Application of Gibberellin Growth Regulatory Substance (GA3) and Modification of Planting Media on the Growth of Stem Tubers Porang (*Amorphophalus muelleri* Blume) Madiun Variety 1

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Abstract. The purpose of this study was to determine the effect of giving growth regulators GA3 and modification planting media on the growth of tuber stems of the porang plant Madiun variety 1. The growth parameters observed were: day of bud's emergence, the weight of porang tubers, diameter of porang tubers, plant height, stem diameter, leaf area and dry weight of porang plants. Data analysis of this study used two-way ANOVA analysis and continued with the Tukey. The results of this study showed that the treatment with ZPT GA3 60 ppm showed lower growth compared to the overall treatment. This is shown in all vegetative growth parameters: plant height (21.2 cm); stem diameter (0, 38 cm); leaf area (46.4 cm^2) and dry weight (1.32 g). While the treatment without ZPT GA3 application showed better growth with the highest average value. This is shown in the plant height (31.56); the stem diameter (0.62 cm); leaf area (70.6 cm) and the dry weight (2.71 g). Meanwhile, the parameters of tuber weight and tuber diameter of plants tended to decrease with the highest reduction values experienced by C0P4 plants, which were 66.75 gr and 2.02 cm, respectively.

1 Introduction

Introduction. Porang plant (*Amorphophallus* muelleri Blume) var. Madiun 1 is a plant that has the potential to be developed due to the increasing demand for exports. This is because porang has a high glucomannan content. Glukomaman found in porang tubers is 67%. However, porang cultivation is rarely carried out because it has a long growing period [1,2]. The propagation of porang plants usually uses bulbils, tubers and seeds. Porang tubers are single tubers which are generally smooth in texture and yellowish-orange in color [3,4]. Porang cultivation is still rarely done because of the very long growth period. The growth phase of porang is divided into 3: 1st vegetative phase which lasts 6-7 months which is marked by the emergence of shoots from tubers; vegetative phase 2 lasts for 5-6 months and the

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generative phase of porang occurs at the beginning of the rainy season [5]. One of the methods of shortening the dormancy period is by applying the growth regulator Gibberellins. Gibberellin is a growth regulator which can shorten the dormancy period. Gibberellins can stimulate seed germination, stem and root elongation and leaf expansion, flowering and fruit senescence [6]. Based on research by [7] soaking *Amorphophallus paeoniifolius* tubers with GA3 20 ppm gave a large number of shoots. Research by [8] giving GA3 a concentration of 60 ppm can provide the highest leaf area value for your plants. Research by [9] giving GA3 to soaking salak seeds with a concentration of 60 ppm for 55 minutes can increase germination and maximum growth potential, as well as increase seedling height and root length.

Another strategy that can be used to shorten the dormancy period of porang plants is to modify the planting medium. The appropriate planting medium will provide optimal growth in seeds. One of the porang planting media that can be used is a mixture of soil, husk charcoal and compost. Topsoil is the top soil layer which contains lots of high nutrients so it can provide good nutrition for plants [10,11]. Charcoal husk as a planting medium provides a balanced number of macro- and micro-pores, which results in high water absorption and air circulation [12,13]. Based on [14] it is known that the use of husk charcoal as a planting medium can affect root growth such as increasing root volume and root length [14]. Meanwhile, the addition of compost as a planting medium can help meet the nutritional needs of nutrients in plant growth so that plant development during vegetative growth can provide maximum results [15].

Porang plants require loose, fertile soil texture and high porosity in order to provide good growth. Therefore, the application of gibberellin growth regulatory substances and modification of the plant media are expected to provide better growth of porang plants.

