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Effects of Plant Growth Regulator Types and Planting Media on the Growth of Moringa (*Moringa oleifera* L.) Stem Cuttings

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Abstract. Moringa (*Moringa oleifera* L.) is known as the tree of life because of its high nutritional content and health and economic benefits. However, moringa cultivation in Indonesia remains suboptimal, mainly due to the limited availability of quality seedlings. Vegetative propagation through stem cuttings can produce uniform seedlings, but its success depends on plant growth regulators and planting media. This study aimed to determine the effects of plant growth regulators and planting media on the growth of moringa stem cuttings. The experiment was conducted in a screen house at SITANDU, Banten, from October to December 2025 using a factorial Randomized Block Design with two factors. The first factor was plant growth regulator type: control, Rootone-F 0.03%, shallot extract 60%, mung bean sprout extract 60%, and young coconut water 60%. The second factor was planting medium: rice husk charcoal + soil, compost + soil, and cattle manure + soil, each at a 1:1 ratio. The results showed that Rootone-F 0.03% improved several growth parameters, particularly shoot length at 6 WAP, leaf number, and root length. Rice husk charcoal and soil were the best media for shoot and root growth. The combination of Rootone-F 0.03% and rice husk charcoal + soil produced the best response, particularly in shoot number, leaf number, and root length.

Keywords: rice husk charcoal, Rootone-F, soil, Vegetative propagation

INTRODUCTION

Moringa (*Moringa oleifera* L.) is widely known as the “tree of life” or “miracle tree” because its leaves, stems, seeds, flowers, and roots have health and economic value (Puspitasari *et al*., 2023). This plant has potential as a functional food, herbal product, and industrial raw material due to its bioactive compounds, antioxidants, vitamins A, C, and E, and essential minerals such as calcium, iron, and magnesium (Mustariani, 2023). The demand for moringa-derived products, including leaf powder, seed oil, herbal tea, supplements, and cosmetics, continues to increase in domestic and international markets (Isnan & Muin, 2017). In Banten, the first export of moringa leaf powder reached 0.32 tons valued at IDR 14 million in January 2022, followed by 27 tons valued at IDR 500 million to the United States in April 2022 (BantenNews.co.id, 2022). Nationally, Indonesian moringa leaf exports reached 4,350 tons valued at USD 13.75 million from January to September 2024, with major destinations including China, Malaysia, Australia, and several African countries, and main production centers in Blora, Sumenep, and East Nusa Tenggara (BRMP, 2025). However, moringa cultivation in Indonesia remains suboptimal due to limited cultivation technology, particularly in seedling production (Wasonowati *et al*., 2018).

The availability of high-quality seedlings is essential for supporting large-scale moringa cultivation. Vegetative propagation through stem cuttings is a practical method because it can produce uniform seedlings that are genetically similar to the parent plant, while maintaining desirable traits such as growth performance, morphology, and productivity (Chiyaroh *et al*., 2021). In moringa cultivation, stem cuttings are suitable for seedling production because they promote faster growth, better root formation, and more branches (Maryani & Suryadama, 2019). However, one of the main constraints in stem cutting propagation is the difficulty of root formation, which is influenced by internal factors such as plant species, cutting age, and cutting material, as well as external factors including temperature, humidity, nutrient availability, planting media, and plant growth regulators (Fauza *et al*., 2016).

Plant growth regulators and planting media are important factors that determine the success of moringa stem cutting propagation. Natural plant growth regulators, such as shallot extract, mung bean sprout extract, and young coconut water, contain endogenous hormones and are considered affordable and environmentally safe alternatives (Kurniati *et al*., 2017). Previous studies reported that shallot extract improved shoot length and leaf number in stem cuttings (Salmah *et al*., 2022) and produced higher growth responses than synthetic plant growth regulators in mulberry cuttings (Abror & Noviyanti, 2019). In addition, suitable planting media should provide nutrients, moisture, aeration, and pathogen-free conditions to support cutting growth (Chiyaroh *et al*., 2021). Since rice husk charcoal, compost, and cattle manure have different physical and chemical characteristics, their effects on supporting moringa cutting growth may vary. Therefore, this study aimed to determine the effects of different plant growth regulators and planting media, as well as their interaction, on the growth of moringa stem cuttings.

RESEARCH METHODOLOGY

This experimental study was conducted in the screen house of the Integrated Agricultural System Area (SITANDU), Curug District, Serang City, Banten, Indonesia (6.17°S; 106.19°E), from October to December 2025. The materials used included moringa stem cuttings, soil, rice husk charcoal, compost, cattle manure, clean water, young coconut water, shallot extract, mung bean sprout extract, Rootone-F, Dithane M-45 80 WP, polybags, plastic covers, bamboo, and 75% paranet. The tools used included a machete, knife, measuring tape, hygrometer, ruler, blender, cloth filter, hand sprayer, measuring cylinders, analytical balance, and caliper. The experiment was arranged in a factorial Randomized Block Design with two factors. The first factor was plant growth regulator type (Z), consisting of Z0 = Without PGR (control), Z1 = Rootone-F 0.03%, Z2 = shallot extract 60%, Z3 = mung bean sprout extract 60%, and Z4 = young coconut water 60%. The second factor was planting medium (M), consisting of M1 = rice husk charcoal + soil (1:1), M2 = compost + soil (1:1), and M3 = cattle manure + soil (1:1). There were 15 treatment combinations with three replications, resulting in 45 experimental units. Each experimental unit consisted of two stem cuttings, for a total of 90 moringa stem cuttings.

RESEARCH IMPLEMENTATION

The research site was prepared by clearing weeds and installing 75% paranet on a 2 m bamboo frame to maintain microclimate stability. The planting media were prepared by mixing soil with rice husk charcoal, compost, or cattle manure at a 1:1 ratio, then placed into 25 cm × 25 cm polybags and arranged at 15 cm × 15 cm spacing. Moringa stem cuttings were obtained from healthy five-year-old parent plants, with each cutting measuring 30 cm in length, 2–3 cm in diameter, and having at least two buds. Before plant growth regulator treatment, all cuttings were soaked in Dithane M-45 80 WP fungicide for 15 minutes and then air-dried. Shallot extract and mung bean sprout extract at 60% concentration were prepared by mixing 1200 mL of extract stock with 800 mL of clean water. Young coconut water treatment was prepared by mixing 1200 mL of young coconut water with 800 mL of clean water, while Rootone-F 0.03% was prepared by dissolving 0.6 g of Rootone-F powder in 2 L of clean water. The cuttings were soaked to a depth of 8 cm in natural plant growth regulator solutions for 6 hours, while the Rootone-F treatment was applied for 0.25

hours. After treatment, the cuttings were air-dried for 10 minutes and planted at approximately 10 cm depth, with one cutting per polybag. The cuttings were covered with transparent plastic for 6 weeks after planting, and maintenance included watering every 2 days, weeding, and disease control when fungal symptoms appeared. The observed variables were shoot emergence time, number of shoots, shoot length, number of leaves, number of roots, root length, and survival percentage. Shoot number, shoot length, and leaf number were observed at 2, 4, 6, and 8 weeks after planting, while root number, root length, and survival percentage were recorded at 8 weeks after planting. Root observations were conducted by carefully removing the cuttings from the polybags and cleaning the roots with water. Survival percentage was calculated based on the number of living cuttings compared with the total number of planted cuttings.

