Vol. 14, No. 6 (2025): 2046 - 2056 http://dx.doi.org/10.23960/jtepl.v14i6.2046-2056

JURNAL TEKNIK PERTANIAN LAMPUNG

ISSN 2302-559X (print) / 2549-0818 (online)
Journal homepage : https://jurnal.fp.unila.ac.id/index.php/JTP

Effect of Indole Butyric Acid (IBA) Application and Spliced Grafting on the Growth of Garuda Clone Cassava

Menis Triana[1], Yusnita[2,✉], Dwi Hapsoro[2], Setyo Dwi Utomo[2], Fitri Yelli[2]

[1] Master Program in Agronomy, Faculty of Agriculture, University of Lampung, INDONESIA.

[2] Department of Agronomy and Horticulture, Faculty of Agriculture, University of Lampung, INDONESIA.

Article History:

Received : 18 June 2025
Revised : 30 July 2025
Accepted : 01 August 2025

Keywords:

Cassava,
Grafting,
Growth,
IBA,
Production.

Corresponding Author:
✉ yusnita.said@yahoo.com
(Yusnita)

ABSTRACT

Increasing cassava production is required to maintain supply sustainability and meet seed demand. The use of splice grafting and the application of auxin IBA are expected to accelerate rooting and enhance the productivity of cassava. The objective of this research is to study the effect of IBA application on the growth of cuttings and grafted seedlings of cassava. The research was conducted from October 2024 to February 2025 at the Integrated Field Laboratory of the Faculty of Agriculture, University of Lampung, Natar District, South Lampung. The experiment was designed according to randomized block design (RBD) with factorial treatments arrangement (3×2). The first factor was IBA concentration consisted of three levels, namely without IBA (A0), 1000 ppm (A1), and 2000 ppm IBA (A2). The second factor consisted of 2 types of plant materials, namely cuttings seedlings (B1) and slanted graft seedlings (B2). The results show that the application of IBA significantly increases the growth and production of cassava compared to without IBA application. IBA at 2000 ppm is the best concentration for the observed variables. The use of planting materials, whether cuttings or slanted grafts, both enhance the yield of cassava.

1. INTRODUCTION

Cassava (*Manihot utilisma* or *Manihot esculenta* Crantz) is a root plant that has been cultivated for a long time in Indonesia and has various benefits, including as food, animal feed, fuel, and industrial raw materials. Its use in the industrial sector continues to increase, especially as an alternative energy source such as biofuel and bioethanol, and as part of the diversification of food based on local potential (Ariningsih, 2016). The advantages of cassava lie in its extensive adaptability, high productivity, and relatively low planting costs, making it the main food alternative after rice and corn (Subagio, 2022). FAO calls it a 21st century crop because of its contribution to food security, poverty alleviation, and national economic improvement (Howeler *et al*., 2013). In addition, cassava is an export commodity with high economic value, with varying starch and dry material content (Rahmiati *et al*., 2016).

Lampung Province is the largest cassava producer in Sumatra, with a contribution of 81.16% or 7.25 million tons (Director General of Food Crops, 2024). This area has a variety of superior clones, such as UJ 5, Thailand or UJ 3, BW 1, and Adira, which are spread across several districts, including Central Lampung, North Lampung, and East Lampung (Kanafi, 2022). Although production is high, increased production is still necessary to maintain supply sustainability and meet the growing demand for seedlings. The main development strategy involves the application of five farming pilars (*panca usaha tani*), especially the use of superior seeds derived from plant stems that are more than 11 months old (Setiawan, 2017). One way to increase cassava productivity is by the grafting technique, combining rubber cassava (*Manihot glaziovii*) as the top stem (entres) and cultivated cassava as the rootstock.

Rubber cassava (*Manihot glaziovii*) has broad adaptability, large leaves, and resistance to pests, as well as high photosynthesis ability that increases photosynthetic production for tuber growth (Lakitan, 1993). The grafting technique is used to combine rootstock and scion to maintain superior character and increase photosynthesis efficiency (Hartmann *et al*., 2014). Rubber cassava has the ability to grow quickly, is vigorous and resistant to pruning, so it is very suitable as a top stem (Utomo, 2024). Growth regulators such as IBA (*indole-butyric acid*) and BA(*benzyladenine*) play a role in root and crown growth, where the application of IBA 2000 ppm has been shown to be effective in increasing the number of roots and shoots and producing better graft unions (Yusnita *et al*., 2024; Nguyen *et al*., 2020). The use of splice grafting and auxin IBA applications is expected to accelerate rooting and increase cassava productivity (Santoso, 2009; Hartmann *et al*., 2011).

The purpose of this study is to study the effect of IBA application on cassava cuttings and rootstocks of grafted seedlings on rooting and growth of crowns. It is expected that through this study, the use of IBA can accelerate plant growth and increase cassava productivity. The findings of this study can also be a reference in the development of more optimal cultivation methods, especially in terms of vegetative propagation and the provision of quality seeds.

2. MATERIALS AND METHODS

The research was conducted in the Integrated Field Laboratory, Faculty of Agriculture, University of Lampung, Natar District, South Lampung from October 2024 to February 2025. The materials used in this study were Garuda clone cassava cuttings, rubber cassava, IBA, KOH, HCl, fungicides with the active ingredient Mancozeb 80%, Furadan, urea, KCl, SP36, cow bokashi fertilizer. The tools included cutting tools, measuring flasks, measuring cups, analytical scales, water hoses, brushes, hand sprays, meters, plastic and rubber ropes. Figure 1 presented the union of the rootstock of the Garuda clone and the rubber cassava as the upper trunk.

