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Effect of Moringa Leaf Liquid Organic Fertilizer (*Moringa oleifera L*) Concentration on The Vegetative Growth of Rose Cuttings (*Rosa hybrida L*)

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Abstract: This study aimed to analyze the effect of moringa leaf liquid organic fertilizer (LOF) concentration on the vegetative growth of rose cuttings (*Rosa hybrida* L.), as assessed by the number of shoots and leaves. This quantitative study employed an experimental method with a one-factor Completely Randomized Design (CRD). The six treatment levels were P0 (0%; water as the control), P1 (10%), P2 (30%), P3 (50%), P4 (70%), and P5 (90%), with four replications per treatment, resulting in 24 experimental units. Observations were conducted on days 8, 14, 20, 26, and 32. The data were analyzed using the Kolmogorov-Smirnov test, a homogeneity-of-variance test, and one-way ANOVA. Descriptively, the total numbers of shoots for P0-P5 were 7, 10, 7, 6, 5, and 4, respectively, whereas the total numbers of leaves were 25, 14, 19, 4, 4, and 4. The normality-test significance values were 0.271 for the number of shoots and 0.266 for the number of leaves; the median-based homogeneity values with adjusted degrees of freedom were 0.473 and 0.673, respectively. The one-way ANOVA results indicated no significant differences among treatments in either the number of shoots ($p = 0.286$) or the number of leaves ($p = 0.667$). Therefore, under the conditions of this study, variation in moringa leaf LOF concentration did not significantly affect the vegetative growth of rose cuttings.

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INTRODUCTION

Rose (*Rosa hybrida L.*) is an important floricultural commodity because of its aesthetic and economic value and its wide range of uses as a cut flower, potted plant, garden ornament, fragrance material, and decorative product. Developments in rose cultivation and breeding indicate that the quality of vegetative growth provides an essential foundation for flower productivity and quality (De Vries & Dubois, 2020). In propagation by stem cuttings, successful root, shoot, and leaf formation is influenced by the physiological condition of the planting material and the growing environment (Kim et al., 2018).

The growing medium, moisture, and nutrient availability support the early growth of rose cuttings. Studies on rose cuttings have shown that growing-medium composition and the application of growth-promoting substances may affect shoot number, shoot length, leaf number, and flower formation (Megawati & Tambing, 2021). The application of LOF to roses may also produce different responses depending on the source material and dosage. Banana-peel LOF, for example, has been reported to affect shoot and leaf numbers, with the best results obtained at a particular dosage (Butar-Butar, 2024), whereas vegetable-waste LOF has been reported to affect the time of shoot emergence and the number of leaves (Mulyanti, 2018).

The use of liquid organic fertilizers and plant-based biostimulants is an alternative approach for reducing dependence on synthetic fertilizers. Moringa leaves (*Moringa oleifera L.*) have potential as a raw material for LOF because they contain minerals, amino acids, vitamins, antioxidants, and phytohormones, including auxins, gibberellins, cytokinins, and zeatin (Mashamaite et al., 2022). These components may support cell division and elongation, photosynthetic activity, nutrient uptake, and plant tolerance to stress (Yuniati et al., 2022). In general, moringa leaf extract has been investigated as a relatively inexpensive and environmentally friendly organic biostimulant for various cultivated plants (Karthiga et al., 2022).

Several studies have reported positive plant responses to moringa leaf extract or LOF. Moringa leaf extract has been reported to enhance wheat germination and early growth (Yasmeen et al., 2013), support the growth and antioxidant system of common bean under saline conditions (Rady et al., 2013), and improve the growth of Welsh onion at certain concentrations (Mare et al., 2023). Other findings indicate that plant responses are not always linear: low concentrations may stimulate growth, whereas higher concentrations may inhibit growth because of hormetic effects or allelochemical compounds (Perveen et al., 2021). Different findings have also been reported for lettuce and orchids, indicating that the effectiveness of moringa leaves is influenced by plant species, concentration, growing medium, and application method (Ainurvia et al., 2022; Bandang et al., 2021).

Although the potential of moringa leaves as a source of LOF and biostimulants has been widely reported, information on the vegetative response of rose cuttings to a range of moringa leaf LOF concentrations remains limited. Therefore, this study aimed to analyze the effects of 0%, 10%, 30%, 50%, 70%, and 90% moringa leaf LOF concentrations on the numbers of shoots and leaves produced by rose cuttings. The findings are expected to provide a basis for determining a more appropriate application concentration and to support the development of enrichment materials for plant physiology laboratory manuals.

