Jurnal Agronomi Indonesia
(Indonesian Journal of Agronomy)

ISSN 2085-2916 | e-ISSN 2337-3652
April 2025, *53*(1), 122-130
DOI: https://dx.doi.org/10.24831/jai.v53i1.61432

Research Article

Improving cassava growth and yield through auxin paste treatment on cuttings: A clonal comparison

Naufal Dani Fauzan [1], Yusnita Yusnita [2*], Sandi Asmara [3], Agus Karyanto [2], and R. A. Diana Widyastuti [2]

[1] Agronomy Graduate Program, Faculty of Agriculture, University of Lampung, Jl. Prof. Dr. Ir. Sumantri Brojonegoro No.1, Kota Bandar Lampung, Lampung 35141 INDONESIA
[2] Department of Agronomy and Horticulture, Faculty of Agriculture, University of Lampung, Jl. Prof. Dr. Ir. Sumantri Brojonegoro No.1, Kota Bandar Lampung, Lampung 35141 INDONESIA
[3] Department of Agricultural Biological Engineering, Faculty of Agriculture, University of Lampung, Jl. Prof. Dr. Ir. Sumantri Brojonegoro No.1, Kota Bandar Lampung, Lampung 35141 INDONESIA
* Corresponding author (✉ yusnita.1961@fp.unila.ac.id)

Edited by:
Ahmad Rifqi Fauzi
Trilogy University

Received:
19 December 2024
Accepted:
21 April 2025
Published online:
23 April 2025

Citation:
Fauzan, N. D., Yusnita, Asmara, S., Karyanto, A., & Widyastuti, R. A. D. (2025). Improving cassava growth and yield through auxin paste treatment on cuttings: A clonal comparison. *Jurnal Agronomi Indonesia (Indonesian Journal of Agronomy), 53*(1), 122-130. DOI: https://dx.doi.org/10.24831/jai.v53i1.61432

ABSTRACT

Cassava is an important crop for carbohydrate production, primarily propagated through stem cuttings. Auxin has been proven for decades to be an effective material for increasing the rooting of cuttings. The combination of NAA and IBA is more effective than a single auxin and synergizes in promoting root growth. This study aimed to evaluate the growth and yield of cassava clones to different auxin concentrations of NAA+IBA mixture. The research used a randomized complete block design arranged in a factorial with 9 treatments repeated 3 times. The first factor was the type of cassava clone, consisting of K1 = Garuda, K2 = Katsesart, and K3 = Roti, while the second factor was the concentration of NAA + IBA (1:1), namely A0 (0 ppm), A1 (1,000 ppm), and A2 (2,000 ppm). The results showed that clones responded differently to auxin concentration. Increasing the auxin concentration from 1,000 ppm to 2,000 ppm did not increase growth and yield, irrespective of clones. The application NAA + IBA (1:1) significantly increased fresh leaf weight, plant height, fresh stem weight, total number of roots, and number of storage roots as compared to the control at 8 months after planting (MAP). At 8 MAP, the Kasetsart clone produced higher growth and yield than Garuda and Roti clones, as indicated by the average plant height, total number of roots, and number of storage roots.

Keywords: hormone; IBA; *Manihot esculenta*; NAA; production

INTRODUCTION

Cassava (*Manihot esculenta* Crantz.) is a global crop with about 105 countries cultivating it and is a global commodity to answer the challenges of climate (Pushpalatha & Gangadharan, 2020; de Olanda Souza et al., 2023). The roots are the third most important source of carbohydrates in the tropics because of their high starch production, tolerant to drought, and suitability to soil with low fertility (Okogbenin et al., 2013; Li et al., 2017; Velmurugan et al., 2024). Indonesia is among the top 10 cassava producers in the world, after Brazil and Cambodia. The productivity curve of Indonesian cassava has always increased for 2 decades (1998-2022) from 12.19 to 27.19 tons ha^{-1} with a shrinking area of 1.2 million ha of land to 499 thousand ha (FAOSTAT, 2024).

Although cassava productivity has increased, Indonesian cassava production has continued to decline in the past decade (Endaryanto et al., 2022). Lampung, as a province that contributes the highest cassava production in Indonesia, actually has low productivity when compared to other provinces, which is around 26 tons ha^{-1} (Suryani et al., 2023). Other provinces such as West Sumatra, North Sumatra, and Central Kalimantan have productivity of ≥30 tons ha^{-1} (Ministry of Agriculture, 2020). Cassava clones that are widely planted by farmers in Lampung province include the Garuda, Katsesart, and Roti clones (Yelli et al., 2023; Pranowo et al., 2021). The Garuda clone has an early harvest age (≤8 months), the Katsesart clone has a high starch content (20-25%), and the Roti clone has a sweet tuber taste (Wahyuni & Noerwijati, 2021; Setiawan et al., 2024).

