Substitution of ZA with organic fertilizer on the cultivation of porang (Amorphophallus muelleri Blume).

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Abstract. Climate change causing problems for many cultivated crops. Porang (Amorphophallus muelleri Blume) requires specific environmental and climatic conditions to grow optimally. Fertilization is one of the efforts to increase the yield of porang in the midst of unpredictable climate change. This study aims to determine the effect of substitution (inorganic with organic fertilizer) on porang cultivation to get the right fertilizer dosage to recommend to farmers. This research was held on March - July 2020 in BKPH Pojok agricultural land, Purwodadi, Central Java which has an average elevation 498.7 m asl and a normal temperature range between 26°-28.5°Celcius. This research was using Randomized Completely Block Design (RCBD) one factor - dosage comparison of ZA and organic fertilizer consist of: 100:0%, 75:25%, 50:50%, 25:75%, 0:100%, and 0:0% in four replications. The highest yield was obtained by treating 100% ZA fertilizer (increasing yield of 86.79% with a total yield of 19.8 tons/ha). Substitution of 75% ZA fertilizer with 25% organic fertilizer and 100% organic fertilizer gave no significant difference effect (increasing yield of 32.08% - 37.73% with total yield of 14 - 14.6 tons/ha).

1. Introduction
Porang (Amorphophallus muelleri Blume) is one of the Indonesian export commodities with high economic value cause its tuber can produce glucomannan which can be used in industry as a component of food production and pharmacy [1]. The record of porang production from Porang Indonesia Research and Development Center [2], this time porang production in Indonesia is about 10 tons/ha while industrial demand reaches 3.400 tons/year. The long life span of plants and low production in Indonesia is the weakness factors for porang as an export commodity so that various efforts to increase production are needed.

For optimal growth, porang is very selective towards climate and environment, therefore optimal climatic and environmental conditions are the most important part of porang cultivation and become one of the challenges for extensification. Porang grows in the lowlands to 1000m asl with temperatures between 25-35°C, an average rainfall per month from 300-500 mm on vegetative period or 1.000-1.500 mm/year evenly distributed throughout the year. When the temperature is above 35°C, plant leaves will burn while the low temperature will cause plant dormancy [3]. Warm and humid conditions are necessary for leaf growth, while dry conditions are necessary for tuber development. Porang grows well in soil with a pH of 6-7 (neutral) [4]. Porang needs shade trees on planting that blocking sunlight between 50-60% [5] so that it is better cultivated in an agroforestry system under forest plant stands such as Dalbergia latifolia (sonokeling/Indonesian Rosewood), Tectonsa grandis (jati/teak trees), or Swietenia...
mahagoni (mahogany trees). According to Sulistiyo et al. [6], the growth and yields of porang are better if planted in forests than in the fields. Porang cultivation on agroforestry system with fertilization can be used for maintaining land fertility and productivity in the long term [7]. Therefore, climate change and agricultural environmental conditions become the most influential factor on porang cultivation.

The research was carried out in BKPH Pojok, Purwodadi, Indonesia during the long dry season due to climate change. Fertilization is the most possible effort to increase porang yields in the midst of unpredictable climate change and extensification problems. Nitrogen is the most limiting plant nutrient in many agricultural lands of the world [8]. N fertilizers such as Urea and ZA have been used in plant cultivation as a source of N. ZA (Zwavezlure ammonia) was chosen because it is slightly hygroscopic and non-volatile, providing N and also S for the plants. Sulfur in tubers serves to improve tuber quality, such as size, color, aroma, and taste. Sulfur in plants can suppress excessive nitrate, so the negative effects of nitrate fertilization can be prevented, therefore the use of ZA fertilizer is more recommended than urea.

Plant cultivation goals are optimal and sustainable yields. Fertilization is an activity that must be present in every plant cultivation activity. Inorganic fertilizers are known to have adverse impacts on the environment as well as long-term soil health and productivity. The research result of [9], showed that the large and continuous application of chemical nitrogen (N) fertilizers has shown a detrimental effect on groundwater quality, especially its nitrate content which is harmful to health and adversely affects the environment through the emission of NH3 and NOx gases. Organic agriculture is the ‘spearhead’ of sustainable agriculture where one of the elements is the use of organic fertilizers in crop cultivation. Therefore, the use of organic fertilizers both in total and in substitution needs to be studied as an effort to increase plant and soil productivity sustainably. So the purpose of this research is to determine the effect of substitution (inorganic with organic fertilizer) on porang cultivation to get the right fertilizer dosage to recommend to farmers.

