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(RESEARCH ARTICLE)

Increased growth of Porang (*Amorphophallus muelleri* Blume) seedlings on various bulbil weights with auxin application

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Abstract

Porang is a plant that contains quite high glucomannan. In 2021 the export value of porang has increased by 160% from 2019. The increase in demand for porang is still not supported by the availability of porang tubers so porang exports cannot be maximized. Efforts to meet the availability of porang tubers are to maximize the technical cultivation factory with the availability of quality seeds. This study aims to determine the interaction of bulbil weight and auxin, obtain the best combination of auxin and bulbil weight, as well as the effect of knowing auxin, and the effect of bulbil weight on increasing the growth of porang seedlings. The research was carried out experimentally in the form of a 3 x 4 factorial, arranged using a completely randomized design. Factor I, bulbil weight (5 – 11, >11 – 17, and >17 – 23 g per bulbil). Factor II, auxin concentration (0, 150, 300, and 450 mg.l-1). From these two factors, 12 combinations were obtained, and each combination was repeated 3 times to obtain 36 experimental units. Each experimental unit contained 3 plants in 3 polybags so a total of 108 plants were observed. Parameters observed were the days of shoot emergence, height, stem diameter, root volume, and fresh seedling weight. The results showed that the combination of bulbil weight >17 – 23 g and an auxin concentration of 300 mg.l-1 gave the best results for the growth of porang seedlings on all observation parameters. Bulbil weight > 17 – 23 g markedly increased seedling growth in all observation parameters, and administration of auxin concentration of 300 mg/l-1 also significantly increased porang seedling growth in all observed parameters.

Keywords: Bulbil; Auxin; Porang; Indonesia

1. Introduction

Porang (*Amorphophallus muelleri* Blume) is a commodity that is of concern to the government because its demand continues to increase, especially for export. According to [1] porang plants contain glucomannan which is quite high, which is around 35%. [2] said that apart from being used as food, glucomannan is also used as a raw material for various industries, namely as a paper adhesive, filler for tablet (medicine) manufacture, colloidally suspended mineral binder in mining, and as a drinking water purifier. Comes from rivers by precipitating suspended silt in the water.

In 2019 Indonesia has exported porang in the form of chips, flour, and fresh preparations to various countries, namely China, Vietnam, Thailand, Australia, Pakistan, Taiwan, Cambodia, and Hong Kong [3]. In 2021 people will experience an increase in export value of 160%, namely 14.8 thousand tons from 2019, namely 5.7 thousand tons. The increasing demand for porang is still not supported by the availability of sufficient porang tubers [4]. Efforts to meet the availability of porang tubers, one of which is to maximize plant cultivation techniques supported by the availability of quality seeds.

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Porang plant propagation in general is through two ways of propagation, namely vegetatively using stem tubers and leaf tubers (bulbil or frog tubers), while generatively through seeds. Propagation by seeds requires a harvest time of about 3 – 4 years for the first harvest, while propagation with tubers will be detrimental to farmers because porang plants are plants with a single tuber so if the tubers are used for propagation it will reduce the amount of farmer's production [5]. Based on this, the most effective way to propagate porang is by bulbil.

The bulbil is a vegetative organ in the form of a dark-colored protrusion that grows on a leaf stalk which can be located at the base of the petiole or the leaflets of the porang plant with varying sizes ranging from small sizes which are only a few grams to large sizes weighing up to 23 g per bulbil [5].

The results of the study [6], bulbils weighing 10.74 g had the highest germination power and plant height compared to bulbils weighing 9.69 g. This is in line with the results of research [7], bulbils with a size of 9.10 g have the largest height and stem diameter compared to plants originating from bulbils with a size of 1.88 g, this is because the larger the size of the bulbil, the more food reserves will be so as to support the growth of shoots faster. According to [8], bulbils weighing 12.66 g – 16.96 g per bulbil were able to increase the viability of porang plant seeds and could increase the fresh weight of the plants produced compared to bulbils which weighed 5.63 g – 7.11 g per seed.

Apart from bulbil size, porang growth can also be stimulated by growth regulators. Plant growth regulators are organic compounds that are not nutrients, which are active at low concentrations and will have a physiological effect on plants [9].

One of the growth regulators that can be used to increase human growth is auxin. Auxin can stimulate faster root formation. One type of auxin commonly used is NAA (Naphthalene Acecit Acid), which is an organic compound that has a role in helping the process of cell elongation, stimulating root formation in plant cuttings. According to [10], giving auxin can stimulate growth to accelerate root formation, but if given at too high a concentration it will inhibit plant growth and can even become toxic and kill plants.