Several studies have been done to increase cassava productivity such as soil manipulation (Anwar et al., 2023), root manipulation (Tokunaga et al., 2020), and hormonal applications like exogenous auxin (Zierer et al., 2021). Auxin has been proven for decades to be used as a material to increase rooting of cuttings (Kumar et al., 2019; Tien et al., 2020; Rajan & Singh, 2021). The use of auxin has been proven effective in accelerating root initiation and increasing the number of adventitious roots (Guan et al., 2015). However, auxin application on cutting as planting material is rarely evaluated.

Auxins that are often used to increase the rooting of cuttings are naphthalene acetic acid (NAA) and indole butyric acid (IBA) (Husen & Pal, 2007; Yusnita et al., 2024). Several previous studies have stated that the combination of NAA and IBA is better than a single auxin, e.g., in Malay apple and pepper (Artha et al., 2015; Yusnita et al., 2018). The combination of NAA and IBA has a synergistic effect in increasing root growth (Blythe et al., 2007; Kaushik & Shukla, 2020). In addition to increasing the number of roots, auxin can also increase the number of storage roots (Kolachevskaya et al., 2019). Differences in cassava genotypes have different growth characteristics and responses to the type and concentration of auxin given. It has been reported in tissue culture (Medina et al., 2007). This study aimed to evaluate the growth and yield of cassava clones to different auxin concentrations of NAA+IBA mixture.

MATERIALS AND METHODS

This research was conducted from July 2023 to April 2024 in Tulang Bawang Barat Regency, Lampung Province, Indonesia (-4.6378977, 105.0811664). This experiment utilized a factorial randomized complete block design (RCBD). The first factor was cassava clone (K1: Garuda, K2: Kasetsart, and K3: Roti); while the second factor was the concentration level of NAA + IBA (1:1), namely (A0: 0 ppm, A1: 1,000 ppm, and A2: 2,000 ppm). Each treatment was repeated 3 times, and each experimental unit contained 10 cuttings.

The stem cuttings were obtained from 8-month-old plants according to Murray and Cohen (2021). Auxin powder with 95% purity, consisting of naphthalene acetic acid (NAA) and indole-3-butyric acid (IBA) was used as raw materials for auxin paste. The auxin was dissolved in 90% ethanol plus 1 M KOH as a pH neutralizer. To form auxin paste, the auxin solution was mixed with talc powder as a carrier material for auxin, fungicide with 80% mancozeb active ingredient for controlling fungi, and insecticide with 3 GR carbofuran active ingredient for controlling pests.

The land was plowed using a tractor, and then a raised bed was made with a height of 50 cm and a width of 40 cm. Each experimental unit size is 2 m in width and 5 m in length. Planting distance used 1 m x 1 m, facilitating 10 plants.

To maintain soil fertility, organic fertilization of cow manure was applied one week before planting using 1 ton ha^{-1}. NPK fertilizer was applied twice with a total dose of 200 kg ha^{-1} of urea, 100 kg ha^{-1} of SP-36, and 100 kg ha^{-1} of KCl. The first application used all SP-36, half of urea, and half of KCl at one month after planting (MAP). At three MAP, the rest of urea and KCl fertilizers were applied.

The cassava stem of each clone was cut to a length of 20 cm (Hyde et al., 2024). Auxin powder was made from a mixture of NAA and IBA dissolved in alcohol in talc powder and 4% Mancozeb so that NAA+IBA (1:1) / (w:w) 1,000 ppm and 2,000 ppm were obtained (Higuchi et al., 2021). Auxin paste was made by mixing NAA+IBA powder (1:1) with water in a ratio of 1:1, namely 1 g NAA+IBA (1:1): 1 mL water. Auxin paste was applied by a brush to the base of the cuttings up to 5 cm, then waited until it dried.

Observations were made at 4 and 8 MAP. Observation variables were the number of leaves, fresh leaf weight, plant height, fresh stem weight, total number of roots (all adventitious roots that appear on the stem), number of storage roots (all adventitious roots that have a diameter >5 mm), storage root weight, and total plant weight. Observation data were tested using ANOVA, and if significantly different, they would be further tested using the least significant difference (LSD) test at the 5% significance level.

