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Effect of IBA (Indole Butyric Acid) Concentration on the Growth of Avocado Plant Cuttings (*Persea americana* Mill)

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ABSTRACT

The demand for avocados in Indonesia continues to rise, while the availability of high-quality seedlings remains limited. Propagation through stem cuttings with the application of IBA (Indole Butyric Acid) is expected to improve propagation success. This study aims to determine the effect of IBA concentration on the growth of avocado stem cuttings. The research was conducted in Bojonegoro, East Java, using a Completely Randomized Design (CRD) with one factor, namely five concentrations of IBA: 0, 75, 100, 125, and 150 ppm. Observed parameters included shoot length, number of shoots, number of leaves, and number of primary roots. The results showed that IBA concentration had a significant effect on all observed parameters, while cutting length had no significant effect. A concentration of 100 ppm produced optimal growth of 1.92 cm, 2.50 shoots, and 4.33 leaves. The treatment without IBA resulted in the lowest values. The application of IBA at concentrations of 75–100 ppm effectively enhanced the growth of avocado stem cuttings, particularly in shoot and leaf development.

1. INTRODUCTION

Avocados are recognized as a prominent fruit among Indonesian people. This fruit is classified as a significant horticultural crop that is widely used by the community and has high economic value. Availability of avocado fruits is related to harvesting season which is influenced by geographical location such as October to February in West Java, but June to August in North Sumatra (Rumaisha *et al*., 2025). BPS (2023) recorded that the avocado harvest in East Java reached 1757.35 and was a large contribution in terms of avocado production, but this amount was not sufficient for domestic needs, so imports from outside were needed. Andajani *et al*., (2020) stated that the availability of avocado stem cuttings was the main obstacle in avocado tree cultivation. Avocado propagation from seeds results in substantial genetic variation, which reduces their desirability for orchard use. In contrast, rooting cuttings can be achieved only through methods that are complicated, lengthy, and expensive (Hiti-Bandaralage *et al*., 2017).

Stem cuttings offer the advantages of rapid and inexpensive plant propagation, producing genetically identical clones that mature faster than seedlings (Sarkar *et al*., 2022). The main disadvantages, however, are a lack of genetic diversity, which makes the resulting plants more susceptible to diseases and pests, and a higher risk of crop failure if a widespread pest or disease outbreak occurs. Propagating avocado plant seeds using cuttings is more effective because it allows the propagation of plants that maintain the same characteristics as the parent plant, producing uniform plants and a relatively short planting time (Wijaya & Budiana, 2014). Avocado stem cuttings can be done because avocado stems have a cambium stem structure (Marpaung & Hutabarat, 2015). The seeding process using cuttings still often experiences failure in root formation, so the application of plant growth regulators (PGR) can increase the success of developing plant cuttings. According to Azmi & Handriatni (2018), PGR is a non-nutritive organic compound which,

when given in certain amounts, has the capacity to increase or suppress physiological processes that occur in plants. Indole Butyric Acid (IBA) is a group of synthetic auxins that is applied to improve the growth of plant roots.

The effectiveness of IBA on stem cuttings depends on the specific concentration applied. If the concentration exceeds the optimal level, it can result in detrimental effects on plants. On the other hand, using concentrations less than the optimal range can produce unsatisfactory results. For example, Aminah *et al*. (1995) reported that root formation in Shorea leprosula cuttings was significantly improved by IBA treatment, and the optimal dose was 20 µg per cutting, which produced 70% rooted stem within 12 weeks. Rooting success decreased when higher doses were applied. Sulistiana (2013) also reported that synthetic PGR (Rootone-F) improve growth parameters as compared with those of controls. The treatment combination of Rootone-F 0.4 g/cuttings with middle cutting material give the best results on the root weight. The use of external growth substances at the wrong concentration can disrupt plant metabolic functions and overall growth. Yeshiwas *et al*. (2015) reported the use of IBA on the stenting-propagated rose cuttings and found that concentration of 1000 ppm resulted in significant positive effects growth parameters including root length, root number, root weight, number of leaves, shoot weight, and shoot length. Tawfik *et al*. (2018) also reported that application of IBA on *Rosa hybrida* stem cuttings significantly increased root growth in term of rooting percentage, number of root, and root length as compared to control (untreated cuttings). IBA is able to boost root development, as well as encourage stem and leaf growth (Rokhani *et al*., 2016).