DATA ANALYSIS

The data were analyzed using analysis of variance (ANOVA) based on a factorial Randomized Block Design. If the ANOVA showed a significant effect, mean comparison was continued using Duncan's Multiple Range Test (DMRT) at the 5% level.

RESULTS AND DISCUSSION

Shoot Emergence Time (days)

Plant growth regulator type, planting medium, and their interaction did not significantly affect shoot emergence time. The average shoot emergence ranged from 4.67 to 19.50 days after planting, indicating that early shoot development was more influenced by internal factors, such as carbohydrate reserves, endogenous hormones, bud viability, and physiological condition of the cuttings, than by external treatments. Pratiwi *et al*. (2019) stated that carbohydrate reserves function as an energy source for early bud development in cuttings. Although not significantly different, the combination Z4M1 showed the fastest numerical shoot emergence at 4.67 days. This tendency may be associated with the naturally occurring cytokinins and auxins in young coconut water, which can stimulate shoot initiation. Renvillia *et al*. (2016) reported that young coconut water contains cytokinins, kinetin, and zeatin that may accelerate shoot emergence in cuttings. In contrast, Z1M3 showed the slowest numerical shoot emergence at 19.50 days, possibly because auxin-dominated Rootone-F primarily promotes root initiation rather than early shoot development.

Table 1. Effect of plant growth regulator types and planting media on shoot emergence time (days)

Plant Growth Regulator (Z)	Planting Media (M)			Average
	M1 Rice husk charcoal + soil (1:1)	M2 Compost + soil (1:1)	M3 Cattle manure + soil (1:1)	
	days			
Z_0 (Without PGR (control))	7.17	7.17	8.00	7.44
Z_1 (Rootone-F 0.03%)	6.00	12.50	19.50	12.67
Z_2 (Shallot extract 60%)	6.67	7.33	7.50	7.17
Z_3 (Mung bean sprout extract 60%)	10.17	14.17	9.50	11.28
Z_4 (Young coconut water 60%)	4.67	7.83	8.83	7.11
Average	6.93	9.80	10.67	
Coefficient of variation (%)				27.42[a]

Note: [a] : Data were transformed using $\sqrt{x + 0.5}$

Widiayani *et al*. (2024) reported that Rootone-F mainly stimulates root initiation rather than early shoot emergence, likely due to its auxin content. Herliana *et al*. (2023) stated that slower shoot emergence in M3 medium may be associated with higher water retention and lower aeration. Ezperanza *et al*. (2023) reported that M1 medium showed faster numerical shoot emergence because of its porous structure and better aeration, which support respiration and meristematic activity. However, the differences were not statistically significant, indicating that shoot emergence was more influenced by internal physiological factors than by the treatments applied.

Number of Shoots (shoots)

The interaction between Z1 and M1 produced the highest number of shoots at all observation times. This combination resulted in 3.92 shoots at 2 WAP, 5.17 shoots at 4 WAP, 5.08 shoots at 6 WAP, and 4.33 shoots at 8 WAP. This indicates that synthetic auxin in Rootone-F was more effective when combined with a porous medium such as rice husk charcoal + soil. Salmah *et al*. (2022) reported that auxin plays an important role in stimulating meristematic activity and cell division, thereby supporting shoot formation in stem cuttings. Rokhmah *et al*. (2022) reported that synthetic plant growth regulators tend to elicit more consistent responses than natural plant growth regulators, owing to their more stable hormone concentrations and faster absorption by plant tissues.

Table 2. Effect of plant growth regulator types and planting media on the number of shoots (shoots)

Observation Time (WAP)	Plant Growth Regulator (Z)	Planting Media (M)			Average
		M1 Rice husk charcoal + soil (1:1)	M2 Compost + soil (1:1)	M3 Cattle manure + soil (1:1)	
		shoots			
2	Z_0 (Without PGR (control))	1.75 bcd	2.67ab	1.00cd	1.81
	Z_1 (Rootone-F 0.03%)	3.92a	1.25 bcd	0.33d	1.83
	Z_2 (Shallot extract 60%)	2.33bc	2.25bc	1.92bcd	2.17
	Z_3 (Mung bean sprout extract 60%)	1.83 bcd	1.92 bcd	0.83cd	1.53
	Z_4 (Young coconut water 60%)	1.92bcd	1.83 bcd	1.42 bcd	1.72
	Average	2.35	1.98	1.10	
	Coefficient of variation (%)				18.69[a]
4	Z_0 (Without PGR (control))	2.17bcde	3.08b	1.42cde	2.22
	Z_1 (Rootone-F 0.03%)	5.17a	1.58bcde	0.83e	2.53
	Z_2 (Shallot extract 60%)	2.92bc	2.50bcd	2.17bcde	2.53
	Z_3 (Mung bean sprout extract 60%)	2.25bcde	2.17bcde	1.00de	1.81
	Z_4 (Young coconut water 60%)	2.33bcde	1.92bcde	1.83bcde	2.03
	Average	2.97	2.25	1.45	
	Coefficient of variation (%)				16.81[a]
6	Z_0 (Without PGR (control))	2.25b	2.75b	1.25b	2.08
	Z_1 (Rootone-F 0.03%)	5.08a	1.83b	1.25b	2.72
	Z_2 (Shallot extract 60%)	2.50b	2.42b	1.92b	2.28
	Z_3 (Mung bean sprout extract 60%)	2.33b	2.25b	1.17b	1.92
	Z_4 (Young coconut water 60%)	2.00b	2.08b	2.17b	2.08
	Average	2.83	2.27	1.55	
	Coefficient of variation (%)				18.84[a]
8	Z_0 (Without PGR (control))	1.17b	2.58b	0.67b	1.47
	Z_1 (Rootone-F 0.03%)	4.33a	1.42b	1.42b	2.39
	Z_2 (Shallot extract 60%)	1.75b	2.42b	0.83b	1.67
	Z_3 (Mung bean sprout extract 60%)	1.92b	1.92b	1.17b	1.67
	Z_4 (Young coconut water 60%)	1.17b	1.67b	1.83b	1.56
	Average	2.07	2.00	1.18	
	Coefficient of variation (%)				22.82[a]

Note: Mean values followed by the same letter within the same observation time are not significantly different according to DMRT at the 5% level.