RESULTS AND DISCUSSION

The effect of clone was very significant, which was shown in almost all variables at 4 MAP and 8 MAP except for total plant weight (Table 1). The effect of NAA+IBA concentration (1:1) was only seen in fresh leaf weight, total number of roots, number of storage roots, and storage root weight. The interaction between the two treatment factors occurred in one of the cassava growth phases (4 MAP or 8 MAP) and did not show any interaction at all in the variables plant height, fresh stem weight, and number of storage roots.

Table 1. Summary of ANOVA of several observation variables of the influence of auxin on the growth and rooting of several cassava clones at 4 and 8 months after planting (MAP).

Observation variables	Clone (C)		Auxin (A)		C x A	
	4 MAP	8 MAP	4 MAP	8 MAP	4 MAP	8 MAP
Number of leaves	**	**	ns	ns	ns	**
Fresh weight of leaves (kg)	**	**	*	*	**	ns
Plant height (cm)	**	**	ns	ns	ns	ns
Fresh weight of stem (kg)	**	**	ns	ns	ns	ns
Total number of roots	**	**	**	**	*	ns
Number of storage roots	**	**	*	**	ns	ns
Weight of storage roots (kg)	**	**	**	ns	**	ns
Total plant weight (kg per plant)	ns	ns	**	ns	*	ns

Note: ns = not significant, * = significant at 5%, ** = significant at 1%

Different clones responded differently to NAA+IBA (1:1) levels at 4 MAP. Garuda and Kasetsart clones were not responsive to increasing NAA+IBA (1:1) levels, they were different from Roti clones, which were responsive to increasing NAA+IBA (1:1) levels up to 2,000 ppm based on the fresh weight of leaves (Figure 1A). Increasing NAA+IBA (1:1) levels in all clones significantly increased the total number of roots compared to the control, but increasing 1,000 ppm to 2,000 ppm NAA+IBA (1:1) in Kasetsart and Roti clones was not significant (Figure 1B).

The influence of different clones on NAA+IBA (1:1) levels was the same in the variables of weight of storage roots and total plant weight. Application of NAA+IBA (1:1) 1,000 ppm or 2,000 ppm increased the weight of storage roots and total plant weight compared to the control, while Kasetsart and Roti clones did not (Figure 1C). Similar to the storage root weight parameter, Garuda clone gave a positive response to the application of NAA+IBA (1:1) up to 2,000 ppm, which could increase the total weight of the plant. We suspect that the influence of the early maturing nature causes the interaction with auxin to make the bulking process faster (Chipeta et al., 2016). The Roti clone, which was previously not seen to increase significantly with the application of NAA+IBA (1:1), turned out to significantly increase the total weight of the plant at NAA+IBA (1:1) by 2,000 ppm (Figure 1D). It has been reported in Feyisa (2021) that different cassava genotypes respond differently to different auxin concentrations.

The Roti clone produced the highest number of leaves compared to the Roti and Kasetsart clones at 4 MAP (Table 2). However, at 8 MAP, the Roti clone had the lowest number of leaves, with an average of 105 leaves (Figure 2). The plant's ability to retain leaves is in line with the characteristics of drought resistance (Okogbenin et al., 2013;

Orek et al., 2020). This indicates that the Roti clone is not more resistant than the Garuda and Kasetsart clones. The Garuda clone is responsive to the application of NAA+IBA (1:1) 1,000 ppm paste, which can produce the highest number of leaves of 227,8 leaves, in contrast to the Kasetsart and Roti clones, which tend to increase the number of leaves with increasing concentrations of NAA+IBA (1:1) but are still not significant. The increased number of leaves indicates that the auxin previously applied to the basal cuttings can be translocated to the shoot parts of the plant (Korobova et al., 2023).