RESEARCH METHODS

Research Type and Design

This study was quantitative and employed an experimental method using a one-factor Completely Randomized Design (CRD). The independent variable was the concentration of moringa leaf LOF, whereas the dependent variables were the numbers of shoots and leaves produced by rose cuttings. Each treatment was replicated four times.

Experimental Design

The experimental design was used to test the effect of moringa leaf liquid organic fertilizer (*Moringa oleifera L.*) concentration on the vegetative growth of rose plants (*Rosa hybrida L.*) as enrichment material for a plant physiology laboratory manual. The experiment used a one-factor CRD with six concentration levels and four replications, yielding 24 experimental units. The six moringa leaf LOF concentration levels were as follows:

1) P0 (0%): 1,000 mL of water as the control.
2) P1 (10%): 100 mL of LOF + 900 mL of water.
3) P2 (30%): 300 mL of LOF + 700 mL of water.
4) P3 (50%): 500 mL of LOF + 500 mL of water.
5) P4 (70%): 700 mL of LOF + 300 mL of water.
6) P5 (90%): 900 mL of LOF + 100 mL of water.

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Table 1. Completely Randomized Experimental Design

Treatment (% concentration)	Replications			
	U1	U2	U3	U4
P0 (0%)	P0.U1	P0.U2	P0.U3	P0.U4
P1 (10%)	P1.U1	P1.U2	P1.U3	P1.U4
P2 (30%)	P2.U1	P2.U2	P2.U3	P2.U4
P3 (50%)	P3.U1	P3.U2	P3.U3	P3.U4
P4 (70%)	P4.U1	P4.U2	P4.U3	P4.U4
P5 (90%)	P5.U1	P5.U2	P5.U3	P5.U4

Note: P0 = control; P = treatment; U = replication.

Population and Sample

The target population comprised rose plants (*Rosa hybrida L.*) with characteristics appropriate for the experimental requirements. The sample consisted of 24 rose stem cuttings, each 25 cm long, planted in 24 polybags. The samples were randomly assigned to six treatment levels, with four replications per treatment. Each experimental unit received moringa leaf LOF according to the predetermined concentration and application interval, after which vegetative growth was observed using the numbers of shoots and leaves as the response variables.

Time and Location of the Study

The study was conducted from March 30 to May 13, 2024, in the Biology Greenhouse at Universitas Pendidikan Mandalika (UNDIKMA). Growth was observed for 32 days.

Research Instruments and Procedures

The research instruments comprised all equipment and materials required for preparing the liquid organic fertilizer (LOF), producing rose stem cuttings, planting and watering the experimental units, conducting observations, and documenting each stage of the study. These instruments were selected to ensure that all experimental activities were carried out systematically, accurately, and consistently across the treatments and replications. The research procedures were implemented sequentially, beginning with LOF preparation and continuing through stem cutting, planting, treatment application, plant maintenance, observation, and documentation, as described in the following stages.

Preparation and Fermentation of Moringa Leaf LOF

1) Equipment and Materials Used to Prepare LOF

Table 2. Equipment Used for LOF Fermentation

No.	Equipment	Function
1.	Bucket	Used as the LOF fermentation container.
2.	Weighing scale	Used to weigh the materials required to prepare the LOF.
3.	Graduated cylinder	Used to measure the liquid ingredients required to prepare the LOF.
4.	Blender	Used to grind the moringa leaves.
5.	Stirring utensil	Used to stir the LOF during mixing.
6.	Knife/cutter	Used to slice the palm sugar.
7.	Gloves	Used to protect the hands during the fermentation process.
8.	Strainer/filter	Used to separate the fermented LOF liquid from the solid residue.
9.	Plastic bottle	Used to store the prepared LOF before application.
10.	Camera	Used to document the LOF fermentation process.

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Table 3. Materials Used for LOF Fermentation

No	Material	Function
1.	Moringa leaves, 3.7 kg	The primary raw material used to prepare the LOF.
2.	EM4, 370 mL	Serves as a microbial inoculant and accelerates the decomposition of organic matter into nutrients that can be readily absorbed by plants.
3.	Rice-washing water, 37.5 L	Used as the solvent medium to support and accelerate fermentation.
4.	Palm sugar, 2.5 kg	Serves as an energy source for microorganisms.