[a] : Data were transformed using $\sqrt{x + 0.5}$

The interaction between Z1 and M1 produced the highest number of shoots at all observation times. This combination resulted in 3.92 shoots at 2 WAP, 5.17

shoots at 4 WAP, 5.08 shoots at 6 WAP, and 4.33 shoots at 8 WAP. This indicates that synthetic auxin in Rootone-F was more effective when combined with a porous medium such as rice husk charcoal + soil. Salmah *et al*. (2022) reported that auxin plays an important role in stimulating meristematic activity and cell division, thereby supporting shoot formation in stem cuttings. Rokhmah *et al*. (2022) reported that synthetic plant growth regulators tend to elicit more consistent responses than natural plant growth regulators, owing to their more stable hormone concentrations and faster absorption by plant tissues.

Among the planting media, M1 produced the highest number of shoots, followed by M2, while M3 produced the lowest values. The better response in M1 was likely related to the porous structure of rice husk charcoal, which improves aeration, drainage, and moisture balance around the cutting base. These conditions support respiration and metabolic activity required for shoot development. Mustaman & Fatman (2017) stated that M3 may have higher water retention and a denser structure, which can reduce aeration and inhibit shoot formation, especially during the early growth stage. Therefore, the use of rice husk charcoal + soil as a planting medium may provide a more favorable environment for early shoot initiation and development in moringa stem cuttings.

Shoot Length (cm)

Table 3. Effect of plant growth regulator types and planting media on shoot length (cm)

Observation Time (WAP)	Plant Growth Regulator (Z)	Planting Media (M)			Average
		M1 Rice husk charcoal + soil (1:1)	M2 Compost + soil (1:1)	M3 Cattle manure + soil (1:1)	
		cm			
2	Z_0 (Without PGR (control))	2.23	1.43	0.93	1.53
	Z_1 (Rootone-F 0.03%)	1.92	1.20	0.11	1.08
	Z_2 (Shallot extract 60%)	1.77	1.55	0.78	1.37
	Z_3 (Mung bean sprout extract 60%)	1.33	1.49	0.32	1.05
	Z_4 (Young coconut water 60%)	0.91	0.89	0.58	0.79
	Average	1.63a	1.31a	0.55b	
	Coefficient of variation (%)				20.83[a]
4	Z_0 (Without PGR (control))	4.71	3.36	1.81	3.29a
	Z_1 (Rootone-F 0.03%)	4.62	3.02	0.67	2.77ab
	Z_2 (Shallot extract 60%)	2.16	2.15	1.50	1.94bc
	Z_3 (Mung bean sprout extract 60%)	2.34	1.61	0.68	1.54c
	Z_4 (Young coconut water 60%)	1.74	1.75	0.86	1.45c
	Average	3.12a	2.38a	1.10b	
	Coefficient of variation (%)				19.18[a]
6	Z_0 (Without PGR (control))	4.49	3.70	1.99	3.40ab
	Z_1 (Rootone-F 0.03%)	6.57	5.56	0.93	4.36a
	Z_2 (Shallot extract 60%)	2.81	2.63	1.62	2.35b
	Z_3 (Mung bean sprout extract 60%)	3.71	1.88	0.58	2.06b
	Z_4 (Young coconut water 60%)	2.06	1.92	1.60	1.86b
	Average	3.93a	3.14a	1.35b	
	Coefficient of variation (%)				21.77[a]
8	Z_0 (Without PGR (control))	3.20	3.23	2.13	2.85
	Z_1 (Rootone-F 0.03%)	6.75	5.02	1.26	4.35
	Z_2 (Shallot extract 60%)	3.75	3.14	0.74	2.54
	Z_3 (Mung bean sprout extract 60%)	1.85	2.23	0.75	1.61
	Z_4 (Young coconut water 60%)	2.50	2.64	1.71	2.28
	Average	3.61a	3.25a	1.32b	
	Coefficient of variation (%)				11.69[b]

Note: Mean values followed by the same letter in the same row or column are not significantly different, whereas values followed by different letters are significantly different according to Duncan's Multiple Range Test (DMRT) at the 5% level. [a] : Data were transformed using $\sqrt{x + 0.5}$

[b] : Data were transformed twice using $\sqrt{x + 0.5}$.

Shoot length increased at 4 WAP in almost all treatments. At this stage, Z1 and Z0, particularly in M1 and M2, showed higher shoot length than the natural plant growth regulator treatments. This indicates that moringa stem cuttings still utilize endogenous hormones and stored food reserves to support shoot elongation. Auxin plays an important role in cell elongation by increasing cell wall elasticity, allowing meristematic tissues to expand. Waniatri *et al*. (2019) also reported that cuttings in good physiological condition and with sufficient food reserves can support shoot growth even without external plant growth regulator application.

Z1 produced the greatest shoot length at 6 WAP, especially in M1 and M2 media. This shows that the effect of synthetic auxin became more apparent during the active growth stage. Heryanto (2019) reported that Rootone-F contains auxin compounds, such as NAA and IBA, which can stimulate cell division and shoot elongation when applied at an appropriate concentration and supported by sufficient water and light. However, the interaction between plant growth regulator and planting medium was not significant, indicating that shoot length was mainly affected by the individual effects of plant growth regulator type and planting medium.