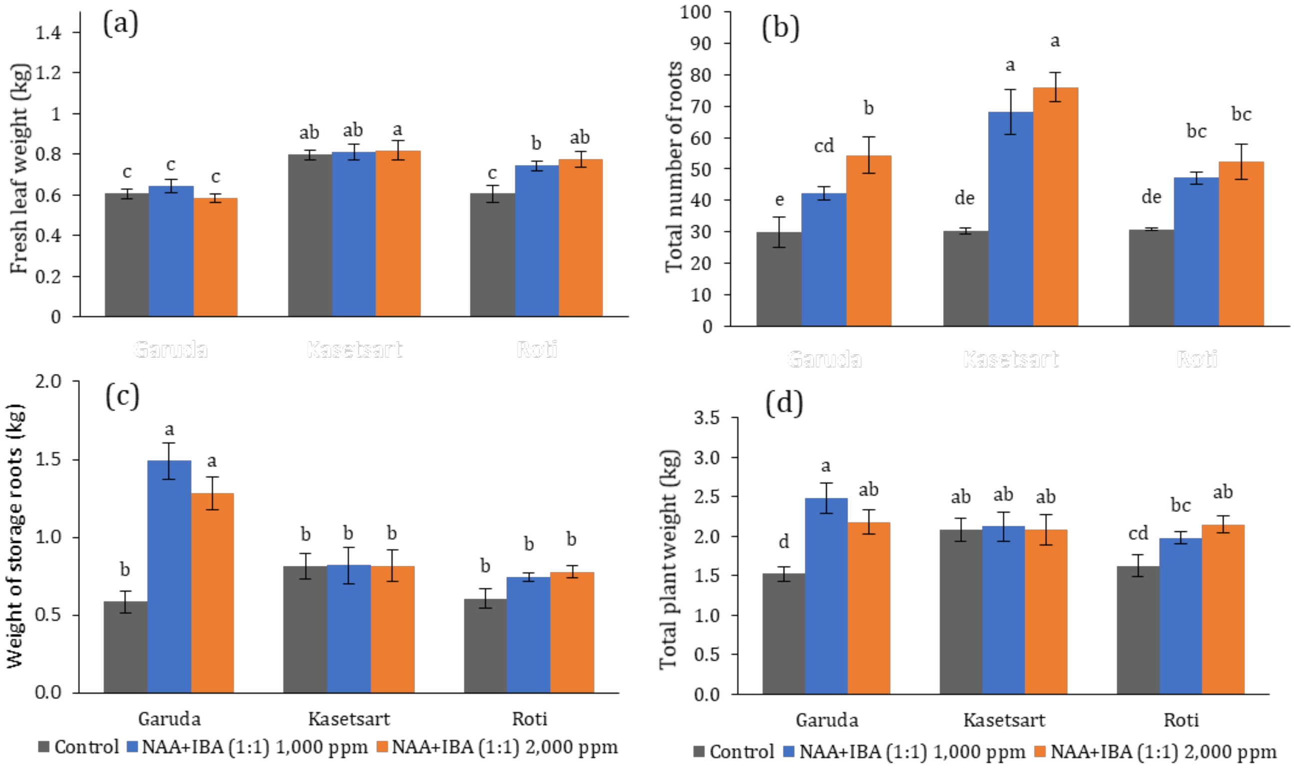

Figure 1. Biomass production of cassava clone from different NAA+IBA treatments at 4 months after planting. a. Fresh leaf weight; b. Total number of roots; c. Weight of storage roots; d. Total plant weight. Bars followed by the same letter are not significantly different by LSD 5%. Bars represent S.E.

Cassava clones had different plant heights, e.g., the Garuda had a lower plant height than the Roti and Kasetsart at 4 and 8 MAP (Figure 2 and Figure 3), in line with Cai et al. (2024). The Kasetsart and Roti clones have the same height at 4 MAP, but at 8 MAP the Kasetsart clone has a higher plant height than the Roti clone (Table 2). The Kasetsart and Roti clones, which had similar plant heights, also produced high fresh stem weights compared to the Garuda clone.

Table 2. Shoot characteristics of differences in cassava clones at 4 and 8 months after planting (MAP).

Clone	Number of leaves (per plant)	Fresh weight of leaves (kg per plant)	Plant height (cm per plant)		Fresh stem weight (kg per plant)	
	4 MAP	8 MAP	4 MAP	8 MAP	4 MAP	8 MAP
Garuda	100.56c	1.26b	96.30b	311.50c	0.328b	3.68b
Katsesart	108.19b	2.07a	114.22a	375.15a	0.467a	5.14a
Roti	117.04a	1.48b	123.31a	333.13b	0.497a	4.64a
LSD (0.05)	6.22	0.25	10.99	13.45	0.075	0.56

Note: Numbers in the same column and factor followed by the same letter are not significantly different based on the LSD test at 5% level.

The highest total root number in the Kasetsart clone (4 and 8 MAP) also produced the highest number of storage roots (8 MAP) (Table 3; Figure 4). However, with the high number of storage roots, it has not completely produced a high storage root weight, unlike the Garuda clone with a lower total root number and number of storage roots producing the highest storage root weight (Table 3). Similar findings have been reported by Adu et al., (2018) indicating that some cassava genotypes with fewer storage roots can produce higher fresh root weights. Based on these results, it also shows that the Garuda clone is more effective in storing assimilate partitions to tubers. As reported by Li et al., (2016), genotypes that have high tuber weight with low shoot growth possess a strong assimilate supply.