2) Steps for preparing and fermenting moringa leaf LOF

a) Prepare all equipment and materials required to produce the LOF.
b) Collect the moringa leaves, wash them thoroughly, and drain them before grinding.
c) Grind the moringa leaves using a blender.
d) Place 37.5 L of rice-washing water in the fermentation bucket.
e) Cut 2.5 kg of palm sugar into small pieces and dissolve it to obtain approximately 2.5 L of sugar solution.
f) Prepare 370 mL of EM4.
g) Combine all ingredients in the bucket containing the rice-washing water and stir until homogeneous.
h) Seal the bucket tightly and ferment the mixture for 14 days.
i) Observe changes in color and odor during fermentation.
j) Filter the fermented product before using it for watering.
k) Document each stage of LOF preparation.

Preparation of Rose Stem Cuttings

1) Equipment And Materials Used To Prepare Rose Stem Cuttings

Table 4. Equipment and Materials Used to Prepare Rose Stem Cuttings

No.	Equipment/Material	Function
1.	Knife/cutter	Used to cut the rose stems for propagation.
2.	Ruler	Used to measure the length of the stem cuttings.
3.	Camera	Used to document the activities.
4.	Twenty-four rose stem cuttings, each 25 cm long	Used as the primary planting material for the cutting and planting procedures.

2) Steps for Preparing the Cuttings

a. Prepare all equipment and materials required for the rose stem-cutting process, ensuring that the cutting tools are clean and ready for use.
b. Select mature, healthy rose stems that are free from visible pests, diseases, and physical damage.
c. Cut the selected stems into 24 uniform sections, each measuring approximately 25 cm in length.
d. Document each stage of the stem-cutting process through written notes and photographs for research records.

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Planting and Watering the Rose Cuttings

1) Equipment and materials used for planting and watering

Table 5. Equipment Used for Planting and Watering Rose Cuttings

No.	Equipment	Function
1.	Polybag	Used as a planting container in place of a pot.
2.	Weighing scale	Used to measure the mass of soil used in each polybag.
3.	Small hand shovel	Used to place soil into the polybags.
4.	Graduated cylinder	Used to measure the volume of each LOF concentration.
5.	Plastic bottle	Used as a container for each treatment solution during watering.
6.	Camera	Used to document the activities.

Table 6. Materials Used for Planting and Watering Rose Cuttings

No	Material	Function
1.	Moringa leaf LOF	Used as the fertilizer and treatment solution for watering the plants.
2.	Garden soil, 0.5 kg per polybag	Used as the growing medium.
3.	Rose stem cuttings, each 25 cm long	Used as the planting material.

Planting and Watering Procedures

a) Prepare all equipment and materials.
b) Fill each polybag with 0.5 kg of garden soil as the growing medium.
c) Plant one rose stem cutting in each polybag to obtain 24 experimental units.
d) Water the plants with moringa leaf LOF according to the assigned treatment concentration every three days for 30 days.
e) Document the planting, watering, and plant-growth processes.

Data Collection Techniques

Data were collected through experimental observation and documentation. Experimental observations were conducted to record the numbers of shoots and leaves at each moringa leaf LOF concentration. Documentation covered the LOF fermentation process, planting, watering, and the vegetative development of the rose cuttings under each treatment.

Data Analysis Techniques

The data on the numbers of shoots and leaves were analyzed using SPSS through the following procedures.

Normality Test

The Kolmogorov-Smirnov test was used to assess the data distribution. The data were considered to meet the normality criterion when the significance value was greater than 0.05.

Homogeneity-of-Variance Test

Levene's test was used to assess the equality of variances among treatment groups. The variances were considered homogeneous when the significance value was greater than 0.05.

One-Way ANOVA

One-way ANOVA was used to test differences in the mean numbers of shoots and leaves among the six moringa leaf LOF concentrations. The null hypothesis (H0) stated that

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there were no differences in the means among treatment groups, whereas the alternative hypothesis (H1) stated that at least one group mean differed. H0 was rejected when $p < 0.05$.

RESULTS AND DISCUSSION

The vegetative growth of the rose cuttings was observed for 32 days. The observed parameters were the numbers of shoots and leaves. Observations were conducted five times, on days 8, 14, 20, 26, and 32 after planting (DAP). All tables, figures, and statistical-analysis outputs are presented in full below.