The application of the IBA hormone to avocado plant cuttings is expected to encourage the formation of primary roots and the emergence of shoots so that there is the formation of new leaves which will be able to provide a food source in the form of photosynthesis. Pujaningrum & Simanjuntak (2020) research on cobusta coffee (*Coffea canephora*) cuttings, the application of IBA at concentrations of 50 ppm, 100 ppm, 150 ppm, 200 ppm, 250 ppm, and 300 ppm showed that using 100 ppm significantly increased shoot height, achieving an average increase of 3.46 cm, the 300 ppm treatment had an average value The lowest shoot height was 2.40 cm. The growth rate of Robusta coffee stem cuttings with a IBA concentration of 100 ppm showed the highest average value, namely 2.62 cm/week, which was significantly different from the 300 ppm treatment which had the lowest average value, namely 1.63 cm/week.

The aim of this study is to assess how the concentration of the Indole Butyric Acid (IBA) hormone affects the success of avocado stem cuttings. It is hoped that the results of this research will provide information in determining the optimal length of cutting material and the optimal provision of PGR IBA for the growth of avocado (*Persea americana* Mill) stem cuttings.

2. RESEARCH MATERIALS AND METHODS

Research was conducted on farmers' land in Mayangrejo Village, Kalitidu District, Bojonegoro Regency, East Java. The research implementation period starts from June 2023 to August 2023. This research was structured according to RAL with 1 factor, namely the IBA PGR concentration with five different levels: 0 ppm (Z0), 75 ppm (Z1), 100 ppm (Z2), 125 ppm (Z3), and 150 ppm (Z4).

The tools used in this research consisted of a knife, scissors, digital scales, camera, ruler, 75% polynet, transparent plastic, stationery items, measuring tape, hoe, measuring pole, and a 1000 ml beaker intended for soaking avocado stems. Materials to be used include avocado plant stem cuttings, planting media (garden soil, cocopit and compost), 20 x 15 polybags, labels, water, 95% alcohol, and pure IBA PGR (Merck).

2.1. Preparation of Cutting Material

The selection of planting material for propagating avocado cuttings has certain criteria, which include sources from strong and healthy mother trees that are not attacked by pests and diseases, the tree has good production, has a straight trunk configuration, displays cuttings that are neither too old nor too young, with specified lengths of 15 cm, 20 cm and 25 cm. Then the bottom of the cutting or the prospective root area, was trimmed with a knife to create a slightly tapered surface with the aim of widening the surface area for potential root formation and making it easier to embed it in the planting material. Stem cuttings were taken from the Vienna variety avocado orchard in Wonocolo Village, Kedewan District, Bojonegoro Regency.

2.2. Preparation of IBA

Concentration of 1000 ppm = 1 gram (1000 mg) of IBA dissolved in 1 liter of distilled water. Thus, to make a solution of IBA 75 ppm, 100 ppm, 125 ppm and 150 ppm by weighing IBA 75 mg (0.075 g) 100 mg (0.1 g) 125 ppm (0.125 g) 150 ppm (0.150 g) then put the IBA into the measuring rod and add 10 – 15 drops of 95% alcohol. Shake until the IBA dissolves. After that, add distilled water to a volume of 1000 ml.

2.3. Planting Avocado Cuttings

The cuttings to be planted are first soaked in IBA hormone at each concentration for 15 minutes, while for the control treatment the cuttings are soaked in water, then the cuttings are planted in polybags that have been filled with planting medium, ensuring that one third of the cuttings are buried in the ground. The cuttings are planted in an upright position, the cuttings are covered with transparent plastic for 1 month to maintain humidity. The polybags are then arranged according to the experimental plan. Cuttings are planted under paranet shade to reduce the amount of light exposure experienced by the plants and to facilitate rainfall retention and minimize the effects of wind exposure. Caring for cuttings includes watering when necessary by looking at the condition of the planting medium. Prevention of pests and diseases, by removing diseased seeds so that they do not spread to other seeds. Weeds are carried out around the place where the cuttings grow.

