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Research Article

Propagule origin and soil organic carbon content determine the growth and yield of *Amorphophallus muelleri* Blume

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ABSTRACT

Amorphophallus muelleri Blume, *locally called* Iles-iles *or* porang, *has become a new commercial commodity in Indonesia. The tuber, as the most economic value, contains high glucomannan a long-chain carbohydrate widely used in the food, beverage, and medicine industries. It has been speculated that the high variation in yield among the farmers is due to different planting materials origin and soil organic carbon (SOC) content. This research was carried out to evaluate the growth and yield of A. muelleri from other planting materials origin and the levels of SOC. The research was carried out at IPB Experimental Station, Leuwikopo Bogor, Indonesia from December 2021 to August 2022, using a nested design, The main plot was the level of SOC (2, 3, 4, and 6%), and the sub-plot was planting material origins (seeds, bulbils, and tubers from leaf cuttings). Results showed that SOC status determined growth and yield. where it significantly affected plant height, stem diameter, leaf number, canopy width, bulbils number, corm fresh weight, and corm diameter. The SOC at a level of 6% stimulated the highest plant growth and yield. Planting materials also determined the growth and yield of A. muelleri. Plants originating from bulbils produced the highest yields, followed by tuber from leaf cuttings and seeds. It is recommended to plant bulbils accompanied by maintaining SOC at a level of 6%.*

Keywords: *Bulbils; glucomannan; iles-iles; leaf cutting;* porang

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INTRODUCTION

Amorphophallus muelleri Blume syn *A. oncophyllus* is a member of the Araceae. In Indonesia, it is known as *iles-iles*, *porang*, or *coplok* (East Java) and *lotrok* (Yogyakarta) (Sugiyama & Santosa, 2008). The *porang* plant is native to Indonesia and has long been known and used by the community for generations (Saleh et al., 2015). One of the characteristics that differentiates porang from other species is the rhombus-shaped spots on the stem and the presence of aerial bulbils in the leaf veins and midribs (Indriyani & Widoretno, 2016). Currently, *porang* has been cultivated commercially to produce glucomannan, a long-chain carbohydrate widely used in the food, beverage, and medicine industries (Santosa, 2014). In Indonesia, *A. muelleri* production in 2020 reached 32,000 tons of dry tubers with an area of 19,950 ha most of which came from the Pasuruan, Madiun, Wonogiri, Bandung, and Maros areas (IAARD, 2021).

High variation in tuber yield is the main problem occurring in cultivation, which causes high uncertainty in farmers' income (Santosa, 2014). Many efforts have been made to increase productivity, including using certified seeds, fertilization, irrigation, and pest and disease control (Santosa et al., 2003; Santosa et al., 2011). Even though the Indonesian Ministry of Agriculture has issued cultivation SOPs to standardize production (Santosa, 2014), the level of productivity is still below expectation. According to Sugiyama and Santosa (2008), the potential yield of *A. muelleri* reaches 40 tons of fresh corm per hectare. Still, according to Santosa et al. (2003), the average productivity at the farmer level is only 6-10 tons ha^{-1}.

According to Sugiayama and Santosa (2008), the main factor in determining *A. muelleri* yield is the size of the tubers at planting, where tubers measuring > 100 g can provide high production with a harvest age of less than three years. Nevertheless, the attainment of planting material of such size is not easy because of the high price and limited availability in the market. As a result, many farmers produce seeding to obtain desirable sizes of propagates using various planting materials (PM) such as seeds, bulbils, tuber skin, and leaf cuttings (Santosa, 2014). Although many studies have been carried out to produce propagation material (Santosa et al., 2016a; 2016b; Hidayah et al., 2018; Sari et al., 2019), studies comparing the growth of *A. muelleri* plants from various planting materials are still limited.

