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Study of Paclobutrazol Dosage and Seed Size on Growth and Yield of Porang (*Amorphophallus onchophyllus* P.)

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ABSTRACT

The konjac plant (Amorphophallus oncophyllus Prain.) contains high glucomannan with many benefits. This experiment aimed to study effect of paclobutrazol dose and seedling size on the growth and yield of konjac plants. The research was arranged factorially based on a Completely Randomized Design with two factor. The first factor (paclobutrazol dose) consisted of P0: 0.0 g/plant, P1: 0.05 g/plant, P2: 0.10 g/plant, P3: 0.15 g/plant, P4: 0.20 g/plant. The second factor (seed size) consisted of U1: 20-50 g/seed, U2: 100-150 g/seed, U3: 200-250 g/seed. Observation parameters included plant height, canopy diameter, stem diameter, stem sturdiness, number of buds, weight and diameter of tubers. Results showed that paclobutrazol dose of 0.20 g/ plant had a significant effect on stem sturdiness, weight and diameter of the tubers. The maximum of tuber weight obtained by paclobutrazol application of 0.2 g/plant was estimated to be 1,533 g with tuber diameter of 167 mm. Small size seed (20-50 g) produced the largest number of buds and did not differ markedly from those of medium size seed (100-150 g). Large size seed (200-250 g) produced the best konjac plants in term of canopy diameter, stem sturdiness, weight and diameter of tubers.

1. INTRODUCTION

The porang or konjac plant (*Amorphophallus oncophyllus* Prain.) is a herbaceous plant with a plant height of up to 1.5 m (Fernida, 2009) and produces tubers. As one of the biological riches of tubers in Indonesia, porang plants are cultivated on Perhutani land under industrial forest stands (Wahyuningtyas *et al.* 2013) and have the advantage of being a producer of carbohydrates, fats, proteins, minerals, vitamins, and food fiber or glucomannan. The primacy of the food fiber content makes the porang plant very potential to be developed as an export commodity (Indriyani & Widoretno, 2016).

Exports of porang as food and industrial raw materials have increased in recent years, because porang tubers have a higher glucomannan content than other tubers. This

commodity farming business generates quite high economic value due to significant export demand. Porang-based products, especially noodles, tofu, similar rice, and glucomannan flour are preferred by the Japanese (Hidayat *et al*., 2012). The high potency of porang has caused many farmers to cultivate it intensively in open land. Madiun, Trenggalek and Ponorogo Regencies are the areas with the largest porang cultivation area in Indonesia.

The active growth period of porang plants depends on the length of the rainy season with average range of 4-5 months, while during the dry season, porang plants experience a period of dormancy. Dormancy is the period when plants experience translocation of assimilate products from leaves and stems to other organs, such as tubers and bulbils ("frogs"). The short period of active growth makes it difficult to increase productivity (Hidayat *et al*., 2013). One of the efforts to increase the productivity of porang plants is by using paclobutrazol growth regulator.

Cultivation of porang plants can be done using several sources of seeds and one of them is tubers (whole tubers that are in the ground). Procurement of porang tubers as a source of seeds requires a large amount of money. For this reason, it is necessary to study the right tuber size to reduce the cost of procuring seeds so that they are cheaper, but produce high production tubers. Large tubers certainly have a better effect on plant growth and yield compared to seed sources with medium or small tubers.

The size of tubers as seeds affects the productivity of plants. The larger the tuber size for seeds will increase the plant height (pseudo stem) and tuber yield. Hopkin & Norman (2004) explained that during metabolic processes, carbohydrates in food storage are converted into energy by amylase enzymes, which are transferred to meristematics and used for plant growth. Saleh *et al.* (2015) stated that in porang plants, tubers measuring of 200 g are sufficient to be used as seeds and can produce tubers of more than 500 g.

