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Potato (*Solanum tuberosum* L.) Planlet Acclimatization on Various Auxin Concentrations and Growing Media

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ABSTRACT
The provision of quality potato seeds is a problem faced by farmers. Tissue culture propagation is an effort to increase the availability of quality seeds. The success of tissue culture is influenced by the ability to control environmental conditions, growth regulators, and growing media at the acclimatization stage. The research aims to determine the interaction between the use of auxin concentrations and the planting medium and to obtain the appropriate concentration of auxin and planting medium for potato acclimatization. The research used a split-plot design with 2 factors and 3 replications. The main plot is the auxin concentration consisting of 3 levels; 1 ppm, 2 ppm, and 3 ppm. Subplots are planting media consisting of 3 levels; husk charcoal:vermicompost, cocopeat:vermicompost, and husk charcoal:cocopeat:vermicompost. Data were analyzed using ANOVA and followed by DMRT at a 5% level. The results showed that there was an interaction between the treatment of 3 ppm IAA concentration and the planting medium of husk charcoal:cocopeat:vermicompost on the plant height parameter 4 WAP. The IAA concentration of 3 ppm was better than the concentration of 1 ppm in the parameter number of leaves 8 WAP. The growing media of husk charcoal:cocopeat:vermicompost was better than the growing medium of charcoal husk:vermicompost on the parameters of plant height 8 WAP, number of leaves 8 WAP, leaf length and leaf width 8 WAP.

Keywords: Acclimatization, Auxin, Growing Media, Potato

INTRODUCTION

Potatoes are the most widely consumed carbohydrate source in the world after rice, corn, and wheat. The content of potatoes includes carbohydrates, minerals, calories, fat, and vitamins which are good for health. Potatoes are one of the important commodities that are prioritized for development because of their high economic value and the potential to support food diversification (1). The increasing population and industries that use potato raw materials cause the demand for potatoes to increase every year. According to (13), Indonesian potato consumption per capita reached 2,547 kg in 2020, then increased by 2,820 kg in 2021. This increase in potato consumption shows that the quality and quantity of potato production need to be increased to meet national potato needs.

Indonesia's potato production compared to other countries is still relatively low, namely in 37th position with a total production of 1.36 million tons. According to (6), the largest potato producing country in 2021 is China with a total production of 94.36 million tons. The second position is held by India with a total production of 54.23 million tons and in the third position is Ukraine with a total production of 21.35 million tons.

According to (3), in 2021 Indonesia will still import fresh potatoes from Germany, Canada, and England with a total of 4,328 tons to meet national demand for potatoes, especially for industrial needs. Indonesia's potato production in 2019-2021 experienced fluctuations. Potato production in 2019 was 1.31 million tonnes but decreased to 1.28 million tonnes in 2020. Production increased again

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to 1.36 million tonnes in 2021 and is expected to continue to increase in the following year to reduce the value of fresh potato imports in Indonesia.

The low production of potatoes in Indonesia is due to the low availability of certified seeds, making it difficult for farmers to meet consumer demand which continues to increase every year. The low availability of quality potato seeds is the reason why farmers still use potato seeds that come from tubers from previous harvests. Using potato tubers that come from the previous harvest and not from certified seeds will hurt overall crop yields because it can reduce productivity (20).

Seeds or seedlings are the key to success in potato cultivation. The planting material obtained so far comes from previous generations of tubers so there is a decrease in quality. Efforts that can be made to obtain quality planting material are through tissue culture propagation technology. Rapid seed propagation technology carried out through tissue culture can shorten time and increase the quantity of seeds with a high level of quality (9).

The challenge in the tissue culture propagation process is the acclimatization stage. This phase is called the critical phase of the plant, because the plant must adapt to the drastic environmental differences between the greenhouse and the culture bottle. The success of acclimatization is influenced by the ability to control environmental conditions, growth regulators, and planting media. Therefore, it is important to pay attention to the suitability of the concentration of growth regulators given and the planting media used during the acclimatization stage so that potato seedlings can grow and develop optimally.

Indole Acetic Acid (IAA) is the most widely used auxin growth regulator which functions in stimulating cell division, differentiation of transport tissue, cell elongation, and root initiation (11). The addition of auxin to potato seeds resulting from tissue culture will accelerate the growth and length of plant roots. Accelerating root growth is expected to increase the percentage of life, because roots are important plant organs in absorbing water and nutrients that plants need for the process of growing and developing.