Soil organic carbon (SOC) status in the soil is often a limiting factor in the productivity of tuber crops such as cassava (Anwar et al., 2023) and taro (Alghifari et al., 2023). From an ecological perspective, there have been many studies on the role of SOC in ensuring soil physical, biological, and chemical fertility and maintaining nutrient balance and soil pH stability (Darma et al., 2020). However, there is still no research regarding the role of SOC in supporting *A. muelleri* cultivation, which is more resilient to climate factors and precision cultivation. This research aimed to evaluate the growth and yield of *A. muelleri* from different planting materials and levels of SOC. The implications of SOC on the resilience of *A. muelleri* to climate change and precision cultivation are also discussed.

MATERIALS AND METHODS

Research site

The research was conducted from December 2021 to August 2022 at IPB Experimental Station in Leuwikopo Darmaga, Bogor, Indonesia (-6.549398N,106.71615E; 218 m above sea level). During the study, the average monthly rainfall was 260.7 mm (the highest was June, 463.7 mm, and the lowest was January, 106.6 mm). The number of rain days within a month ranged from 20 to 31, meaning the experiment occurred during the rainy season.

The soil in the research location is Latosol type. The soil had 1.79% organic-C, 0.22% total nitrogen, 0.53 ppm available phosphorus, 69.71 ppm total phosphorus, 13.94 ppm total potassium, cation exchange capacity 14.41 cmol kg^{-1}, and pH 4.84.

Research design

The experiment used a nested design consisting of two factors and three replications. The first factor was SOC level (2%, 3%, 4%, 6%). The second factor was various types of planting material (seeds, bulbils, and corm from leaf cuttings-CLC).

The research started with preparing the planting material (PM). Seeds were obtained from 3-year-old plants harvested after the berries turned red. Bulbils were obtained from 2-year-old plants. Corm from leaf cuttings (CLC) was obtained by seeding leaflet cuttings for about six months before the research was conducted. The leaflet cuttings were obtained from 2-year-old plants. The stages of preparing planting material are shown in Figure 1.

Soil sample for analysis was collected before land preparation. The land was plowed with a tractor, and then a raised bed was made as high as 15 cm, 100 cm wide, and 400 cm long. Cow manure was spread according to the SOC treatment levels, and NPK 15-15-15 fertilizer was applied side dressing at a dose of 150 kg ha^{-1}. After spreading the manure and NPK, the beds were covered with black plastic mulch. The beds were then incubated for two weeks before planting.