Table 4. Effect of plant growth regulator types and planting media on the number of leaves (leaves)

Observation Time (WAP)	Plant Growth Regulator (Z)	Planting Media (M) M1 Rice husk charcoal + soil (1:1)	M2 Compost + soil (1:1)	M3 Cattle manure + soil (1:1)	Average
		leaves			
2	Z_0 (Without PGR (control))	3.00	0.00	0.00	1.00
	Z_1 (Rootone-F 0.03%)	9.17	0.00	0.00	3.06
	Z_2 (Shallot extract 60%)	3.17	0.00	0.00	1.06
	Z_3 (Mung bean sprout extract 60%)	1.50	0.00	0.00	0.50
	Z_4 (Young coconut water 60%)	0.00	0.00	0.00	0.00
	Average	3.37a	0.00b	0.00b	
	Coefficient of variation (%)				17.05^b
4	Z_0 (Without PGR (control))	11.17b	10.00b	1.17b	7.44
	Z_1 (Rootone-F 0.03%)	41.33a	9.00b	0.00b	16.78
	Z_2 (Shallot extract 60%)	5.67b	3.50b	0.00b	3.06
	Z_3 (Mung bean sprout extract 60%)	7.33b	7.17b	0.00b	4.83
	Z_4 (Young coconut water 60%)	10.83b	5.00b	0.00b	5.28
	Average	15.27	6.93	0.23	
	Coefficient of variation (%)				21.76^b
6	Z_0 (Without PGR (control))	10.00	17.50	6.50	11.33b
	Z_1 (Rootone-F 0.03%)	40.50	24.00	4.33	22.94a
	Z_2 (Shallot extract 60%)	11.33	17.17	0.00	9.50b
	Z_3 (Mung bean sprout extract 60%)	8.50	6.17	0.00	4.89b
	Z_4 (Young coconut water 60%)	12.83	10.17	0.50	7.83b
	Average	16.63a	15.00a	2.27b	
	Coefficient of variation (%)				22.50^b
8	Z_0 (Without PGR (control))	9.17bc	12.33bc	1.17c	7.56
	Z_1 (Rootone-F 0.03%)	59.50a	21.83b	0.00c	27.11
	Z_2 (Shallot extract 60%)	16.67bc	12.33bc	0.67c	9.89
	Z_3 (Mung bean sprout extract 60%)	4.33bc	1.50c	1.33c	2.39
	Z_4 (Young coconut water 60%)	5.83bc	8.67bc	7.83bc	7.44
	Average	19.10	11.33	2.20	
	Coefficient of variation (%)				28.28^b

Note: Mean values followed by the same letter within the same observation time are not significantly different according to DMRT at the 5% level.

^{b} : Data were transformed twice using $\sqrt{x + 0.5}$

M1 and M2 produced higher shoot length than M3 at all observation times. This was likely due to better aeration, water retention, and nutrient availability in M1 and M2, which supported shoot elongation. Mariana (2020) reported that rice husk charcoal or compost-based media can improve shoot length in stem cuttings by increasing aeration and nutrient availability. In contrast, the lower shoot length in M3 may be related to poorer aeration and excessive moisture retention, which can inhibit water and nutrient uptake.

Number of Leaves (leaves)

The number of leaves was affected by plant growth regulator type, planting medium, and their interaction at certain observation times, particularly at 4 and 8 WAP. Leaf number generally increased with plant age, indicating active vegetative growth. Z1, especially when combined with M1, produced the highest leaf number, reaching 41.33 leaves at 4 WAP and 59.50 leaves at 8 WAP. This suggests that synthetic auxin in Rootone-F supported meristematic activity, cell division, and leaf formation. Mulyani and Ismail (2015) reported that Rootone-F can enhance cell division and elongation in cuttings, resulting in greater leaf formation.

Among the planting media, M1 consistently produced the highest average number of leaves, followed by M2, while M3 produced the lowest values. The better response in M1 was likely due to its favorable physical properties, particularly good aeration and moisture balance, which supported nutrient uptake and shoot development. Good aeration helps maintain oxygen availability in the medium, allowing physiological processes and leaf formation to occur more optimally.

A higher number of leaves also indicates greater potential photosynthetic capacity because leaves are the main organs for photosynthesis. Therefore, the Z1M1 combination was the most favorable treatment for increasing leaf formation and supporting the vegetative vigor of moringa stem cuttings. Darise *et al*. (2023) reported that greater leaf numbers can increase photosynthetic activity, enabling plants to produce more energy for growth and development.

Number of Roots (roots per plant)

Root formation is an important indicator of the success of stem-cutting propagation because roots support water and nutrient uptake for continued plant growth. The results showed that the number of roots was significantly affected by planting medium, whereas plant growth regulator type and its interaction with planting medium did not. Although Z1M1 produced the highest numerical number of roots, this result should be interpreted as a numerical tendency rather than a confirmed interaction effect.

Table 5. Effect of plant growth regulator types and planting media on the number of roots (roots per plant).

Plant Growth Regulator (Z)	**Planting Media (M)**			**Average**
	M1 Rice husk charcoal + soil (1:1)	M2 Compost + soil (1:1)	M3 Cattle manure + soil (1:1)	
	roots per plant			
Z_0 (Without PGR (control))	2.17	0.00	0.00	0.72
Z_1 (Rootone-F 0.03%)	17.83	0.00	0.00	5.94
Z_2 (Shallot extract 60%)	5.67	0.00	0.00	1.89
Z_3 (Mung bean sprout extract 60%)	3.67	0.00	0.00	1.22
Z_4 (Young coconut water 60%)	0.00	0.00	0.00	0.00
Average	5.87a	0.00b	0.00b	1.96
Coefficient of variation (%)				22.06[b]

Note: Mean values followed by the same letter in the same row are not significantly different, whereas values followed by different letters are significantly different according to Duncan's Multiple Range Test (DMRT) at the 5% level.
[b]: Data were transformed twice using $\sqrt{x + 0.5}$

Root formation occurred only in M1, while no roots were formed in M2 and M3. This indicates that the physical condition of the planting medium was more important for root initiation than plant growth regulator application alone. Rice husk charcoal and soil likely provided better porosity, aeration, and drainage, thereby supporting oxygen availability and root development. Wulandari *et al*. (2017) stated that soil mixed with rice husk charcoal has high porosity, good aeration, and good drainage, which can support root growth. The absence of root formation in M2 and M3 was presumably related to excessive moisture and poor aeration in the media. High moisture can reduce oxygen availability around the cutting base, inhibit root respiration, and increase the risk of tissue decay before root initiation occurs. Field conditions, such as fungal growth and termite attack, may also have contributed to the inhibition of root formation in less porous media.

Although some cuttings produced shoots, root formation did not always occur simultaneously. This indicates that shoot emergence and root initiation are two different physiological processes. Shoot emergence is generally supported by stored food reserves and endogenous hormones in the cutting material, whereas root formation requires a more specific hormonal balance and suitable environmental conditions. Waniatri *et al*. (2019) stated that shoot emergence in cuttings is more influenced by food reserves and endogenous hormones in the shoot region, while root formation depends on more specific environmental and hormonal conditions.