A. Rootstock (Garuda clone)	B. Scion or entres (rubber cassava)	C. Grafting (join rootstock and scion)	D. Covering after planting
			

Figure 1. Cassava stem and stem integration

2.1. Experimental Design

The experiment was designed in a randomized block design (RBD) with factorial arrangement (3×2), and 6 treatment combinations were obtained. Each treatment was repeated three times. The first factor was three levels of IBA concentration, namely without IBA (A0), 1000 ppm (A1) and 2000 ppm IBA (A2). The second factor consisted of 2 types of cassava plant materials, namely cuttings (B1) and spliced grafting seeds (B2). Each experimental unit consisted of 10 seedlings planted with a distance of 1m × 1m on a ridge measuring 1.4m × 0.5m. Two types of cassava seedlings were used in this experiment: stem cuttings of the Garuda clone and seedlings from spliced grafting. For seedlings from splice grafting, the Garuda clone was used as the rootstock (25 cm), and rubber cassava was used for the scion (entres) with a length of 30 cm. IBA was applied by smearing on the base of the cassava seedlings (stem cuttings and splice grafting) with a brush before planting.

2.2. Measurement and Analysis

Variables in this study included shoot height, number of leaves, number of shoots observed from 1 to 16 week after planting (WAP), number of branching, longest root length, number of productive roots, number of fibrous roots, total number of roots, productive root weight, fibrous root weight, total root weight, plant weight, and tuber diameter measured at plant age of 16 WAP. ANOVA was performed using excel and R studio 4.3.2 software. If there is a significant difference between treatments, then Fisher LSD test was carried out at α = 5%.

3. RESULTS AND DISCUSSION

3.1. Results

Table 1 summarizes analysis of variance (ANOVA) performed to the collected data. It shows that the treatment of IBA significantly affects the growth and yield of cassava as indicated by all observed variables except for the number of shoots produced. The type of planting material (cuttings or graftings) had a very significant effect on all observation variables except the number of shoots, and the weight of the fibrous roots. There was a very significant interaction between IBA and planting material on all observation variables, except for the number of shoots, the number of productive roots, and the diameter of the tubers.

Table 1. Summary of ANOVA of the various effects of IBA application on the growth of Garuda clone cuttings at age 16 WAP.

No	Observation Variables	Factor A	*p*-value	Factor B	*p*-value	A×B	*p*-value	CV (%)
1	Shoot height (cm)	**	0.0000	**	0.0000	**	0.0000	0.31
2	Number of leaves	**	0.0000	**	0.0000	**	0.0001	0.98
3	Number of shoots (stems)	ns	3.182	ns	0.455	ns	0.455	17.98
4	Number of branching	**	0.0000	**	0.0000	**	0.0000	0.02
5	Longest root length (cm)	**	0.0000	**	0.0000	**	0.0000	2.41
6	Number of productive roots	**	0.0000	**	0.0077	ns	0.1974	4.87
7	Number of fibrous roots	**	0.0000	**	0.0016	**	0.0029	5.92
8	Total number of roots	**	0.0000	**	0.0000	**	0.0002	2.53
9	Tuber diameter (cm)	**	0.0000	**	0.0002	ns	0.2501	2.80
10	Weight of productive root (kg)	**	0.0000	**	0.0000	**	0.0000	2.28
11	Weight of fibrous root (kg)	**	0.0000	ns	0.3166	**	0.0000	7.06
12	Total root weight (kg)	**	0.0000	**	0.0000	**	0.0000	2.28
13	Shoot weight (kg)	**	0.0000	**	0.0000	**	0.0000	1.99

Note: ** = Significant difference in the F test (α= 1%); ns = No significant difference on the F test (α=1%); A = IBA application; B = Type of planting material (cuttings and splice grafting), CV = Coefficient of variance

Table 2. Effect of IBA application and seed types on the average height of Garuda clone cassava at age of 16 WAP

Treatment	Control (IBA 0)	IBA 1000 ppm	IBA 2000 ppm
Stem Cutting	197.1 f	219.0 d	230.3 c
Spliced Grafting	208.4 e	252.4 b	266.5 a

Note: The average values followed by the same letter do not differ from each other based on the 5% LSD test. [LSD 5% = 1.29]

Shoot Height

The results showed that average height of the cassava shoots due to IBA 1000 ppm treatment in cutting-seeded origin plants was from 197.1 cm (control) to 219.0 cm, and the application of IBA 2000 ppm significantly increased the shoot height further to 230.3 cm (Table 2). The significant effect also occurred in plants from grafting seeds, where the application of IBA 1000 ppm significantly increased the average shoot height from 208.4 cm (control) to 252.4 cm, and the increase in IBA concentration to 2000 ppm significantly increased the shoot height to 266.5 cm. The significant interaction between IBA auxins and seedling origin is shown by an increase in shoot height due to a higher IBA 2000 ppm treatment in grafted seedlings, compared to plants cultivated from cuttings.

Number of Leaves

The same positive effect of IBA also occurs on cassava plants from grafting seedlings. An application of 1000 ppm of

IBA on the rootstock significantly increased the number of leaves from 71 (control) to 74 leaves, and an increase in the concentration of IBA to 2000 ppm could further increase the number of leaves to 78 (Table 3). In all auxin treatments (control, 1000 ppm, and 2000 ppm IBA), the average number of leaves in plants derived from grafting seedls was greater (71–78 strands) than those of plants derived from cuttings (48-60 strands).