Application the right dose of paclobutrazol can effectively inhibit growth and maximize tuber development. This is because paclobutrazol is a plant regulator that effectively suppresses meristem growth by inhibiting gibberellin synthesis (Widaryanto *et al.* 2011) and suppressing cell elongation in porang plants, thereby increasing yields. Paclobutrazol effectively regulates plant growth by suppressing excessive shoot growth and increasing tuber yield. If the plant has produced maximum canopy growth in producing food, then vegetative growth should be stopped and assimilates is translocated towards tuber enlargement so as to maximize plant yield. Inhibition of gibberellin production results in cell division, but new cells do not elongate (Sambeka *et al.* 2012). This is supported by the research of Esmaielpour *et al.* (2011) that paclobutrazol reduced plant height, tuber formation time, root dry weight and stem diameter, but increased leaf dry weight and potato tuber dry weight.

The application of paclobutrazol on different sizes of seed tubers is expected to have a different effect on the yield of porang plants. Large seed tubers give maximum results, but the application of paclobutrazol can intensify the growth and yield of tubers from small and medium sized seeds. The purpose of this study was to determine the effect of paclobutrazol dosage and tuber size of porang seeds on vegetative growth and yield of porang plants.

2. MATERIALS AND METHODS

The research was conducted on land located in Krandang hamlet, Sawahan village, Madiun district, East Java at an altitude of ±100 m asl, with latitude and longitude

coordinates of -7.54967 S, 111.54365 E, average annual rainfall 2,000 mm/y, temperature 20 – 35 ℃, and humidity 60-78%. Research began in December 2021 until May 2022.

2.1. Design of Experiment

This research was a factorial study consisting of 2 (two) factors Completely Randomized Design (CRD). The first factor is the dose of paclobutrazol, which consists of 5 (five) levels, including P0 (Control, 0.0 g/plant), P1 (0.05 g/plant), P2 (0.10 g/plant) (Suwinda, 2019), P3 (0.15 g/plant) (Rahayu *et al.*, 2018), and P4 (0.20 g/plant) (Anggraeni *et al.*, 2015). The second factor is the size of the porang seed tubers (U), which consists of 3 (three) levels, including U1 (small size, 20-50 g/seed) (Arifin *et al.*, 2014), U2 (medium size, 100-150 g/seed) (Dewi, 2020), and U3 (large size, 200-250 g/seed) (Saleh *et al.*, 2015). The combination of these two factors resulted in 15 (fifteen) combination treatments and each combination treatment was replicated 3 (three) times and each experimental unit was observed as many as 4 sample plants.

2.2. Research Procedures

The implementation of the research began with the selection of seed tuber planting materials. The seed tubers were obtained from porang farmers in Kepel village, Kare sub-district, Madiun Regency and the seeds were selected based on the predetermined size. The seed tubers were selected from good, whole tubers. Other criteria for the selected tubers were healthy, the skin is intact, not peeling, and not moldy. The seed tubers was then classified based on weight, namely small seed tubers (20-50 g), medium seed tubers (100-150 g), and large seed tubers (200-250 g) (Figure 1). During storage, the seeds should not be piled up.

Figure 1. The size of porang tuber seeds

Preparation for planting begins with preparing the land and arranging polybags with a spacing of 40 x 40 cm. Each block is separated by a 60 cm wide space. Paranets are installed on the land to reduce direct solar radiation. The planting medium is prepared by mixing soil, compost and animal manure for cows and goats with a ratio (1:1:1). Then put the planting medium into a polybag as much as 3/4 of the full size. Planting is done by placing the tuber seeds one by one into a polybag which already contains planting media with the buds facing upwards. Application of paclobutrazol on porang plants is done by dissolving paclobutrazol liquid in distilled water. Watering was divided into two application times, namely at the age of 12 weeks after planting and 13 weeks after planting. Paclobutrazol solution is given to plants by sprinkling it on the planting medium (soil drench).

Plant maintenance included watering, replanting (for porang plants that grow abnormally, die or do not grow until 2 weeks of age), removal of weedy plants growing around the porang plants. NPK fertilization was carried out 2 times, namely at the age of 30 days after planting (DAP) and 60 DAP at a rate of 15 g/plant. Bedding was performed when the porang plants have buds and were experiencing high growth. Pest and disease control was carried out by spraying insecticides and fungicides. Harvesting was done after the plants enter a dormant period which was marked by the falling of the stems, yellowing of the leaves, the plants drying out to brown. Observation parameters include:

1) Plant height (cm): measurements were taken using a tape measure on the highest stem starting from the base of the stem to the branching point.
2) Leaf canopy diameter (cm): measurements were made using a tape measure on the widest leaf canopy.
3) Stem diameter (mm): measurements were made using calipers on the stem with a height of 10 cm from the base of the stem.
4) Stem sturdiness (Likert scale): observations were made by categorizing the appearance of all stems in one polybag based on the criteria of the Linkert scale that had been made based on direct observations in the study area. The scores obtained are then averaged. The Linkert scale criteria for porang stem robustness according to Hidayah et al. (2022) are as follows:
   a) Score 1 (not sturdy): the stem bends easily when exposed to rain or wind and does not straighten again, the stem is not perpendicular or the stem is tilted, the diameter of the stem at the base is smaller than the tip, and the stem collapses the fastest with an active period < 120 DAP.
   b) Score 2 (quite sturdy): the stem bends easily when exposed to rain or wind but returns to being straight again, the lower stem is perpendicular, but the upper part is slightly curved, the diameter of the stem at the base and the top is almost the same.
   c) Score 3 (sturdy): the stem does not bend easily and remains upright even though it is exposed to rain or rather strong winds, the lower stem is upright, but the upper part is slightly slanted, and the diameter of the stem at the base is slightly larger than that of the top.
   d) Score 4 (more sturdy): the stem remains upright even though it is exposed to rain or a rather strong wind, the stem is perpendicular from the base to the top, the diameter of the large stem is at the base and the higher it gets smaller.
   e) Score 5 (very sturdy): the position of the stem remains upright even though it is exposed to rain and strong winds, the stem is perpendicular from the base to the top, the diameter of the stem is large at the base and getting smaller and higher, and the stem lays down the longest with an active period >162 DAP.
5) Number of shoots (buds): calculated from the number of stems that grow from the bulbs planted during the growth period.
6) Tuber weight (g) : measurement was carried out immediately after harvest after the tubers were cleaned of dirt and dry roots. Tuber weight was measured by weighing tuber weight using a digital scale.
7) Tuber diameter (mm): tuber diameter was measured using a caliper and the part measured was the part of the tuber with the longest diameter.

2.3. Data analysis

Research data were analyzed using analysis of variance (ANOVA). If the ANOVA produces a significant effect, then proceed with the Least Significant Difference (LSD)

test at the 5% level to determine the difference between treatments. Simple linear regression analysis was performed to determine how far the effect of paclobutrazol dose and seed tuber size had on the growth and yield of porang plants.

3. RESULTS AND DISCUSSION

3.1. Plant height

The paclobutrazol dose treatment did not significantly affect plant height, however, the treatment of seed size had a significant effect on plant height at all ages of observation. Medium sized seed tubers (100-150 g) showed porang plant height which was significantly different from small seed tubers (20-50 g), but not significantly different from large seed tubers (200-250 g). Plant height resulted from small size seeds was not significantly different from that of large seed tubers (Table 1).

Table 1. Effect of paclobutrazol dosage and seed size on porang plant height at age 14 to 20 WAP

Treatment	Plant height (cm)			
	14 WAP	16 WAP	18 WAP	20 WAP
Paclobutrazol dose (g/plant)				
Control	121.91	127.04	128.47	128.47
0.05	121.85	126.18	126.23	126.23
0.10	121.63	124.85	125.09	125.09
0.15	121.28	123.17	123.88	123.88
0.20	121.06	122.52	122.87	122.87
Seed size (g/seed)				
20-50	116.13 a	117.86 a	118.22 a	118.22 a
100-150	126.98 b	130.32 b	131.31 b	131.31 b
200-250	121.52 ab	126.08 ab	126.41 ab	126.41 ab

Note : The mean numbers followed by the same lowercase letters in the same column and treatment were not significantly different in the 5% of LSD test.