Root Length (cm)

The Z1M1 combination produced the highest root length (2.02 cm) and was significantly different from the other treatments. This value was higher than the control treatment (0.47 cm), shallot extract 60% (0.63 cm), and mung bean sprout extract 60% (0.08 cm) in the same medium. The higher root length in Z1M1 was likely related to the auxin content in Rootone-F, particularly IBA and NAA, which play an important role in stimulating cell division, cell differentiation, and root initiation. Arinasa (2015) stated that the combination of IBA and NAA, or IAA and NAA, can support optimal root growth in cuttings and enhance plants' ability to absorb water and nutrients.

Table 6. Effect of different plant growth regulators and planting media on root length (cm)

Plant Growth Regulator (Z)	Planting Media (M)			Average
	M1 Rice husk charcoal + soil (1:1)	M2 Compost + soil (1:1)	M3 Cattle manure + soil (1:1)	
	cm			
Z_0 (Without PGR (control))	0.47b	0.00b	0.00b	0.16
Z_1 (Rootone-F 0.03%)	2.02a	0.00b	0.00b	0.67
Z_2 (Shallot extract 60%)	0.63b	0.00b	0.00b	0.21
Z_3 (Mung bean sprout extract 60%)	0.08b	0.00b	0.00b	0.03
Z_4 (Young coconut water 60%)	0.00b	0.00b	0.00b	0.00
Average	0.64	0.00	0.00	
Coefficient of variation (%)				21.12[a]

Note: Mean values followed by the same letter in the same row or column are not significantly different, whereas values followed by different letters are significantly different according to Duncan's Multiple Range Test (DMRT) at the 5% level.
[a] : Data were transformed using $\sqrt{x + 0.5}$

Root elongation occurred only in M1, while M2 and M3 did not produce roots. This indicates that M1 had more suitable physical properties for root formation and elongation. Rice husk charcoal is porous and can improve soil structure, aeration, and root zone conditions. Hidayat *et al*. (2025) stated that a good planting medium should provide sufficient water, nutrients, and root space for plant growth. Airansi *et al*. (2022) also reported that rice husk charcoal can increase organic carbon content, maintain root zone moisture, and support root development.

The significant interaction between Z1 and M1 indicates that root elongation was influenced by the compatibility between synthetic auxin and a suitable planting medium. Rootone-F supplied auxin compounds that stimulated root initiation, while rice husk charcoal improved the physical condition of the medium by increasing porosity and aeration. Rootone-F can stimulate cutting growth, especially root formation, when applied at an appropriate concentration. Tamba *et al*. (2019) also explained that auxin at an optimal concentration can stimulate root elongation by promoting carbohydrate accumulation in the basal part of cuttings, thereby supporting root development.

Survival Percentage (%)

Plant growth regulator type, planting medium, and their interaction did not significantly affect the survival percentage of moringa stem cuttings. However, numerically, Z1 and Z3 showed the highest survival percentage, reaching 83.33%. This tendency may be related to the role of plant growth regulators in supporting root and shoot initiation during the early growth stage. Cahyaningtias *et al*. (2025) stated that Rootone-F application can improve cutting success because auxin absorbed by cutting tissues stimulates cell division and root formation. Ardiansyah *et al*. (2025) also reported that mung bean sprout extract contains auxin and cytokinin, which support organ formation in plant cuttings.

Table 7. Effect of different plant growth regulators and planting media on the survival percentage (%)

Plant Growth Regulator (Z)	Planting Media (M)			Average
	M1 Rice husk charcoal + soil (1:1)	M2 Compost + soil (1:1)	M3 Cattle manure + soil (1:1)	
	%			
Z_0 (Without PGR (control))	50.00	66.67	50.00	55.56
Z_1 (Rootone-F 0.03%)	100.00	83.33	66.67	83.33
Z_2 (Shallot extract 60%)	50.00	83.33	33.33	55.56
Z_3 (Mung bean sprout extract 60%)	100.00	100.00	50.00	83.33
Z_4 (Young coconut water 60%)	50.00	66.67	83.33	66.67
Average	70.00	80.00	56.67	68.89
Coefficient of variation (%)				28.66[a]

Note: [a] : Data were transformed using $\sqrt{x + 0.5}$

Overall, the average survival rate of moringa stem cuttings was 68.89%, indicating that cuttings could survive under different combinations of plant growth regulators and planting media, although responses varied. Survival was likely influenced by physiological condition, food reserves, and environmental factors. Fitri *et al*. (2021) stated that larger cuttings generally contain more food reserves to support survival. Nengsih and Wahyu (2021) reported that a suitable temperature is important for cutting propagation, while Aisyah and Ansar (2023) stated that optimal humidity supports cutting growth. However, Firdaus (2019) emphasized that excessive humidity prior to root formation may increase water accumulation in the medium, leading to cutting decay. Moist media may reduce aeration, promote fungal growth, and increase termite attack. Termites commonly attack cellulose-rich basal and stem tissues, while Astuti *et al*. (2026) reported that moringa stems contain 30.61% cellulose, 27.37% hemicellulose, and 20.78% lignin.

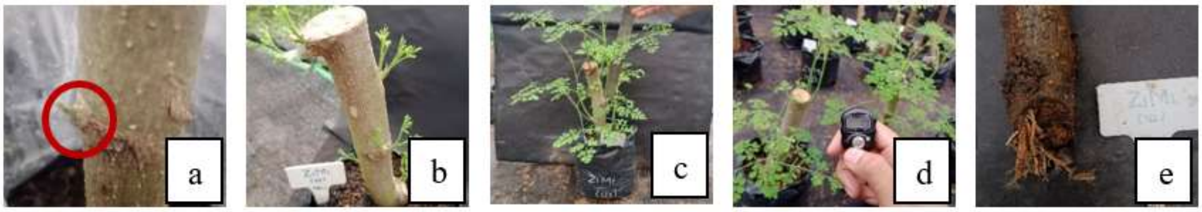

Figure 1. Research observations: (a) shoot emergence, (b) number of shoots, (c) shoot length, (d) number of leaves, and (e) root observation.

Figure 2. Moringa stem cuttings that developed leaves but did not form roots.