Table 3. Effect of IBA application and seed types on the average number of leaves of Garuda clone cassava at age of 16 WAP

Treatment	Control (IBA 0)	IBA 1000 ppm	IBA 2000 ppm
Stem Cutting	48 f	53 e	60 d
Spliced Grafting	71 c	74 b	78 a

Note: The average values followed by the same letter do not differ from each other based on the 5% LSD test. [LSD 5% = 1.14]

Number of Shoot

The application of IBA at both 1000 ppm and 2000 ppm had no significant effect on the average number of shoots at the age of 16 WAP. The number of shoots produced from all treatments ranges from 1.7 to 2.2 stems. The use of cutting seed and grafting seed presented in Figure 2 shows that both produce a number of shoots that are not statistically different from each other, namely 1.9 and 2.0 stems.

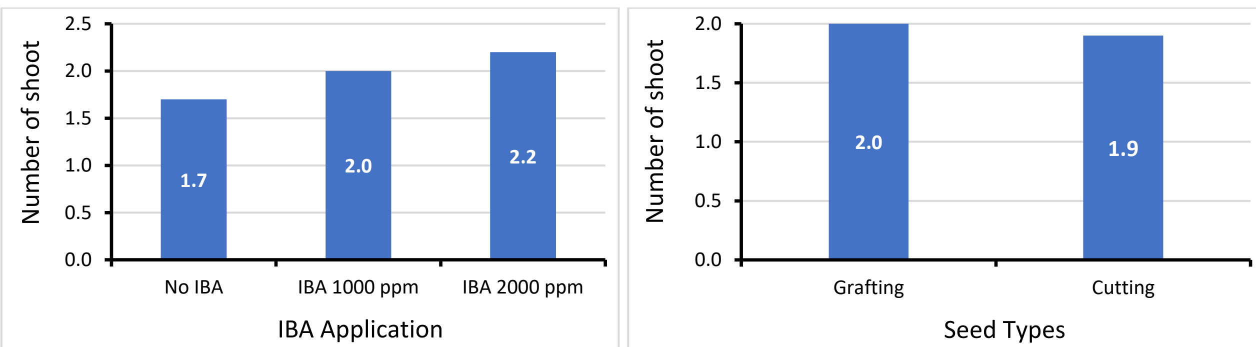

Figure 2. (a) Effect of treatment factor on the number of cassava shoot at the age of 16 WAP: (a) IBA application; (b) Seed types

Number of Branch

For cassava planted from cuttings, the application of IBA at both 1000 ppm and 2000 ppm has no effect on the number of plant branching, namely 1. However, in cassava from grafting seedlings, the auxin application, both 1000 ppm and 2000 ppm significantly increased the branching rate of cassava plants from 2 (control) to 3 levels (Table 4).

Table 4. Effect of IBA application and seed types on the average number of branch of Garuda clone cassava at age of 16 WAP

Treatment	Control (IBA 0)	IBA 1000 ppm	IBA 2000 ppm
Stem Cutting	1 c	1 c	1 c
Spliced Grafting	2 b	3 a	3 a

Note: The average values followed by the same letter do not differ from each other based on the 5% LSD test. [LSD 5% = 0.9]

Longest Root Length

For cassava cultivated using cuttings, the application of IBA to 1000 ppm and 2000 ppm, both of which significantly increased the average length of the longest root of cassava, but the trend of increasing the longest root length was different (Table 5). The application of IBA 1000 ppm increased the longest root length from 56.8 cm (control) to 70.8 cm. The increase in IBA to 2000 ppm also increased the average root length to 66.3 cm, but this value was smaller than that of IBA 1000 ppm application. In cassava from grafting seedlings, the application of 1000 ppm IBA drastically increased the average length of the longest root compared to the control (59.9 cm) to 88.8 cm, and the application of IBA 2000 ppm further increased the root length to 97.1 cm. Table 5 also shows that after IBA application, the average length of the longest roots in cassava from the grafting seeds is longer than that from cuttings.

Table 5. Effect of IBA application and seed types on the average length of longest root of Garuda clone cassava at age of 16 WAP

Treatment	Control (IBA 0)	IBA 1000 ppm	IBA 2000 ppm
Stem Cutting	56.8 e	70.8 c	66.3 d
Spliced Grafting	59.9 e	88.8 b	97.1 a

Note: The average values followed by the same letter do not differ from each other based on the 5% LSD test. [LSD 5% = 3.21]

Number of Productive Roots

The application of IBA 1000 ppm and 2000 ppm significantly increased the number of productive roots from 20 (control) to 26 (IBA 1000 ppm) and 33 (IBA 2000 ppm) (Figure 3). Thus an increase in the concentration of IBA from 1000 ppm to 2000 ppm resulted in a further significant increase in the number of productive roots. The effect of cassava seed types on the number of productive roots shows that grafting seeds produce a significantly greater number of productive roots (i.e. 27 pieces) compared to those of cuttings (i.e. 25 pieces).

