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Differences in Growth And Yield of Moringa Oleifera Leaves By Immersing Seeds And Variations of Planting Medium

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ABSTRACT

Moringa plant breeding generally uses seeds, although there is wide scope for vegetative propagation. So far, the seeds produced to be used as seeds have relatively hard coats, consequently slowing down germination and seedling vigor. Immersing seeds with plant growth regulators (PGR) can be a solution to overcome germination problems. Researching the immersing of plant growth regulators and the composition of planting media, is intended to get the maximum concentration of growth regulators and the right composition of planting media to support the growth of moringa plants. The research was arranged using a Split Plot Design with the main plot of growth regulators, namely: fresh water (Z_1), coconut solution (Z_2), and GA_3 (Z_3). Planting Media as subplots are M_1, M_2, and M_3 where is the ratio of soil: sand: manure according to the treatment composition (1:1:2, 1:2:1, and 2:1:1). Data were tested with ANOVA and continued with DMRT with a 95% confidence interval. Growth regulators showed significant differences in plant height (45.75 cm) at 4 weeks after planting (WAP), stem diameter 6 WAP (8.75 mm), and root length (21.11 cm). While the composition of planting media has a significant effect on plant height 8 WAP (90 cm), stem diameter 2 WAP (4.67mm), number of leaves 4 WAP (8.17 stalks), fresh leaves (189.67g), and dry weight of leaves (39.95g). The combination of planting media treatment and growth regulators has a significant effect and produces differences in stem diameter at the age of 2 and 8 weeks after planting (5.5 mm, and 15.40 mm). It is suggested that the growth regulator treatment used is fresh water so that the roots are longer and deeper and can grip the soil aggregates strongly and grow taller and stronger. The recommended planting media composition is M_1, which can produce the highest number of leaves and leaf weight. For the treatment interaction to have a real effect on stem diameter enlargement, it is recommended to use GA_3 and M_2 planting media composition (Z_3M_2).

Keywords: *composition; functional food; PGR; antioxidant.*

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INTRODUCTION

Moringa is currently a world concern, considering that the nutritional content of this plant is high enough so it is used to treat malnutrition in many developing countries. The moringa is the most useful plant in the world. The leaves have a relatively high content of antioxidants, so they are also used as an ingredient in the cosmetic industry, one of the extracting antioxidants of moringa leaves for hand body cream supply.

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The protein, vitamin C, and vitamin A content is very high and can even reach twice the vitamin C content of oranges and vitamin A of carrots. Moringa leaves contain flavonoids, alkaloids, phenolics, and saponins (Arora et al., 2013) and these flavonoid compounds can increase calcium solubility in kidney stones (Anas et al., 2016).

The increasing demand for moringa leaves for processed production requires research on good moringa cultivation so that production is high and quality (Ekawati and Wati, 2019). Moringa plant breeding generally uses seeds, although there is wide scope for vegetative propagation. So far, the seeds produced to be used as seeds have relatively hard coats, consequently slowing down germination and seedling vigor. One effort to soften the moringa seed coat and accelerate germination is by immersing the seeds in water or in a solution containing both natural and synthetic growth stimulants (Devitriano and Syarifuddin, 2021). The growth regulator such as GA3 in plants plays a role in cell elongation, enlarges the area of the upper part of the leaf, and affects the size of the fruit to be obtained (Adilah et al., 2020).

Early selection of seedlings by sowing the seeds to resulting strong roots, resistance to termite attacks and drought, and good growth of moringa seeds in the planting medium as a source of high biomass. A better planting substrate is porous, sufficiently watered, stable, resistant to temperature, has good humidity, ventilation, and drainage, has high cation exchange capacity, and is also resistant to pests and diseases. In addition to the medium, planting depth also affects root growth and the development of moringa seedlings. Planting depth determines plant vitality. Normal seeds have good growth vitality at optimum depth (Alkansaa et al., 2019).

