Effect of bulbil sizes on growth and corm yield of porang (Amorphophallus muelleri Blume) grown on alfisol soil

M Soedarjo

Indonesian Legume and Tuber Crops Research Institute, Jl.Raya Kendalpayak, P. O. Box 66, Malang 65101
Email: muchdar.soedarjo62@gmail.com

Abstract. Porang (Amorphophallus muelleri Blume) is one of the agribusiness crops in Indonesia and has been becoming an important income source for Indonesian farmers. Since decades ago, porang has been harvested from the forest as its natural habitat, under a shading environment. Due to its high economic value, more farmers have cultivated porang on open land. The present investigation was undertaken on Alfisol soil in the glasshouse, which mimics an open growing environment. The present research aimed at evaluating the effect of different bulbil sizes on the growth and corm yield of porang on Alfisol soil. Five different sizes of porang bulbil as treatments [1.88±0.05 g, 2= 3.21±0.04 g, 3= 4.21±0.04 g, 4= 6.45±0.04 g and 5= 9.10±0.22 g/bulbil] were laid out in completely randomized design and each treatment was replicated 3 times. All data obtained were analyzed by employing the standard deviation from 3 replicates for each treatment. Plant height and plant diameter at an earlier growing stage significantly increased with an increase of bulbil size. Bigger bulbil size also improved significantly the shoot dry weight, the corm diameter, the corm thickness and the fresh weight of corm at harvest. The highest value in all variables measured was attained by the biggest size of bulbil. The present research work suggests to use a bigger bulbil size as much as possible in order to produce a higher corm yield.

1. Introduction
Porang (Amorphophallus muelleri Blume) has been known as a commercial crop by Indonesian farmers since decades ago and was harvested from the forest as its natural habitat [1, 2, 3, 4, 5, 6, 7]. Only in the past few years, farmers have cultivated porang by using porang seedling obtained from germinated bulbil on its natural habitat [8]. In the last two years, the Indonesian Ministry of Agriculture encouraged farmers to increase porang cultivation in order to meet export demand [9]. Porang export within January to July 2020 was reported to be 14,568 ton, which is equivalent to IDR 801.24 billions [10]. The increasing demand of porang for export is probably due to the roles of porang in maintaining human health and healing some human illnesses [11, 12, 13, 14, 15, 16].

Due to its high value, the price of porang corm has been considered to be expensive. Porang plant grown by using seed corm of 49±26 g as planting material produced 636.3±91.7 kg of fresh corm/plant in one growing season, which is equivalent to approximately IDR 6,000/plant [17]. This phenomenon caused farmers highly motivated to cultivate porang plant and increases the number of farmers.
cultivating porang on the open field. Originally, porang plants were found to grow in the forest within the stands of trees. Thus, porang plants were shaded to some degree [1].

The cultivation of porang plant on an open field will eventually be exposed to higher light intensity, different soil fertility and unexpected insects and diseases which could be less favourable for porang plant growth environment. In addition to tropical forest, which is a natural habitat for porang, Indonesia has an abundant amount of agricultural land variable in soil fertility and could be used for porang cultivation. An expansion of porang cultivation on open field is unavoidable in order to increase porang production. Under such circumstances, porang cultivation would undergo environmental constraints, such as higher light intensity, plant damage by insects and diseases and less soil fertility. Alfisol soils is one the soil types abundantly available for agricultural purposes in Indonesia. The previous study revealed normal growth of porang plants on Alfisol soils [8]. Better growth of porang plant grown on saline soil was observed when bigger size of bulbil was used as planting material [8]. The objective of the present investigation was aimed at evaluating the growth responses and corm yield of porang plant grown with different sizes of bulbil as planting material on Alfisol soil.

2. Materials and Methods

2.1. Plant material

The present investigation used bulbils of different sizes as planting materials. Bulbil selection was done carefully in order to obtain bulbil size with minimum variation in each size (Figure 1). The bulbils were stored at room temperature (approximately 28-30°C) from May to October 2019 after harvest from the farmer’s field at Probolinggo regency, East Java, Indonesia. As displayed in Figure 1, the bulbils appeared to germinate in October 2019 during storing. Bulbils were germinated on Alfisol soil to obtain porang seedling at approximately similar size in each group of bulbil size. Due to the different growth of seedling in each group of bulbil size. Only porang seedlings of similar size in each group of bulbil size were selected for transplanting.

