo. The content in organic fertilizer (Table 2) is presented as follow:

**Table 2.** Rojokoyo organic fertilizer content.

| Parameter      | Content  |
|----------------|----------|
| N              | 1.58%    |
| P              | 1.48%    |
| K              | 1.33%    |
| Organic C      | 22.43%   |
| Organic matter | 38.66%   |
| Cu             | 2.14%    |
| Mg             | 1.26%    |
| C/N            | 14.20%   |
| pH             | 7.12     |

Source: Packaging of organic fertilizer

3.2. Observation of porang growth

There is no obtained growth plant data in this research (plant height, stem circumference, and leaf length) after the replacement of KCl with organic fertilizer. This is because most porang plants had falls which were characterized by dry leaves and stems. Porang fell because of the excessively high temperature at the research location, especially the average temperature in March which reached 34.8°C. This temperature causes the leaves of plants to burn [7]. The burned-off leaves will inhibit the process of photosynthesis, so the vegetation of porang plants becomes falls. Porang fell because the plant has entered the dormant phase. Porang plants in their life cycle will enter a dormant phase during the dry season, this condition is characterized by the fall of plant vegetation. At the end of the rainy season, porang tubers that are in the soil will be formed and enlarged because the assimilation of the leaves will begin to be translocated into tubers as the leaves and stems dry up.

3.3. Observation of porang yield

Observation of porang yield was carried out on porang tubers that have been harvested when the plant was 3 years old. The observation parameters of porang yield included the tuber fresh weight, tuber storage weight, tuber diameter, tuber thickness, and tuber chip weight. The results of observation are presented in the following table:

**Table 3.** Parameters of porang yield on various replacement of KCl with organic fertilizer

| Replacement of KCl fertilizer with organic fertilizer | Tuber fresh weight per hectare (ton)* | Tuber storage weight per hectare (ton)* | Tuber diameter (cm)* | Tuber thickness (cm)* | Tuber chip weight per hectare (ton)* |
|-------------------------------------------------------|---------------------------------------|----------------------------------------|----------------------|----------------------|--------------------------------------|
| 100% KCl                                              | 13.90<sup>ab</sup>                    | 13.50<sup>ab</sup>                     | 15.89<sup>ab</sup>   | 8.03<sup>a</sup>      | 3.10<sup>ab</sup>                    |
| 75% KCl: 25% organic fertilizer                       | 17.40<sup>b</sup>                    | 16.90<sup>b</sup>                     | 17.29<sup>b</sup>   | 9.06<sup>b,c</sup>   | 3.80<sup>b</sup>                    |
| 50% KCl: 50% organic fertilizer                       | 17.30<sup>b</sup>                    | 16.30<sup>b</sup>                     | 17.70<sup>b</sup>   | 9.30<sup>c</sup>      | 3.60<sup>b</sup>                    |
| 25% KCl: 75% organic fertilizer                       | 13.00<sup>ab</sup>                    | 12.50<sup>ab</sup>                     | 15.69<sup>ab</sup>   | 7.75<sup>a</sup>      | 2.70<sup>ab</sup>                    |
| 100% organic fertilizer                               | 11.00<sup>a</sup>                    | 10.60<sup>a</sup>                     | 13.95<sup>a</sup>   | 7.45<sup>a</sup>      | 2.20<sup>a</sup>                    |
| Control                                               | 9.30<sup>a</sup>                     | 9.00<sup>a</sup>                      | 13.71<sup>a</sup>   | 7.06<sup>a</sup>      | 1.90<sup>a</sup>                    |

Description: *The numbers in the column followed by the same letter show no real difference in the DMRT test level of 5%
3.3.1. Tuber fresh weight. The results of ANOVA 5% show that KCl replacement with organic fertilizer has a significant effect on the tuber fresh weight. The treatment of 75% KCl:25% organic fertilizer produces the highest tuber fresh weight, which is 17.40 ton/ha (Table 3). Based on the DMRT test of level 5% the result is significantly different from the tuber fresh weight produced on the treatment of 100% organic fertilizer and control, but not significantly different from the tuber fresh weight produced on the treatment of 100% KCl, 50% KCl:50% organic fertilizer, and 25% KCl:75% organic fertilizer.