The main problem of moringa cultivation is farmers' low interest and lack of understanding of its benefits and functions. Therefore, it is necessary to develop the plant. Add hormones and nutrients are needed to increase its nutritional content. Meanwhile, the need for nutritious food is increasing. There is an increase in the demand for Moringa leaf flour in both domestic and foreign markets. This research on the application of immersing seeds with growth regulators (ZPT) and comparing the composition of planting media aims to obtain the right type of ZPT and the right composition of planting media for plant growth.

METHODS

The materials used were moringa seed, topsoil, sand, cow manure, coconut liquid, GA_3, polybags, and freshwater. The tools are hoes, chopping knife, ropes, plastic, scissors, labels, sprayer, meter sticks, calipers, stationery, and others. Research flow chart in Figure 1.

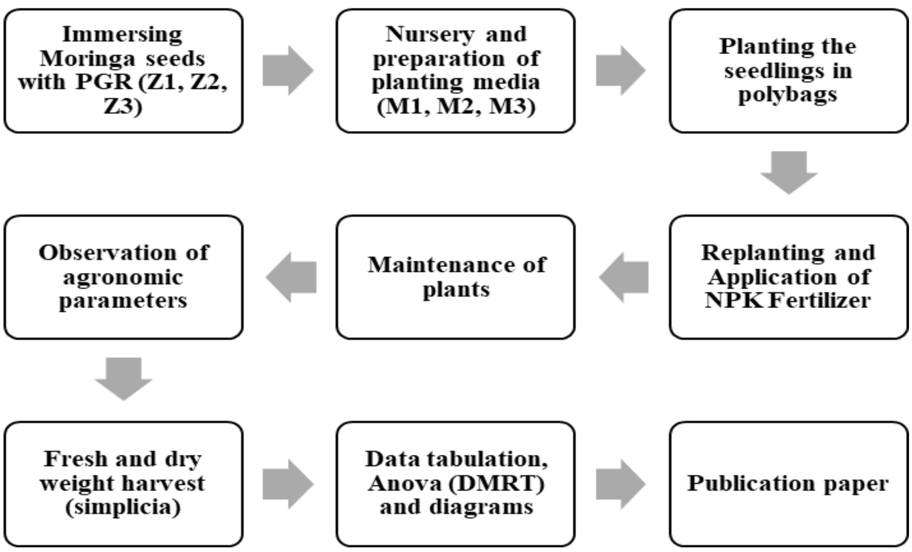

Figure 1. Research flow chart

It is necessary to treat such as adding hormones and nutrients needed to increase its nutritional leaf content and develop the plant growth. The research was arranged using a Split Plot Design with the main plot of growth regulators, namely: fresh water (Z_1), coconut solution (Z_2) , and GA_3 (Z_3). Planting Media as subplots are M_1, M_2, and M_3 where is the ratio of soil: sand: manure according to the treatment composition (1:1:2, 1:2:1, and 2:1:1). Data were examined by Analysis of Variance (F test) and continued by Duncan Multiple Range Test (DMRT). Figure 2 show the layout treatment of the experimental plots.