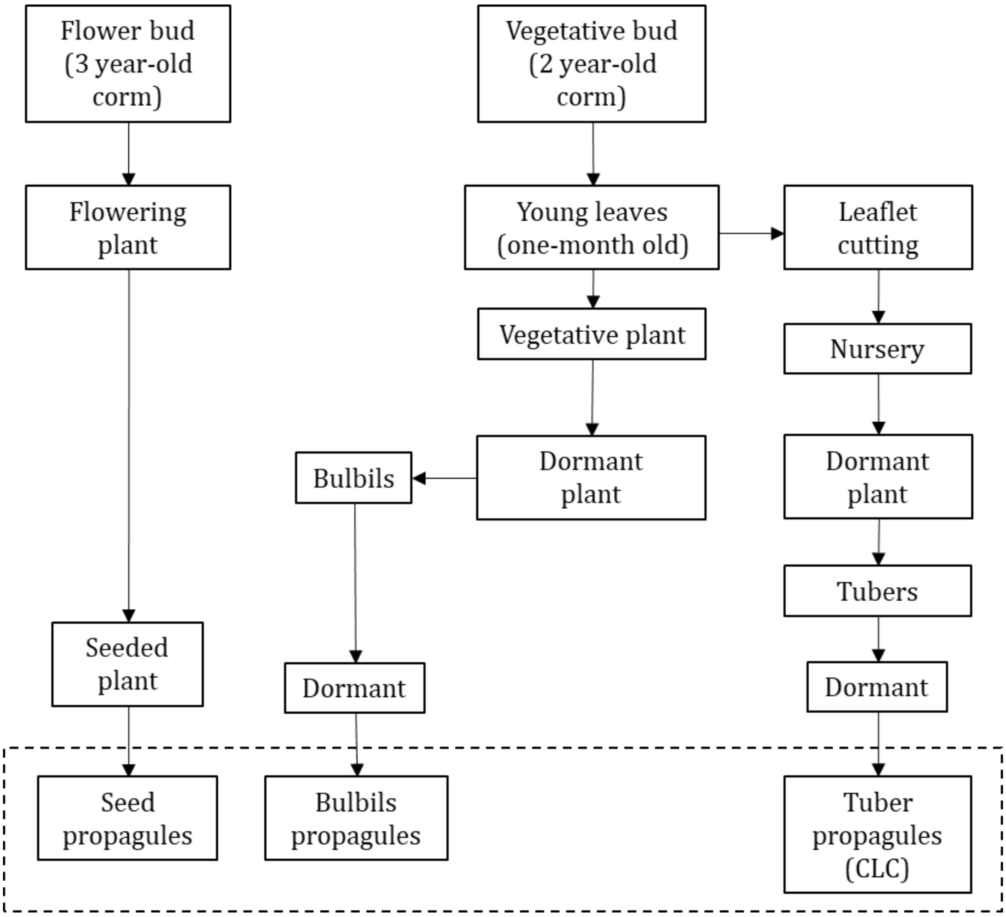

Figure 1. Procedures to obtain planting materials used in this study.

To obtain the soil status of 2%, 3%, 4%, and 6% SOC as treatments, the manure was added following the procedure of Alghifari et al. (2023). Cow manure had about 37.64% organic-C, 2.77% total nitrogen, 0.95% total phosphorus, and 0.34% total potassium, with a pH of 7.62. The amount of manure added to the soil was based on the assumption that the soil weight per hectare as tillage layer of 2,000,000 kg, from a 20 cm cultivated top layer, a bulk density of 1 g cm^{-3}, and a land area of 10,000 m^2. Based on these assumptions, the amount of manure added is presented in Table 1.

Table 1. Amount of goat manure added to soil to obtain a particular level of soil organic carbon.

Soil organic level (SOC)	Original SOC level	Balance SOC (%)	Amount of manure added (ton ha^{-1})^z
2%	1.79%	0.21	11.16
3%	1.79%	1.21	64.29
4%	1.79%	2.21	117.43
6%	1.79%	4.21	223.70

Note: ^{z} organic carbon content 37.64%

Planting was carried out when the bulbils and tubers from the leaf cuttings had sprouted while planting material from seeds had been germinated and had one leaf with an average height of 12 cm. The planting distance was 50 cm x 50 cm x 50 cm, with one PM per planting hole. Thus, one planting bed contained 16 plants. Each replication consisted of three beds. The bed measured 1 m x 4.5 m and the distance between the beds was 50 cm.

Plant growth analysis

Growth observations included plant height, petiole diameter, canopy width, leaf number, and shoot number. Plant height was measured from the soil surface to the tripartite branch, while a caliper measured petiole diameter. Petiole diameter was measured at the base of the petiole 5 cm from the ground using a caliper, 12 weeks after planting (WAP). The width of the leaf canopy was measured horizontally when the leaves were fully grown, from the left to the right side. Number of leaves was counted from the time the plant grows to dormancy. The number of shoots per plant was calculated from the number of active buds.

Production observations included the number of bulbils and corm size (fresh weight and dry weight, diameter, and height of the corm). The bulbil number per leaf was calculated from the last standing leaf when the leaf had senesced. The fresh weight of the corm was measured using a digital scale after the corms were cleaned from the soil with the skin intact. The dry weight of the tubers was measured after the corms were oven-dried at 65 °C for 1.5 x 24 hours. Sampling 100 g of fresh tubers were sliced with a thickness of 1 cm. Corm diameter was measured at the widest part after cleaning from adhering soil. The height of the corm was measured using a ruler from the bottom to the highest position.