2.4. Observation Parameters

2.4.1. Shoot Length (cm)

Measuring shoot length involves assessing shoot growth from its base to the top of the plant shoot using a ruler or meter to determine shoot growth.

2.4.2. Number of Shoots (Fruit)

Observation of shoot number parameters was carried out by directly counting the shoots that appeared on avocado cuttings. Observation time is carried out once a week until the observation period ends.

2.4.3. Number of Leaves (Pieces)

Observations on leaf number parameters were carried out after the leaves appeared on the cutting material. The number of leaves was observed at intervals of one week until the end of the observation. The leaves that are counted are those that have opened completely.

2.4.4. Number of Primary Roots (Fruit)

Observation of the number of primary roots was carried out at the end of the observation period, namely at age 9 (WAP) by dismantling the cuttings from polybags by cleaning the soil attached to the roots and stems and then counting all the primary roots that appeared at the base of the cuttings in each cutting.

2.5. Data Analysis

The data obtained from the measurement results were then analyzed according to a non-factorial completely randomized design (CRD). Testing the effect and treatment as well as the interaction was used F (Didik Variety). Treatments are considered significantly different if the F number of the treatment exceeds the F table at 5%, while treatment is considered ineffective if the F number falls below the F table at 5%. Findings that show a real impact will then proceed to additional BNJ testing at a significance level of 5%.

3. RESULTS AND DISCUSSION

Figure 1 shows some of the avocado seedlings produced in this study. IBA concentrations had varying effects on plant growth parameters, as discussed below.

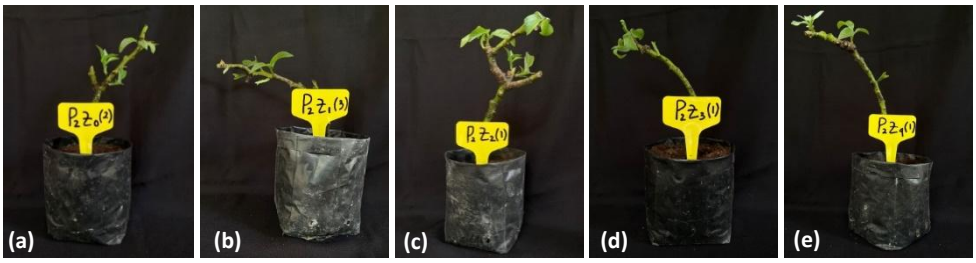

Figure 1. Results of avocado plant seeds under IBA hormone treatment at different concentrations: (a) 0 ppm, (b) 75 pmm, (c) 100 ppm, (d) 125 ppm, and (e) 150 ppm

3.1. Shoot Length

The results of the ANOVA analysis showed that the IBA concentration had a different effect on the shoot length of avocado cuttings from 4 to 9 weeks after planting (WAP). Significant differences between treatments were identified using the 5% BNJ test (Table 1). IBA concentration had a significant influence on the shoot length of avocado cuttings with *p*-value < 0.05. Treatments Z2 (100 ppm) and Z1 (75 ppm) produced the highest shoot length at 9 WAP, respectively 1.92 cm and 2.08 cm, and were significantly different from the control (Z0) which only reached 0.98 cm. Treatments Z3 (125 ppm) and Z4 (150 ppm) showed intermediate results, but were not significantly different from Z0 for most of the observation time. This shows that the optimal IBA concentration in stimulating shoot growth is in the range of 75–100 ppm. Thus, auxin has the ability to stimulate the growth of new shoots (Hasibuan, 2014). The auxin hormone has two main functions, namely accelerating shoot growth and breaking down cells in avocado plants (Pramudito *et al*., 2018). Supriyanto & Saepuloh (2014) argue that the auxin hormone influences shoot growth where cell elongation can occur due to the presence of the auxin hormone. The addition of the IBA hormone can encourage shoot lengthening and shoot growth in avocado plant cuttings.