![Figure 1](image_url)

**Figure 1.** The size of bulbil measured as g fresh weight/bulbil.

2.2. Soil preparation, transplanting and plant caring

Alfisol soil used in the present investigation was obtained from Probolinggo regency, East Java, Indonesia. The soil was sent to the Soil and Plant Chemical Laboratory of Indonesian Legume and Tuber Crops Research Institute (ISO/IEC 17025-2017) for chemical analysis. The soil was first air-dried and crushed to pass through 0.5 mm sieve before analysis. Then, the soil of as much as 3 kg was put into a polyethylene bag. Before transplanting the seedling of porang, the soil was watered to a water field capacity [8]. One seedling for each group of bulbil size was transplanted into one polyethylene bag (see Figure 1 for bulbil size).

Porang plants were watered with tap water every other day to maintain the soil at water field capacity. NPK fertilizer (16:16:16) was applied at a rate of 300 kg/ha. By considering the plant population of 20,000 per ha (based on field plant spacing 80 x 60 cm), the total amount of fertilizer of as much as 15 g/plant/bag was used. Fertilizer was applied 3 times, e.g., 1/3 at planting, 1/3 at 30 days after transplanting (DAT) and 1/3 at 60 DAT at a rate of 5 g/plant, respectively. Fertilizer was placed next to porang shoot (about 5 cm) and was dibbled as deep as 3-4 cm. Subsequently, watering was applied.
Besides watering, weeding and spraying with insecticide and fungicide was done whenever required. Weed and pest observation were done everyday. Thus, any weed observed daily was pulled out by hand. Insecticide and fungicide were applied every two weeks to prevent plants from insects and disease infestation.

2.3. Methods

The present investigation was undertaken in the glasshouse of the Indonesian Legume and Tuber Crops Research Institute (ILeTRI) from October to May 2019. Each treatment, every bulbil size \([1=1.88\pm0.054 \text{ g}, 2=3.21\pm0.044 \text{ g}, 3=4.21\pm0.043 \text{ g}, 4=6.45\pm0.04 \text{ g} \text{ and } 5=9.10\pm0.22 \text{ g}]\) was arranged in completely randomized design and was replicated three times. Plant height and plant diameter were measured at 5 DAT. The dry weight of shoot, corm diameter, the thickness of corm and fresh weight of corm were measured at harvest.

Plant height was measured from the soil surface up to the tip of the shoot. Plant diameter was measured at the shoot right on the soil surface. Additional shoots were formed during the growing period and the aging among shoots was different. The first shoot died earlier than the following shoots. Therefore, the harvest of porang plant was done accordingly. The shoot from each harvest of each treatment was oven-dried at 60°C for 3 days to obtain constant weight and was weighed.

![Figure 2. D1 and D2= corm diameter in one way and another, T= Thickness of corm.](image)

After the last shoot harvest of each treatment, corm was harvested. The diameter of corm was measured in two directions (D1 and D2) and was divided by 2 to get the average corm diameter (Figure 2). Since the thickness of the corm also affected the fresh weight of corm, the thickness (T) of corm was also measured as shown in Figure 2. The diameter of plant, diameter of corm and thickness of corm were measured by using a 0-1500 Vernier Caliper (Einhill Hardware Tool). The corm fresh weight was measured by weighing.

3. Results and Discussion

3.1. Soil chemical analysis

Alfisol soil is considered to be a fertile soil and was characterized with neutral soil pH and contained relatively enough amount of N, P, K\(^+\), Ca\(^{2+}\), Mg\(^{2+}\) and C-organic (Table 1). Porang grown on this soil did not show any symptoms of growth retardation [8]. Fertilization of porang plant in the present investigation at a rate of 300 kg NPK/ha was done to ensure porang plant sufficiently supplied with nutrients N, P and K during its growing period. Under such soil chemical properties and addition of NPK fertilizer, Porang plants grown from different bulbil sizes did not undergo any deficiency symptoms of N, P and K from the date of transplanting to harvest.
Table 1. Soil chemical properties of Alfisol soil.

| Chemical properties          | Units      |
|-----------------------------|-----------|
| pH H₂O (1:5)                | 6.20      |
| N-Total (Kjedahl)           | 0.05 (%)  |
| P₂O₅ Olsen                  | 96.50 ppm |
| K-NH₄OAc. pH 7.0             | 0.88 (Cmol⁺/kg) |
| C-Organ -Walkley & Black    | 1.15 (%)  |
| Na                           | 0.50 (Cmol⁺/kg) |
| Ca                           | 1.05 (Cmol⁺/kg) |
| Mg                           | 3.94 (Cmol⁺/kg) |

3.2. Plant height and shoot diameter of porang plant at 5 DAT

At the beginning of porang growth stage, 5 DAT, a significant difference in plant height and shoot diameter of porang among the treatments was observed (Figures 3A and B). This result indicates that the growth difference at the beginning of porang growth stage was due to the difference in bulbil weight. A bigger bulbil used in the present investigation resulted in better porang plant growth measured as plant height and plant diameter at 5 DAT. Bulbil contains the primary source of energy for growing at the beginning of porang growth stage. Consequently, a bigger bulbil would cause better growth. Bigger bulbil driving better growth of porang at an earlier stage was reported earlier [8]. Sumarwoto (18) also reported that the use of bigger bulbil resulted in better plant growth.