Physiological analysis

The observed physiological characteristics of the plant included the level of leaf greenness, leaf pigment content, and photosynthetic rate. Measuring the green level of leaves using a SPAD tool (Hitachi, Japan) was carried out on leaves at 12 WAP that fully expanded at 10.00 a.m.

Chlorophyll and anthocyanin contents were measured using a spectrophotometer following the method of Sims and Gamon (2002). Briefly, 1 g fresh leaf sample was ground using a mortar, and 1 mL of acetone was added, then put into a measuring flask and added up to 5 mL of acetone. The sample was then centrifuged at 14,000 rpm for 10 seconds. The supernatant was taken out carefully, and the absorbance was measured using a spectrophotometer (λ 470, 537, 647, and 663 nm). The anthocyanin and chlorophyll contents were estimated using the formula:

$$\text{Anthocyanin} = 0.08173*A537 - 0.00697*A647 - 0.002228*A663$$
$$\text{Chlorophyll a} = 0.01373*A663 - 0.00897*A537 - 0.003046*A647$$
$$\text{Chlorophyll b} = 0.02405*A647 - 0.04305*A537 - 0.005507*A663$$

Photosynthesis, stomatal conductance, and transpiration rates were measured using a LICOR 6400 (LICOR, USA). Measurements were taken when the leaves had fully expanded, and bulbils appeared (Fan et al., 2019; Khalil et al., 2019; Mereb et al., 2020).

Statistical analysis

The data obtained were analyzed using analysis of variance (ANOVA). The differences between treatments were then subject to further analysis using the Least Significant Difference Test (LSD).

RESULTS AND DISCUSSION

Analysis of variance

Eight of the 14 variables were significantly influenced by SOC or PM treatment (Table 2). The amount of chlorophyll (a, b, and total a+b), anthocyanin, carotene, and photosynthetic rate was not significantly influenced by either SOC and PM treatments or the SOC×PM interaction. Table 2 shows that the significant influence of the SOC×PM interaction was found in 6 variables: plant height, stem diameter, leaf number, leaflet numbers, tuber wet weight, and tuber diameter.

Plant height and leaf size

Plant height was strongly influenced by the SOC×PM interaction (Table 2). The best combination to encourage plant height was bulbils and 6% SOC (Table 3). The higher the SOC level stimulated the higher the plants. On the other hand, plants from seeds and CLC did not show a consistent pattern of influence with increasing SOC levels. This finding differs from *Xanthosoma undipes*, where Alghifari et al. (2023) reported a constant increase in plant height with increasing SOC. The role of SOC in increasing plant height is most likely related to increased nutrients with increasing doses of cow manure added. According to Biratu et al. (2018), manure is a source of essential nutrients, especially NPK.

Table 2. Recapitulation of results of various types of influence of organic C and planting material.

Variables	F-test			CV (%)
	Soil organic carbon (SOC)	Planting material (PM)	SOC x PM	
Plant height	**	**	**	18.41
Stem diameter	**	**	**	15.80
Number of leaves	**	**	**	21.21
Number of leaflets	ns	**	**	10.05
Leaf canopy width	**	**	**	19.46
Number of bulbils	**	ns	**	15.21
Corm fresh weight	**	**	**	21.02
Corm diameter	**	**	**	14.74
Chlorophyll a	ns	ns	ns	16.29
Chlorophyll b	ns	ns	ns	18.16
Total chlorophyll	ns	ns	ns	16.72
Anthocyanin	ns	ns	ns	20.16
Carotene	ns	ns	ns	14.74
Photosynthetic rate	ns	ns	ns	7.81

Note: **Significant effect at α=1%, ns-non significant at α=5%; CV = coefficient of variation. For the variables number of leaflets, number of bulbils, and corm fresh weight use square root transformation data, i.e. $\sqrt{x+0.5}$

Generally, plant height came from bulbil > CLC > seed at 4% and 6% SOC (Table 3). At 2% and 3% SOC, there was a tendency for plants from seeds to have the lowest height compared to other PMs. The height variation among PMs is probably due to differences in weight among PMs. The tuber weight at planting determines plant height (Santosa et al., 2011; Rosdiana & Santosa, 2019). According to Santosa et al. (2016c), bigger planting material produces bigger and taller leaves. In the present experiment, each kilogram of seeds, bulbils, and CLC contained 2000, 25, and 50 propagules, respectively, thus on average a bulbil was 40 g and a CLC was 20 g.