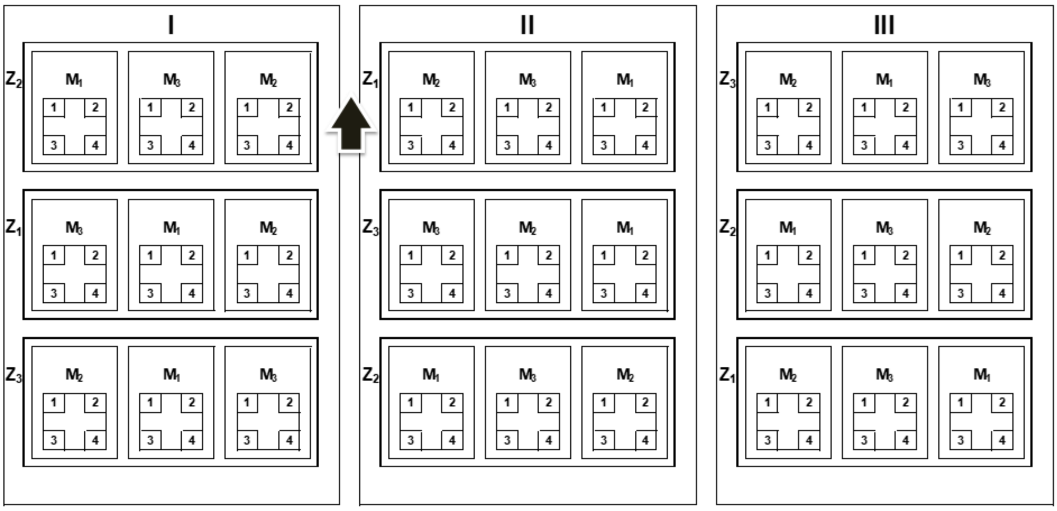

Figure 2. Layout treatment of the experimental plots.

One plot contains 4 plants, the gap between plants is 40 cm, and the gaps between plots are 60 cm (east-west course) and 80 cm (north-south course). All treatment was repeated 3 times (3 treatment blocks: I, II, and III), and the gap between blocks was 1 m. The north is at the top of the picture.

RESULT AND DISCUSSION

Plant height. Treatment of plant growth regulators (PGR) independently caused differences in plant height at 4 WAP. The treatment of planting medium resulted in differences in plant height at 2, 6, and 8 WAP. However the interaction between planting medium and PGR had no significant effect on plant height. The differences in plant height are observed in Table 1.

Table 1. Moringa plant height due to PGR treatment and planting media at 2, 4, 6, and 8 WAP

Treatment	weeks after planting (WAP)			
	2	4	6	8
PGR	plant height (cm)			
Z_1 (freshwater)	21.26	42.99b	63.98	85.75
Z_2 (coconut liquid)	20.00	45.43a	61.26	81.79
Z_3 (GA_3)	20.79	45.75a	62.97	92.21
Medium (topsoil-sand-manure)	plant height (cm)			
M_1 (1:1:2)	23.31a	45.02	61.71b	90.00a
M_2 (1:2:1)	19.45b	44.16	61.73b	87.42ab
M_3 (2:1:1)	19.28b	44.99	64.77a	82.32b

Numbers followed by different letters indicate a significant difference in the .05 DMRT.

Based on Table 1, PGR treatment resulted in a difference in plant height at 4 WAP. Moringa seeds immersed in coconut liquid (45.43 cm) and GA_3 (45.75 cm) had a significantly different plant height compared to freshwater (42.99 cm). Meanwhile, the planting medium with different compositions resulted in different plant heights of the moringa seedlings. At the 2 and 8 WAP, the seedlings planted on M_1 media were significantly higher than those grown on M_2 and M_3.

Moringa seed immersion treatment caused differences in plant height at 4 WAP. Stem diameters were significantly different in size due to seed immersing treatment in the three different PGR types at 2, 4, and 6 MST. Meanwhile, the roots were found to be significantly different in length at 8 WAP due to the PGR in the previous seed immersion. This situation can be explained that PGR, furthermore affecting the rate of germination for subsequent plant growth will also affect the ability of vegetative growth.

Moringa seed immersion treatment caused differences in plant height at 4 WAP, the highest was 45.75 cm (Z_3). Stem diameters were significantly different in size due to seed immersing treatment in the three different PGR types at 2, 4, and 6 MST. This finding be explained that in general PGR has a significant influence on plant vegetative growth because it actively stimulates volume expansion and increases the number of cells that support plant growth. According to Novita et al. (2021) treatment of Gibberellin caused a significant effect on plant height. Applying the Gibberellin (GA_3) will increase the auxin content to stimulate the plant's height growth.

The results of Badiatud Durroh's research, Durroh and Winarti (2020) showed that application of coconut liquid at a concentration of 100 ml/L resulted in the highest fresh leaf weight in sugarcane plants. The addition of organic matter to the soil will improve the dense soil structure to become loose and maintain soil fertility. According to Syawal et al. (2019), the composition of the planting media has a very significant effect on plant height and the number of leaves on the growth and yield of shallots. The pattern of plant height growth that was treated by planting medium and PGR is presented in Figure 3.