A good medium for this research is a planting medium mixed with top soil and chicken manure. Based on research conducted [11], the best planting medium for producing large porang plants is derived from a mixture of soil and husk charcoal or a mixture of soil and manure compared to other planting media. This is because manure contains N, P, and K which play an important role in the process of plant growth.

2. Material and methods

The research was carried out in the experimental garden of the Faculty of Agriculture, University of Riau, and Bina Widya Street km 12.5, Pekanbaru. The materials used in this study were porang bulbils of the Madiun 1 variety, NAA type auxin with the trade name Growtone, fungicides with the trade name Dithane M-45, chicken manure, topsoil, 30 x 30 cm polybag, 1000 ml volume beaker, 100 ml volume measuring cup, stir bar, tape measure, soaking container, a digital scale and vernier caliper.

This research was conducted experimentally in the form of a 3 x 4 factorial which was arranged using a completely randomized design. Factor I, bulbil weight (5 – 11, >11 – 17, and 17 – 23 g per bulbil), factor II, auxin concentration (0, 150, 300, and 450 $mg.l^{-1}$). From these two factors, 12 combinations were obtained, and each combination was repeated 3 times to obtain 36 experimental units. Each experimental unit contained 3 plants in 3 polybags so that the total population observed was 108 plants in 108 polybags.

The parameters observed were the days of shoot emergence, seedling height, stem diameter, root volume, and seedling fresh weight. Research data were analyzed using a linear model of variance. The data obtained was followed by Duncan's New Multiple Range Test (DNMRT) test at the 5% level.

3. Results

3.1. Days of Shoot Emergence

The results of variance showed that the interaction between bulbil weight and auxin concentration and the bulbil weight and auxin concentration had a significant effect on the days of shoot emergence. Further test results are presented in Table 1.

Table 1 Days of shoot emergence with bulbil weight and auxin concentration

Auxin concentration (mg.l-1)	Bulbil weight (g)			Average
	5 – 11	>11 – 17	>17 – 23	
	..... DAP			
0	36.00 e	35.00 e	34.67 e	35.22 c
150	30.00 d	26.00 c	22.00 b	26.00 b
300	29.00 cd	19.67 b	14.00 a	20.89 a
450	29.33 cd	19.67 b	14.33 a	21.11 a
Average	31.08 c	25.08 b	21.25 a	

The numbers in the rows and columns followed by the same lowercase letters were not significantly different according to the DNMRT follow-up test at the 5% level.

The data in Table 1 shows that bulbils weighing >17 g – 23 g which were given auxin concentrations of 300 and 450 mg.l-1 significantly accelerated the emergence of buds on porang bulbils compared to other treatments. The bulbils in this treatment were able to germinate faster and the shoots began to appear above the soil surface at the age of 14.00 – 14.33 days after planting (DAP). A single treatment of bulbil weights >17 g – 23 g and single factor auxin concentrations of 300 and 450 mg.l-1 significantly accelerated the emergence of bulbil shoots compared to other bulbil weights.

3.2. Seedling Height

The results of variance showed that the interaction between bulbil weight and auxin concentration had no significant effect on seedling height, while bulbil weight and auxin concentration had no significant effect on seedling height. Further test results are presented in Table 2.

Table 2 Seedling height with bulbil weight and auxin concentration

Auxin concentration (mg.l^{-1})	Bulbil weight (g)			Average
	5 – 11	>11 – 17	>17 – 23	
	..... cm			
0	13.90 c	15.43 bc	18.48 abc	15.94 b
150	16.82 bc	18.70 abc	21.07 abc	18.86 ab
300	17.89 abc	20.46 abc	27.18 a	21. 84 a
450	20.18 abc	24.09 ab	24.30 ab	22.86 a
Average	17.21 b	19.69 ab	22.76 a	

The numbers in the rows and columns followed by the same lowercase letters were not significantly different according to the DNMRT follow-up test at the 5% level.