2. Materials and method
The research was carried out in BKPH Pojok agricultural land, Guwo, Kemadohbatur village, Tawangharjo, Purwodadi, Central Java on March - July 2020. This research area located at -6°58'18.0"S 111°03'07.0"E, an average elevation of 498.7m asl and normal temperature range between 26°- 28.5°Celsius. This research was using Randomized Completely Block Design (RCBD) one factor (dosage comparison of ZA and organic fertilizer) with six treatment: P1 (100% of ZA); P2 (75% ZA : 25% organic fertilizer); P3 (50% ZA : 50% organic fertilizer); P4 (25% ZA : 75% organic fertilizer); P5 (100% of organic fertilizer); dan P6 (no fertilizer) on 4 replication.

Observation parameters include plant growth and agro-climatic condition (observed every month), also production results include fresh tuber weight, storage weight and weight of dry tuber chips. Data analysis used analysis of variance at 5% level and continued with the 5% DMRT test. Soil chemical analysis was carried out in the Soil Chemistry Laboratory, Faculty of Agriculture, Sebelas Maret University, Surakarta.

3. Result and discussion
3.1 Soil analysis result
BKPH Pojok forest area is an Indonesian Rosewood (Dalbergia latifolia) planting area that constitutes dry land, lithosol soil type. Lithosol soil has a variety of textures and is commonly found in mountain slopes and mountains throughout Indonesia comes from hard rocks and has a low nutrient content. The lithosol soil in the research location has a crumb structure (topsoil) and slightly lumpy (subsoil) with a clay texture.

Soil chemical analysis result (table 1) showed that the soils on Perum Perhutani BKPH Pojok areas have several nutrient contents with low grade including macro essential nutrient. According to Munir [11], lithosol soil generally contains sufficient P and K elements that are still fresh and cannot be absorbed by plants and often deficient N. The low N element in lithosol due to the weathering process
and land development has not been going for a long time. Lithosol soil also contains a small number of secondary minerals. According to Foth [12], this because there is no horizon-forming profiles differentiation and low decomposition process on lithosol soil. C-organic content, C/N ratio, and water content are low in the soil on the study site could make the slower organic matter decomposition process, even the land tightly covered by fallen shade-plant leaves, the soil organic matter was low. Increasing C-organic can be done by fertilization using organic and biological fertilizer, so that the decomposition of organic matter runs faster and able to increase the organic matter content and nutrients in the soil.

**Table 1.** Soil characteristics in the area of Perum Perhutani BKPH Pojok, Kemadohbatur Village, Tawangharjo District, Grobogan Regency.

| No | Soil Parameters       | Resulta | Gradeb |
|----|-----------------------|---------|--------|
| 1  | Nitrogen              | 0.19 %  | Low    |
| 2  | Available Phosphorus  | 7.73 ppm| Medium |
| 3  | Potassiam             | 0.23 me %| Low    |
| 4  | C-Organic             | 1.69 %  | Low    |
| 5  | Organic matter        | 2.91 %  | Medium |
| 6  | Water content         | 7.12 %  | Low    |
| 7  | Ph                    | 5.67    | Rather acid |
| 8  | C / N ratio           | 8.89    | Low    |
| 9  | Porosity              | 45.11 % | Deficient |

*a* Soil chemistry laboratory analysis result (2020)  
*b* Assessment According to the Soil Research Institute [10]

3.2 **Agro-climate observation results**

**Figure 1.** Rainfall in Tawangharjo district during the research period (March-July 2020).

**Figure 2.** Average ambient temperature in BKPH Pojok field during the research period (March-July 2020).

**Figure 3.** Average Soil Temperature in BKPH Pojok field during the research period (March-July 2020).

**Figure 4.** Average humidity in BKPK Pojok field during the research period (March-July 2020).
Porang needs an average rainfall of 300-500 mm/month on the top-vegetative period because rainfall under this scale could interrupt the top-vegetative phase of porang so it would immediately end the phase soon. Meanwhile, from Figure 1 we know that the rainfall during the research period was under 300mm/month. Figure 2 showed that during the research period, the temperature was quite high and approaching 35°C. Low rainfall (Figure 1) followed by high daily temperature (Figure 2) make plants detect dry condition so that make porang immediately finish their vegetative phase, burning, and falling (Figure 6). Soil temperature during the research period was high (Figure 3 showed that soil temperature in May was 34°C). Although, the average humidity is on the adaptative range for porang (Figure 4), and the light intensity also suitable (Figure 5), but high soil temperature makes plants detect dry condition, which is necessary for tuber development so the plants would immediately focus on tuber development.