Number of Shoots

Table 7. Summary of the Number of Shoots

Treatment (% concentration)	U1	U2	U3	U4	Total
P0 (0%)	1	4	1	1	7
P1 (10%)	1	4	3	2	10
P2 (30%)	2	1	2	2	7
P3 (50%)	1	2	1	2	6
P4 (70%)	2	1	1	1	5
P5 (90%)	1	1	1	1	4
Total	8	13	9	9	39

As shown in Table 7, the total numbers of shoots in P0, P1, P2, P3, P4, and P5 were 7, 10, 7, 6, 5, and 4, respectively. The highest number of shoots was recorded in P1 (10%), with 10 shoots, whereas the lowest was recorded in P5 (90%), with 4 shoots. P0 (0%) and P2 (30%) produced the same total number of shoots, namely 7.

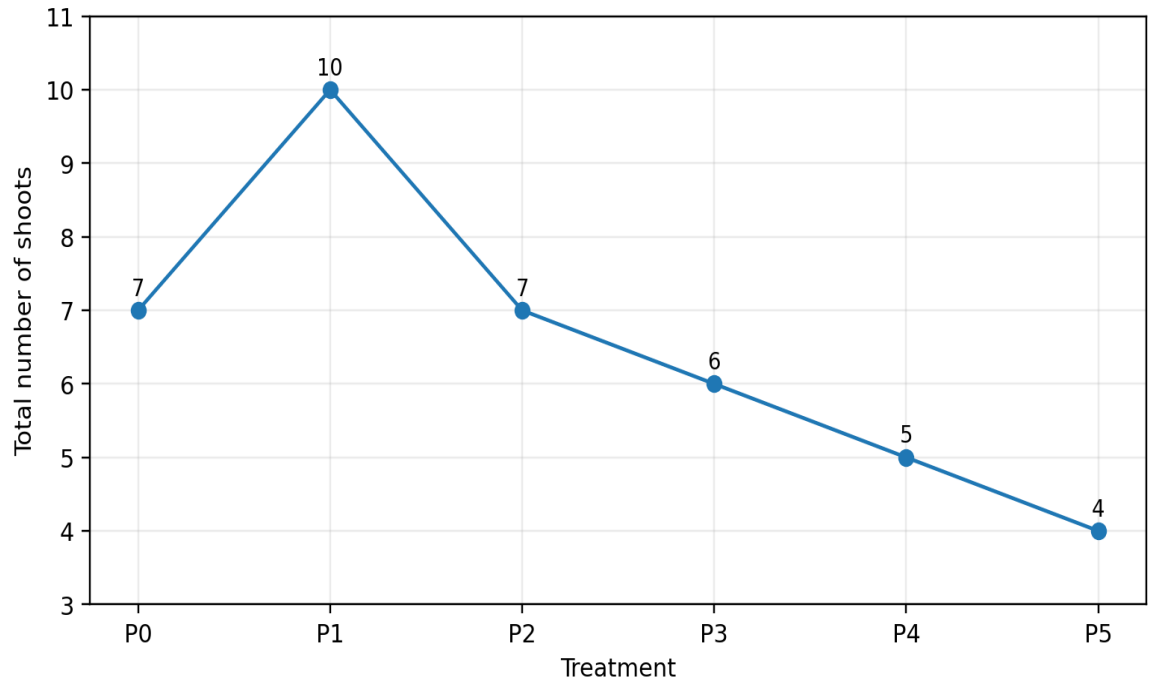

Figure 1. Total Number of Shoots by Treatment

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Figure 1 shows a declining trend in the number of shoots after treatment P1. P1 produced 10 shoots; P0 and P2 each produced 7 shoots; P3 produced 6 shoots; P4 produced 5 shoots; and P5 produced 4 shoots. These descriptive differences were subsequently tested statistically. The Kolmogorov-Smirnov normality test was conducted to assess the distribution of the shoot-number data. The complete output is presented in Table 8.

Table 8. Normality Test Results for the Number of Shoots

One-Sample Kolmogorov-Smirnov Test			Treatment
N			24
Normal Parametersa,b	Mean		3.5000
	Std. Deviation		1.74456
Most Extreme Differences	Absolute		0.138
	Positive		0.138
	Negative		-0.138
Test Statistic			0.138
Asymp. Sig. (2-tailed)c			0.200d
Monte Carlo Sig. (2-tailed)e	Sig.		0.271
	99% Confidence Interval	Lower Bound	0.259
		Upper Bound	0.282

Table 8 shows a Monte Carlo Sig. (two-tailed) value of 0.271 (> 0.05). Based on this value, the shoot-number data in the presented output met the normality criterion.