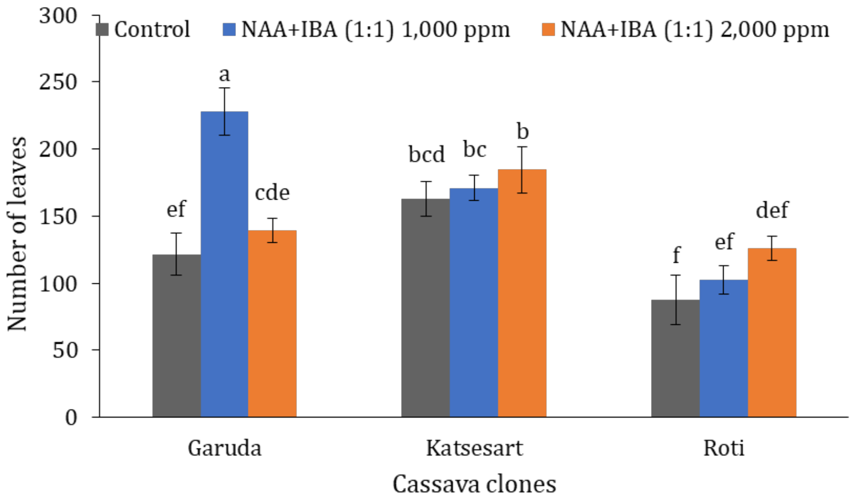

Figure 2. Leaf number of cassava clones from different NAA+IBA levels at 8 months after planting (MAP). Bars followed by the same letter are not significantly different by LSD 5%. Bars represent S.E.

Figure 3. Shoot and root of cassava clones without auxin treatment (control) at 4 months after planting.

Table 3. Influence of cassava clone differences on root parameters at 8 months after planting (MAP).

Clone	Total roots number	Weight of storage roots (kg)
Garuda	30.81b	8.64a
Katsesart	39.70a	6.06b
Roti	32.74b	6.37b
LSD (0.05)	5.00	0.82

Note: Numbers in the same column and factor followed by the same letter are not significantly different based on the LSD test at 5% level.

Table 4. Influence of cassava clone differences on fresh weight of leaves and total root number at 8 months after planting (MAP).

Concentration NAA+IBA (1:1)	Fresh weight of leaves (kg)	Total roots number (per plant)
Control	1.40b	24.85b
1,000 ppm	1.67a	37.00a
2,000 ppm	1.73a	41.41a
LSD (0.05)	0.25	5.00

Note: Numbers in the same column and factor followed by the same letter are not significantly different based on the LSD test at 5% level.

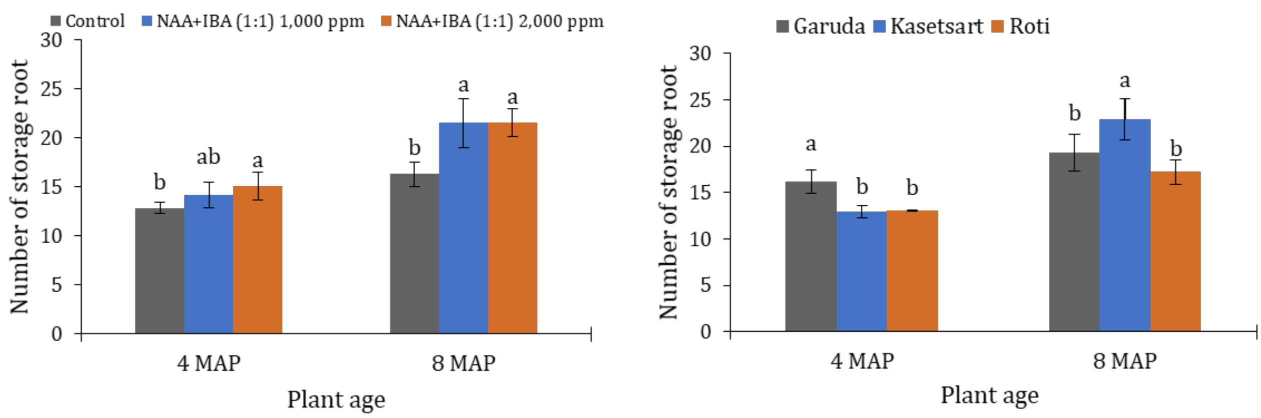

Figure 4. Number of storage roots per plant at 4 and 8 months after planting (MAP); a. Effect of NAA+IBA levels (1:1), b. Effect of cassava clones. Bars followed by the same letter are not significantly different by LSD 5%. Bars represent S.E.