Table 3 shows that the response of stem diameter to SOC and PM treatments was similar to that of the plant height. Such an identical response is probably because plant height and stem diameter have a high correlation as stated by Santosa et al. (2003). Plants originating from bulbils had a higher diameter than those arising from seeds in all SOC treatments. In contrast, plants originating from CLC were not significantly different from those deriving from bulbils at all SOC levels (Table 3).

For all planting materials, 6% SOC encouraged plants to have larger stem diameters than 2% SOC (Table 3). Increasing SOC levels as a result of manure application, hence increasing nutrient supplements to the soil. In other words, cow manure is a good source of nutrients (Biratu et al., 2018).

SOC treatment had a very significant effect on increasing the width of the leaf canopy (Table 3). Higher SOC levels stimulated plants to have wider canopy. Bulbil planted at 6% SOC had the widest leaf canopy (63.37 cm) compared to other PMs, especially at 2% SOC. This is in line with the research results of Saefudin et al. (2021) that the bulbil size significantly affects petiole length.

Table 3. Plant height of *Amorphophallus muelleri* from different soil organic carbon (SOC) and planting material at 24 weeks after planting.

Planting material	SOC (%)				
	2	3	4	6	Average
			Plant height (cm)		
Seed	29.33ef	17.24g	24.20fg	36.68c-e	26.86
Bulbils	33.11d-f	41.44cd	53.87ab	62.36a	47.69
CLC	33.89c-f	43.78b-d	42.72b-d	45.69bc	41.52
Average	32.11	34.15	40.26	48.24	
			Petiole diameter (cm)		
Seed	0.91de	0.56e	1.02d	1.47bc	0.99
Bulbils	1.52bc	1.63abc	1.51bc	2.01a	1.67
CLC	1.28cd	1.82ab	1.64abc	1.72ab	1.61
Average	1.24	1.34	1.39	1.73	
			Canopy width (cm)		
Seed	33.22de	23.61de	40.81bcd	42.27bcd	34.97
Bulbils	42.33bcd	44.78bcd	52.41ab	63.37a	50.72
CLC	37.44cde	44.22bcd	35.68cde	47.62bc	41.24
Average	37.66	37.53	42.96	51.08	

Note: CLC, Corm of leaflet cutting. Values followed by similar alphabets are statistically insignificant different at LSD test α=0.05.

Leaf characteristics and photosynthesis

The number of leaves and leaflets was significantly influenced by the SOC×PM interaction (Table 1). The highest number of leaves was produced by PM of CLC at 4% SOC (Table 4). Without considering the planting material, increasing SOC levels up to 4% increased the number of *A. muelleri* leaves. The findings differ from research on *Xanthosoma undies* (Alghifari et al., 2023) and *A. muelleri* (Sari et al., 2019). According to Sari et al. (2019) bigger cow manure treatment increases the number of *Amorphophallus muelleri* leaves*.* The cause of leaf number being less responsive to SOC 6% in present research is still unclear.

Table 4. Leaf and leaflet number of *Amorphophallus muelleri* from different soil organic carbon (SOC) and planting materials at 24 weeks after planting.