2 Experimental details

The materials used were porang stem tubers, planting media and growth regulators (PGRs). The planting medium consists of top soil, charcoal husk and compost. The PGRs used are gibberellin. Preparation of Planting Media. The planting media used in the study were:

Media 1(P1): Top soil: Charcoal husk: Compost with a ratio of 1:1:1
Media 2 (P2): Top soil: Charcoal husk: Compost with a ratio of 2:1:1
Media 3 (P3): Top soil: Charcoal husk: Compost with a ratio of 1:2:1
Media 4 (P4): Top soil: Charcoal husk: Compost with a ratio of 1:1:2

The planting medium is put in a poly bag of 5 kg. The planting medium is placed in the *Greenhouse* according to the research layout. Preparation, Planting and Maintenance of Plants from Porang Stem Tubers. Porang tuber (*Amorphophallus muelleri* Blume) Var. Madiun 1 used as a treatment had a relatively uniform weight and diameter. Furthermore, porang stem tubers were soaked for 24 hours in a solution of Gibberellins (GA3). The GA3 solution used is 20 ppm (C1) and 60 ppm (C2) [16]. Soaking in gibberellin (GA3) aims to stimulate seed germination and accelerate germination and speed of germination [17,18,19]. Porang tubers that have been soaked with GA3 are then planted in the planting medium. Maintenance of plants is done manually by weeding the plants from weeds. Growth observations include day of shoot emergence, plant height (cm), measurement of leaf area (cm^2), stem diameter (cm)**,** plant dry weight (g) and stem tubers weight (g). The day of emergence of shoots was observed every day after planting. The stem tuber shoots that grow first are shown in Figure 1.

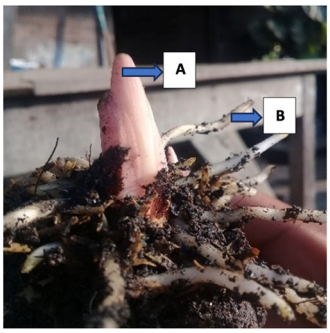

Fig. 1. Growth of Porang Stem Tubers: (A) Stem Tuber Shoots and (B) Porang Plant Roots

Measurement of plant height was carried out after 90 days after planting (DAP) by measuring the base of the stem to the tip of the stem using a ruler [20,21]. Leaf area is determined by gravimetric method. Leaves are drawn and their area is estimated on a sheet of paper by measuring the ratio of the weight of the leaf replica to the total weight of the paper with the following Equation 1 [22].

$$LD = \frac{Wr}{Wt} \times LK \quad (1)$$

Notes:
LD = Leaf area
Wr = Replica weight
Wt = Total paper weigh
LK = Paper Area

The diameter of the plant stems was measured in the final vegetative phase. Measuring stem diameter using calipers [23]. Dry weight of plants is the total dry weight of shoots and roots. The porang plant biomass in the form of shoots and roots is dried in an oven until it reaches a constant weight [24]. The fresh weight of the stem tubers was weighed using a digital scale. The tubers of porang plants are weighed in units of grams/plant [25]. The morphology of the porang stem tuber is shown in Figure 3**.**

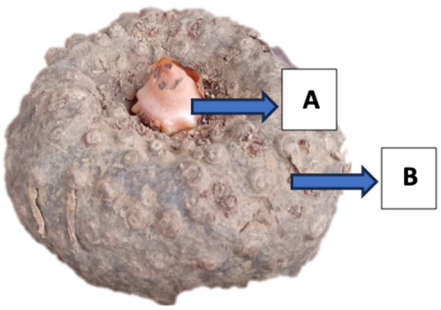

Fig. 2. Morphology of Porang Stem Tubers: (A) Buds of Stem Tubers and (B) Stem Tubers of Porang Plants

This research was arranged in a Completely Randomized Design (CRD) with a factorial pattern. The treatment used was two factors (planting medium and growth regulator) with 5 replications. The first factor is a planting medium with 4 levels (P1, P2, P3 and P4). The second factor was the application of growth regulators / PGRs with 3 levels (C0 / without PGRs), 20 ppm PGRs (C1) and 60 ppm PGRs (C2). Data were analyzed using the ANOVA test and continued with the Tukey test at the 95% level of confidence (α=0.05%).