Planting media can influence root growth which ultimately affects plant growth. The media used for acclimatization must be quite smooth, sterile, and have good air and water circulation. Husk charcoal and cocopeat are examples of media that can be used for acclimatization (15). Husk charcoal has good porosity so that aeration and drainage run smoothly. Cocopeat can absorb and store water and can increase air circulation in the planting medium. Planting media that has balanced pores makes it easier for roots to grow and develop (18). The use of appropriate auxin concentrations and planting media is expected to increase the percentage of plant survival at the acclimatization stage. Therefore, it is necessary to research to determine the appropriate IAA concentration and planting media composition for successful potato acclimatization.

RESEARCH MATERIALS AND METHODS

The research was carried out in *screen house* PT. Agro Lestari Merbabu, Ngablak, Magelang, Central Java from February to April 2023. The materials used are potato plantlets of Granola L., IAA, fungicide, vitamin B1, liquid organic fertilizer, husk charcoal, cocopeat, and vermicompost. The tools used were an acclimatization container measuring 36x30 cm, a plastic lid, paper clips, a hand sprayer, analytical scales, writing tools, label paper, and a ruler.

The research used a Split Plot Design 2 factors with 3 repetitions. The first factor is the main plot IAA concentration which consists of 3 levels, namely 1 ppm, 2 ppm, and 3 ppm. The second

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factor is the subplot planting medium consisting of three levels, namely husk charcoal:vermicompost (1:1), cocopeat:vermicompost (1:1), and husk charcoal:cocopeat:vermicompost (1:1:1).

Research Implementation

The cocopeat planting medium is filtered to obtain finer fibers, and then washed using clean water to reduce the tannin content. The planting medium is then mixed according to the treatment. The mixed media is put into an acclimatization container with a planting media depth of 7 cm. The planting medium is then sterilized using a fungicide with a concentration of 1.5 g/L of water by spraying.

The planting material used is Granola L variety potato planlets month old plant. The planting material is removed from the culture bottle. The roots were cleaned from media that was still attached, then sterilized using fungicide 1.5 g/L water for 5 minutes. The planting material is soaked in the IAA solution according to the treatment for 5 minutes with a solution volume of 50 ml. Planting is done in the morning or evening with a spacing of 6x6 cm. Seedlings were covered for 21 days to reduce evaporation.

IAA spraying with a concentration of 1 ppm was carried out 12 times every 4 days, a concentration of 2 ppm was carried out 6 times every 8 days, and a concentration of 3 ppm was carried out 4 times every 12 days. Maintenance is carried out by spraying vitamin B1 at a concentration of 2 ml/L when the plants are 14 days old with a spraying frequency of once every 7 days. Fertilization is carried out 1 month after planting using liquid organic fertilizer with a concentration of 8 ml/L with a spraying frequency every 7 days.

Observation Parameters and Data Analysis

Observations were carried out for eight weeks after planting with the parameters observed including the percentage of live plants (%), plant height, number of leaves, leaf length, leaf width, and root length. The data were analyzed using analysis of variance at the 5% level, then continued with the Duncan's Multiple Range Test (DMRT) at the 5% level.

RESULTS AND DISCUSSION

The results of the analysis of variance revealed that there was no interaction between IAA concentration and planting media on the percentage of live plants, plant height at 8 WAP, number of leaves, leaf length, leaf width, and root length. This is because both IAA and planting media work independently, where IAA works internally and planting media works externally. The nature of work and the influence of each treatment factor on plant growth are not the same, resulting in a cooperative relationship between treatment factors not influencing each other (10).

Life Percentage

Table 1. Average Percentage of Live Plants with Treatment of IAA Concentration and Planting Media (%)

IAA	Growing media			Average
	Husk charcoal: vermicompost	Cocopeat: vermicompost	Husk charcoal:cocopeat: vermicompost	
1 ppm	100,000	100,000	100,000	100,000 a
2 ppm	100,000	100,000	100,000	100,000 a
3 ppm	100,000	100,000	100,000	100,000 a
Average	100,000 p	100,000 p	100,000 p	(-)

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Note: Average followed by the same letter in the same column and row indicate there is no significant difference based on the 5% DMRT test. The (-) sign indicates no interaction. The data displayed is original data that has been transformed in arcsin form.

The concentration of IAA and planting media showed no significant difference in the percentage of live plants (table 1). The percentage of live plants is influenced by plantlet conditions, growing environment, and acclimatization techniques. According to (16), using plantlets in healthy condition, sufficient age, large seed size, and complete plant organs such as roots, stems and leaves will increase the success of acclimatization. Apart from that, environmental conditions such as the suitability of planting media, temperature, humidity, and accuracy of acclimatization techniques also influence the percentage of live plants.