The data in Table 2 shows that the administration of auxin at a concentration of 300 mg.l-1 to bulbil weights >17 g – 23 g was significantly higher for porang seedlings than the auxin treatment with a concentration of 0 mg.l-1 at bulbil weights >5 g – 11 g and >11 g – 17 g, and auxin concentration of 150 mg.l-1 at bulbil weight >5 g – 11 g, but not significantly different from other treatments. A single factor of bulbil weight >17 g – 23 g significantly increased the height of porang seedlings compared to bulbils >5 g – 11 g, but was not significantly different from bulbils >11 g – 17 g. The single factor auxin concentrations of 300 and 450 mg.l-1 significantly increased the height of porang seedlings compared to auxin 0 mg.l-1, but was not significantly different from administration of auxin concentrations of 150 mg.l-1.

3.3. Stem Diameter

The results of variance showed that the interaction between bulbil weight and auxin concentration had no significant effect on stem diameter, but the auxin concentration and auxin concentration treatments had an effect on stem diameter. Further test results are presented in Table 3.

Table 3 Stem diameter with bulbil weight and auxin concentration

Auxin concentration (mg.l^{-1})	Bulbil weight (g)			Average
	5 – 11	>11 – 17	>17 – 23	
	..... mm			
0	5.44 d	7.46 cd	8.52 bc	7.14 c
150	6.76 cd	8.42 bc	9.77 ab	8.32 b
300	8.51 bc	9.85 ab	10.78 a	9.66 a
450	8.20 bc	9.75 ab	11.04 a	9.71 a
Average	7.23 c	8.87 b	10.03 a	

The numbers in the rows and columns followed by the same lowercase letters were not significantly different according to the DNMRT follow-up test at the 5% level.

Data from Table 4 shows that the administration of auxin concentrations of 300 and 450 mg.l-1 to bulbil weights >17 g – 23 g was markedly larger in diameter to the stem diameter of the porang seedlings compared to the administration of auxin concentrations of 0 mg.l-1 to bulbil weights >5 g – 11 g, >11 g – 17 g, >17 g – 23 g, auxin concentration 150 mg.l-1 at bulbil weight >5 g – 11 g and >11 g – 17 g, auxin concentration 300 mg.l-1 for bulbil weights >5 g – 11 g, and auxin 450 mg.l-1 for bulbil weights >5 g – 11 g, but not significantly different from other treatments. The single factor of bulbil weight >17 g – 23 g markedly increased the diameter of porang seedlings compared to other treatments. The single-factor auxin concentrations of 300 and 450 mg.l-1 significantly increased the diameter of porang seedlings compared to other treatments.

3.4. Root Volume

The results of variance showed that the interaction of bulbil weight and auxin concentration and bulbil weight and auxin concentration had a significant effect on the plant root volume. Further test results are presented in Table 4.

Table 4 Root volume with bulbil weight and auxin concentration

Auxin concentration (mg.l^{-1})	Bulbil weight (g)			Average
	5 – 11	>11 – 17	>17 – 23	
	..... ml			
0	19.00 e	22.00 e	28.50 de	23.17 c
150	24.00 e	35.67 cd	43.83 c	34.50 b
300	36.07 cd	54.67 b	67.00 a	52.58 a
450	35.17 cd	45.03 bc	65.67 a	48.62 a
Average	28.56 c	39.34 b	51.25 a	

The numbers in the rows and columns followed by the same lowercase letters were not significantly different according to the DNMRT follow-up test at the 5% level.

Table 5 shows the administration of auxin concentrations of 300 and 450 mg.l-1 given to bulbil weights >17 g – 23 g significantly increased the root volume of porang seedlings compared to other treatments. The single factor of bulbil weight >17 g – 23 g significantly increased the root volume of porang seedlings compared to other treatments. The single factor auxin concentrations of 300 and 450 mg.l-1 significantly increased the root volume of porang seedlings compared to other treatments.

3.5. Seedling Fresh Weight

The results of variance showed that the interaction between bulbil weight and auxin concentration had no significant effect on plant fresh weight, while a single factor of bulbil weight and auxin concentration had an effect on plant fresh weight. Further test results are presented in Table 5.

Table 5 Fresh weight of shoots with bulbil weight and auxin concentration

Auxin concentration (mg.l^{-1})	Bulbil weight (g)			Average
	5 – 11	>11 – 17	>17 – 23	
	..... g			
0	23.63 f	34.01 ef	59.11 cd	38.92 b
150	34.15 ef	35.20 ef	80.78 abc	50.05 b
300	52.11 de	87.10 ab	101.85 a	80.35 a
450	65.69 bcd	83.00 ab	93.32 a	80.67 a
Average	43.90 c	59.83 b	83.77 a	

The numbers in the rows and columns followed by the same lowercase letters were not significantly different according to the DNMRT follow-up test at the 5% level.