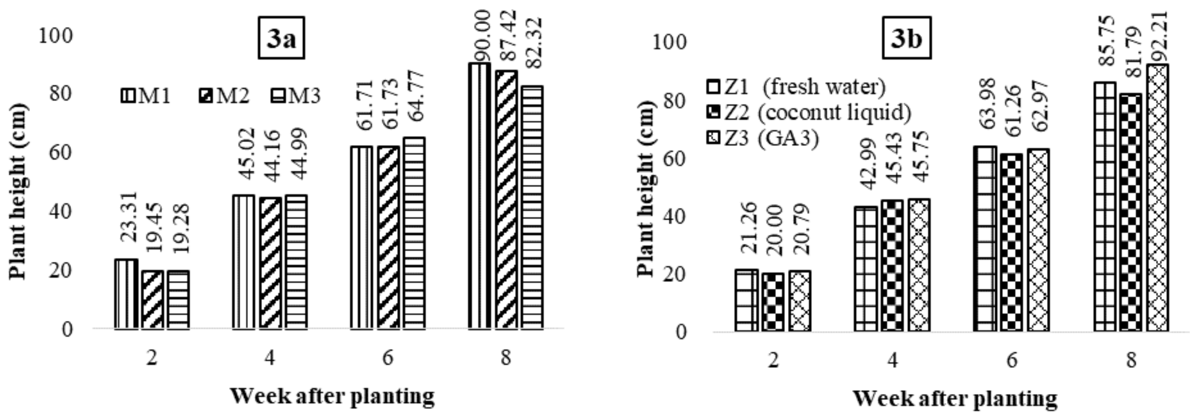

Figure 3a. Increase in the height of Moringa seedlings due to the planting media at 2-8 WAP. Figure 3b. Increase in the height of Moringa seedlings due to PGR at 2-8 WAP.

In this research, the growth was significantly affected by PGR including plant height, root length, and especially stem diameter. The results of the research and statements above also support the importance of immersing seeds in PGR. The function of PGR in addition to accelerating germination also supports the availability of nutrients for further seedling growth. Although in this study the effect of PGR resulted in a significant difference in the parameters of plant height only at 4 WAP on immersion with coconut water and GA_3 (14.08 mm). The largest stem diameter was at 8 MST with immersion in freshwater and GA_3. The longest roots by immersing the seeds in freshwater and GA_3. According to Novita et al. (2021) treatment of Gibberellin caused a significant effect on plant height. Giving the Gibberellin (GA_3) will increase the auxin content to stimulate the plant's height growth.

Agreed with the statement, Sofyan et al. (2022) reported that immersing green grass jelly stems cuttings in PGR was able to increase the growth of cuttings. The best treatment with an average number of shoots of 1.2 stems and 3.2 leaves. Green grass jelly cuttings that have not been able to supply nutrition need to be given additional hormones in the seedlings process. The planting medium is where the roots develop and the stems grow upright. In addition, as a medium to absorb nutrients and water. Each plant has specific planting media criteria so there are differences in the composition of the media for its growth. One of the materials that can be added to get good media criteria is by adding organic matter (Syawal et al., 2019).

The combination of planting media treatment and growth regulators has a significant effect and produces differences in stem diameter at the age of 2 and 8 weeks after planting. The combination of these treatments only had a significant effect on stem diameter, but had no significant effect on other vegetative parameters because their interactions played a more active role in cell division in stems to increase their diameter. However, the application of both treatments independently showed differences in vegetative growth at every observation. Agree with the discussion, Tarigan et al. (2018) stated that treatment of guano fertilizer and mycorrhizal biofertilizers showed a marked influence on the parameters of seedling height, and stem diameter.

The interaction between the Trichoderma as a biological fertilizer and the type of manure as a planting medium significantly affected all growth parameters and fruit tomato production (Giovan et al., 2021). The soil application with organic matter such as tea vermicompost combined with foliar spray resulted in a significant difference in plant height, leaf number, and leaf area in lettuce compared to the control (Hamed et al., 2022). This condition indicates that the combination of treatments needs to be implemented and studied carefully to produce a planting medium that can provide nutrients and soil fertility levels suitable for plant growth and development. The difference in large stem diameter due to the combination of PGR and planting media is presented in Table 2.