Table 1. Effect of IBA Concentration on Shoot Length of Avocado Cuttings Aged 4 – 9 WAP.

IBA Concentration (Z)	Average Shoot Length at Age					
	4 WAP	5 WAP	6 WAP	7 WAP	8 WAP	9 WAP
Z0 (0 ppm)	0.56 a	0.61 a	0.71 a	0.77 a	0.86 a	0.98 a
Z1 (75 ppm)	0.94 bc	1.08 bc	1.22 bc	1.35 bc	1.50 bc	2.08 c
Z2 (100 ppm)	1.17 c	1.31 c	1.46 c	1.58 c	1.76 c	1.92 bc
Z3 (125 ppm)	0.77 ab	0.87 ab	1.00 ab	1.12 ab	1.23 ab	1.40 abc
Z4 (150 ppm)	0.65 ab	0.66 a	0.87 a	0.95 a	1.08 a	1.24 ab
BNJ 5%	**0.28**	**0.35**	**0.33**	**0.36**	**0.39**	**0.72**

Note: Numbers followed by the same letter in the same column showed no significant difference in the 5% LSD test; WAP = week after planting.

Table 2 Effect of IBA Concentration on the number of shoots from avocado cuttings

IBA Concentration (Z)	Number of Shoots
Z0 (0 ppm)	1.31 a
Z1 (75 ppm)	2.22 b
Z2 (100 ppm)	2.50 b
Z3 (125 ppm)	1.74 ab
Z4 (150 ppm)	1.78 ab
BNJ 5%	0.79

Note: Numbers followed by the same letter in the same column are not significantly different in the 5% BNJ test; tn = no effect real.

3.2. Number of Shoots

Data on the average number of shoot emergence on avocado plant cuttings can be seen in (Table 2). The results of the ANOVA analysis showed that the number of shoots on avocado cuttings showed a significant difference between IBA

concentration treatments. The treatment without IBA (Z0) produced the lowest number of shoots (1.31), which was significantly different from Z1 (75 ppm) and Z2 (100 ppm) which respectively produced 2.22 and 2.50 shoots per cutting. Z2 gave the highest results, indicating that an IBA concentration of 75–100 ppm is the optimal range for stimulating shoot formation. Concentrations above 100 ppm (Z3 and Z4) did not increase the number of shoots significantly compared to Z0.

Providing plant PGR hormones and selecting effective cutting sizes can influence the growth of stem cuttings. The growth regulator given to plants is related to the IBA hormone content which can help stimulate growth in roots and leaves. Meanwhile, choosing the length of stem cuttings is related to the amount of energy or food content used to form roots and shoots which will then form leaves (Putri, 2017).

3.3. Number of Leaves

The results of the ANOVA analysis showed that the IBA concentration treatment had a significant effect on the number of leaves at age 9 WAP. This can be seen in (Table 3). The IBA concentration treatment had a significant effect on the number of leaves from avocado cuttings. A concentration of 0 ppm (Z0) produced the lowest number of leaves (2.44 at 9 WAP), while 100 ppm (Z2) produced the highest number of leaves (4.33), significantly different from the other treatments. A concentration of 75 ppm (Z1) also gave high yields (3.63 strands), while concentrations of 125 ppm (Z3) and 150 ppm (Z4) gave lower yields, indicating that increasing the IBA concentration above 100 ppm does not always increase the number of leaves significantly. The IBA hormone stimulates the formation of roots and shoots, which will then form leaves. Providing optimal IBA hormones will support strong root and shoot growth, resulting in a greater number of leaves.