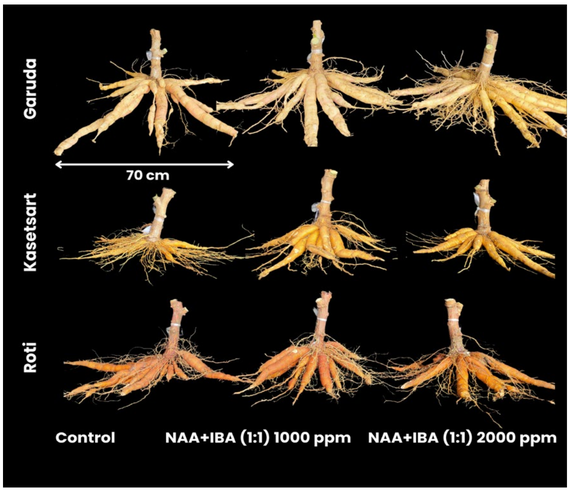

Figure 5. Storage roots of cassava clones from different levels of NAA+IBA at 4 months after planting.

The difference in NAA+IBA (1:1) levels of 1,000 or 2,000 ppm significantly increased the fresh weight of leaves, which was also seen to increase the total root number (Table 4). The increased fresh weight of leaves due to auxin application indicates a greater source capacity so that it is able to transfer greater assimilate results to the root section. The number of storage roots of different NAA+IBA applications is presented in Figure 5.

CONCLUSIONS

There were different responses in each clone tested. However, increasing the auxin concentration from 1,000 ppm to 2,000 ppm did not significantly increase cassava growth and yield. The application of NAA + IBA (1:1) at 1,000 ppm and 2,000 ppm significantly increased fresh leaf weight, plant height, fresh stem weight, total number of roots, and number of storage roots of cassava compared to the control at 8 months after planting (MAP). At 8 MAP, the Kasetsart clone produced higher growth and yield than the Garuda clone and the Roti clone, as indicated by the average plant height, total number of roots, and number of storage roots.

REFERENCES

Adu, M. O., Asare, P. A., Asare-bediako, E., Amenorpe, G., Ackah, F. K., Afutu, E., Amoah, M. N., & Yawson, D. O. (2018). Characterising shoot and root system trait variability and contribution to genotypic variability in juvenile cassava (*Manihot esculenta* Crantz) plants. *Heliyon*, *4*(6), e00665.

Anwar, S., Santosa, E., & Purwono, P. (2023). Cassava growth and yield on ultisol of different soil organic carbon content and NPK fertilizer levels. *Jurnal Agronomi Indonesia (Indonesian Journal of Agronomy), 51*(3), 312-323. https://doi.org/10.24831/jai.v51i3.47806

Artha, D. D., Yusnita, Y., & Sugiatno, S. (2015). The effect of combination application of NAA (naphthaleneacetic acid) and IBA (indole butyric acid) on the rooting of pepper cuttings (*Piper nigrum* Linn) variety Natar 1. (In Indonesian.). *Jurnal Agrotek Tropika*, *3*(1), 1–6. https://doi.org/10.23960/jat.v3i1.1879

Blythe, E. K., Sibley, J. L., Tilt, K. M., & Ruter, J. M. (2007). Methods of auxin application in cutting propagation: A review of 70 years of scientific discovery and commercial practice. *Journal of Environmental Horticulture*, *25*(3), 166–185. https://doi.org/10.24266/0738-2898-25.3.166

Cai, Z., Ruan, L., Wei, W., He, W., Yang, H., Chen, H., Liang, Z., Huang, Z., Lan, X., Zhang, X., Huang, R., Zhao, C., Li, T., He, L., & Li, H. (2024). Morphological, anatomical, and transcriptomics analysis reveals the regulatory mechanisms of cassava plant height development. *BMC Genomics*, *25*, 699. https://doi.org/10.1186/s12864-024-10599-2

Chipeta, M. M., Shanahan, P., Melis, R., Sibiya, J., & Benesi, I. R. M. (2016). Early storage root bulking index and agronomic traits associated with early bulking in cassava. *Field Crops Research*, *198*, 171–178. https://doi.org/10.1016/j.fcr.2016.09.004

de Olanda-Souza, G. H., de Oliveira-Aparecido, L. E., de Moraes, J. R. D. S. C., & Botega, G. T. (2023). Climate change and its influence on planting of cassava in the Midwest region of Brazil. *Environment, Development and Sustainability*, *25*, 1184–1204. https://doi.org/10.1007/s10668-021-02088-3