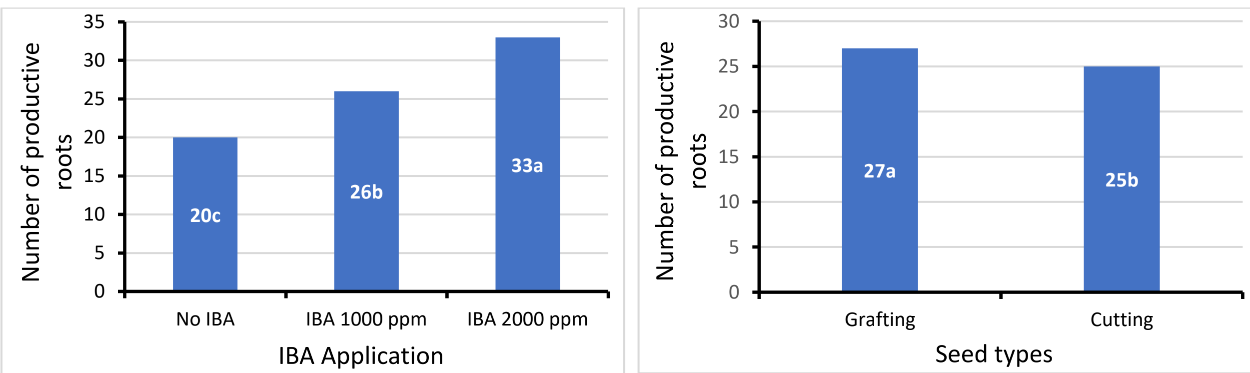

Figure 3. (a) Effect of treatment factor on the number of productive root at the age of 16 WAP: (a) IBA application (LSD = 1.64); (b) Seed types (LSD = 1.34).

Table 6. Effect of IBA application and seed types on the average number of fibrous roots of Garuda clone cassava at age of 16 WAP

Treatment	Control (IBA 0)	IBA 1000 ppm	IBA 2000 ppm
Stem Cutting	30 d	43 c	54 b
Spliced Grafting	30 d	46 c	67 a

Note: The average values followed by the same letter do not differ from each other based on the 5% LSD test. [LSD 5% = 4.86]

Fibrous Roots

The interaction of IBA application and seed types significantly influences the number of fibrous roots (Table 6). The average number of fiber roots without auxin, both in cassava from cuttings and from grafting seeds is 30. Application of IBA of 1000 ppm on cuttings significantly increased the number of fibrous roots to 43 and an application of IBA of 2000 ppm, resulting in a further significant increase in the number of fibrous roots to 54. Similarly, for planting material from grafting, the application of IBA 1000 ppm significantly increased the number of fibrous roots to 46. The application of IBA 2000 ppm resulted in an increase in the number of fiber roots that were more than the increase that occurred in cuttings, which was 67. Thus, cassava plants from spliced grafting seeds applied by IBA have a higher number of fibrous roots (46 and 67) than seedlings from cuttings applied by IBA (43 and 54).

Total Number of Roots

Cassava plants from grafting seeds with IBA application have a positive impact on the total number of roots.

Application of 1000 ppm IBA to rootstocks increased the number of total roots of 74.3, compared to control of 50 (Table 7). Increasing the concentration of IBA to 2000 ppm increases the total number of roots to 100.7. Thus, the average total number of roots in cassava plants from grafting seeds applied by IBA has a higher total number of roots (74.3 and 100.7) than the plants from cuttings applied by IBA (67.5 and 86.0). Cassava plants derived from cuttings with IBA application of 1000 ppm, significantly increased the total number of roots from 49.3 (control) to 57.5. A further increase in concentration (2000 ppm) resulted in an increase in the total number of roots to 86.

Table 7. Effect of IBA application and seed types on the total number of roots of Garuda clone cassava at age of 16 WAP

Treatment	Control (IBA 0)	IBA 1000 ppm	IBA 2000 ppm
Stem Cutting	49.3 e	67.5 d	86.0 b
Spliced Grafting	50.0 e	74.4 c	100.7 a

Note: The average values followed by the same letter do not differ from each other based on the 5% LSD test. [LSD 5% = 3.27]

Tuber Diameter

The average diameter of cassava tuber without IBA application was 2.2 cm while the use of IBA application at 1000 ppm and 2000 ppm, both significantly increased the tuber diameter (Figure 4a). The increase in IBA concentration was followed by an increase in the diameter of the tuber produced, which was 3.4 cm, and 3.6 cm, respectively. The diameter of the tuber produced due to the use of planting material showed that the average diameter of the tubers of cassava plants with cuttings (3.2 cm) was significantly higher than with grafting seeds (2.9 cm) (Figure 4b).

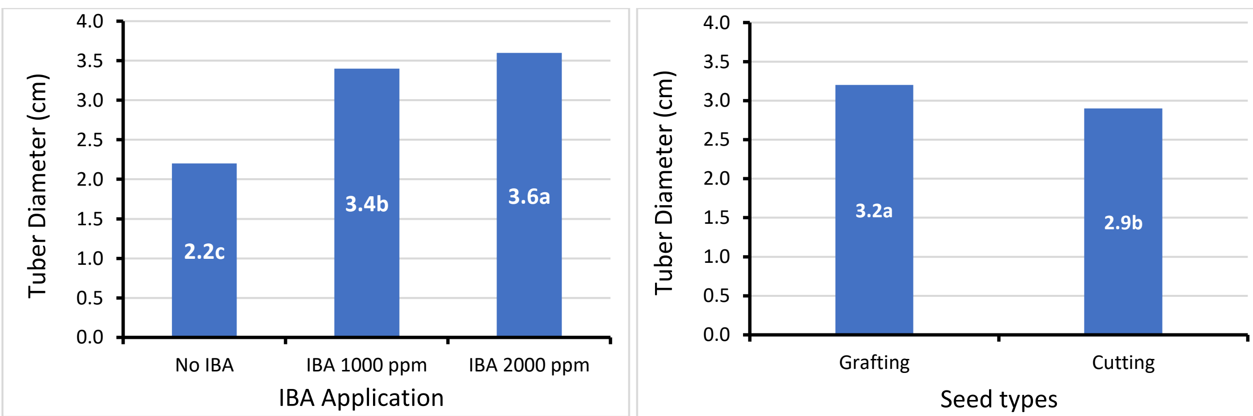

Figure 4. (a) Effect of treatment factor on the tuber diameter at the age of 16 WAP: (a) IBA application (LSD = 0.11); (b) Seed types (LSD = 0.09)