Levene's test was conducted to assess the equality of variances among treatment groups. The complete output is presented in Table 9.

Table 9. Homogeneity-of-Variance Test for the Number of Shoots

Variable	Basis of Calculation	Levene Statistic	df1	df2	Sig.
Number of shoots	Based on mean	4.224	5	18	0.010
Number of shoots	Based on median	1.054	5	18	0.417
Number of shoots	Based on median and with adjusted df	1.054	5	5.383	0.473
Number of shoots	Based on trimmed mean	3.505	5	18	0.022

Table 9 shows different significance values depending on the basis of calculation: 0.010 (based on the mean), 0.417 (based on the median), 0.473 (based on the median and with adjusted degrees of freedom), and 0.022 (based on the trimmed mean). The interpretation in this manuscript refers to the median-based value with adjusted degrees of freedom, which was 0.473 (> 0.05). The differences among these calculation approaches should be considered when interpreting the ANOVA results.

Table 10. One-Way ANOVA for the Number of Shoots

Source	Sum of Squares	df	Mean Square	F	Sig.
Between groups	5.375	5	1.075	1.358	0.286
Within groups	14.250	18	0.792		
Total	19.625	23			

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The one-way ANOVA results in Table 10 show F = 1.358 and p = 0.286 (> 0.05). Therefore, H0 was not rejected, indicating that the number of shoots did not differ significantly among the six moringa leaf LOF concentrations.

Number of Leaves

The observed numbers of leaves under the six treatment levels and four replications are presented in Table 11.

Table 11. Summary of the Number of Leaves

Treatment (% concentration)	U1	U2	U3	U4	Total
P0 (0%)	1	22	1	1	25
P1 (10%)	1	11	1	1	14
P2 (30%)	1	1	1	16	19
P3 (50%)	1	1	1	1	4
P4 (70%)	1	1	1	1	4
P5 (90%)	1	1	1	1	4
Total	6	38	6	21	70

As shown in Table 11, the total numbers of leaves in P0, P1, P2, P3, P4, and P5 were 25, 14, 19, 4, 4, and 4, respectively. The highest number of leaves was recorded in the control treatment, P0 (0%), with 25 leaves, followed by P2 (30%) with 19 leaves and P1 (10%) with 14 leaves. P3, P4, and P5 each produced 4 leaves.

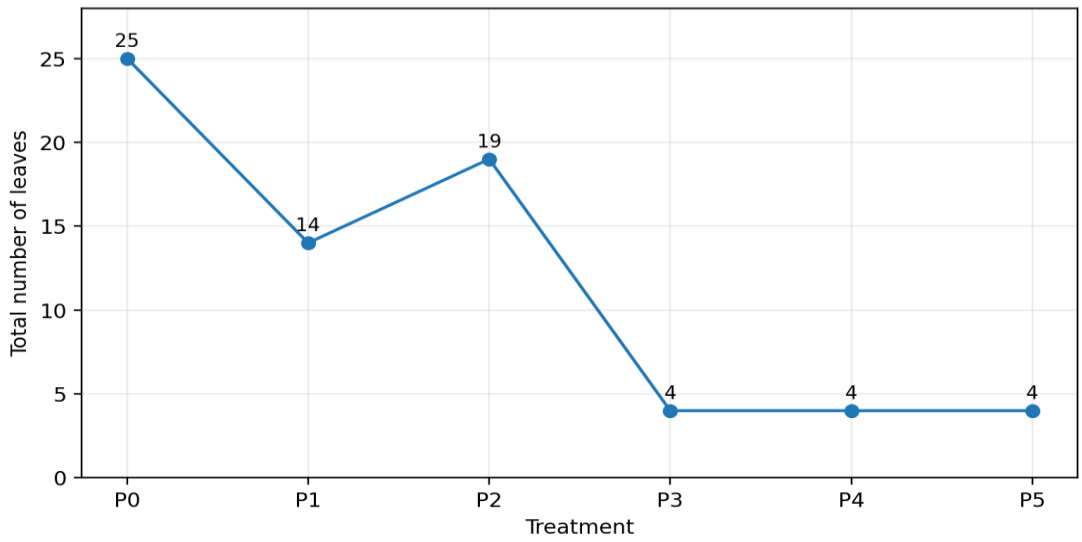

Figure 2. Total Number of Leaves by Treatment

Figure 2 shows that the highest number of leaves was recorded in P0, with 25 leaves, followed by P2 with 19 leaves and P1 with 14 leaves. P3, P4, and P5 had the same value, with 4 leaves each. The data were subsequently analyzed using normality, homogeneity-of-variance, and one-way ANOVA tests. The Kolmogorov-Smirnov normality test for the leaf-number data is presented in Table 12.