Table 2. Moringa stem diameter due to PGR and planting medium at 2, 4, 6, and 8 WAP

Treatment	weeks after planting (WAP)			
	2	4	6	8
PGR	stem diameter (mm)			
Z_1 (freshwater)	3.61b	8.08a	8.29ab	12.55
Z_2 (coconut liquid)	4.17a	7.67b	7.96b	12.29
Z_3 (GA_3)	4.17a	8.42a	8.75a	14.08
Medium (topsoil-sand-manure)	stem diameter (mm)			
M_1 (1:1:2)	4.67a	8.26	8.40	12.71
M_2 (1:2:1)	3.39b	8.17	8.29	13.58
M_3 (2:1:1)	3.89b	8.03	8.06	12.64

Numbers followed by different letters indicate a significant difference in the .05 DMRT.

The GA3 (Z_3) generally resulted in the largest stem diameter at 2, 4, and 6 WAP compared to the seeds treated by coconut liquid (Z2) and freshwater (Z_1) immersion. The treatment of the M1 planting medium showed a larger stem diameter (4.67 mm) than M_2 and M_3 at 2 WAP.

The growth of moringa stem diameter due to the treatment of planting medium and ZPT is presented in Figure 4.

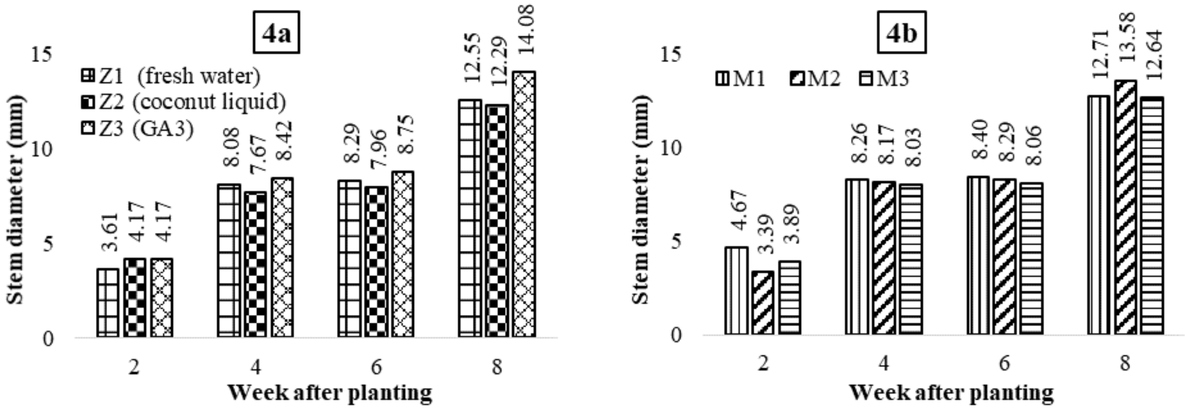

Figure 4a. Moringa stems diameter growth due to PGR at 2-8 WAP. **Figure 4b.** Increase in the height of moringa seedlings due to the planting medium at 2-8 WAP.

PGR affected significant differences in stem diameter at 2,4 and 6 WAP. However, at 8 WAP the stem diameters were the same as PGR immersion treatment. The planting medium resulted in different stem diameters (4.67 mm) at 2 WAP only, while further observations did not result in differences.

The combination of PGR and planting medium showed a significant interaction that caused differences in the diameter of the moringa stems at 8 WAP. The difference in stem diameter due to their interaction is presented in Table 3.