Medium-sized seed tubers produce better growth in plant height because the buds of seed tubers are still relatively young, so they are still actively dividing and growing when the environment and internal factors are in a favorable condition. The same thing happened to the small seed tubers, which showed growth that was not significantly different from the large tubers. Medium and small seed tubers are able to grow almost the same as large tubers because the embryos in the buds are still young to carry out maximum cell division. The size of the seed tuber only affects the food reserves used during early growth and embryo maturity at the point of growth. The size of the seed tubers will affect the supply of nutrients used in the formation of vegetative periods such as buds, roots, stems and subsequent growth. Plant height growth of medium-sized seed tubers on the second bud of seed tubers grows very fast and is bigger than the first shoot. The results of photosynthesis are used by plants for cell division such as enlargement of the vegetative organs at the beginning of the vegetative phase. Addai & Scott (2011) suggested that in vegetative propagation, initial growth and development are affected by the amount of food stored in the tubers. Jedeng (2011) stated that the size of seed tubers is related to their protein content and seed size affects the speed of growth and production.

The dose of paclobutrazol did not significantly affect plant height, but tended to reduce porang plant height up to 0.20 g/plant. The paclobutrazol dose of 0.20 g/plant was applied to porang plants aged 3 months, when the porang plants had passed the peak of the fast (exponential) vegetative growth period. According to Kumalasari *et al.* (2019), the log or exponential phase is the phase where growth reaches its maximum, cells actively divide and experience elongation. In this case, paclobutrazol has not been able to significantly inhibit the growth rate of stems and leaves.

3.2. Leaf Canopy Diameter

The dose of paclobutrazol did not significantly affect the diameter of the porang leaf canopy, however, the treatment of seed tuber size had a significant effect on the leaf canopy diameter at all ages of observation. Large seed tubers (200-250 g) produced a wider leaf canopy diameter and were significantly different from the other seed size (Table 2).

Table 2. Effect of paclobutrazol dosage and tubers size on leaf canopy diameter of porang plants age 14 - 20 WAP

Treatment	Leaf Canopy Diameter (cm)			
	14 WAP	16 WAP	18 WAP	20 WAP
Paclobutrazol dose (g/plant)				
Control	116.65	116.98	118.57	118.57
0.05	116.32	116.92	117.12	117.12
0.10	115.80	116.32	116.35	116.35
0.15	114.69	116.17	116.28	116.28
0.20	113.25	115.64	115.71	115.71
Seed size (g/seed)				
20-50	105.79 a	107.01 a	107.17 a	107.17 a
100-150	116.23 b	117.77 b	118.76 b	118.76 b
200-250	124.01 c	124.44 c	124.49 c	124.49 c

Note : The mean numbers followed by the same lowercase letters in the same column and treatment were not significantly different in the 5% of LSD test.

Large seed tubers produce a wider leaf canopy diameter than other seed sizes. This is because the large seed tubers have a larger food supply as compared to the smaller seed s. The size of the seed tubers acts more as a food reserve to ensure or guarantee that the plant seeds grow well because they are supported by sufficient or excess food reserves. The high carbohydrate content in tubers produces higher energy to spur plant growth. Planting porang using large seed tubers besides the availability of food reserves is higher, also the embryos at the buds are more mature. According to the statement of Arifin *et al.* (2014), large tuber size affects plant vegetative growth. According to Farida (2018), the peak of seed viability is reached when the seeds are physiologically ripe. Seed tubers taken at the physiological maturity level have high growth potential, germination, and growth strength.

The diameter of the leaf canopy is better for large seed tubers because they have an average of only 1 (one) bud, so that the growth of the leaf canopy on the main shoot is more optimal and produces a wider leaf canopy diameter than the leaves produced from medium-sized seedlings and small. Small and medium sized seed tubers tend to

produce more than one bud causing the available food reserves to be divided for use in the growth of other shoots, so that the ability of plant leaves to receive light as a photosynthetic process is less than optimal. According to Zaini *et al.* (2017), buds that grow faster and earlier will inhibit the growth of other buds due to competition between buds.

The diameter of the leaf canopy in plants can affect physiological processes in plants, because the largest organ in the canopy is the leaf and is related to the process of plant photosynthesis. Santrum *et al*. (2021) stated that the wider the leaf, the more chlorophyll it contains, so that photosynthesis will take place faster. The faster the rate of photosynthesis, the faster the plant grows and produces. The wider diameter of the plant leaf canopy will receive wider light so that more photosynthetic is produced. The resulting photosynthesis is rearranged by the process of respiration to produce energy needed by cells to carry out activities such as cell division and enlarging plant parts.