Planting material (PM)	SOC (%)				
	2	3	4	6	Average
			Leaf number		
Seed	1.0b	1.3b	1.1b	1.7b	1.2
Bulbils	1.4b	1.0b	1.1b	1.0b	1.1
Corm of leaflet cutting (CLC)	2.5b	2.2b	4.4a	2.6ab	2.9
Average	1.0	1.0	2.0	1.0	
			Leaflet number per leaf		
Seed	6.4g	7.0e-g	10.1c-g	12.4b-d	8.9
Bulbils	8.7defg	10.4c-f	14.4b	21.2a	13.7
Corm of leaflet cutting (CLC)	6.6fg	10.6b-e	9.6c-g	13.4bc	10.1
Average	7.0	9.0	12.0	16.0	

Note: Values followed by similar letters are insignificantly different at LSD test α=0.05.

PM from seeds and bulbils produced fewer leaves in the 6% SOC than in the 2% SOC treatment (Table 4). Visual field observations indicated plants from seeds and bulbils tended to dormant earlier than those from CLC at 24 WAP. Santosa et al. (2014) stated that dormancy in *A. muelleri* plants could be delayed by KNO_3 application. Further research is needed on why plants originating from CLC postponed dormancy.

Different planting materials had different abilities to produce leaves (Figure 2). Plants from CLC had more than one leaf at the end of the observation. At planting, seeds and bulbils had a single shoot, while CLC had more than one main shoot. Usually, each *A. muelleri* corm has a single active bud (Santosa et al., 2016b). However, Santosa et al. (2016a) stated that damaging the main growing bud due to disease or physical disturbance will encourage the growth of axillary buds, resulting in more than one active bud or shoot.

Interestingly, the CLC buds or shoots did not show any signs of damage. It is speculated that tubers of CLC have physiological abnormalities that stimulate the growth of more shoots. Further research is needed to evaluate factors affecting the CLC production of more than one active bud.

Figure 2. Number of leaves from different planting materials (PM). A-PM of seed, B-PM of bulbil, C-PM of corm of leaflet cutting.

The number of leaflets was significantly influenced by the SOC×PM interaction (Table 2). Generally, the higher SOC level stimulated a greater leaflets number of all PM. The highest number of leaflets was plants of bulbils grown in 6% SOC. According to Sugiyama and Santosa (2008), the leaf size influences the number of leaflets, where the bigger the leaf the more the number of leaflets produced. In this study, plants from bulbils with a SOC of 6% had the largest canopy width, as shown in Table 3. This means that planting bulbils on land with a 6% SOC level encouraged bigger leaves with more leaflets.

SOC treatment did not significantly increase chlorophyll contents (a, b, total), anthocyanins, carotene, and photosynthesis rate (Table 5). The absence of these differences, especially from the SOC treatment, indicated that the application of manure fertilizer did not affect those variables. According to Sugiyama and Santosa (2008), *A. muelleri* is a recently domesticated plant that has not undergone a significant genetic change. Thus, photosynthetic components may be less affected by various nutrient conditions. There have been many photosynthesis studies in the genus *Amorphophallus* under the influence of shade (Santosa et al., 2003; Supriyono et al., 2022). However, physiological studies on photosynthesis related to fertilization and SOC are rarely carried out on *A. muelleri*.

Bulbils and corm yield

The number of bulbils per leaf was significantly influenced by SOC status, not planting material (Table 6). The higher SOC level produced a higher number of bulbils. On average, 6% SOC encouraged plants to have the highest number of bulbils (2.55 units), compared to 2% (1.25 units). According to Sugiyama and Santosa (2008), the number of bulbils depends on the number of leaf veins, canopy width, and plant age. In general, increasing SOC level increased leaf size (Table 3) and number of leaflets (Table 4), which explains why increasing SOC increased the number of bulbils.

Table 5. Pigments and photosynthetic rate of *Amorphophallus muelleri* from different soil organic carbon (SOC) and planting materials at 12 weeks after planting.