CONCLUSION AND RECOMMENDATIONS

The application of Rootone-F 0.03% (Z1) improved the growth of moringa (*Moringa oleifera* L.) stem cuttings, particularly in shoot length, number of leaves, and root length. Rootone-F 0.03% produced a shoot length of 4.36 cm at 6 weeks after planting (WAP), 16.78 leaves at 4 WAP, 22.94 leaves at 6 WAP, 27.11 leaves at 8 WAP, and an average root length of 0.67 cm. The rice husk charcoal + soil medium at a 1:1 (M1) ratio was the most suitable planting medium, producing 2.97 shoots at 4 WAP, a shoot length of 3.93 cm at 6 WAP, 19.10 leaves at 8 WAP, 5.87 roots per plant, and a root length of 0.64 cm. The interaction between plant growth regulators and planting media affected the number of shoots, the number of leaves at 4 and 8 WAP, and root length. The combination of Rootone-F 0.03% and rice husk charcoal + soil produced the best response, particularly in shoot number, leaf number, and root length, with 5.17 shoots at 4 WAP, 59.50 leaves at 8 WAP, and a root length of 2.02 cm. For moringa stem cutting propagation, Rootone-F at 0.03% combined with rice husk charcoal and soil at a 1:1 (Z1M1) ratio is recommended, as it supports better vegetative growth and root development. Further studies are needed to evaluate organic planting media, such as compost and cattle manure, using improved decomposition and sterilization processes to reduce pathogen incidence and increase rooting success.

REFERENCES

Alpina, L., I. D. Dharmawibawa., & T. L. Hajiriah. (2022). Proporsi Sari Labu Kuning (*Cucurbita moschata*) terhadap Karakteristik Yoghurt Layak Konsumsi Ditinjau dari pH dan Uji Organoleptik. *Bioscientist : Jurnal Ilmiah Biologi*, *10*(2), 579. https://doi.org/10.33394/bioscientist.v10i2.5250

Barakat, H., & M. F. Y. Hassan. (2017). Chemical, Nutritional, Rheological, and Organoleptical Characterizations of Stirred Pumpkin-Yoghurt. *Food and Nutrition Sciences*, *08*(07), 746–759. https://doi.org/10.4236/fns.2017.87053

Badan Standardisasi Nasional. 2009. SNI No. 01-2981-2009. Syarat Mutu Yogurt. Jakarta: Badan Standardisasi Nasional.

Campos, L., P. Tuma., T. Silva., D. Gomes., C. D. Pereira., M. H. F. Henriques. (2024). Low Fat Yoghurts Produced with Different Protein Levels and Alternative Natural Sweeteners. *Foods*, 13, 250. https://doi.org/10.3390/foods13020250

Hendarto, D. R., A. P. Handayani., E. Esterelita., & Y. A. Handoko. 2019 Mekanisme biokimiawi dan optimalisasi *Lactobacillus bulgaricus* dan *Streptococcus thermophilus* dalam pengolahan yoghurt yang berkualitas. *J. Sains Dasar*, *8*(1), 13-19. http://dx.doi.org/10.21831/jsd.v8i1.24261

Humaira, A. W., Zainuri., & M. D. Ariyana. (2025) "Pengaruh Konsentrasi Penambahan Sari Labu Madu (Cucurbita moschata D.) terhadap Mutu Yogurt Dengan Penstabil Glukomanan Porang." *Jurnal Edukasi Pangan, 3(2), 37-48.*

Kumala, I., & L. Nurlaela. (2015). Pengaruh penambahan puree labu kuning dan lama pengocokan (agitasi) terhadap sifat organoleptik es krim yoghurt. *E-Jornal Boga*, *4*(37), 202-210.

Lismawati, L., T. Tutik., & N. Nofita. (2021). Kandungan beta karoten dan aktivitas antioksidan terhadap ekstrak buah labu kuning (Cucurbita moschata). *Jurnal Mandala Pharmacon Indonesia*, *7*(2), 263-273.

Musoffin, A., I. Kentjonowaty., & O. R. Puspitarini. (2024). Pengaruh Berbagai Jenis Gula terhadap Nilai pH, Sineresis dan Kualitas Organoleptik Yoghurt. *Dinamika Rekasatwa*, *7*(1).

Najiah, T. (2014). *Pengaruh Proporsi Sari Labu Kuning (Cucurbita moschata) Dan lama fermentasi terhadap karakteristik yoghurt labu kuning* (Doctoral dissertation, Universitas Islam Negeri Maulana Malik Ibrahim).

Nurhikmah, I. R., A. R. Fitriyanti., H. Sulistyaningrum., & Y. K. Sya'di. (2023). Karakteristik Fisik Dan Karakteristik Kimia Firm Yoghurt Dengan Penambahan Pure Labu Kuning. In *Prosiding Seminar Nasional Unimus* (Vol. 6).

Raharjanti, Z., Y. B. Pramono., & A. N. Al-Baarri. (2019). Nilai pH dan Kekentalan Cocogurt dengan Penambahan Ekstrak Daun Stevia. *Jurnal Teknologi Pangan*, 3(2), 305–308.

Rahmawati, S., A. Napirah., F. Fitrianingsih., & A. B. Kimestri. (2023). Karakteristik Organoleptik Yogurt Susu Ultra High Temperature (UHT) dengan Penambahan Bakteri Lactobacillus acidophilus. *Jurnal Ilmiah Peternakan Halu Oleo*, *5*(3), 240.

Rasdianah, N., D. R. P. Papeo., N. A. Thomas., M. S. Latif., & W. R. Suleman. (2024). Pembuatan Yogurt Dari Labu Kuning (Cucurbita Moschata) Sebagai Minuman Kesehatan. *Jurnal Farmasi Teknologi Sediaan Dan Kosmetika*, *1*(2), 64–71. https://doi.org/10.70075/jftsk.v1i2.22

Suharto, E. L. S., Y. F. Kurnia., & F. Ferawati. (2021). Pengaruh Penambahan Gula Aren (Arrenga pinnata Merr.) dengan Konsentrasi yang Berbeda pada Yogurt terhadap Total Asam Tertitrasi, pH, dan Total Bakteri Asam Laktat. *Jurnal Peternakan Indonesia (Indonesian Journal of Animal Science)*, *23*(3), 284. https://doi.org/10.25077/jpi.23.3.284-289.2021

Swasti, Y. R., Purwijantiningsih, E., & Pranata, F. S. (2024). Antioxidant activities and mutagenic compounds in coconut and palms.

Abror, M., & Noviyanti, D. D. (2019). Pengaruh beberapa jenis ZPT terhadap pertumbuhan setek batang murbei (*Morus alba* L.). *Journal Nabatia*, 7(1), 19–28. https://share.google/OhwmsNdB4KILVMw4Q.