The dose of paclobutrazol did not significantly affect the diameter of the leaf canopy of the plants, but tended to reduce the diameter of the porang leaf canopy up to 0.20 g/plant. Paclobutrazol did not significantly affect growth inhibition because paclobutrazol only had an effect on tuber formation in the soil because it was absorbed directly by the roots of the porang plant compared to the absorption of paclobutrazol by the top of the porang plant.

3.3. Stem Diameter

The paclobutrazol dose treatment had no significant effect on porang stem diameter, however the treatment of seed size had a significant effect on stem diameter at all ages of observation. Medium-sized seed tubers (100-150 g) produced larger stem diameters and were significantly different compared to the small tuber treatment (20-50 g), but not significantly different from large tubers (200-250 g). In addition, stem diameter resulted from small size seeds (20-50 g) was not significantly different from that of large seed tubers (Table 3).

Table 3. Effect of paclobutrazol dosage and seed size on stem diameter of porang plants at age 14-20 WAP

Treatment	Stem Diameter (cm)			
	14 WAP	16 WAP	18 WAP	20 WAP
Paclobutrazol dose (g/plant)				
Control	72.48	73.31	73.76	73.76
0.05	69.86	70.62	70.95	70.95
0.10	68.88	69.43	69.48	69.48
0.15	68.50	69.01	69.23	69.23
0.20	68.50	69.00	69.33	69.33
Seed size (g/seed)				
20-50	58.97 a	59.64 a	60.15 a	60.15 a
100-150	78.50 b	78.96 b	79.16 b	79.16 b
200-250	71.46 ab	72.23 ab	72.35 ab	72.35 ab

Note : The mean numbers followed by the same lowercase letters in the same column and treatment were not significantly different in the 5% of LSD test.

The insignificant different of stem diameters resulted from medium and small seed tubers as compared to those of large seed size indicate that there is a fast plant growth rate on small and medium seed size because the cells are still actively dividing with the favourable environmental conditions. If the buds in one plant are averaged, medium-sized seed tubers produce a larger stem diameter because there is more than one buds, compared to large tubers which tend to produce only one stem. Based on observations in the field, this was due to the buds from small and medium seed tubers appear relatively faster than those of large seed size. In addition, the two seed size were able to produce very fast second bud growth and were bigger than the first bud. According to Hijra *et al*. (2021), the availability of a suitable food supply promotes rapid initial growth.

The use of medium-sized seed tubers is sufficient to provide food reserves for the maximum growth phase. The bigger the stem, the greater the plant absorbs the nutrients and water needed to support growth and development. According to the statement of Supriyono *et al*. (2022), the larger the stem diameter, the better and optimal the growth is because the stem is an organ that distributes nutrients from the roots to the leaves, as well as distributes photosynthetic results to all plant tissues. This allows plants derived from medium-sized seed tubers to carry out the photosynthesis process earlier, so that more photosynthetic results are obtained. At the beginning of the vegetative phase, the results of photosynthesis are used by plants for cell division such as enlargement of the vegetative organs. The use of medium-sized seed tubers with the availability of sufficient food reserves can increase the percentage of growing seeds.

Doses of paclobutrazol up to 0.20 g/plant did not show a significant effect on stem diameter, however, there was a tendency for porang stem diameter to decrease. Paclobutrazol has more influence on the formation of tubers that are in the soil and is related to accelerating the sinking process of porang plants. According to Mastur (2015), one of the physiological approaches to increase plant productivity is to use the concepts of sources and sinks. The source is an organ or tissue that produces or exports photosynthate, while the sink is an importer or recipient of photosynthate. Based on this study, the main sources of porang are the canopy of leaves and stems, while the main sinks of porang are tubers (in the ground) and bulbils or "frogs" (round-shaped brown lumps that grow on the leaves).

3.4. Number of Buds

The paclobutrazol dose treatment had no significant effect on the number of buds, however the treatment of the seed size had a significant effect on the number of buds of porang plants. Small seed tubers (20-50 g) produced more bud and but not significantly different from the treatment of medium sized seed tubers. It, however, significantly different from that of large seed size tubers (200-250 g) (Table 4).