3 Results and Discussion

3.1 The day of the emergence of the porang plant buds

The Day of the Emergence of the Porang Plant Buds. Based on the Two Way ANOVA test, it is known that the PGRs GA3 factor has a significant influence on the emergence of porang shoots with a value of p = 0.000 (p <0.05), as well as the planting media factor which also has a significant effect with a value of p = 0.035 (p <0.05) . While the interaction factor of ZPT GA3 and planting media did not have a significant effect with a p = 0.210 (p> 0.05). The average days of emergence are shown in Figure 3.

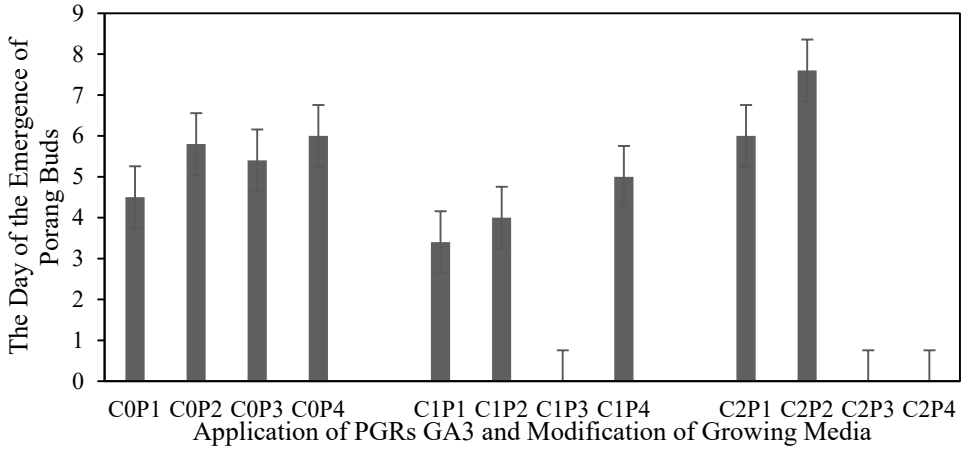

Fig. 3. The day the buds of the Porang plant (*A. muelleri* Blume) appear: C0P1 (Without PGRs with modified of growing medium ratio 1:1:1); C0P2 (without PGRs with modified of growing medium ratio 2:1:1); C0P3 (without PGRs with modified of growing medium ratio 1:2:1); C0P4 (without PGRs with modified of growing medium ratio 1:1:2); C1P1(PGRs GA3 20 ppm with modified of growing medium ratio of 1:1:1); C1P2 (PGRs GA3 20 ppm with modified of growing medium ratio 2:1:1); C1P3 (PGRs 20 ppm with modified of growing medium ratio 1:2:1); C1P4 (PGRs 20 ppm with modified of growing medium ratio 1:1:2); C2P1(PGRs GA3 60 ppm with modified of growing medium ratio of 1:1:1); C2P2 (PGRs GA3 60 ppm with modified of growing medium ratio 2:1:1); C2P3 (PGRs 60 ppm with modified of growing medium ratio 1:2:1); C1P4 (PGRs 60 ppm with modified of growing medium ratio 1:1:2).