Treatment	Pigment content (mg g^{-1})					Photosynthetic rate
	Chl-a	Chl-b	Total Chl	Anthocyanin	Carotene	(μmol CO_2 m^{-2} s^{-1})
SOC level						
SOC 2%	1.26	0.42	1.68	0.05	0.47	29.16
SOC 3%	1.43	0.48	1.91	0.05	0.49	29.71
SOC 4%	1.23	0.41	1.63	0.04	0.42	31.65
SOC 6%	1.28	0.42	1.65	0.04	0.43	31.77
Planting material (PM)						
Seed	1.23	0.41	1.64	0.04	0.43	29.45
Bulbils	1.30	0.44	1.74	0.04	0.46	31.30
CLC	1.33	0.44	1.77	0.05	0.48	30.96

Note: Values followed by similar alphabets are statistically insignificant different at LSD test α=0.05.

Table 6. Bulbil numbers, corm fresh weight, and corm diameter of *Amorphophallus muelleri* from different soil organic carbon (SOC) and planting materials at 24 weeks after planting.

Planting	SOC (%)				
material (PM)	2	3	4	6	Average
	Number of bulbils per leaf				
Seed	1.0	1.0	2.1	2.1	1.5
Bulbils	1.3	2.3	3.2	3.4	2.5
CLC	1.4	1.6	2.1	2.1	1.8
Average	1.0	2.0	2.0	3.0	
	Corm fresh weight (g)				
Seed	31.66f	65.20ef	185.24d-f	311.28b-e	148.43
Bulbils	514.71b	359.99b-d	464.44bc	932.11a	567.81
CLC	194.70c-e	484.02b	388.12b-d	479.60b	386.61
Average	247.02	303.07	345.93	574.33	
	Corm diameter (cm)				
Seed	3.92g	4.85fg	7.49e	8.74b-e	6.25
Bulbils	10.21bc	9.65b-d	10.74b	13.70a	11.07
CLC	6.71ef	8.12c-e	7.95de	8.55c-e	7.83
Average	6.94	7.54	8.72	10.33	

Note: Values followed by similar alphabets are statistically insignificant different at LSD test α=0.05.

SOC treatment significantly affected the average corm fresh weight whereas plants from CLC treated with 6% SOC produced a lower weight than those from bulbils (Table 6). However, plants from CLC had bigger corm numbers because each plant produced more than one tuber (Figure 3). It should be noted that planting bulbils resulted in the highest corm fresh weight. Previously, Sumarwoto (2005) mentioned plants from bulbils produce 100-200 g of corm in one growing period. In the present study, the corm produced was bigger than those reported by Sumarwoto (2005), i.e., more than 350 g in all SOC treatments. Thus, maintaining SOC during *A. muelleri* growth is essential because, according to Sugiyama and Santosa (2008), corm size development continues to increase until the plant goes dormant.