Small and medium sized seed tubers showed higher bud numbers and were significantly different from the treatment of large seed size tubers. Gusmalawati (2013) stated that in porang plants there is a polyembryonic phenomenon. Polyembryony occurs when there is more than one embryo in one planted seed (Nugroho *et al*. 2006). The number of buds produced by small size seed tubers is greater because the embryos on the buds are still relatively young, so they have many active embryos to produce prospective new buds and are able to provide a fast growth rate. According to the statement of Ichsan *et al*. (2013), small seed tubers have an imbibition stage that is completed more quickly so that they can immediately continue the activation and growth stages. This is supported by the statement of Turhadi & Indriyani (2015) where

seeds from large tubers tend to grow only one bud. The main growing point of large seed tubers is located in the center which protrudes inward so that it takes longer for large tuber seeds to grow buds to the soil surface. Meanwhile, the growth of buds appear from small seed tubers is faster than those of the large seed tubers which tend to take a little longer. According to Sumarwoto (2004), seedlings that grow earlier will cause faster growth than seedlings that grow slower. This causes the small size seed tubers to be able to support the growth of early buds faster and provide opportunities for faster root formation.

Table 4. Effect of paclobutrazol dose and seed size on the number of bud of porang plants

Treatment	Number of Buds
Paclobutrazol dose (g/plant)	
Control	1.92
0.05	1.86
0.10	1.78
0.15	1.78
0.20	1.78
Seed size (g/seed)	
20-50	2.13 b
100-150	1.98 b
200-250	1.35 a

Note : The mean numbers followed by the same lowercase letters in the same column and treatment were not significantly different in the 5% of LSD test.

3.5. Stem Sturdiness

The paclobutrazol dose of 0.20 g/plant produced porang stems that were stronger and significantly different from other treatments. There was an increase in the sturdiness of the stems of porang plants due to the effect of the 0.20 g/plant dose of paclobutrazol by 34.43% compared to the control. Meanwhile, the large porang seed size (200-250 g) produced sturdier stems and was significantly different from other seed size treatments. There was an increase in the sturdiness of the stems of porang plants due to the effect of the treatment of large seed tubers by 16% compared to the treatment of small seed tubers and 17% compared to medium seed tubers (Table 5).

Table 5. Effect of paclobutrazol dose and seed size on stem vigor of porang plants

Treatment	Stem sturdiness
Paclobutrazol dose (g/plant)	
Control	3.02 a
0.05	3.19 b
0.10	3.22 b
0.15	3.56 c
0.20	4.06 d
Seed size (g/seed)	
20-50	3.25 a
100-150	3.21 a
200-250	3.77 b

Note : The mean numbers followed by the same lowercase letters in the same column and treatment were not significantly different in the 5% of LSD test.

Paclobutrazol dose of 0.20 g/plant produced stronger stems. This is because paclobutrazol inhibits overgrowth of plants. This statement is supported by Wijana *et al*. (2015), where application of paclobutrazol can divert the use of carbohydrates which were originally used for vegetative growth, but are then allocated for the formation of tuber weight and tuber diameter. Thus, this inhibition process causes an ideal plant growth rate based on the physical sturdiness of the porang plant and the resistance of the stems to withstand wind speeds and high rainfall.

Large size seed tubers produce stronger stem growth than other seed size tubers. Stem sturdiness is a variable related to the quality of the porang plant which is assessed based on the established Likert scale. The significant difference in the sturdiness of porang stems is due to the balanced height and stem diameter supported by their physical appearance. As explained by Junaedi *et al*. (2010) that plant vigor is determined by the magnitude and variation of plant height and stem diameter. However, when viewed numerically, the plant height and the stem diameter do not guarantee or ensure that the sturdiness of the resulting stem will be good either. The use of large size seed tubers shows the appearance of stems that remain upright even though they are exposed to heavy rain or rather strong winds and the stems are perpendicular from the base to the top. In addition the plants have large stem diameter at the base and getting smaller at the top. The greater the value of the stem sturdiness, the stronger the plant will be. According to Arifin *et al*. (2014), if the rate of photosynthesis is going well, which is characterized by fast growth and development, the photosynthate produced in the form of plant biomass such as roots, leaves and stems will increase, so that it will produce sturdy plants. Figure 2 shows the performance of porang plants based on the seed sizes.