Based on Figure 3, it is known that the application of 20 ppm PGRs GA3 gives the fastest average bud emergence value, which ranges from 3-5 days after planting. It is suspected that giving GA3 concentration of 20 ppm can accelerate the growth of porang stem tuber shoots. Gibberellin can stimulate cell division activity so that it helps cell division and the formation of genetic structures (RNA and DNA), the formation of cell and tissue structures, accelerates growth and development, and helps the process of seed germination [26]. The mechanism of GA3 in promoting cell elongation is divided into 2 ways, namely increasing auxin levels and stimulating the formation of α-amylase enzymes. In addition, Gibberellin (GA3) is a hormone capable of triggering the activity of hydrolytic enzymes such as α-amylase which is able to hydrolyze starch into glucose as a food reserve due to stimulation of respiration. Glucose is then broken down into pyruvate and enters the Krebs cycle to produce energy in the form of ATP. This energy is able to play a role in tuber metabolism so that it can accelerate the emergence of shoots on tubers [27]. Besides that, the buds that grow are also stimulated by the plant media. The fastest growth of shoot buds is by modifying the topsoil: husk charcoal: compost planting medium with a ratio of 1:1:1. This is because the composition of the planting medium is able to provide adequate conditions and nutrients to grow plant shoots.

Soil and husk charcoal have better physical properties in supporting shoot cuttings, namely providing porosity and soil aeration conditions and supported by compost content which plays a role in providing additional organic nutrients. Compost applied to the soil not only provides the nutrients needed by plants, but can also increase soil porosity, soil microbial population, infiltration and water storage capacity in the soil and increase soil fertility [28]. Plants with the application of PGRs GA3 at a concentration of 60 ppm gave the slowest shoot growth time, which ranged from 6-8 days. High concentrations of GA3 can stimulate the production of the auxin hormone. At high concentrations of auxin, it can trigger the presence of oxidase compounds such as IAA oxidase which will inhibit shoot growth [29,30]. This is in accordance with [31,32], which stated that PGRs in too high amounts would inhibit plant metabolic processes such as photosynthesis and respiration. The C1P3, C2P3 and C2P4 treatments did not form buds for 4 months. This is presumably due to the effect of soil modification with lower topsoil content. Top soil provides high levels of nutrients compared to compost or husk charcoal. Porang plants are plants that require high levels of nutrients, especially in tuber formation [33].

3.2 Weight and diameter of porang plant stem tubers

Weight and Diameter of Porang Plant Stem Tubers**.** Tuber weight is one of the most important parameters in the success of the crop production process. In this study, the initial and final tuber weight measurements were carried out to see the differences that occurred before and after planting. Based on the measurements, it is known that the weight of the tubers tends to shrink, so an analysis of the reduction in tuber weight is carried out. Based on the Two-Way ANOVA test, it is known that the planting media factor has a significant effect on reducing tuber weight with a value of $p = 0.047$ ($p < 0.05$). Meanwhile, the PGRs GA3 factor did not have a significant effect with a value of $p = 0.064$ ($p > 0.05$). Likewise, the interaction factor of PGRs and planting media did not have a significant effect with a value of $p = 0.073$ ($p > 0.05$). The average initial and final tuber weight is shown in Figure 4.