Plant height

Table 2. Average Plant Height at 4 WAP with Treatment of IAA Concentration and Planting Media (cm)

IAA	Growing media			Average
	Husk charcoal: vermicompost	Cocopeat: vermicompost	Husk charcoal:cocopeat: vermicompost	
1 ppm	14,667 b	16,603 b	15,833 b	15,700
2 ppm	15,300 b	18,503 b	17,233 b	17,011
3 ppm	17,533 b	16,267 b	23,010 a	18,937
Average	15,833	17,122	18,692	(+)

Note: Average followed by the same letter in the same column and row indicate there is no significant difference based on the 5% DMRT test. The (-) sign indicates no interaction.

There was an interaction between IAA concentration treatment and planting media on plant height at 4 WAP. The combination of 3 ppm IAA and husk charcoal:cocopeat:vermicompost planting media was a treatment combination that had the highest plants compared to other treatments (table 2). This proves that in this combination of treatments there is a synergistic relationship that can work together effectively in the cell elongation process. It is suspected that an IAA concentration of 3 ppm is the right concentration and can meet the plant's auxin needs in accelerating the process of cell elongation.

IAA acts as a stimulant that encourages cell elongation and also encourages cell activity (19). If given at the right concentration, IAA can stimulate faster plant growth. If the concentration is too high it can disrupt cell division activity and potentially cause death (17).

The composition of the planting medium consisting of a combination of husk charcoal:cocopeat:vermicompost has a good structure with a balanced ratio of macro and micro pores. This condition allows the roots to absorb nutrients and water more optimally (12). Roots can absorb and translocate water and nutrients for optimal photosynthesis processes (7). Increasing the rate of photosynthesis will affect plant growth, one of which is plant height (4).

Table 3. Average Plant Height at 8 WAP with Treatment of IAA Concentration and Planting Media (cm)

IAA	Growing media			Average
	Husk charcoal: vermicompost	Cocopeat: vermicompost	Husk charcoal: cocopeat: vermicompost	
1 ppm	24,233	26,900	29,633	26,922 a
2 ppm	26,233	30,967	31,433	29,544 a
3 ppm	27,333	29,533	35,233	30,700 a

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Average	25,933 q	29,133 pq	32,100 p	(-)

Note: Average followed by the same letter in the same column and row indicates there is no significant difference based on the 5% DMRT test. The (-) sign indicates no interaction.

There was no interaction between plant height parameters at 8 WAP, but the planting medium alone had a significant effect on plant height at 8 WAP. The planting medium treatments of cocopeat:vermicompost and husk charcoal:cocopeat:vermicompost were not significantly different, however the husk charcoal:cocopeat:vermicompost treatment was significantly different from the husk charcoal:vermicompost treatment (table 3). This is because the planting media cocopeat:vermicompost and husk charcoal:cocopeat:vermicompost can provide the water and nutrients that plants need in the vegetative phase of the plant.

Number of Leaves, Leaf Length, and Leaf Width

Table 4. Average Number of Leaves, Leaf Length, and Leaf Width with Treatment of IAA Concentration and Planting Media

Age	Treatment	Parameters		
		Number of Leaves	**Leaf Length (cm)**	**Leaf Width (cm)**
4 WAP	**IAA concentration**			
	1 ppm	23,044 a	1,163 a	0,804 a
	2 ppm	24,489 a	1,311 a	0,794 a
	3 ppm	19,856 a	1,327 a	0,879 a
	Growing media			
	Husk charcoal:vermicompost	18,556 p	1,152 p	0,727 p
	Cocopeat: vermicompost	24,078 p	1,327 p	0,863 p
	Husk charcoal:cocopeat:vermicompost	24,756 p	1,322 p	0,888 p
8 WAP	**IAA concentration**			
	1 ppm	42,656 b	2,639 a	1,746 a
	2 ppm	50,700 ab	2,822 a	2,062 a
	3 ppm	56,744 a	2,789 a	2,081 a
	Growing media			
	Husk charcoal: vermicompost	43,011 q	2,419 q	1,704 q
	Cocopeat: vermicompost	46,733 pq	2,799 pq	2,058 pq
	Husk charcoal:cocopeat:vermicompost	60,356 p	3,032 p	2,127 p
Interaction		(-)	(-)	(-)

Note: Average followed by the same letter in the same column and row indicates there is no significant difference based on the 5% DMRT test. The (-) sign indicates no interaction.