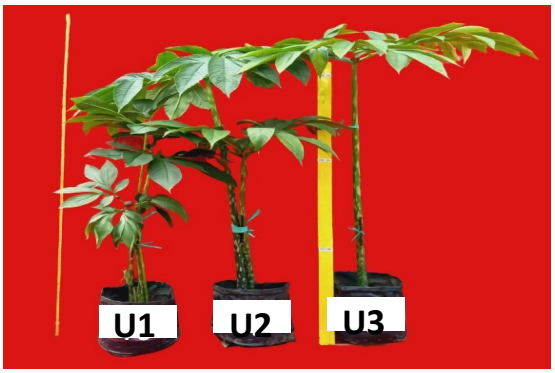

Figure 2. Performance of porang plants age 16 WAP based on seed size: small (20-50 g), medium (100-150 g), and large (200-250 g)

3.6. Tuber Weight and Tuber Diameter

The paclobutrazol dose of 0.20 g/plant produced the largest tuber weight and tuber diameter and was significantly different from the control and other paclobutrazol dose treatments. There was an increase in tuber weight and tuber diameter of porang plants due to the effect of treatment with paclobutrazol 0.20 g/plant respectively by 47.57% and 17.68% as compared to the control. Meanwhile, the tuber size of the large size porang seeds (200-250 g) produced the largest tuber weight and tuber diameter and was significantly different from the others. There was an increase in tuber weight and tuber diameter of porang plants due to the treatment of large seed tuber size respectively by 64.60% and 20.33% as compared to the treatment of small seed tuber size (Table 6).

Table 6. Effect of paclobutrazol dose and seed size on porang tuber weight and diameter

Treatment	Tuber weight (g)	Tuber diameter (mm)
Paclobutrazol Dose (g/plant)		
Control	1028.02 a	141.55 a
0.05	1287.80 b	155.12 b
0.10	1336.30 b	155.30 b
0.15	1401.76 b	160.89 c
0.20	1517.04 d	166.57 d
Seed size (g/seed)		
20-50	1001.32 a	141.95 a
100-150	1292.96 b	154.90 b
200-250	1648.26 c	170.81 c

Note : The mean numbers followed by the same lowercase letters in the same column and treatment were not significantly different in the 5% of LSD test.

The application of paclobutrazol at 0.20 g/plant had a significant effect on the weight and diameter of the tubers of porang (Table 6). Based on the simple linear regression analysis (Figure 3 and Figure 4) it shows that the trend line is that the higher the dose given, the greater the weight and diameter of the tubers. The R^2 value on both graphs is high (0.90) which means that 90% of the dose given has a high effect on the weight and diameter of the tuber. The equation for the line $y = 2184\ x + 1095.8$ shows that a dose of 0.20 g/plant can produce a tuber weight (y) of 1.533 g (Figure 3). While the regression line equation $y = 111.62\ x + 144.72$ shows that a dose of 0.20 g/ plant can produce a porang tuber with diameter (y) of 167 mm (Figure 4). According to Masniawati (2016), this is because paclobutrazol is a growth regulator which has the characteristic of reducing tissue metabolism and also plays a role in inducing tuber development.

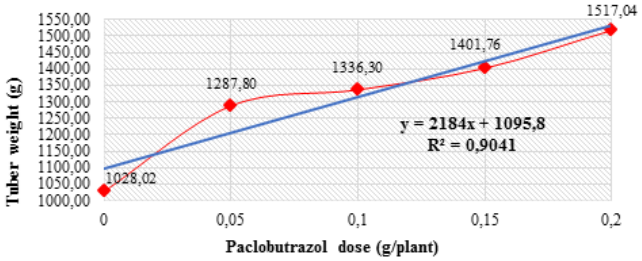

Figure 3. Simple linear regression of the relationship between paclobutrazol doses and porang tuber weight

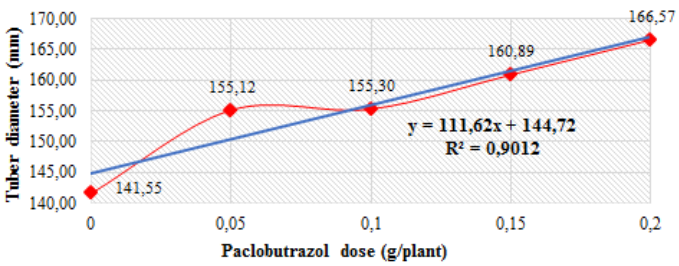

Figure 3. Simple linear regression of the relationship between paclobutrazol doses and porang tuber diameter