Productive Root Weight

Without IBA application, cutting-derived cassava plants produce a higher productive root weight or root tuber than those derived from graft seedlings (1.7 kg *vs*. 0.9 kg) (Table 8). In plants from cuttings, the application of IBA at 1000 ppm and 2000 ppm, both of which increased the productive root weight to 2.9 kg and 3.0 kg, respectively, where these two values did not differ from each other. In cassava plants from grafted seedlings, the application of IBA 1000 ppm and 2000 ppm both also significantly increased the productive root weight, i.e. to 2.5 kg and 2.9 kg, the increase in the concentration of IBA from 1000 ppm to 2000 ppm resulted in a further significant increase in productive root weight.

Table 8. Effect of IBA application and seed types on the weight (kg) of productive root of Garuda clone cassava at age of 16 WAP

Treatment	Control (IBA 0)	IBA 1000 ppm	IBA 2000 ppm
Stem Cutting	1.7 d	2.9 ab	3.0 a
Spliced Grafting	0.9 e	2.5 c	2.9 b

Note: The average values followed by the same letter do not differ from each other based on the 5% LSD test. [LSD 5% = 0.09]

Weight of Fibrous Roots

The results showed that in cassava plants from cutting seeds, the application of 1000 ppm and 2000 ppm IBA, both significantly increased the weight of fibrous roots from 8 g (control) to 18 g and 20 g, the two values were not different (Table 9). Plants derived from grafting seeds, the application of IBA 1000 ppm increased the weight of the fibrous roots from 11 g (control) to 13 g, and the application of IBA 2000 ppm further increased the weight of the fibrous roots even higher, i.e. to 24 g.

Table 9. Effect of IBA application and seed types on the weight (g) of fibrous root of Garuda clone cassava at age of 16 WAP

Treatment	Control (IBA 0)	IBA 1000 ppm	IBA 2000 ppm
Stem Cutting	8 e	18 b	20 b
Spliced Grafting	11 d	13 c	24 a

Note: The average values followed by the same letter do not differ from each other based on the 5% LSD test. [LSD 5% = 0.002]

Table 10. Effect of IBA application and seed types on the total root weight (kg) of Garuda clone cassava at 16 WAP

Treatment	Control (IBA 0)	IBA 1000 ppm	IBA 2000 ppm
Stem Cutting	1.69 c	2.94 a	3.02 a
Spliced Grafting	0.93 d	2.51 b	2.92 a

Note: The average values followed by the same letter do not differ from each other based on the 5% LSD test. [LSD 5% = 0.09]

Total Root Weight

For cassava plants from cutting seeds, IBA application of 1000 ppm and 2000 ppm were both able to significantly increase total root weight from 1.69 kg (control) to 2.94 kg and 3.02 kg, both of which did not differ from each other (Table 10). The application of IBA 1000 ppm and 2000 ppm on grafted seedlings can also significantly increase the total root weight from 0.93 kg (control) to 2.51 kg, and 2.92. The difference is that the increase in IBA concentration from 1000 ppm to 2000 ppm resulted in a further increase in total root weight (from 2.51 kg to 2.92 kg).

Above-Ground Biomass Weight

The weight of above-ground biomass of plants cultivated using cuttings without IBA (control) is 1.9 kg. This value is higher than that of control plants from grafting seeds which resulted in above-ground biomass weight of 1.2 kg. The application of IBA of 1000 ppm and 2000 ppm on cuttings and grafting seeds significantly increased the weight of plant cuttings, namely to 3.6 kg and 3.5 kg in plants derived from cuttings and respectively to 2.7 kg and 3.7 kg in plants from grafting (Table 11). In other words, in cassava plants from grafting seedlings, the increase in IBA concentration from 1000 ppm to 2000 ppm results in a further increase in its starting weight, while in cutting-origin plants, both applications of 1000 ppm IBA and 2000 ppm, both increase the weight of cuttings with average values that are not different from each other.

Table 11. Effect of IBA application and seed types on the weight (kg) of above-ground biomass of Garuda clone cassava at 16 WAP

Treatment	Control (IBA 0)	IBA 1000 ppm	IBA 2000 ppm
Stem Cutting	1.9 d	3.6 a	3.5 b
Spliced Grafting	1.2 e	2.7 c	3.7 a

Note: The average values followed by the same letter do not differ from each other based on the 5% LSD test. [LSD 5% = 0.09]

Tuber Orientation Geometry

Figure 5 and 6 respectively present the visual appearance of tubers geometry of cassava cultivated from cuttings and grafting seeds. Tuber orientation geometry was measured using the length of the longest distance of the two tuber tips (Waainjenberg, 1993). The tuber geometry is important factor related to the force required to uplift the cassava during harvesting, especially if the harvesting process is performed manually (Amponsah *et al*., 2017). Tuber geometry is determined by seed position during initial planting, where seed planted vertically produced tuber in a more symmetrical horizontal distribution so that more force is required to uplift the tubers, as compared to those seeds planted obliquely (Waainjenberg, 1993).