The data in Table 5 shows the administration of auxin concentrations of 300 and 450 mg.l-1 to bulbil weights >17 g – 23 g significantly increased the fresh weight of porang seedlings compared to the administration of auxin concentrations of 0 mg.l-1 to bulbil weights >5 g – 11 g, >11 g – 17 g, >17 g – 23 g, auxin concentration 150 mg.l-1 at bulbil weight >5 g – 11 g, >11 g – 17 g, auxin concentration 300 mg.l-1 on bulbil weight >5 g – 11 g, and auxin concentration of 450 mg.l-1 on bulbil weight >5 g – 11 g, and not significantly different from other treatments. Bulbils with treatment weights > 17 g – 23 g significantly increased the fresh weight of porang seedlings compared to bulbils > 5 g – 11 g and 11 g – 17 g. The single-factor auxin concentrations of 300 and 450 mg.l-1 significantly increased the fresh weight of porang seedlings compared to auxin concentrations of 0 and 150 mg.l-1.

4. Discussion

The day bulbil shoots appeared (Table 1) after being treated with a combination of bulbil weight and auxin application and each factor (bulbil weight and auxin) had a significant difference. This is presumably because auxin plays a role in cell division and activation of hormones which function to encourage the formation of enzymes for germination. According to [12], auxin can increase osmotic pressure, increase cell permeability to water, cause a reduction in pressure on the cell wall, increase protein synthesis, increase plasticity, and cell wall development, so that water osmosis into the cell resulting in elongated cells.

Water that osmosis into the cell activates the hormone gibberellin which was previously in a bound and inactive form. This gibberellin hormone will encourage the formation of hydrolytic enzymes such as: α-amylase enzymes, protease enzymes, ribonuclease enzymes, β-gluconase enzymes, and phosphatase enzymes. These enzymes will diffuse into the endosperm and catalyze food reserves into: sugars, amino acids, and nucleosides that support embryo growth in seed germination. The greater the weight of the bulbil, the more food reserves it contains so that cell division will be faster and shoots can appear faster. This is in line with the statement [13], that simultaneously with the imbibition process, food reserves in plant seeds will be broken down into sugar by the amylase enzyme so that it can produce energy that is useful for cell activity and growth.

The combination treatment of bulbil weight >17 – 23 g given auxin concentration of 450 mg.l-1 had longer shoot emergence days than the treatment of bulbil weight >17 – 23 g with auxin concentration of 300 mg.l-1. This is because the concentration of 300 mg.l-1 is the optimal concentration to stimulate the growth of porang seedlings, if the concentration is added more optimally it will interfere and cause the growth of porang seedlings to decrease. This is in accordance with the opinion [13], that auxin with a concentration that exceeds the optimal limit or is too high will induce ethylene production. Ethylene has a function as an inhibitor (inhibitor) of plant growth so that the plant will experience a decrease in growth.

Observations of porang seedling height in Table 2 were also relatively different after being given treatment (a combination of bulbil weight with auxin application or each factor). This is because the administration of higher concentrations of auxin to bulbils with greater weight will stimulate cell division which has an impact on increasing plant height. This is in accordance with research [14], that there was an increase in the height of the Waves of Love plant by giving NAA 20 ppm, which was 17.44 cm compared to without giving NAA, which was 13.19 cm, this is because NAA stimulates enlargement also stimulates cell division thereby affecting plant height.

Differences in plant height due to differences in the days of emergence of shoots, bulbils with larger weights shoot faster than bulbils with lower weights, therefore plants will also carry out photosynthesis earlier to meet energy needs in the next growth stage. Plant height is influenced by the condition of the initial food reserves available in the bulbil. Bulbils that have more food reserves have a greater growth speed so that they are earlier in photosynthesis and faster in the formation of plant vegetative organs. This is in line with the results of a study [15], which showed that larger porang planting material provided better plant growth with the use of 5 g and 2.5 g bulbils resulting in plant heights of 13.76 cm and 12.61 cm.