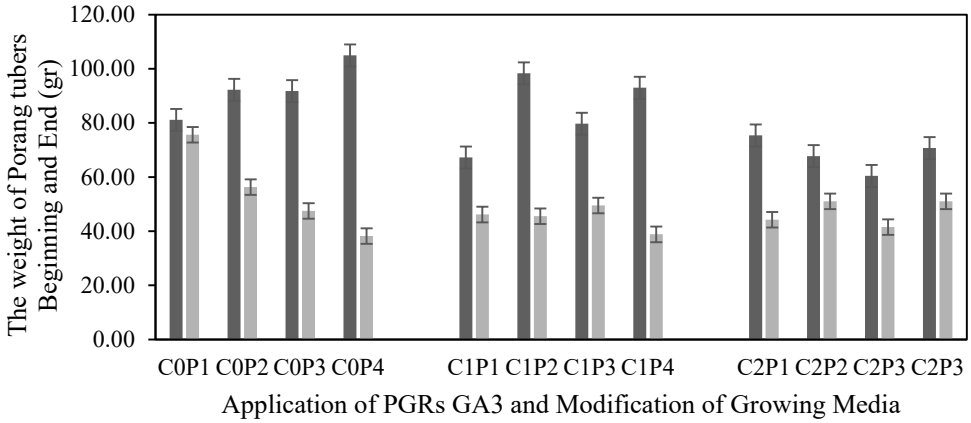

Fig. 4. The weight of Porang tubers (*A. muelleri* Blume) Beginning and End: C0P1 (Without PGRs with modified of growing medium ratio 1:1:1); C0P2 (without PGRs with modified of growing medium ratio 2:1:1); C0P3 (without PGRs with modified of growing medium ratio 1:2:1); C0P4 (without PGRs with modified of growing medium ratio 1:1:2); C1P1(PGRs GA3 20 ppm with modified of growing medium ratio of 1:1:1); C1P2 (PGRs GA3 20 ppm with modified of growing medium ratio 2:1:1); C1P3 (PGRs 20 ppm with modified of growing medium ratio 1:2:1); C1P4 (PGRs 20 ppm with modified of growing medium ratio 1:1:2); C2P1(PGRs GA3 60 ppm with modified of growing medium ratio of 1:1:1); C2P2 (PGRs GA3 60 ppm with modified of growing medium ratio 2:1:1); C2P3 (PGRs 60 ppm with modified of growing medium ratio 1:2:1); C1P4 (PGRs 60 ppm with modified of growing medium ratio 1:1:2)

Based on Figure 4, it is known that the highest tuber weight shrinkage was the C0P4 treatment. The high shrinkage is thought to be due to reduced photosynthate results transferred to the tubers. The low photosynthate yield is thought to be due to the use of compost that is too high. Compost in the planting medium causes the pH of the soil to become acidic, thereby disrupting the growth process of the porang plant. In addition, compost can also cause a soft soil texture which causes plant roots to become weak so that the absorption process of nutrients needed for photosynthesis is disturbed [34]. Low nutrient supply will reduce photosynthate which ultimately transports photosynthate to the tubers a little, so that the size of the tubers is small. The shape of the small tubers greatly influences the development of the plant [35]. Meanwhile, the lowest tuber weight loss was found in the C0P1 treatment. This is presumably due to the modification of the planting media that was carried out to be able to provide optimal nutrients for porang plants. The use of topsoil is able to fulfill nutrients for porang plant growth because it has sufficient mineral and organic materials for plants [36]. In addition, the addition of husk charcoal is able to create a number of macro and micro pores, so that it has good water absorption and aeration [37]. On the other hand, the addition of compost can spur the development of microorganisms in the soil [38]. Thus, the modification of the right planting media is able to meet the nutritional needs of plants [39]. Porang plant vegetative growth includes plant height, leaf area and stem diameter. Plant height is growth related to the growth of stems and leaves of plants [42]. The average yield of porang plant vegetative growth is shown in Figure 5.