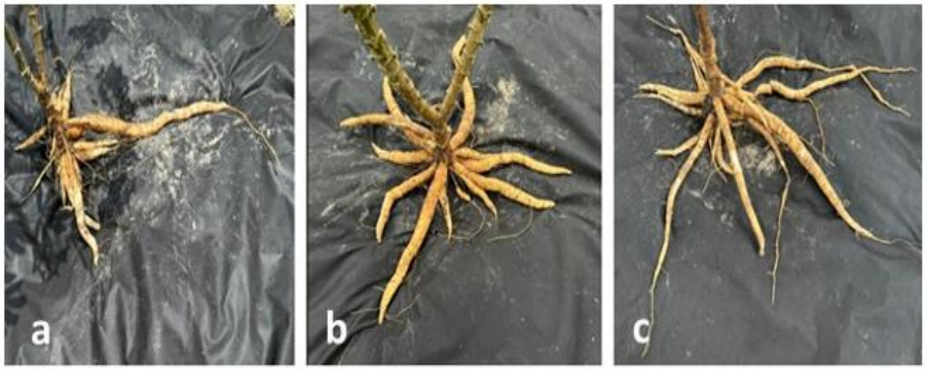

Figure 5. Effect of IBA application on root orientation of Garuda cassava planted from cutting seeds at age 16 WAP: (a) control, without IBA; (b) IBA 1000 ppm; (c) IBA 2000 ppm

Figure 6. Effect of IBA application on root orientation of Garuda cassava planted from grafting seeds at the age of 16 WAP: (a) control, without IBA; (b) IBA 1000 ppm; (c) IBA 2000 ppm.

Cassava plants derived from cuttings, the application of IBA increased tuber orientation with average longest geometry distance of 109.8 cm (control) to 131.8 cm (IBA 1000 ppm), and 124.7 cm with IBA 2000 ppm (Table 12). Using spliced grafting, the effect of IBA significantly increased the average tuber orientation from distance of 115.8 cm (control) to 137.3 cm (IBA 1000 ppm), and further increased drastically to 168.2 cm with IBA 2000 ppm. Thus, the tuber orientation of cassava planted from the grafted seeds, all IBA treatments resulted in wider tuber area as compared to those from cuttings.

Table 12. Effect of IBA application and seed types on the diameter geometry (kg) of Garuda clone cassava at age of 16 WAP

Treatment	Control (IBA 0)	IBA 1000 ppm	IBA 2000 ppm
Stem Cutting	109.8 f	131.8 c	124.7 d
Spliced Grafting	115.8 e	137.3 b	168.2 a

Note: The average values followed by the same letter do not differ from each other based on the 5% LSD test. [LSD 5% = 4.31]

3.2. Discussion

The results of the study showed that the IBA treatment applied through the base of the cuttings and the slanted joined seeds of Garuda clones significantly increased the growth and production of Garuda cloned cassava. This shows that the application of auxin ZPT is able to stimulate the formation of shoots and roots (Kuntoro *et al.*, 2016; Azmi & Handriatni, 2018). The insignificance of the treatment effect on the number of shoots is most likely due to the nature of IBA, which is an artificial auxin hormone whose main function is to stimulate root formation, rather than directly stimulate bud growth. Although well-growing roots can support the bud formation process, the impact is indirect and usually takes longer to be seen. Variations in physiological responses from planting materials such as cuttings and joints also affect the number of shoots that appear. Some plant species may not be very responsive to IBA applications, or may have a high natural ability to form buds even without treatment. This condition is due to auxin being able to increase the hydrolysis of nutrient reserves in stems and leaves (Abidin & Metali, 2015).

On the other hand, environmental conditions also play a significant role in influencing the results, where temperature, humidity, lighting, type of planting media, and various forms of environmental stress can suppress or disguise the influence of IBA and splicing techniques. Naturally, cassava plants have a tendency to grow vertically first (apical growth) before producing lateral shoots. This is closely related to apical dominance, which is a common hormonal mechanism in plants, in which apical shoots suppress the development of side shoots. Aulsin, including IBA, plays a role in inhibiting the growth of lateral shoots, so that plant growth is more focused upwards in order to obtain optimal light. Thus, it can be concluded that IBA is a synthetic hormone that specifically functions to stimulate root growth, especially adventitious roots in vegetative propagation such as cuttings, through the process of cell division and elongation in the pericamium or root meristem tissue. Auxin has its own role in the process of cell division, elongation, and differentiation. At the organ level, one of its functions is to encourage the formation of calluses and somatic embryos (Hapsoro & Yusnita, 2020).

Application of IBA at a concentration of 1000 ppm improves cassava growth and yield. Further increase in concentration to 2000 ppm results in better cassava growth and production compared to 1000 ppm. It is suspected that the concentration of 2000 ppm is more suitable in inducing the growth of shoots and roots of Garuda clones. The results obtained in the study of Elfandari (2012), showed that the application of IBA with a concentration of 2,000 ppm is the best concentration in supporting the rooting of cassava mini stem cuttings. Yusnita *et al*. (2024) also reported that IBA at a concentration of 2000 ppm is the best concentration in increasing the number of primary and secondary roots in P. colubrinum. According to Azmi & Handriatni (2018), the administration of auxin from the outside with the right concentration is able to spur the growth of vegetative organs of plants such as root shoots or leaf shoots, because exogenous auxins can increase and spur the activity of endogenous auxins already present in the cuttings so that they can spur the growth of shoots in the cuttings earlier.

The use of planting materials, both cuttings and slanted sambug, significantly increases cassava growth and yield. Cuttings generally already have a well-developed root system before the grafting process is carried out, so that they are better able to absorb water and nutrients optimally in the early stages of growth. This condition has the potential to have a positive influence on parameters such as root weight and stem diameter, which tend to be higher in this type of seedling.