3.3 Effect of treatment on the growth of porang (Amorphophallus muelleri Blume)
The vegetative growth of porang plants in this research cannot be measured. This was because in the first observation after giving ZA fertilizer substitution treatment with organic fertilizers, more than 50% of porang plant samples in the research area had fallen (Figure 6), while the vegetative growth parameters of porang could be measured if the plant samples were upright and still green. Second and third observation presented on Figure 7 and Figure 8. Early falling of porang plants can be caused by applying fertilizer as a component of studies or climatic and environmental conditions.
The large application of N fertilizer according to Lingga [13] could become one factor on plant fallen cause the lower part of the plant becomes weak while the plant grows very dense. The fall of porang top-vegetative part also indicates that the plant has entered the bottom vegetative phase (tuber) so N elements in the tissue and photosynthetic (nutrients) will be transported into the tuber. This is a common and scientific mechanism for tubers where the top of the plant dies, but the tubers develop and enlarge. Dry conditions (Figure 2, 3, 4) during the research period can also trigger porang plants to complete the upper vegetative phase early and immediately focus on tuber development. Temperatures above 35 °C (Figure 2) cause the leaves of porang plant has burned. The Indonesian Meteorology, Climatology and Geophysics Agency recorded that 2020 was the second hottest year with an anomaly value of 0.7°C.

Many porang plants also did not grow a flower. The research result of Gosnell [14] showed that ZA fertilizer can suppress the potential for flowering greater than urea fertilizer in sugarcane, the same effect can also occur in porang, where nitrogen tends to stimulate the growth of vegetative organs [13], formation and development of tubers. The advantage of this is that all the nutrients are focused on the enlargement of the tubers. On the other hand, the low rate of flowering means that there will be fewer generative seeds to be used for the next cropping.
3.4 Effect of treatment on the yield of porang (Amorphophallus muelleri Blume)

Based on Table 2, it is known that the highest yield of porang tubers was obtained from 100% ZA fertilizer treatment with 19.8 tons/ha fresh tuber. Meanwhile, the average production of Indonesian porang tubers is around 10 tons per hectare [10]. This showed that fertilization has a significant effect in increasing the yield of porang. The use of the highest dose of ZA fertilizer (100% of the recommended dose of 200 kg/ha) in this study was able to increase the yield of porang up to 86.79% from the control treatment (without fertilization). This shows that the highest dose given still can increase the yields of porang. N element in ZA which is more quickly available to plants than organic fertilizers will be directly used by plants and at the end of the vegetative period, the nutrients will be directly transported into the tubers for tuber development.

Table 2. Effect of treatment on the fresh tuber, storage and dry tuber chip weight of porang.

| Treatment combination (ZA : Organic Fertilizer) | Fresh tuber weight (tons/ha) | Storage tuber weight (tons/ha) | Dry tuber chip weight (tons/ha) |
|-----------------------------------------------|-----------------------------|-------------------------------|-------------------------------|
| P1 (100:0%)                                   | 19.8 a                      | 18.9 a                        | 4.3 a                         |
| P2 (75:25%)                                   | 14.6 ab                     | 13.8 ab                       | 3.0 b                         |
| P3 (50:50%)                                   | 10.8 b                      | 10.5 b                        | 2.1 b                         |
| P4 (25:75%)                                   | 12.3 b                      | 11.9 b                        | 2.6 b                         |
| P5 (0:100%)                                   | 13.9 ab                     | 13.6 ab                       | 2.9 b                         |
| P6 (0:0%)                                     | 10.6 b                      | 10.2 b                        | 2.0 b                         |
| Average                                       | 13.7                        | 13.2                          | 2.8                           |

Note: Mean followed by the same letters is not significantly different at α = 5%.