Ardiansyah, M. Y., Ningsih, E. M. N., Nugroho, Y. A., & Wardhani, T. (2025). Pengaruh bagian asal stek batang dan zat pengatur tumbuh kecambah kacang hijau terhadap pertumbuhan bibit sambung nyawa (*Gynura procumbens* (Lour.) Merr.). *Jurnal Ilmu-Ilmu Pertanian*, 19(1), 153–163. https://doi.org/10.31328/ja.v19i1.7066.

Airansi, A., Indriyanto, & Asmarahman, C. (2022). Pengaruh penambahan arang sekam terhadap pertumbuhan semai sengon (*Falcataria moluccana* (Miq.) Barneby & J. W. Grimes) dan jati (*Tectona grandis* L.f.). *Jurnal Penelitian Hutan Tanaman*, 19(2), 111–122. https://doi.org/10.20886/jpht.2022.19.2.111-122.

Arinasa, I. (2015). Pengaruh konsentrasi Rootone-F dan panjang setek pada pertumbuhan *Begonia tuberosa* Lmk. *Jurnal Hortikultura*, 25(2), 142–149. https://doi.org/10.21082/jhort.v25n2.2015.p142-149.

Astuti, W., Pradnya, I. N., Sulistyaningsih, T., Suwandi, L. A. C., Wati, A. S. F., Saputro, E. A., & Fitri, Z. A. (2026). Valorization of *Moringa oleifera* stem into activated carbon for dye removal: Coupled effects of lignocellulosic composition and pyrolysis temperature. *Trends in Sciences*, 23(1), 1-18. https://doi.org/10.48048/tis.2026.11067

BantenNews.co.id. 2022. Ekspor Daun Kelor Banten. https://bit.ly/3OsHbaX. [6 September 2025].

Berita BRMP Perkebunan. 2025. "Superfood" Daun Kelor: Nilai Gizi, Ekonomi, dan Lingkungan. https://bit.ly/3PZLKdg. [26 Juni 2025].

Cahyaningtias, H., Suyani, I. S., & Su'ud, M. (2025). Pengaruh posisi bahan tanam dan lama perendaman Rootone-F terhadap pertumbuhan stek batang nilam *(Pogostemon cablin* Benth.). *Jurnal Ilmiah Pertanian*, 1(1), 27–38. https://doi.org/10.51747/zha95d93.

Chiyaroh, L. N. A., Karno, & Lukiwati, D. R. (2021). Pengaruh jenis ekstrak kecambah dan pupuk kandang pada komposisi media tanam terhadap pertumbuhan setek murbei (*Morus alba*). *Journal Agro Complex*, 5(1), 32–40. https://doi.org/10.14710/joac.5.1.32-40.

Darise, R. H., Guniarti, & Triani, N. (2023). Pengaruh media tanam dan konsentrasi zat pengatur tumbuh IAA terhadap pertumbuhan stek pucuk tanaman kayu putih (*Melaleuca cajuputi*). *Agricultural Journal,* 6(1), 129–140. https://doi.org/10.37637/ab.v6i1.1120.

Ezperanza, P., Suryadi, E., & Amaru, K. (2023). Penggunaan komposisi media tanam arang sekam, cocopeat, dan zeolit pada sistem irigasi tetes terhadap pertumbuhan dan hasil tanaman melon. *Journal of Integrated Agricultural Socio Economics and Entrepreneurial Research*, 1(2), 19–24. https://doi.org/10.26714/jiasee.1.2.2023.19-24.

Fauza, S., Sabrina, T., & Hanum, H. (2016). Pengaruh komposisi media tanam dan aplikasi Azotobacter chroococcum terhadap pertumbuhan setek tanaman tin (*Ficus carica* L.). *Jurnal Pertanian Tropik*, 3(1), 91–99. https://doi.org/10.32734/jopt.v3i1.2961.

Firdaus, R. A. (2019). Efektivitas pemberian zat pengatur tumbuh auksin jenis IBA dan NAA terhadap pertumbuhan tanaman pacar kuku (*Lawsonia inermis* L.) melalui teknik stek mikro. *Skripsi*. Universitas Islam Negeri Maulana Malik Ibrahim. http://etheses.uin-malang.ac.id/id/eprint/14975.

Fitri, T., Pujawati, E. D., & Payung, D. (2021). Pengaruh pemberian Rootone-F terhadap pertumbuhan stek ramin (*Gonystylus bancanus*). *Journal Sylva Scienteae*, 4(1), 175–183. https://doi.org/10.20527/jss.v4i1.3105.

Herliana, R., Cartono, & Hizqiyah, I. Y. N. (2023). Efektivitas media tanam PUKCAPEDIA terhadap pertumbuhan tanaman hias sirih Brazil (*Philodendron hederaceum* Brasil). *Biofarm: Jurnal Ilmiah Pertanian*, 19(2), 272–279. https://doi.org/10.31941/biofarm.v19i2.3289.

Heryanto, W. (2019). Pengaruh sumber bahan setek dan lama perendaman Rootone-F terhadap pertumbuhan setek tanaman Xanthostemon kuning (*Xanthostemon chrysanthus* F. Muell.). *Skripsi*. Universitas Islam Riau. https://repository.uir.ac.id/1874/1/154110180.pdf.

Hidayat, H. S. C., Hidayati, N., & Arfianto, F. (2025). Respon pertumbuhan stek pucuk kaca piring terhadap aplikasi hormon pengatur tumbuh dan tiga komposisi media tanam. *Jurnal Ilmu-Ilmu Pertanian*, 9(3), 732–743. https://doi.org/10.32585/ags.v9i3.6925.

Isnan, W., & Muin, N. (2017). Ragam manfaat tanaman kelor (*Moringa oleifera* Lamk.) bagi masyarakat. *Info Teknis Eboni*, 14(1), 63–75. https://bit.ly/4dhX8tb.

Kurniati, F., Sudartini, T., & Hidayat, D. (2017). Aplikasi berbagai bahan ZPT alami untuk meningkatkan pertumbuhan bibit kemiri sunan *(Reutealis trisperma*). *Jurnal Agro*, 4(1), 40–49. https://doi.org/10.15575/1307.

Mariana, M. (2017). Pengaruh media tanam terhadap pertumbuhan setek batang nilam (*Pogostemon cablin* Benth). *Agrica Ekstensia*, 11(1), 1–8. https://bit.ly/4nkOUF9.