Partial replacement of KCl with organic fertilizer can increase the tuber's fresh weight. This is evidenced by the tuber fresh weight on the treatment of 75% KCl:25% organic fertilizer and 50% KCl:50% organic fertilizer which were higher than the tuber fresh weight on the treatment of 100% KCl. This increase was due to the input of organic matter from organic fertilizer which was applied to replace part of the KCl dose. The organic matter content of organic fertilizer can improve the physical, chemical, and biological properties of soil [9]. Such conditions can improve the soil ability in providing nutrients for plants because the availability of organic matter will increase the soil cation exchange capacity that serves to release nutrients for plants.

The high result of tuber fresh weight on the treatment of 75% KCl 25% organic fertilizer and 50% KCl:50% organic fertilizer shows that the KCl partial replacement with organic fertilizer is able to increase the efficiency of nutrient absorption, especially potassium from fertilizer by plants. The application of organic fertilizers can not replace the overall use of inorganic fertilizers but can increase the efficiency of nutrient absorption from inorganic fertilizers [10]. The condition makes the availability and absorption of potassium elements by porang plants run optimally. The availability of potassium element plays a role in determining the tuber's fresh weight because it is involved in the translocation activity of photosynthate (water and carbohydrates) to the tuber [11].

3.3.2. Tuber storage weight. The results of ANOVA 5% show that the replacement of KCl with organic fertilizer has a significant effect on the tuber storage weight. The treatment of 75% KCl:25% organic fertilizer produces the highest tuber storage weight, which is 16.90 ton/ha (Table 3). Based on DMRT test level 5% this result is significantly different from the tuber storage weight on the treatment of 100% organic fertilizer and control, but not significantly different from the tuber storage weight on the treatment of 100% KCl, 50% KCl:50% organic fertilizer, and 25% KCl:75% organic fertilizer. The results showed that the replacement of 100% KCl with organic fertilizer has not been able to produce the highest tuber storage weight, but the partial replacement of KCl with organic fertilizer is able to increase the tuber storage weight more than the use of 100% KCl fertilizer.

The treatment of 75% KCl:25% organic fertilizer and 50% KCl:50% organic fertilizer produces a high tuber storage weight because potassium elements are available enough to support the optimal process of tuber formation and enlargement. The availability of sufficient potassium elements in the tuber-producing plant will increase the weight of the tuber yield [12]. This is in accordance with the fact that potassium has an important role in the translocation activity of photosynthate derived from leaves to photosynthesis storage organs such as tubers [13].

The increase of tuber storage weight is also due to organic fertilizer that acts as a partial replacement dose of KCl and is able to improve soil fertility. The increase in soil fertility is caused by the content of organic matter, macro, and micronutrients contained in organic fertilizers. The addition of organic matter can improve soil fertility because it is able to increase the activity of soil microorganisms in decomposition nutrients to be available to plants [14]. Fertile soil conditions allow plants to grow optimally, especially roots and leaves so that the formation and enlargement of tubers run optimally. The activity of tuber formation is influenced by the condition of growth and development of leaves as an assimilate producing organ (source) [15].

3.3.3. Tuber diameter. The results of ANOVA level 5% showed that the KCl replacement with an organic fertilizer in porang cultivation under sonokeling stand has a significant effect on the tuber diameter. The treatment of 50% KCl:50% organic fertilizer produces the highest tuber diameter, which is 17.70 cm (Table 3). Based on DMRT test level 5% the result is significantly different from the tuber
diameter produced on the treatment of 100% organic fertilizer and control, but not significantly different from the tuber diameter produced on the treatment of 100% KCl, 75% KCl:25% organic fertilizer, and 25% KCl:75% organic fertilizer. The replacement of 100% KCl with organic fertilizer has not been able to produce the highest tuber diameter. This can be seen from the low tuber diameter produced on the treatment of 100% organic fertilizer which is 13.95 cm.

Partial replacement of KCl with organic fertilizer is able to increase the tuber diameter. This is evidenced by the tuber diameter on the treatment of 75% KCl:25% organic fertilizer and 50% KCl:50% organic fertilizer are higher than the tuber diameter on the treatment of 100% KCl. The increase was due to this replacement dose being able to meet the needs of nutrient, water, and growing space conditions that optimally for tuber enlargement. The process of tuber enlargement is strongly influenced by the availability of nutrients, water, and the condition of the tuber growing space [16].