Organic fertilizers give lower yields on the fresh weight of tubers because the treatment is carried out near the final vegetative phase of the plant so that the application of organic fertilizers (which are slow-release) has a less significant effect. However, organic fertilizers are an investment for soil health and productivity in the long term, so that their presence is still needed in crop cultivation, especially to improve soil conditions in the research location (Table 1). Substitution of 75% ZA fertilizer with 25% organic fertilizer and 100% organic fertilizer gave no significant difference effect (increasing yield of 32.08% - 37.73% with a total yield of 14 - 14.6 tons/ha). This shows that organic fertilizers still have an important role in increasing crop production. However, its application does not completely replace the role of inorganic fertilizers, but it must be taken slowly by paying attention to soil conditions and plant needs so as not to drastically reduce productivity. The fresh weight of the tuber, the storage weight, and the weight of the tuber chips are interrelated variables and have a positive correlation. This means that the addition of fresh weight will also increase the storage weight, and dry tuber chips weight.

4. Conclusion

Based on the result of the research we can conclude that dry conditions (low rainfall followed by high ambient temperature and soil temperature) due to the climate change during the research period prompted porang to enter the bottom vegetative phase, marked by the fall of the plant. Fertilization is an effective effort to increase porang yields amid unpredictable climate change and extensification problems. The provision of non-volatile urea can be utilized properly by plants during the vegetative phase which will end soon so that N is immediately transported for the development and enlargement of tubers. The research result showed that 200kg/ha of ZA fertilizer is the recommended base dosage amount where the application must be followed by organic fertilizers to increase plant and soil productivity sustainably.

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References
[1] Dwiyono K, Sunarti T C, Suparno O and Haditjaroko L 2014 Penanganan pascapanen umbi iles-iles (Amorphophallus muelleri Blume) studi kasus di Madiun Jawa Timur J. of Agr. Tech. 3 179–88
[2] Pusat Penelitian dan Pengembangan Porang Indonesia 2013 Budidaya dan pengembangan porang (Amorphophallus muelleri Blume) sebagai salah satu potensi bahan baku lokal (Malang: Universitas Brawijaya) p 15
[3] Sumarwoto 2012 Budidaya iles-iles kuning untuk kesejahteraan masyarakat Ed Budiadi, Permadi DB, Umi LP Agroforestri porang: Masa depan hutan Jawa (Yogyakarta: Faculty of Forestry, UGM Press.) pp 28–38
[4] Saleh et al. 2015 Tanaman porang: pengenalan, budidaya dan pemanfaatannya (Bogor: Food Crops Research and Development Center) p 9
[5] Jansen PCM, Wilk, and Hetterscheid W 1996 Amorphophallus Blume Ex Decaisne Plant Resources of South-East Asia 9 Plants Yielding Non-Seed Carbohydrates ed M Flach and F Rumawas (Leiden: Backhuys Publ.) pp 45–50
[6] Sulistiyo R H, Soetopo L and Damanhuri 2015 Eksplorasi dan identifikasi karakter morfologi porang (Amorphophallus muelleri B.) di Jawa Timur J. of Plant Production 3 353–61
[7] Rofik K, Setiahadi R, Puspitawati IR and Lukito M 2017 Potensi produksi tanaman porang (Amorphophallus Muelleri Blume) di Kelompok Tani MPSDH Wono Lestari Desa Padas Kecamatan Dagangan Kabupaten Madiun. J. Ilmu Pertanian, Kehutanan dan Agroteknologi Agri-Tek 17 53–65
[8] Dwivedi B S, Singh V K, Meena M C, Dey A and Datta S P 2016 Integrated nutrient management for enhancing nitrogen use efficiency Indian Journal of Fertilizers 12 62–71
[9] Prasad R 2009 Efficient fertilizer use: the key to food security and better environment J of Trop. Agr. 47 1–17
[10] Balai Penelitian Tanah 2009 Analisis kimia tanah, tanaman, air, dan pupuk (Bogor: Balai Penelitian Tanah) p 211
[11] Munir M 1996 Tanah-tanah utama Indonesia (Jakarta: Dunia Pustaka Jaya)
[12] Foth H D 1994 Dasar-dasar ilmu tanah (Jakarta: Erlangga)
[13] Lingga P 2008 Petunjuk penggunaan pupuk (Jakarta: Penebar Swadaya)
[14] Gosnell J M 1970 A comparison of the effect of urea and sulphate of ammonia on sugarcane Proc. of The South African Sugar Technologists’ Association (South Africa: SASTA) pp 200–3