Paclobutrazol inhibits gibberellins production during the reaction steps from gibberellin oxidation to caurenic acid oxidation within gibberellin biosynthesis, thereby slowing or causing a reduction in the rate of cell division (Serly *et al*., 2013). Therefore, paclobutrazol is able to reduce tissue metabolism, inhibit plant growth, and inhibit gibberellin biosynthesis which plays a role in the process of cell and plant tissue growth, thereby reducing plant growth. This will indirectly speed up the process of transferring assimilation results to reproductive growth to fill porang tubers. Meanwhile, paclobutrazol 0.2 g/plant caused the formation of chlorophyll in porang plants to increase so that the photosynthate yield obtained would also be even greater. According to Sambeka *et al.* (2012), paclobutrazol increases the chlorophyll content of leaves so that photosynthetic activity can run well and inhibition of buds stimulates photosynthetic results to be used for the formation of carbohydrates in tubers that results in a significant effect on the weight of porang tubers. This statement is supported by Wijana *et al*. (2015), that application of paclobutrazol can regulate vegetative growth by inhibiting the formation of gibberellins for plant cell elongation, resulting in a diversion of the use of carbohydrates which were originally used for vegetative growth, to be allocated for maximum tuber formation (Figure 5).

Figure 5. Yield of porang tuber at age 26 WAP by paclobutrazol dose: 0.05 g/plant; 0.10 g/plant; 0.15 g/plant; and 0.20 g/plant

Large size seed tubers (200-250 g) produced the highest tuber weight and tuber diameter as compared to those of medium (100-150 g) and small (20-50 g) seed tubers. This is because the planting of porang using large size seed tubers besides the availability of food reserves is higher, the embryos in the buds are also more mature. According to Sutopo (2004), seed tubers whose embryos are physiologically ripe have been perfectly formed and have sufficient food reserves. Large seed tubers have a large food supply compared to the smaller seed tubers. Large seed tubers produce higher tuber weight because the food reserves in the seed tubers are still enough so they can produce good growth. According to Saleh *et al*. (2015), planting porang using seed tubers measuring 200 g is suitable enough to be used as seeds and can produce tubers weighing of 500 g. A'yun *et al*. (2015) stated that carbohydrates will be broken down again by plants and used for plant growth. Plants with high yields occur because they are also supported by good vegetative growth. In accordance with the statement of Wulandari (2014), the better the growth of plants there is a tendency to produce tubers with larger sizes because plant production is largely determined in the vegetative growth phase.

Healthy plant growth will result in good production. In accordance with the statement of Arifin *et al*. (2014), the amount of anabolic which is then transported and

stored as a food reserve determines the tuber weight per plant. A low amount of assimilate results in a lower tuber weight per plant and vice versa. This is supported by Dewi (2020) where plant production is largely determined during vegetative growth, so the better the plants grow, the bigger the tubers will be.

4. CONCLUSIONS AND SUGGESTIONS

The paclobutrazol dose of 0.2 g/plant had a significant effect on stem sturdiness, weight and diameter of porang tubers. Based on simple linear regression analysis, the maximum tuber weight obtained by the effect of paclobutrazol dose of 0.2 g/plant was estimated to be 1,533 g and the tuber diameter was expected to be 167 mm. Meanwhile, the size of seed tubers has a significant effect on growth and yield. Small seed tubers (20-50 g) produced the highest number of buds but were not significantly different from medium seed tubers (100-150 g). Medium sized seed tubers (100-150 g) and small seed tubers (20-50 g) produced plant height and stem diameter which were not significantly different from large seed tubers (200-250 g). Large seed tubers (200-250 g) produced the best leaf canopy diameter, stem sturdiness, weight and tuber diameter as compared to other seed tuber treatments. It is necessary to carry out further research on the dosage of paclobutrazol by increasing the dose level to a higher or greater than 0.20 g/plant and a more varied application time of paclobutrazol in order to obtain the right application time to produce porang plants optimally.

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