Table 3. Moringa stem diameter due to the combination of PGR and planting medium at 2 and 8 WAP

Treatment	PGR (ml/L)			Average
	Z_1 (freshwater)	Z_2 (coconut liquid)	Z_3 (GA_3)	
Medium (topsoil-sand-manure)	2 WAP stem diameter (mm)			
M_1 (1:1:2)	3.67c	5.50a	4.83ab	4.67a
M_2 (1:2:1)	3.50c	3.33c	3.33c	3.39b
M_3 (2:1:1)	3.67c	3.67c	4.33bc	3.89b
Average	3.61b	4.17a	4.17a	
Medium (topsoil-sand-manure)	8 WAP stem diameter (mm)			
M_1 (1:1:2)	12.02bc	13.83ab	12.28bc	12.71
M_2 (1:2:1)	12.88abc	12.47bc	15.40a	13.58
M_3 (2:1:1)	12.77abc	10.57c	14.57ab	12.64
Average	12.55	12.29	14.08	

Numbers followed by different letters indicate a significant difference in the .05 DMRT.

Based on Table 3, the largest stem diameter at 2 WAP was obtained in the combination of soil-sand-manure (1:1:2) planting medium and immersing seeds with coconut liquid (5.50 mm) which was significantly different from all other combinations of treatment, except M_1Z_3. At 8 MST the largest diameter was found in the M_2Z_3 (15.40 mm) which was significantly different from M_1Z_1, M_1Z_2, M_2Z_2, and M_3Z_2.

Treatment of the planting medium produced significantly different plant growth components such as stem diameter at 2 WAP. Planting medium according to the level of fertility and soil structure will support plant growth and development. The planting medium is where the roots develop and the stems grow upright. In addition, as a medium to absorb nutrients and water. Each plant has specific planting media criteria so there are differences in the composition of the media for its growth. One of the materials that can be added to get good media criteria is by adding organic matter (Syawal et al., 2019). While (Giovan et al., 2021) stated the application of 2 kg/plot of rabbit manure organic fertilizer produced the highest plants of 34.42 cm of okra and was significantly different from plants that were not treated at 5 WAP for stem diameter.

The pattern of differences in stem diameter growth that received a combination of planting medium and PGR is presented in Figure 5.

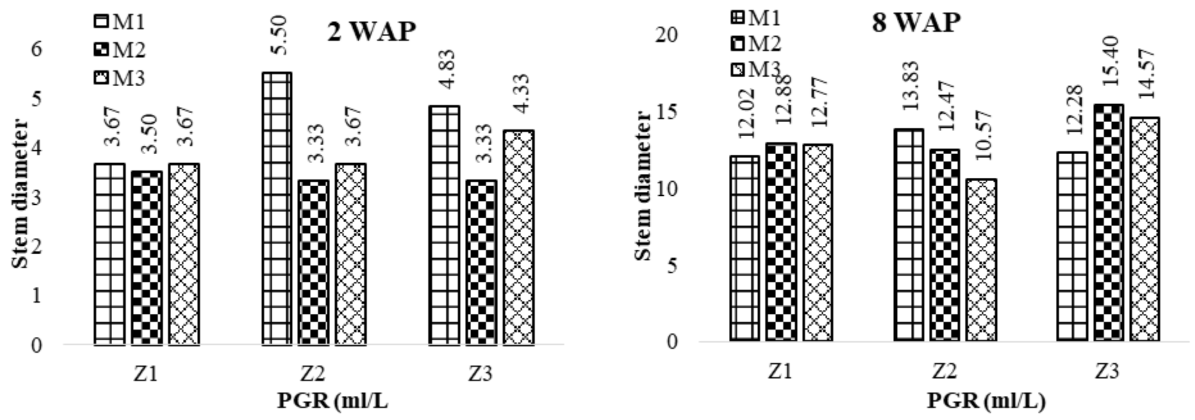

Figure 5. Moringa stems diameter growth pattern due to the interaction of PGR and planting medium at 2 WAP and 8 WAP.

The diameter of the stems of moringa grown on M_1 planting medium with seeds from coconut liquid immersion at 2 WAP tended to be larger than the diameter of moringa stems on M_2 and M_3 planting media with original seeds from freshwater and GA_3 immersion.