Endaryanto, T., Zakaria, W. A., Indah, L. S. M., & Seta, A. P. (2022). Strategies and policies to increase competitiveness of cassava in Lampung province, Indonesia. *Jurnal Manajemen & Agribisnis*, *19*(3), 492–500. https://doi.org/10.17358/jma.19.3.492

FAOSTAT. (2024). *Crops and livestock products*. FAO. https://www.fao.org/faostat/en/#data/QCL

Feyisa, A. S. (2021). Micropropagation of cassava (*Manihot esculenta* Crantz): review. *Extensive Reviews*, *1*(1), 49–57. https://doi.org/10.21467/exr.1.1.4486

Guan, L., Murphy, A. S., Peer, W. A., Gan, L., Li, Y., & Cheng, Z. M. (2015). Physiological and molecular regulation of adventitious root formation. *Critical Reviews in Plant Sciences*, *34*(5), 506–521. https://doi.org/10.1080/07352689.2015.1090831

Higuchi, M. T., Ribeiro, L. T. M., de Aguiar, A. C., Zeffa, D. M., Roberto, S. R., & Koyama, R. (2021). Methods of application of indolebutyric acid and basal lesion on ‘ Woodard ’ blueberry cuttings in different seasons. *Revista Brasileira de Fruticultura*, *43*(5), e-022. https://doi.org/10.1590/0100-29452021022

Husen, A., & Pal, M. (2007). Metabolic changes during adventitious root primordium development in *Tectona grandis* Linn. f. (teak) cuttings as affected by age of donor plants and auxin (IBA and NAA) treatment. *New Forests*, *33*, 309–323. https://doi.org/10.1007/s11056-006-9030-7

Hyde, P. T., Esan, O., Diebiru-Ojo, E. M., Iluebbey, P., Kulakow, P. A., Peteti, P., & Setter, T. L. (2024). Development of methods for improving flowering and seed set of diverse germplasm in cassava breeding. *Plants*, *13*(3), 382. https://doi.org/10.3390/plants13030382

Kaushik, S., & Shukla, N. (2020). Effect of IBA and NAA and their combination on the rooting of stem cuttings of African marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gainda. *Journal of Pharmacognosy and Phytochemistry*, *9*(3), 1460–1461. https://doi.org/10.22271/phyto.2020.v9.i3x.11517

Kolachevskaya, O. O., Lomin, S. N., Arkhipov, D. V, & Romanov, G. A. (2019). Auxins in potato : Molecular aspects and emerging roles in tuber formation and stress resistance. *Plant Cell Reports*, *38*, 681-698. https://doi.org/10.1007/s00299-019-02395-0

Korobova, A., Ivanov, R., Timergalina, L., Vysotskaya, L., Nuzhnaya, T., Akhiyarova, G., Kusnetsov, V., Veselov, D., & Kudoyarova, G. (2023). Effect of low light stress on distribution of auxin (Indole-3-acetic Acid) between shoot and roots and development of lateral roots in barley plants. *Biology*, *12*(6), 787. https://doi.org/10.3390/biology12060787

Kumar, S., Malik, A., Yadav, R., & Yadav, G. (2019). Role of different rooting media and auxins for rooting in floricultural crops: a review. *International Journal of Chemical Studies*, *7*(2), 1778–1783.

Li, S., Cui, Y., Zhou, Y., Luo, Z., Liu, J., & Zhao, M. (2017). The industrial applications of cassava: current status, opportunities and prospects. *Journal of the Science of Food and Agriculture*, *97*(8), 2282–2290. https://doi.org/10.1002/jsfa.8287

Li, Y. Z., Zhao, J. Y., Wu, S. M., Fan, X. W., Luo, X. L., & Chen, B. S. (2016). Characters related to higher starch accumulation in cassava storage roots. *Scientific Report, 6*, 19823. https://doi.org/10.1038/srep19823

Medina, R. D., Faloci, M. M., Gonzalez, A. M., & Mroginski, L. A. (2007). In vitro cultured primary roots derived from stem segments of cassava (*Manihot esculenta*) can behave like storage organs. *Annals of Botany*, *99*(3), 409–423. https://doi.org/10.1093/aob/mcl272

Ministry of Agriculture. (2020). *Outlook of Ubi Kayu*. (In Indonesian.). Agricultural Data Center and Information System.