Meanwhile, oblique graft seedlings generally do not have perfectly formed roots, so their success depends more on the process of post-graft tissue unification to form new roots. This stage requires more time and energy, which can lead to slower growth or show a different developmental pattern compared to cuttings. However, both cuttings and oblique seedlings, both have a significant influence on the development of the rooting system such as root length, number of productive roots, fibrous roots, which are formed, so in general these three aspects are positively correlated with the total number of roots. An increase in productive root weight, and total root weight also occurred when IBA was given with a concentration of 2000 ppm. Likewise with the weight of productive roots; The more productive roots are formed, the total root weight will also increase, and vice versa. This is because the levels contained in auxins, in this case IBA, which are responded to by plants, are physiologically different so that they affect a lot or less the number of shoots.

The application of IBA to cassava cuttings is used to meet the needs of plant growth regulators that play a role in the regeneration of shoots or shoots and roots. When the roots are formed compactly and perfectly, then shoot growth occurs. This is in accordance with the opinion of Kastono (2005) that the formation and growth of shoots will occur after the roots are well formed. In addition, IBA treatment can increase the speed of transportation and movement of carbohydrates to the base of the cuttings which will indirectly spur the formation of cuttings roots, so that the formation of good roots will accelerate the formation of new shoots (Aminah *et al*., 1995; Apriliani *et al*., 2015). This is corroborated by research by Kuntoro *et al*. (2016) also showing that the application of auxin hormones, including IBA, is able to increase bud height, wet and dry bud weight, root length, and wet and dry root weight.

The application of IBA applied to the base of the cuttings as well as at the angled connection point results in a success rate of up to 100%. The success of the joint is marked by the appearance of new shoots from the upper trunk (scion). This shows that the IBA application with grafting planting material is very optimally used. According to Hartmann *et al.* (2010), the success of grafting is supported by the formation of a connection between the rootstock and the upper trunk. Calluses will form and strengthen the connection link. The success of the grafting technique is indicated by the appearance of new shoots from the upper stem (scion), which signifies successful tissue union and the physiological activity of the plant returns to normal. The application of IBA (Indole Butyric Acid) helps to accelerate callus formation and tissue differentiation, thereby supporting the success of the joint. However, although buds appear as a sign of success, the number of buds produced between treatments shows statistically insignificant results. This means that even if the joints are visually successful, the IBA treatment has not shown any noticeable difference in increasing the number of buds consistently. This insignificant difference is caused by the levels contained in auxins, in this case IBA that is responded to by plants differently physiologically, so that it affects a lot or less the number of shoots. According to Husnan (2000), the effectiveness of ZPT is influenced by 3 factors, namely plant factors (species, varieties, plant age and physiological conditions of plants), growth regulating factors (concentration, time and method of administration), and environmental factors (temperature, humidity, light and others).

4. CONCLUSION AND SUGGESTION

At 16 WAP, cassava growth and rooting from grafting seeds is significantly higher than those of cutting seeds, as indicated by shoot height, number of leaves, number of branching, longest root length, and number of productive roots. However, in terms of productivity, cassava plants from grafting seeds have a lower average productive root diameter, productive root weight, and total root weight than plants cultivated using cuttings.

The application of IBA at both 1000 ppm and 2000 ppm significantly improved growth and rooting in cassava plants, both from cuttings and from grafts, which was indicated by the improvement of all parameters of observation of growth and rooting, except the number of shoots. In cutting-origin plants, an increase in IBA concentrations from 1000 ppm to 2000 ppm results in the same productive root weight, while in grafting plants, an increase in IBA concentrations from 1000 ppm to 2000 ppm results in a further increase in productive root weight.

It is necessary to make observations at the age of 10 months, to find out whether cassava from grafted seedlings produces a higher tuber weight than the original cutting. The application of grafting techniques and the use of IBA has the potential to improve the quality and yield of plant production. However, because this method requires additional costs and more complex procedures, careful economic analysis is required. It is important to ensure that the increase in results achieved is able to cover even beyond the costs that have been incurred, so that the investment is truly financially beneficial.

ACKNOWLEDGEMENT

This study was partially supported by the 2025 BLU Grant, Penelitian Pascasarjana Scheme, Universitas Lampung, contract 639/UN26.21/PN/2025.

REFERENCES

Abidin, N., & Metali, F. (2015). Effects of different types and concentrations of auxins on juvenile stem cuttings for propagation of potential medicinal *Dillenia suffruticosa* (Griff. ex Hook. F. & Thomson) Martelli shrub. *Research Journal of Botany*, ***10***(3), 73–87. https://doi.org/10.3923/rjb.2015.73.87

Aminah, H., Dick, J.M., Leakey, R.R.B., Grace, J., & Smith, R.I. (1995). Effect of indole butyric acid (IBA) on stem cuttings of *Shorea leprosula*. *Forest Ecology and Management*, ***72***(2-3), 199–206.

Ariningsih, E. (2016). Peningkatan produksi ubi kayu berbasis kawasan di Provinsi Jawa Barat dan Sulawesi Selatan. *Analisis*

Kebijakan Pertanian, ***14***(2), 125–148.