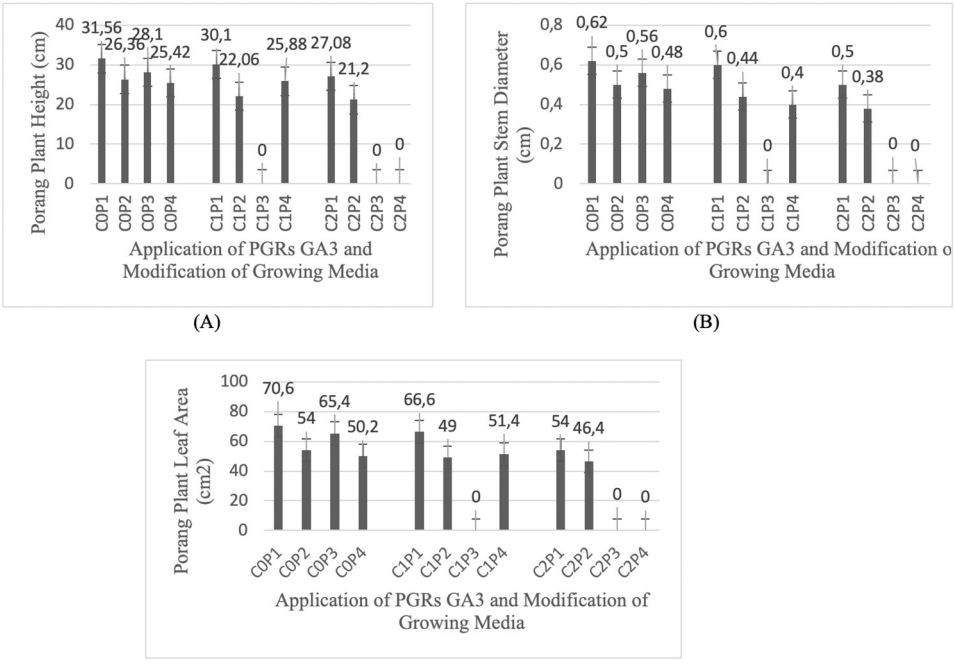

Fig. 5. Vegetative growth of 4-month-old Porang (*A. muelleri* Blume) plants including: (A) Plant height; (B) Stem diameter; (C) Leaf Area: C0P1 (Without PGRs with modified of growing medium ratio 1:1:1); C0P2 (without PGRs with modified of growing medium ratio 2:1:1); C0P3 (without PGRs with modified of growing medium ratio 1:2:1); C0P4 (without PGRs with modified of growing medium ratio 1:1:2); C1P1(PGRs GA3 20 ppm with modified of growing medium ratio of 1:1:1); C1P2 (PGRs GA3 20 ppm with modified of growing medium ratio 2:1:1); C1P3 (PGRs 20 ppm with modified of growing medium ratio 1:2:1); C1P4 (PGRs 20 ppm with modified of growing medium ratio 1:1:2); C2P1(PGRs GA3 60 ppm with modified of growing medium ratio of 1:1:1); C2P2 (PGRs GA3 60 ppm with modified of growing medium ratio 2:1:1); C2P3 (PGRs 60 ppm with modified of growing medium ratio 1:2:1); C1P4 (PGRs 60 ppm with modified of growing medium ratio 1:1:2)

Based on the Two-Way ANOVA test, it was found that the application factor of PGRs GA3 and the planting media modification factor had a significant effect on plant height, stem diameter and number of leaves. Meanwhile, the interaction of PGRs and growing media had no effect on the vegetative growth of porang plants. Based on Figure 4.6 the highest vegetative growth of porang plants including plant height, stem diameter and leaf area was found in the C0P1 treatment. This is presumably due to modification of the planting medium with a ratio of 1:1:1 which is the optimal composition in terms of nutrient content, aeration, texture and soil structure. According to [43] reported that topsoil media : rice husk charcoal: manure with a composition of 1:1:1 gave the best growth in height and diameter of potato tillers. The top soil layer contains lots of nutrients and organic matter which causes plants to grow well [44]. Modification of the planting medium using rice husk charcoal can maintain humidity in the area around the roots so that it can maintain the absorption of nutrients by plants [45]. In addition, husk charcoal as a planting medium can improve soil porosity and moisture which can encourage the growth of microorganisms that are useful for soil and plants [46]. The use of compost as a planting medium is able to increase nutrients which are useful for plant height growth [47]. In addition, compost will improve the physical properties of the soil which causes the soil to become loose [48]. Compost contains nitrogen (N) which can stimulate plant growth, especially stems, branches and leaves. The elements N, P, K contained in this planting medium can facilitate plant metabolic processes and the rate of photosynthesis [49]. Element K in the planting medium functions as an activator of photosynthesis, translocation of sugars, maintains turgor, stimulates root formation [50].