On the treatment of 50% KCl:50% organic fertilizer is available as an optimal growing space for the process of tuber formation and enlargement. The availability of the growing space is due to the loose soil structure. Changes in soil structure become loose due to the content of organic matter in organic fertilizers that are a source of energy for soil microorganisms. This condition makes the activity of soil microorganisms increase so as to change the aggregate structure of the soil into loose. Soil with a loose structure is able to increase the tuber diameter because in these conditions there is an optimal growing space for tuber enlargement [17]. Enlargement of tubers is closely related to the activity of division and enlargement of cells [18]. Such activities can run optimally if there is enough space for cell division and enlargement.

3.3.4 Tuber thickness. The results of ANOVA level 5% show that the KCl replacement with organic fertilizer has a very significant effect on the tuber thickness. The treatment of 50% KCl:50% organic fertilizer produces the highest tuber thickness of 9.30 cm (Table 3). Based on DMRT test level 5% the result is significantly different from the tuber thickness on the treatment of 100% KCl, 25% KCl:75% organic fertilizer, 100% organic fertilizer, and control, but not significantly different from the tuber thickness on the treatment of 75% KCl:25% organic fertilizer. This shows that a replacement dose of 75% KCl:25% organic fertilizer and 50% KCl:50% organic fertilizer can increase the tuber thickness as evidenced by the tuber thickness in this treatment is higher than the treatment of 100% KCl.

The replacement dose of 50% KCl:50% organic fertilizer can produce the highest tuber thickness because the dose can improve the physical properties of the soil that can support the process of formation and enlargement of tubers optimally. The structure and aggregate of the soil turned loose due to the addition of organic matter into the soil [19]. The loose soil condition makes the tuber enlargement activity run optimally because in those conditions it makes it easier for plant roots to absorb nutrients and water [20].

On the treatment of 50% KCl:50% organic fertilizer is available enough potassium elements for porang plants to perform the optimal process of tuber formation and enlargement. The availability of potassium that is able to meet the needs of plants can optimize the process of tuber formation because potassium plays a role in the transportation of photosynthate and activation of starch-forming enzymes [21]. Optimally running tuber formation and enlargement activities are characterized by an increase in the size of tubers including length, thickness, and diameter [22].

3.3.5 Tuber chip weight. The results of ANOVA level 5% show that the KCl replacement with organic fertilizer has a significant effect on the tuber chip weight. The treatment of 75% KCl:25% organic fertilizer produces the highest tuber chip weight at 3.80 ton/ha (Table 3). Based on DMRT test level 5% the result is significantly different from the tuber chip weight produced on the treatment of 100% organic fertilizer and control, but not significantly different from the tuber chip weight produced on the treatment of 100% KCl, 50% KCl:50% organic fertilizer, and 25% KCl:75% organic fertilizer.

Partial replacement of KCl with organic fertilizer is able to increase the tuber chip weight. This is evidenced by the tuber chip weight on the treatment of 75% KCl:25% organic fertilizer and 50% KCl:50% organic fertilizer is higher than the tuber chip weight on the treatment of 100% KCl. The
increase of tuber chip weight on the treatment because there is potassium element that can meet the needs of porang plants. Sufficient potassium elements in porang plants due to the application of organic fertilizer as a KCl partial replacement is able to increase the efficiency of nutrient absorption, especially potassium. The application of organic fertilizer combined with inorganic fertilizers can improve fertilization efficiency [23]. Adequate need for potassium elements in porang plants will optimize the activity of tuber formation and enlargement because the element plays a role in the process of starch synthesis [24]. The availability of sufficient potassium elements will support the translocation activity of assimilation from the assimilate-producing organs (leaves) to the assimilate storage organs (tubers) [25].

4. Conclusion
Based on the results and discussion can be concluded that KCl gives a strong effect on the yield of porang which includes the tuber fresh weight, tuber storage weight, as well as tuber chip weight and organic fertilizer is able to replace the role of KCl. The usage of KCl and organic fertilizer was selected based on the yield of the highest tuber diameter and thickness and appeared with the same percentage (50% KCl:50% organic fertilizer).

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