![Figure 3. Effect of bulbil weight on plant height (cm, A) and plant diameter (cm, B) at 5 DAT.](image)

3.3. Total number of shoots and shoot dry weight at harvest

Porang plants were harvested periodically since the aging of shoots per polyethylene bag was different, the first shoot emerging from bulbil was aging earlier than the following shoots. The emergence of the additional shoot took place during the growing stage. Thus, earlier aging shoots were subjected to an earlier harvest. As depicted in figure 4A that the number of shoots harvested in each group of porang bulbil weight was similar. Thus, bulbil weight up to 9.10 g/bulbil did not cause variability in the number of shoots. The total number of shoots generated up to harvest for each bulbil was less than 3.

![Figure 4.](image)
Figure 4B depicted a significant difference in shoot dry weight among the bulbil weight used as planting material. The bigger the bulbil used, the higher the shoot dry weight produced. As indicated by Figures 3A and B, the bigger bulbil resulted in better porang plant growth, measured as plant height and plant diameter at the earlier growing stage (5 DAT). The present investigation suggests that better plant growth at the earlier growing stage ensured the better plant growth of porang plant at the rest of the growing stage until harvest. As a result, porang dry weight at harvest was significantly higher when bigger bulbil was used as planting material.

3.4. Corm performances, diameter and thickness of corm

The effect of bulbil weight as planting material on corm production (performances, diameter and thickness) was depicted in Figure 4 and Figures 5A and B, respectively. It was clearly observed that the size of corm produced at harvest was increasing with an increase of bulbil weight used Figure 5. As depicted in Figure 5, the size of corm produced by the bulbil weight of 3.21±0.044 g/bulbil (number 2), 4.21±0.043 g/bulbil (number 3) looked similar. However, they were significantly different when measured in terms of corm diameter and corm thickness Figures 6A and B. Figures 6A and B displayed significant differences in corm diameter and corm thickness among the bulbil weight used. These figures suggest that the use of bigger bulbils consistently resulted in bigger corm diameter and thickness at harvest. Since the weight of corm is dependent on corm diameter and corm thickness, the measurement of corm diameter must be accompanied with the measurement of corm thickness.

![Figure 4. Effect of bulbil weight on total number of porang plant (A) and porang plant dry weight (B) at harvest.](image_url)

![Figure 5. Effect of bulbil weight as planting material on porang corm performances at harvest.](image_url)
3.5. Fresh weight of porang corm at harvest

The fresh weight of corm was shown to be significantly affected by the bulbil weight as planting material (Fig. 7). Parallel to the corm diameter and corm thickness, the use of bigger bulbil weight significantly increased the fresh weight of corm at harvest. The result of the present investigation also indicates that corm diameter and corm thickness are important parameters closely related to corm fresh weight (see Figs. 6A and B). Consequently, higher corm diameter and corm thickness will ensure the higher corm fresh weight of porang at harvest. Besides, higher corm yield was shown to be in parallel to better plant growth, presented in shoot dry weight, when bigger bulbil weight used (see Figure 4B). Bigger bulbil was also reported to cause better porang plant growth and corm yield [18]. The present investigation reported that better plant growth due to bigger size of bulbil as planting material would significantly result in higher corm yield at harvest. Thus, the present investigation suggests using the bigger bulbil size as much as possible to produce a higher yield of porang corm on Alfisol soil.

4. Conclusions

The size of bulbil affected significantly the growth and corm yield of porang (*Amorphophallus muelleri* Blume) on Alfisol soil. Bigger bulbil weight used as planting material resulted in higher plant height
and plant diameter at 5 DAT. Bigger bulbil size also produced higher shoot dry weight, corm diameter, corm thickness and fresh weight of corm at harvest.

Acknowledgement
The author would like to thank the Indonesian Legume and Tuber Crops Research Institute (ILeTRI), The Indonesian Agency for Agricultural Research and Development, the Indonesian Ministry of Agriculture to make the present research done.