Table 3.Effect of IBA concentration on the average number of leaves of avocado cutting

IBA Concentration (Z)	Average Number of Leaves					
	4 WAP	5 WAP	6 WAP	7 WAP	8 WAP	9 WAP
Z0 (0 ppm)	0.74	1.22	1.74	1.93	2.30	2.44 a
Z1 (75 ppm)	0.96	1.70	2.48	2.85	3.26	3.63 bc
Z2 (100 ppm)	1.15	1.70	2.30	2.52	2.81	4.33 c
Z3 (125 ppm)	1.00	1.59	2.22	2.48	2.85	3.11 ab
Z4 (150 ppm)	0.67	1.33	2.00	2.26	2.67	2.93 ab
BNJ 5%	tn	tn	tn	tn	tn	0.99

Note: Numbers followed by the same letter in the same column showed no significant difference in the 5% BNJ test; tn = no effect real; MST = Week after Planting.

3.4. Number of Roots

Figure 2 shows root of some of the avocado seedlings produced in this study. The results of the ANOVA analysis showed that there was no interaction in the treatment of IBA concentration on the number of primary roots of avocado cuttings. The average value of the number of primary roots for the IBA concentration treatment can be seen in (Table 4). The treatment results of giving the highest IBA concentration were Z2 (100 ppm) with an average of 0.19 and the smallest average value was when giving a concentration of 150 ppm. In the IBA concentration treatment, there was no

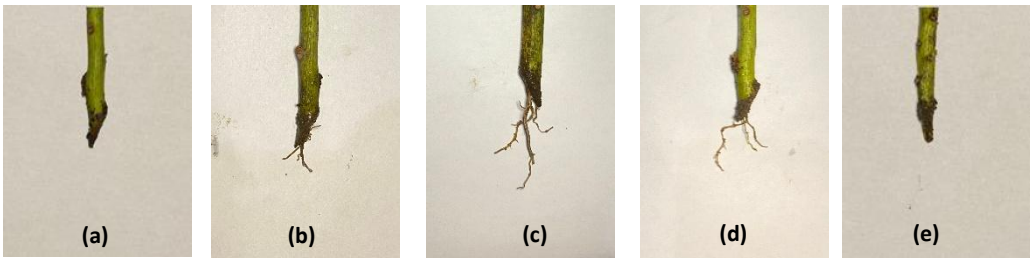

Figure 2. Effect of IBA concentrations on the plant root: (a) 0 ppm, (b) 75 pmm, (c) 100 ppm, (d) 125 ppm, and (e) 150 ppm

significant effect on the number of roots of the cuttings. According to Ussudur *et al*., (2020) adding appropriate concentrations of the IBA hormone and appropriate levels of the auxin hormone can produce optimal root growth. Root growth in cutting propagation is the main focus, this is because the roots act as the foundation and tool for absorbing nutrients and important nutrients in the soil which are needed for the development of new shoots and leaves.

Table 4 Effect of IBA concentration on the number of roots of avocado cuttings

IBA Concentration (Z)	Number of Roots (Fruits)
Z0 (0 ppm)	0.00
Z1 (75 ppm)	0.04
Z2 (100 ppm)	0.19
Z3 (125 ppm)	0.04
Z4 (150 ppm)	0.00
LSD 5%	**tn**

Note: Numbers followed by the same letter in that column the same shows no significant difference in the 5% BNJ test; tn = not significant

IBA is able to encourage root growth by stimulating cell division in the cuttings that have been cut and the absorption of nutrients and nutrients (Karyanti *et al*., 2014). There are several factors that influence the growth of stem cuttings, including environmental conditions, source of media/planting material, and length of stem cuttings. Generally, young stems used for cuttings often fail because the roots do not grow before the shoots (Ussudur *et al*., 2020).

4. CONCLUSION

Providing the IBA hormone was able to increase the success of avocado plant cuttings with shoot length reaching 2.08 cm, number of shoots 2.50, number of leaves 4.33 and number of roots 0.19. Giving IBA hormone concentrations to the success of cuttings must be taken into account. If too high a concentration is used, it can cause bad effects on the plant, while using a concentration that is less than the optimal level can produce insufficient results in the growth of cuttings in avocado plants.

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