Murray, F. V. N., & Cohen, J. E. (2021). Efficacy of shoot production of cassava using the multiple shoot removal technique for rapid propagation. *Journal of Agricultural Science*, *159*(3–4), 177–187. https://doi.org/10.1017/S0021859621000356

Okogbenin, E., Setter, T. L., Ferguson, M., Mutegi, R., Ceballos, H., Olasanmi, B., & Fregene, M. (2013). Phenotypic approaches to drought in cassava: review. *Frontiers in Physiology*, *4*, 93. https://doi.org/10.3389/fphys.2013.00093

Orek, C., Gruissem, W., Ferguson, M., & Vanderschuren, H. (2020). Morpho-physiological and molecular evaluation of drought tolerance in cassava (*Manihot esculenta* Crantz). *Field Crops Research, 255,* 107861. https://doi.org/10.1016/j.fcr.2020.107861

Pranowo, D., Setiawan, K., Hadi, S., & Yuliadi, E. (2021). Cassava (*Manihot esculenta* Crantz) clones description cultivated in six districts in Lampung Province. (In Indonesian.). *Inovasi Pembangunan : Jurnal Kelitbangan*, *9*(3), 271-280. https://doi.org/10.35450/jip.v9i03.249

Pushpalatha, R., & Gangadharan, B. (2020). Is cassava (*Manihot esculenta* Crantz) a climate "Smart" crop? a review in the context of bridging future food demand gap. *Tropical Plant Biology*, *13*, 201–211. https://doi.org/10.1007/s12042-020-09255-2

Rajan, R. P., & Singh, G. (2021). A review on the use of organic rooting substances for propagation of horticulture crops. *Plant Archives*, *21*(1), 685–692.

Setiawan, K., Priyati, S. D., Hadi, M. S., & Ardian, A. (2024). The effect of micro boron fertilizer dosages on the growth and yield of UJ-5 cassava (*Manihot esculenta* Crantz.) clone. *Proceedings of the 1st International Conference on Industry Science Technology and Sustainability (IConISTS 2023), 1*, 23–32. https://doi.org/10.2991/978-94-6463-475-4_4

Suryani, A., Masyhuri, M., Waluyati, L. R., & Utami, A. W. (2023). Risk analysis on the cassava value chain in central Lampung Regency. *Agraris*, *9*(2), 150–173. https://doi.org/10.18196/agraris.v9i2.333

Tien, L. H., Chac, L. D., Oanh, L. T. L., Ly, P. T., Sau, H. T., Hung, N., Thanh, V. Q., Doudkin, R. V., & Thinh, B. B. (2020). Effect of auxins (IAA, IBA and NAA) on clonal propagation of Solanum procumbens stem cuttings. *Plant Cell Biotechnology and Molecular Biology*, *21*(55&56), 113–120.

Tokunaga, H., Anh, N. H., Dong, N. V., Ham, L. H., Hanh, N. T., Hung, N., Ishitani, M., Tuan, L. N., Utsumi, Y., Vu, N. A., & Seki, M. (2020). An efficient method of propagating cassava plants using aeroponic culture. *Journal of Crop Improvement*, *34*(1), 64–83. https://doi.org/10.1080/15427528.2019.1673271

Velmurugan, M., Janaharshini, R., Rani, C. I., Venkatachalam, S. R., & Saravanan, P. A. (2024). Cassava breeding: Classical to recent breeding approaches for food, industry and climate resilience. *Journal of Environmental Biology*, *45*(5), 487–497. http://doi.org/10.22438/jeb/45/5/MRN-5309

Wahyuni, T. S., & Noerwijati, K. (2021). Cassava genotypes selection for high yield and high starch content in advanced yield trials. *IOP Conference Series: Earth and Environmental Science*, *733*, 012127. https://doi.org/10.1088/1755-1315/733/1/012127

Yelli, F., Dwi Utomo, S., Setiawan, K., & Surtono, A. (2023). Socialization of cassava seed propagation through plant tissue culture technology to Wira Bakti 1 farmer group in Central Lampung, Lampung. (In Indonesian.). *Abdimas Galuh*, *5*(1), 337–345.

Yusnita, Y., Hapsoro, D., Prayogi, A. N., 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*, *46*(1), 28–37. https://doi.org/10.17503/agrivita.v46i1.3899

Yusnita, Y., Jamaludin, J., Agustiansyah, A., & Hapsoro, D. (2018). A combination of IBA and NAA resulted in better rooting and shoot sprouting than single auxin on malay apple (*Syzygium malaccense* (L.) Merr. & Perry) stem cuttings. *Agrivita*, *40*(1), 80-90. https://doi.org/10.17503/agrivita.v40i0.1210

Zierer, W., Rüscher, D., Sonnewald, U., & Sonnewald, S. (2021). Tuber and tuberous root development. *Annual Review of Plant Biology*, *72*(1), 551–580. https://doi.org/10.1146/annurev-arplant-080720-084456