In the treatment that was given the application of PGRs GA3, vegetative growth tended to be lower than the control. Plant growth is controlled by endogenous hormones, so that PGRs GA3 will interact with endogenous hormones in plant metabolic processes. When interacting there is an adjustment of endogenous hormones with exogenous hormones that determine the success of induction. Based on research by [51] stated that giving GA3 50 ppm did not have a real effect on the growth of green beans. This is presumably because the hormone GA3 has not been able to interact with endogenous plant hormones. In addition, hormones affect the response in many parts of the plant, but the response depends on the plant species, hormone concentrations and the phase of plant development. In treatment C1P3, C2P3 and C2P4 did not experience growth. This is presumably because the presence of the endogenous hormone gibberellins in the tubers is sufficient so that the administration of exogenous gibberellin hormones can inhibit the growth of porang tubers [52]. According to [53] that growth regulators can work effectively at certain concentrations where it is said that concentrations that are too low are not effective in stimulating growth and high concentrations can inhibit plant growth. Modification of the growing media with an unequal ratio causes lower growth. This can be seen in the C1P3 and C2P3 treatments. In the treatment containing more rice husk charcoal, the porosity of the planting medium becomes large enough so that the planting medium quickly allows water to pass through and the plants tend to experience a lack of water to sustain their growth [54]. The C2P4 treatment had the most compost content. Growing media that contains higher compost causes soil acidity to occur more quickly [55]. In addition, if a growing medium has an unbalanced ratio of nutrients, it will result in immobilization of nutrients so that the levels of nutrients that can be used by plants are reduced [56].

The dry weight of plants is an indication of the success of plant growth, because dry weight is an indication of plant metabolic activity after the water content has decreased (Alius et al., 2017). Based on the Two-Way ANOVA test, it was found that the interaction of PGRs GA3 and planting media had a significant effect with a value of $p = 0.009$ ($p>0.05$). The average dry weight of porang plants is shown in Figure 6.