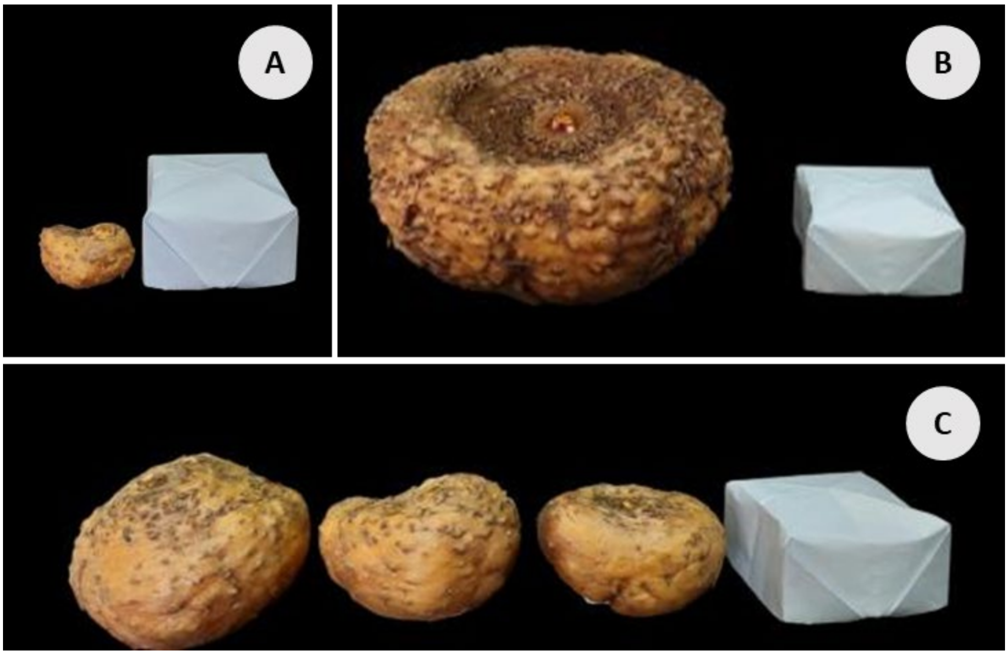

Figure 3. Typical corm shape and number per plant from different planting materials (PM). A-PM of seed; B-PM of bulbil; C-PM of corm of leaflet cutting (CLC). White box size 10 cm x 10 cm x 5 cm (L×W×H).

Plants from bulbils grown in the 6% SOC had the highest corm fresh weight compared to other treatment combinations, i.e. 932.11 g, which was almost two times higher than similar PM grown in 2% SOC (Table 6). Plants from seeds in the 2% SOC had the lowest corm weight, namely 31.66 g, almost 10% of the same planting material grown in 6% SOC. These results indicate that maintaining SOC > 2% is important *A. muelleri* production, mainly if planting material uses seeds. The research finding aligns with Alghifari et al. (2023) and Afifah et al. (2014). According to Afifah et al. (2014), *A. muelleri* produces larger corms if their vegetative growth is vigorous. Previously, Santosa et al. (2003) developed an allometric equation between petiole diameter and corm weight at harvest; the bigger petiole indicates a bigger corm weight.

SOC treatment significantly increased corm diameter (Table 6). Plants from bulbils in the 6% SOC had the highest corm diameter, followed by those in the lower SOC content treatment. Conversely, plants from seeds in the 2% SOC had the smallest corm yield among the other PM and SOC treatments. The shape of the *A. muelleri* corm in this study was depressed-globose, especially for planting material from seeds and bulbils, while the corm originating from CLC tended to have a globose shape (Figure 3). Corm diameter also reflected the weight; the larger corm diameter usually had a heavier weight. However, this study did not observe the correlation between corm diameter and its weight.

This research shows the importance of selecting planting materials and adjusting SOC level in cultivating *A. muelleri*. Plant material or propagules from bulbils showed superiority over seeds and CLC in producing corms even at a 2% SOC (Table 6). CLC's ability to produce more than one corm is also an interesting finding in perspective of propagule production for subsequent farming. Planting seeds is still prospective, but maintaining 4 to 6% SOC should be considered. However, it is worth noting that increasing SOC is a big effort for farmers because higher SOC levels mean a larger amount of organic material should be incorporated to farm; see Table 1 for its illustration.

Further research is required on the role of SOC content in *A. muelleri* on a field scale with more diverse environmental conditions. In addition, Alghifari et al. (2023) recommend evaluating different SOC sources for a better understanding of SOC roles such as husk charcoal. The relationship between SOC level and soil moisture is also an interesting study aspect to sustain *A. muelleri* production under climate change conditions.

CONCLUSION

The origin of the propagules influenced the growth and yield of *A. muelleri*, where plants from bulbils produced higher growth and yields than plants originating from seeds and corm from leaf cuttings (CLC). Plants from CLC had more than one corm, in contrast to plants from seeds and bulbils, which only produced a single corm. Thus, bulbils are recommended for harvesting corm, while CLC is more recommended for planting for propagating material. The growth and yield of *A. muelleri* were determined by the SOC level. The 6% SOC-supported plants produced the highest fresh corm weight for both bulbil and CLC. Field-scale testing is highly recommended to evaluate the effectiveness of increasing SOC content commercially.

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