Table 4 shows that at the age of 4 WAP, the IAA concentration treatment and the planting media did not have a significant effect on the number of leaves, leaf length and leaf width. At the age of 8 WAP in the IAA treatment with concentrations of 2 ppm and 3 ppm, the number of leaves was not significantly different, but at a concentration of 3 ppm the number of leaves was significantly more than in the treatment with a concentration of 1 ppm. It is suspected that at 8 WAP, plants need higher levels of auxin to increase protein synthesis. This is because protein synthesis can be increased by providing auxin at optimum levels to plants. The resulting protein is used as a component in the development of new plant organs such as leaves (8).

Endogenous auxin produced by plants and exogenous auxin supplied to plants in the form of synthetic growth regulators influence the process of cell division and elongation in plants. When

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plants absorb auxin it will activate the plant's food reserve energy. These food or carbohydrate reserves are used as an energy source to stimulate cell division, one of which is leaf formation (2).

In the parameters of plant height, number of leaves at 8 WAP, leaf length at 8 WAP, and leaf width at 8 WAP, the planting media treatments of cocopeat:vermicompost (1:1) and husk charcoal:cocopeat:vermicompost (1:1:1) were not significantly different, however, the husk charcoal:cocopeat:vermicompost (1:1:1) was significantly different from the treatment of husk charcoal:vermicompost (1:1). This is because the planting media cocopeat:vermicompost (1:1) and husk charcoal:cocopeat:vermicompost (1:1:1) can provide the water and nutrients needed in the vegetative phase of the plant.

Husk charcoal contains the nutrients nitrogen, phosphorus, and potassium. Plants need a lot of the nutrient N as a basic component for the synthesis of chlorophyll, protein, and amino acids during the vegetative growth process of plants. Using husk charcoal as a growing medium alone still has drawbacks, because it is crumbly structure causes this medium to be very porous, resulting in low water holding capacity. The low binding capacity allows the water and nutrients provided to easily escape. Therefore, husk charcoal must be combined with other media such as cocopeat. The addition of cocopeat which can absorb more water can complement the shortcomings of the charcoal husk media. The planting medium consisting of a combination of husk charcoal:cocopeat: vermicompost (1:1:1) has a good structure, namely it has a balanced ratio between macro and micro pores. This condition allows the roots to absorb nutrients and water more optimally (12).

The macronutrients N, P, K, Ca, Mg, and S are found in vermicompost in fairly high concentrations which are important for plant growth and development and are needed by plants in large quantities. In addition, vermicompost helps improve soil structure and balance soil pH, making the medium suitable for acclimatization (5). According to (14), the more nutrients a plant absorbs, the faster its metabolism will be. The greater the metabolic process, the greater the influence on the photosynthesis process. The results of photosynthesis are used in several aspects of plant growth and development, including increasing plant height and leaf formation. Plants that have lots of leaves, large surface size of the leaves, and rich in chlorophyll can synthesize large amounts of carbohydrates which ultimately helps the vegetative growth of the plant.

Root Length

Table 5 shows the IAA concentration treatments and planting media. This is because all IAA concentration treatments given have the same ability to influence root length. The planting media used is also able to provide good growing space for plants, especially in providing water and nutrients.

Table 5. Average Root Length at 8 WAP with Treatment of IAA Concentration and Planting Media (cm)

IAA	Growing media			Average
	Husk charcoal: vermicompost	Cocopeat: vermicompost	Husk charcoal: cocopeat: vermicompost	
1 ppm	3,000	3,867	3,167	3,344 a
2 ppm	2,433	3,033	3,367	2,944 a
3 ppm	2,867	4,067	3,667	3,533 a
Average	2,767 p	3,656 p	3,400 p	(-)

Note: Average followed by the same letter in the same column and row indicates there is no significant difference based on the 5% DMRT test. The (-) sign indicates no interaction.

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CONCLUSION

There was an interaction between the IAA concentration treatment of 3 ppm and the planting medium of husk charcoal:cocopeat:vermicompost (1:1:1) on plant height parameters at 4 WAP. An IAA concentration of 3 ppm provided better growth than a concentration of 1 ppm at a leaf number parameter of 8 WAP. The planting medium for husk charcoal:cocopeat:vermicompost (1:1:1) provides better growth than the planting medium for husk charcoal:vermicompost (1:1) on plant height parameters of 8 WAP, number of leaves 8 WAP, leaf length, and leaf width 8 WAP.

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