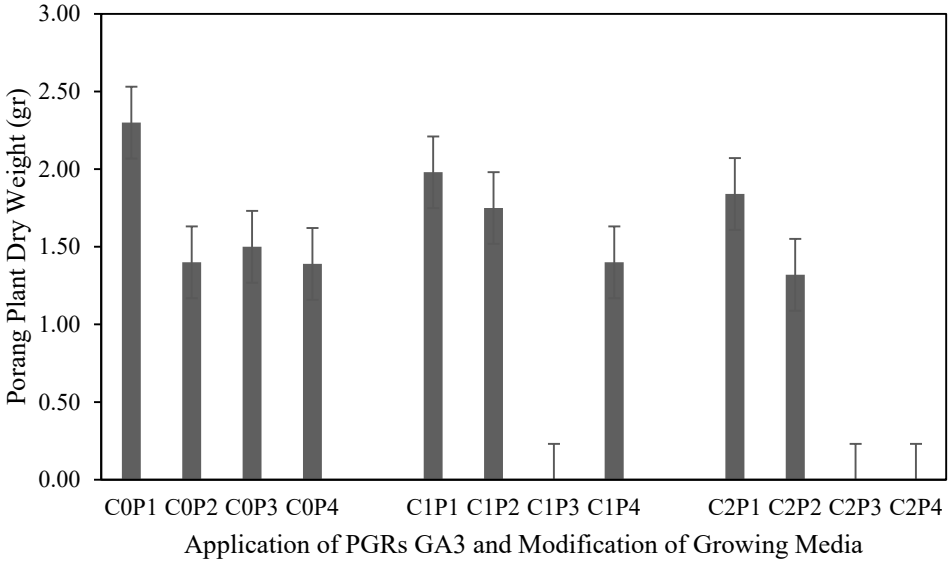

Fig. 6. Dry weight of porang plants (*A. muelleri* Blume) 4 months old: C0P1 (Without PGRs with modified of growing medium ratio 1:1:1); C0P2 (without PGRs with modified of growing medium ratio 2:1:1); C0P3 (without PGRs with modified of growing medium ratio 1:2:1); C0P4 (without PGRs with modified of growing medium ratio 1:1:2); C1P1(PGRs GA3 20 ppm with modified of growing medium ratio of 1:1:1); C1P2 (PGRs GA3 20 ppm with modified of growing medium ratio 2:1:1); C1P3 (PGRs 20 ppm with modified of growing medium ratio 1:2:1); C1P4 (PGRs 20 ppm with modified of growing medium ratio 1:1:2); C2P1(PGRs GA3 60 ppm with modified of growing medium ratio of 1:1:1); C2P2 (PGRs GA3 60 ppm with modified of growing medium ratio 2:1:1); C2P3 (PGRs 60 ppm with modified of growing medium ratio 1:2:1); C1P4 (PGRs 60 ppm with modified of growing medium ratio 1:1:2)

Based on Figure 6, the C0P1 treatment had the highest average dry weight of plants. It is suspected that the endogenous hormones in porang plants can stimulate plant growth. Endogenous hormones such as auxins, cytokinins and gibberellins play a role in plant growth and development. The physiological roles of auxins, cytokinins and gibberellins include encouraging cell elongation, cell division, apical dominance, xylem phloem tissue differentiation and stimulating root formation [57]. Modification of the planting medium is also able to meet the nutrition of porang plants to grow. According to [58] that the combination of soil : husk charcoal: compost with a ratio of 1:1:1 is able to provide the best results for the growth and production of tomato plants. Topsoil has good water holding capacity and nutrients. The addition of husk charcoal to the planting medium can improve soil structure to increase water absorption and facilitate root growth [59]. Rice husk charcoal has many pores which can increase aeration, as well as high porosity. This property is thought to make it easier for roots to penetrate the media and the root elongation area will be larger and can accelerate root development [60]. Roots can play a role in the absorption of nutrients and water in the soil, then the roots continue to grow thereby affecting the weight of the roots. Besides that, the addition of compost plays a role in increasing soil organic matter. Particles of organic matter from a planting medium are constituents of the pore space which functions as a source of water and air, as well as a space for roots to penetrate. The more pore space will be able to expand the root system and the roots can more easily absorb nutrients and water in the soil, but the less pore space, the root development will be hampered. This characteristic is very important for seedling roots because it is closely related to the physical, chemical and biological properties of plant roots [61]. The lowest average dry weight was shown in the C2P2 treatment. In addition, the application of PGRs GA3 caused several

treatments to not be able to grow, such as C1P3, C2P3 and C2P4. It is suspected that the addition of GA3 of 20 ppm and 60 ppm can increase the concentration of the endogenous hormone gibberellin which in turn suppresses other hormones thereby inhibiting plant growth. In addition, modification of the planting medium with an unequal ratio where there is more husk charcoal and compost cause the growth of plants to be stunted. This is thought to occur due to the presence of a high compost composition which can cause the media to become moister and retain excess water, so that plant roots will become soft and weak. This is in accordance with the statement from [34] that adding too much compost can cause plant roots to become weak. The soil will be very soft and contain more nitrogen, plant height growth will be compromised, and the plant may not grow firmly in the soil. The high composition of husk charcoal is also thought to cause the media to not be able to hold enough water due to its porous nature so that the media does not have enough water and the tubers are unable to continue growing up to the canopy.

4 Conclucion

The growth of porang stem tubers was affected by the application of PGRs GA3 and modification of the planting medium. The best treatment for porang plant growth was the C0P1 treatment (without the application of PGRs GA3 with modified planting media, top soil: husk charcoal: compost with a ratio of 1:1:1), as follows: (1) Days of emergence of Shoots: 4 days; **(**2) The lowest shrinkage of tubers: 5.51gr; (3) Reduction of the lowest tuber diameter of 1.08 cm; (4) Highest plant height: 31.56; (5) Leaf Area: 70.6 Cm^2; (6) Dry weight: 2.71 gr.

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