References
[1] Rofikoh K, Setiahadi R, Puspitawati I R, Lukito M 2016 Potensi produksi tanaman porang (Amorphophallus muelleri Blume) di kelompok tani MPSDH Wono Lestari Desa Padas Kecamatan Dagangan Kabupaten Madiun (Yield potential of porang (Amorphophallus muelleri Blume) at farmers cooperative MPSDH Wono Lestari, Padas, Dagangan, Madiun) AGRI-TEK: Jurnal Ilmu Pertanian, Kehutanan dan Agroteknologi. 17 2 1411-5336 [In Indonesian].
[2] Abriyani A 2012 Tepung porang di Karangtengah tembus pasar luar negeri (Porang flour at Karangtengah goes to International market). (Wongori: Solopos.com) [In Indonesian].
[3] Ahmad F 2019 Ekspor ke China dan Jepang-petani NU sukses budidaya tanaman porang (Export to China and Japan-NU farmer successfully cultivate porang). (Purwakarta: NU Online) [In Indonesian].
[4] Al Alawi M 2017 Porang Madiun menjadi buruan pengusaha Jepang dan China (Porang in Madiun is a target for the businessman from Japan and China). (Madiun: kompas.com) [In Indonesian].
[5] Gesha 2019 Umbi porang laku di Vietnam Rp 708.45 Juta (Corms of porang was sold for IDR 708.45) [In Indonesian].
[6] Handayani D Y 2019 Ekspor porang di Jatim meningkat dua tahun terakhir (Porang export form East Java increased in the last two years) [In Indonesian].
[7] Somantri A 2019 Dianggap menguntungkan, warga Cidadap Sukabumi berlomba budidaya porang (Due to beneficial, farmers in Cidadap Sukabumi cultivated porang) [In Indonesian].
[8] Soedarjo M, Baliadi Y and Djufry F 2020 Growth response of porang (Amorphophallus muelleri Blume) grown with different sizes of bulbils on saline soil International Journal of Research Studies in Agricultural Sciences. 6 4 8-16
[9] Sugara H 2020 Kementan dorong madiun kembangkan tanaman porang untuk ekspor (The Indonesian Ministry of Agriculture recommended Madiun regency for porang development). (Madiun: Monitor) [In Indonesian].
[10] Abdul 2020 Nilai ekspor porang tembus Rp 801.24 milyar per Juli 2020 (Export value of porang reached IDR 801.24 billions by July 2020). (Madiun: ANTARA News Jatim) [In Indonesian].
[11] Yoshida M, Vanstone C A, Parsons W D, Zawistowski J and Jones P J H 2006 Effect of plant sterols and glucomannan on lipids in individuals with and without type II diabetes Europ. J. Clin. Nutrit. 60 4 529–537.
[12] Yeh S L, Lin M S and Chen H L 2007 Inhibitory Effects of a Soluble Dietary Fiber from Amorphophallus konjac on Cytotoxicity and DNA Damage Induced by Fecal Water in Caco-2 Cells Planta Med. 73 14 1384-1388.
[13] Carlos A, Vasques C A R, Rossetto S, Halmenschlager G, Linden R, Heckler E, Fernandez M S P and Alonso J L L 2008 Evaluation of the pharmaco therapeutic efficacy of Garcinia cambogia plus Amorphophallus konjac for the treatment of obesity Phytother. Res. 22 9 1135–1140.
[14] Alonso-Sande M, Tejeiro-Osorio D, Remuñán-López C and Alonso M J 2009 Glucomannan, a promising polysaccharide for biopharmaceutical purposes Europ. J. Pharmaceutics and Biopharmaceutics 72 2 453–462.
[15] Jagatheesh K, Arumugam V, Elangoan N and Kumar PP 2010 Evaluation of the anti-tumor and
antioxidant activity of *Amorphophallus paeonifolius* on dmba induced mammary carcinoma *Internat. J. Chem. Pharmaceutic. Sci.* 1 2 40-50.

[16] Soedarjo M 2015 Acquisition of the technique to analysis of foods function toward human health function and analysis of these functions in Indonesian indigenous tuber crops. Postdoctoral Research Report, as a result of mutually beneficial collaboration between Indonesian Agency For Agricultural Research And Development and Kyushu University, Fukuoka, Japan. 38p

[17] Santosa E, Susila A D, Lontoh A P, Mine Y and Sugiyama N 2016 NPK levels and application methods on productivity of *Amorphophallus muelleri* Blume in intercropping system *J. Jamu Indonesia* 1 2 1-8

[18] Sumarwoto 2004 Pengaruh pemberian kapur dan ukuran bulbil terhadap pertumbuhan iles-iles (*Amorphophallus muelleri* Blume) pada tanah ber-Al tinggi (The effects of liming and bulbil sizes on the growth of iles-iles (*Amorphophallus muelleri* Blume) in high level of AL_{EXC} soil) *Ilmu Pertanian*. 11 2 45-53 [In Indonesian]