Mariana, M. (2020). Pengaruh media tanam terhadap pertumbuhan stek batang naga merah (*Hylocereus polyrhizus*). *Agrosamudra: Jurnal Penelitian*, 7(1), 24–30. https://doi.org/10.33059/jupas.v7i1.2343 .

Marliana, E., Setyaningrum, T., & Suwardi. (2022). Pertumbuhan stek batang sirih merah (*Piper crocatum* Ruiz) pada berbagai waktu perendaman ekstrak bawang merah dan komposisi media tanam. *Jurnal Agroteknologi*, 6(1), 33–41. https://doi.org/10.55180/agi.v6i1.231.

Maryani, I., & Suryadama, I. G. P. (2019). *Tak selebar daun kelor* (*Moringa oleifera* Lam). ISBN: 978-602-451-482-2. CV. K-Media. Yogyakarta.

Mulyani, C., & Ismail, J. (2015). Pengaruh konsentrasi dan lama perendaman Rootone-F terhadap pertumbuhan stek pucuk jambu air (*Syzygium semaragense*) pada media oasis. *Jurnal Penelitian*, 2(2), 1–9. https://ejurnalunsam.id/index.php/jagrs/article/view/305/226.

Mustaman, M., & Fatman, M. (2017). Pengaruh pemberian berbagai jenis pupuk kandang dan media tanam yang berbeda terhadap pertumbuhan dan produksi tanaman mentimun (*Cucumis sativus* L.). *Agrovital: Jurnal Ilmu Pertanian Universitas Al Asyariah*, 2(2), 88–92. https://bit.ly/4de7SbZ.

Mustariani, B. A. A. (2023). *Ragam bioaktivitas kombinasi tanaman kelor: Ekstraksi, fitokimia, dan antibakterinya*. ISBN: 978-623-261-543-4. CV. Samudra Biru. Yogyakarta.

Nengsih, Y., & Wahyu, A. D. (2021). Pertumbuhan stek kopi robusta (*Coffea canephora*) dengan pemberian ekstrak bawang merah. *Jurnal Media Pertanian*, 6(1), 43–47. https://doi.org/10.33087/jagro.v6i1.108.

Pratiwi, Y. I., Nisak, F., & Gunawan, B. (2019). Peningkatan laju pertumbuhan awal stek batang tanaman anggur dengan limbah urine sapi. *Jurnal Hasil Penelitian (JHP17)*, 4(2), 137–143. https://share.google/wR3RjkSZcP6v6LnHf.

Puspitasari, D., Meliyana, S. M. R., Jayadilaga, Y., Rhesa, M., & Saleh, A. R. (2023). Pengenalan manfaat dan pengolahan *Moringa oleifera* pada anak di BTN Kasumberang Kabupaten Gowa. *Jurnal Hasil-Hasil Pengabdian dan Pemberdayaan Masyarakat,* 2(1), 72–77. https://doi.org/10.35580/jhp2m.v2i1.171.

Renvillia, R., Bintoro, A., & Riniarti, M. (2016). Penggunaan air kelapa untuk setek batang jati (*Tectona grandis*). *Journal Sylva Lestari*, 4(1), 61–68. https://doi.org/10.23960/jsl1461-68.

Rokhmah, N. A., Sutardi, S., & Ikrarwati. (2022). Pengaruh media tanam dan zat pengatur tumbuh pada pertumbuhan bibit kelor (*Moringa oleifera*) asal stek batang. *Prosiding Seminar Nasional Hasil Penelitian Agribisnis VI*, 6(1), 293–300. https://jurnal.unigal.ac.id/prosiding/article/view/7719/4944#.

Salmah, Putra, I., Maulidia, V., & Jalil, M. (2022). Pengaruh jenis ZPT dan jenis bahan setek terhadap pertumbuhan setek batang tanaman kelor (*Moringa oleifera* L.). *Jurnal Agrotek Lestari*, 8(2), 122–130. https://doi.org/10.35308/jal.v8i2.4907.

Tamba, R. A. S., Martino, D., & Sarman. (2019). Pengaruh pemberian auksin (NAA) terhadap pertumbuhan tunas tajuk dan tunas cabang akar bibit karet (*Hevea brasiliensis* Muell. Arg) okulasi mata tidur. *Jurnal Agroecotenia*, 2(2), 11–20. https://doi.org/10.22437/agroecotania.v2i2.8737.

Waniatri, W., Hendrayana, Y., Supartono, T., Nuelaela, A., & Amalia, K. (2019). Pengaruh zat pengatur tumbuh alami dan asal stek batang terhadap pertumbuhan bibit pohon beunying (*Ficus fistulosa* Reinw. ex Blume). *Prosiding Seminar dan Call for Papers Konservasi untuk Kesejahteraan Masyarakat I*, Fakultas Kehutanan Universitas Kuningan, 200–210. https://journal.uniku.ac.id/index.php/prosiding-fahutan/article/view/3706.

Wasonowati, C., Endang, S., Didik, I., & Budiastuti, K. (2018). Pertumbuhan bibit kelor (*Moringa oleifera* Lamk.) dari biji dan setek dengan interval pemberian air yang berbeda. *Seminar Nasional Universitas Sebelas Maret*, 2(1), 175–181. https://semnas.bpfp-unib.com/index.php/SENATASI/article/view/42.

Widiayani, N., Jasadina, I. M., & Nasaruddin. (2024). Pengaruh konsentrasi auksin dan sitokinin terhadap keberhasilan dan pertumbuhan stek tanaman kakao *(Theobroma cacao* L.). *Journal Agrivigor*, 15(1), 40–59.

https://doi.org/10.20956/ja.v15i1.43233.
Wulandari, F., Astiningrum, M., & Tujiyanta. (2017). Pengaruh jumlah daun dan macam media tanam pada pertumbuhan stek jeruk nipis (*Citrus aurantifolia* Swingle). *Jurnal Ilmu Pertanian Tropika dan Subtropika*, 2(2), 48–51. https://doi.org/10.31002/VIGOR.V2I2.487.
ugar from special region of Yogyakarta Indonesia. *Food Research*, *8*(4), 336-342. https://doi.org/10.26656/fr.2017.8(4).251
Zakaria, D., A. S. Zuidar., D. Sartika., & N. Yuliana. (2023). Pengaruh Lama Waktu Perebusan Biji Labu Kuning Terhadap Sifat Sensori dan Aktivitas Antioksidan Pada Minuman Fermentasi Yoghurt. *Jurnal Agroindustri Berkelanjutan*, *2*(2), 297-309.