Planting media includes important components that support plant growth and development so the composition must be suitable for the needs of each plant. In this study, the ideal composition that supports the formation of the most number and weight of leaves, tallest plant, and largest stem diameter in M_1 planting medium with soil composition: sand: manure (1:1:2). By adding two parts of organic matter (manure) to the composition of the planting medium, the soil is more loose and fertile for plant growth. Because the results of research by Jamidi et al. (2021) on oil palm seedlings by too little dose of cow manure given to the planting medium, were only able to supply nutrients in small amounts they did not show a real effect on seedling growth.

Number of leaves (stalks). The number of leaves was significantly different only in the planting medium at 4 WAP. In the other observations, both treatments independently or in combination had the same effect on the number of leaves (Table 4).

Table 4. Number of moringa leaves due to PGR and planting medium at 2, 4, 6 and 8 WAP

Treatment	weeks after planting (WAP)			
	2	4	6	8
Immersing	moringa leaves (stalks)			
Z_1 (freshwater)	3.22	8.06	8.17	11.39
Z_2 (coconut liquid)	3.11	7.72	8.22	10.94
Z_3 (GA_3)	2.67	7.89	8.06	11.28
Medium (topsoil-sand-manure)	moringa leaves (stalks)			
M_1 (1:1:2)	2.67	8.17a	8.22	10.67
M_2 (1:2:1)	3.00	8.00ab	8.22	11.44
M_3 (2:1:1)	3.33	7.50c	8.00	11.50

Numbers followed by different letters indicate a significant difference in the .05 DMRT.

The planting medium (M_1) with soil:sand:manure composition (8.17 stalks) produced the highest number of leaves and it was significantly different than M_3 (7.50 stalks), but not significantly different than M_2 (8.0 stalks) at 4 WAP.

Treatment of the planting medium produced significantly different plant growth components such as number of petioles at 4 WAP. The addition of organic matter to the soil will improve the dense soil structure to become loose and maintain soil fertility. According to Syawal et al. (2019), the composition of the planting media has a very significant effect on plant height and the number of leaves on the growth and yield of shallots.

The fresh and dry weight of the canopy. The fresh and dry canopy weights observed at 8 WAP showed only the planting medium treatment had a significantly different effect. While the immersing seeds by PGR and their interaction with the planting medium had no significant effect on the fresh and dry weight of the moringa canopy.

Table 5. Fresh and dry shoot weights due to PGR and planting medium at 8 WAP

Treatment	PGR (ml/L)			Average
	Z_1 (freshwater)	Z_2 (coconut liquid)	Z_3 (GA_3)	
Medium (topsoil-sand-manure)	fresh weight (g)			
M_1 (1:1:2)	188.33	190.00	190.67	189.67a
M_2 (1:2:1)	135.83	118.50	151.50	135.28b
M_3 (2:1:1)	167.00	178.33	130.17	158.50ab
Average	163.72	162.28	157.44	
Medium (topsoil-sand-manure)	dry weight (g)			
M_1 (1:1:2)	40.19	39.19	40.47	39.95a
M_2 (1:2:1)	24.66	26.21	32.96	27.94b
M_3 (2:1:1)	28.65	42.67	28.00	33.11ab
Average	31.17	36.02	33.81	

Numbers followed by different letters indicate a significant difference in the .05 DMRT.

The planting medium showed a different effect on the fresh and dry weight of the moringa canopy at 8 WAP. The planting medium M_1 (189.67g and 39.95g) was significantly different in producing fresh and dry canopy weights compared to M_2 (135.28g and 27.94g), but not significantly different than M_3 (158.50g and 33.11g).

According to Fitrianah et al. (2012), the composition of the soil planting medium: cow manure (1:1) gave the highest plant length and number of red Gendola leaves. The composition of the planting media 2:1 resulted in the widest leaves, fresh weight, and heaviest plant total dry weight. Badiatud Durroh, (Durroh and Winarti, 2020), the heaviest fresh weight of sugarcane leaves were produced in the compost treatment of 327.16 grams. Agreeing with that statement, Mariana (2017) reported that the planting medium had a significant effect on the number of leaves, wet weight, and dry weight of patchouli seedlings. Khan et al. (2023) stated, the organic matter sources (OM) and effective microbes (EM) significantly altered wheat growth and dry matter production. The poultry manure has improved the leaf area, dry matter, and crop growth rate. The sufficiency of OM for obtaining enhanced production.