Azmi, R., & Handriatni, A. (2018). Pengaruh macam zat pengatur tumbuh alami terhadap pertumbuhan setek beberapa klon kopi robusta (*Coffea canephora*). *Biofarm: Jurnal Ilmiah Pertanian*, ***14***(2), 71–81. https://doi.org/10.31941/biofarm.v14i2.794

Apriliani, A., Anelio, A., dan Sumirwen. (2015). Pemberian beberapa jenis dan konsentrasi auksin untuk menginduksi perakaran pada stek pucuk buyur (*Pterospermum javanicum* Jungh.) dalam upaya perbanyakan tanaman revegetasi. *Jurnal Biologi Universitas Andalas*, ***4***(3), 178-187.

Elfandari, H. (2012). Pengaruh Pemberian Berbagai Konsentrasi IBA dan Jumlah Stek Buku Terhadap Perakaran Stek Batang Mini Tanaman Ubi Kayu (*Manihot esculenta* Crantz). [*Undergraduate Theses*]. Universitas Lampung. Bandar Lampung.

Hapsoro, D., & Yusnita. (2020). *Kultur Jaringan: Teori dan Praktik*. Andi Publisher, Yogyakarta.

Hartmann, H.T., Kester, D.E., Davies, F.T., Jr., & Geneve, R.L. (2010). Chapter 11: Principles of grafting and budding. In *Plant propagation: Principles and practices* (8^{th} ed.). Pearson Education, Prentice Hall: 415–463.

Hartmann, H.T., Kester, D.E., Davies, F.T., Jr., & Geneve, R.L. (2011). Chapter 9: The principle of propagation by cuttings. In *Crop Propagation: Principles and Practice* (8th ed.). Prentice Hall.

Hartmann, H.T., Kester, D.E., Davies, F.T., Jr., & Geneve, R.L. (2014). *Hartmann and Kester's plant propagation: Principles and Practices* (8th ed.). Prentice Hall International Inc.

Howeler, R.H., Lutaladio, N., & Thomas, G. (2013). *Save and Grow: Cassava, a Guide to Sustainable Production Intensification*. Food and Agriculture Organization, Rome: 129 p.

Husnan, H. (2000). Multiplikasi dan Pengakaran Tunas in Vitro Tempuyung (*Sonchus arvensis* L.) Serta Pertumbuhan Bibit Pasca Aklimatisasi. [*Undergraduate Theses*]. Institut Pertanian Bogor.

Kanafi, R.I.S. (2022). *Badan Pangan Nasional Minta Lampung Kelola Ubi Kayu Jadi Bahan Pangan*. Accesed on 22 November 2025 from https://www.antaranews.com/berita/3256357

Kastono, D. (2005). Tanggapan pertumbuhan dan hasil kedelai hitam terhadap penggunaan pupuk organik dan biopestisida gulma siam (*Chromolaena odorata*). *Ilmu Pertanian*, ***12***(2), 103-116.

Kuntoro, D., Sarwitri, R., & Suprapto, A. (2016). Pengaruh macam auksin pada pembibitan beberapa varietas tanaman jati (*Tectona grandis* L.). *VIGOR: Jurnal Ilmu Pertanian Tropika dan Subtropika*, ***1***(1), 7–11.

Lakitan, B. (1993). *Dasar-Dasar Fisiologi Tumbuhan*. PT Raja Grafindo Persada, Jakarta.

Nguyen, T.Q., Nguyen, B.H., Tran Thi, D.H., Duong Thi, O., Nguyen, Q.N., & Vo, C.C. (2020). Rooted cuttings by IBA (indole butyric acid) and NAA (naphthalene acetic acid) in black pepper (*Piper nigrum*): A case study in Vietnam. *International Journal of Chemical Studies*, ***8***(3), 1880–1885. https://doi.org/10.22271/chemi.2020.v8.i3z.9480

Rahmiati, T.M., Purwanto, Y.A., Budijanto, S., & Khumaida, N. (2016). Sifat fisikokimia tepung dari 10 genotipe ubi kayu (*Manihot esculenta* Crantz) hasil pemuliaan. *Jurnal Agritech*, ***36***(4), 459–466. https://doi.org/10.22146/agritech.16771

Santoso, B.B. (2009). *Pembiakan Vegetatif Dalam Hortikultura*. UNRAM Press. 145 pp.

Setiawan, E. (2017). Efektivitas pemberian IAA, IBA, NAA, dan root-up pada pembibitan kesemek. *Jurnal Hortikultura Indonesia*, ***8***(2), 97–103. https://doi.org/10.29244/jhi.8.2.97-103

Subagio, A., Nafi, A., Diniyah, N., Fitriyana, N.I., Mandala, M., Avivi, S., & Restanto, D.P. (2019). *Membangun Negeri Dengan Singkong – Building the Country with Cassava*. Universitas Jember.

Utomo, S.D., Setiawan, K., Fatmawati, A., Yelli, F., Ardian, S., Asyarati, N.K., Edy, A., Safitriyani, T., Rugayah, R., Ikhsan, K.N., Hidayat, K.F., Saputri, E.G., Ramadian, S., Pramesti, O.J., Widyastuti, R.A.D., Indriyani, V.R., & Rahmawati, A. (2024). *Grafting Ubi Kayu Menggunakan Batang Bawah Singkong Karet*. CV. Anugrah Utama Raharja. Bandar Lampung.

Yusnita, Y., Hapsoro, D., Prayogi, A., Agustiansyah, A., & Karyanto, A. (2024). Successful grafting of two Indonesian clones of *Piper nigrum* L. with *P. colubrinum* Link.: Effects of IBA and NAA on rooting and effects of BA on grafting. *AGRIVITA Journal of Agricultural Science*, ***46***(1), 28–37. https://doi.org/10.17503/agrivita.v46i1.3899