The results of observations of stem diameter (Table 3) showed a significant difference with the addition of auxin concentrations at the same bulbil weight, increasing the stem diameter of the seedlings. Similar to the addition of seedling height, the diameter of the stem of the seedling will also increase if the concentration of auxin given is higher and the bulbil weight is greater, this is because cell division will be faster and increase the size of the stem diameter. According to [10], auxin will release H+ and this ion will lower the pH resulting in a loosening of the cell wall. Auxin affects cell development, namely auxin can increase osmotic pressure, increase cell permeability to water, cause a reduction in pressure on the cell wall, increase protein synthesis, increase plasticity and cell wall development. In conjunction with cell permeability, the presence of auxin increases the diffusion of water into the cell. This happens because auxin supports an increase in the permeability of water entry into the cell so that the absorption of water by the seed is faster so that the seed quickly experiences imbibition and germinates so that respiration occurs. Respiration is the process of overhauling food reserves to produce simpler compounds and energy that functions for the process of cell elongation, cell enlargement, and plant photosynthesis.

Observation of root volume (Table 4), combination of bulbil weight and auxin concentration was significantly different. This relates to the ability of auxin to increase the seed imbibition process if the concentration increases so that the enzymes that function to break down the bulbil food reserves will increase, the greater the weight of the bulbil, the more food reserves contained in the bulbil and the more it can be broken down. into energy for the process of cell division in the formation of roots. According to [16], water imbibition was followed by a large increase in enzyme activity and respiration. Enzyme activity increases catabolism, namely the breakdown of starch, fat and protein into substances such as sugars, fatty acids and amino acids which can be translocated to active growth sites.

Root volume affects plant growth, the greater the root volume, the more plant growth will increase. This can be seen from the day the plant shoots appeared (Table 1), the plant that has the largest root volume then shoots appear faster than the others. Plants with the largest root volume, the age of shoot emergence is 14.00–14.33 days. Compared to plants that have a smaller root volume, the day the shoots appear is 19.67 – 36.00 days. This is in accordance with the statement [17], that plant roots function to absorb salts, minerals, water and flow them to the plant body which requires them to be used for germination and plant growth. Plants that have a larger volume, the more absorption of nutrients so that they can meet the needs of nutrients needed by plants for their growth.

Parameters of fresh seed weight (Table 5) the results tended to be significantly different after being treated with a combination of bulbil weight and auxin application at various concentrations. This is related to the parameters of plant height, stem diameter and root volume. In Tables 2, 3, and 4 it is clear that these three parameters are influenced by auxin concentration and bulbil weight. Increase. Giving auxin stimulates porang growth, root formation and leaf formation so that it will affect the plant's wet weight.

The bulbil weight factor for the parameters of shoot emergence days, height, stem diameter, root volume and seedling fresh weight (Tables 1, 2, 3, 4 and 5) gave significantly different results, where bulbils with higher weights were significantly better than with small bulbils. According to [7], this is because the greater bulbil weight will provide more nutrition and produce better growth than the smaller bulbil size.

The auxin factor with increasing concentrations gave results that tended to be significantly different for all parameters. According to [18], auxin plays a role in stimulating or accelerating cell elongation. Giving exogenous auxin will increase the activity of endogenous auxins that are already present in plants, thereby encouraging cell division to promote better

plant growth. [19] Stated that auxin is a plant hormone that can regulate many physiological processes such as growth, cell division, and differentiation as well as protein synthesis. Giving auxin triggers accelerated growth and development of shoots. According to [20], auxin plays a role in cell division by controlling the activity of CDK (cyclin-dependent kinase), an enzyme that causes division in eukaryotic cells.

5. Conclusion

Based on the results of the research that has been done, it can be concluded that:

- There was an interaction between auxin concentration and bulbil weight in accelerating the day of shoot emergence and increasing root volume, but there was no interaction between auxin concentration and bulbil weight in increasing height, stem diameter and fresh weight of porang seedlings.
- Bulbil weight >17 g – 23 g accelerated the day of emergence of shoots, increased height, stem diameter, root volume and fresh weight of porang seedlings compared to bulbil weights of 5 g – 11 and >11 g – 17 g.
- Treatment with an auxin concentration of 300 $mg.l^{-1}$ accelerated the day of emergence of porang shoots, increased the number of shoots, seedling height, stem diameter, root volume and fresh weight of porang compared to concentrations of 0, 150 and 450 mg.l-1.
- The combination of giving auxin concentrations of 300 $mg.l^{-1}$ and 450 $mg.l^{-1}$ to bulbils weighing >17 g – 23 g was the best for increasing the growth of porang plant seeds compared to other treatments.

Compliance with ethical standards

Disclosure of conflict of interest

All authors declare there is no conflict of interest in this paper.

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