(Giovan et al., 2021) reported the application of Trichoderma to various sources of manure had a significant effect on all parameters of tomato growth and production. Treatment of Trichoderma doses with various levels had a significant effect on the age of flowering start, number of fruits per sample, fruit weight per sample, fruit production per plot, and fruit production per hectare but not significant on the parameters of plant height, stem diameter, number of flowers and percentage flowers become fruit.

The results of Badiatud Durroh's research, (Durroh and Winarti, 2020) showed that the treatment of various types of organic fertilizers as planting medium and the concentration of coconut liquid sprayed on plants showed an interaction at the leaf fresh weight. Application of amino acids containing growth regulators and organic fertilizers through the soil (Rini Sulistiani et al., 2023) where applied in treatment combination causes significantly different interactions on the yield of Moringa leaves. The heaviest fresh-weight of Moringa leaves was found at treatment without amino acids and Eco farming organic fertilizer concentration of 2.0 ml/L.

The Root Length and Volume. Root length was significantly different at 8 WAP by immersing the seeds with PGR, while the planting medium and their interactions of them had the same effect. Root volume experienced no significant differences due to independent or combined treatments.

Table 6. Moringa root length and volume due to PGR and planting medium treatment at 8 WAP

Treatment	PGR (ml/L)			Average
	Z_1 (freshwater)	Z_2 (coconut liquid)	Z_3 (GA3)	
Medium (topsoil-sand-manure)	Root length (cm)			
M_1 (1:1:2)	19.33	15.00	17.33	17.22
M_2 (1:2:1)	21.00	19.00	22.00	20.67
M_3 (2:1:1)	23.00	19.33	23.00	21.78
Average	21.11a	17.78b	20.78a	
Medium (topsoil-sand-manure)	Root volume (cm^3)			
M_1 (1:1:2)	0.77	0.97	0.93	0.89
M_2 (1:2:1)	0.77	1.00	0.60	0.79
M_3 (2:1:1)	0.67	0.93	0.83	0.81
Average	0.73	0.97	0.79	

Numbers followed by different letters indicate a significant difference in the .05 DMRT.

Immersing moringa seeds in freshwater and GA_3 caused significantly different root lengths compared to seeds immersed in coconut liquid. However, the seeds immersed in freshwater had no significant difference in root length with GA_3 immersion. The longest roots by immersing the seeds in freshwater (21.11g) and GA3 (20.78g)

Planting medium according to the level of fertility and soil structure will support plant growth and development. Mariana (2017) stated a good planting medium that is able to provide sufficient amounts of water and nutrients for plant growth. The planting medium must have good air and water management, solid aggregates, and the ability to hold adequate water and space for sufficient root growth.

Safitri et al., (2021) stated that the combination treatment between the concentration of growth regulators and a compound of media types for all parameters showed no effect on treatment interactions. Although not significantly different, the compound of soil and manure tended to increase the number of shoots, root volume, and root length.

CONCLUSION

The coconut liquid (45.43 cm) and gibberellin (45.75 cm) resulted in significant differences in plant height at 4 WAP. The freshwater (21.11 cm) and gibberellins (20.78 cm) produced significantly different root lengths at 8 WAP. The longest roots in freshwater treatment. The PGR treatment was not significantly different on the moringa fresh and dry shoots, and roots volume. The composition of topsoil-sand-manure with a ratio of 1:1:2 (M_1) produced the highest plant height, the largest moringa fresh (189.67g) and dry (39.95g) shoot at 8 WAP while the planting medium was not significantly different on the length and volume of the moringa root. The coconut liquid combined with composition of topsoil-sand-manure with a ratio of 1:2:1 (10.57g) produces the largest moringa stem diameter at 2 WAP and the largest diameter at gibberellin combined with topsoil-sandy-manure with a ratio of 1:2:1 (15.40 mm) at 8 WAP. Further research uses M_1 media or similar soil textures for maximum growth. Immersing the seeds before planting can use freshwater.

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