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Table 12. Normality Test Results for the Number of Leaves

One-Sample Kolmogorov-Smirnov Test			Treatment
N			24
Normal Parametersa,b	Mean		3.5000
	Std. Deviation		1.74456
Most Extreme Differences	Absolute		0.138
	Positive		0.138
	Negative		-0.138
Test Statistic			0.138
Asymp. Sig. (2-tailed)c			0.200d
Monte Carlo Sig. (2-tailed)e	Sig.		0.266
	99% Confidence Interval	Lower Bound	0.254
		Upper Bound	0.277

Table 12 shows a Monte Carlo Sig. (two-tailed) value of 0.266 (> 0.05). Based on this value, the leaf-number data in the presented output met the normality criterion. The homogeneity-of-variance test is presented in Table 13.

Table 13. Homogeneity-of-Variance Test for the Number of Leaves

Variable	Basis of Calculation	Levene Statistic	df1	df2	Sig.
Number of leaves	Based on mean	5.828	5	18	0.002
Number of leaves	Based on median	0.648	5	18	0.667
Number of leaves	Based on median and with adjusted df	0.648	5	6.900	0.673
Number of leaves	Based on trimmed mean	4.377	5	18	0.009

Table 13 shows significance values of 0.002 (based on the mean), 0.667 (based on the median), 0.673 (based on the median and with adjusted degrees of freedom), and 0.009 (based on the trimmed mean). The interpretation in this manuscript refers to the median-based value with adjusted degrees of freedom, which was 0.673 (> 0.05). The differences among these calculation approaches should be considered when interpreting the ANOVA results.

Table 14. One-Way ANOVA for the Number of Leaves

Source	Sum of Squares	df	Mean Square	F	Sig.
Between groups	103.333	5	20.667	0.648	0.667
Within groups	574.500	18	31.917		
Total	677.833	23			

The one-way ANOVA results in Table 14 show F = 0.648 and p = 0.667 (> 0.05). Therefore, H0 was not rejected, indicating that the number of leaves did not differ significantly among the six moringa leaf LOF concentrations.

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Discussion

Shoot Development in Rose Plants (*Rosa hybrida L.*)

Descriptively, P1 (10%) produced the highest number of shoots, with 10 shoots, whereas P5 (90%) produced the lowest number, with 4 shoots. P0 and P2 each produced 7 shoots, P3 produced 6 shoots, and P4 produced 5 shoots. Although the results tended to be better at lower concentrations than at higher concentrations, the one-way ANOVA result ($p = 0.286$) indicated that the differences were not significant. The pattern of a stronger response at a low concentration followed by a decline at higher concentrations is consistent with the concept of hormesis, whereby moringa leaf extract may stimulate growth at low doses but potentially inhibit growth at higher doses (Perveen et al., 2021).

The normality value for the number of shoots was 0.271, whereas the homogeneity value used in this manuscript was 0.473 based on the median with adjusted degrees of freedom. However, because the mean-based Levene significance value in Table 4.3 was 0.010, the assumption-test results differed according to the calculation method. Consequently, the ANOVA conclusion should be interpreted cautiously and in relation to the complete output presented. Biologically, the effectiveness of moringa leaf LOF is influenced by its phytohormone and mineral composition, extraction method, concentration, and application method (Mashamaite et al., 2022; Karthiga et al., 2022).

The results of this study differ from those of several studies reporting positive effects of moringa leaf extract on plant growth. Moringa leaf extract has been reported to improve early wheat growth (Yasmeen et al., 2013), support common-bean growth under saline conditions (Rady et al., 2013), and improve Welsh-onion growth at certain concentrations (Mare et al., 2023). These differences may be related to variations in plant species, the age of the planting material, extract formulation, application method, observation period, and environmental conditions.

In roses, vegetable-waste LOF has been reported to affect the time of shoot emergence (Mulyanti, 2018), whereas banana-peel LOF at certain dosages has been reported to affect the numbers of shoots and leaves (Butar-Butar, 2024). Different LOF raw materials have different nutrient and bioactive-compound profiles; therefore, their effects cannot be directly equated with those of moringa leaf LOF. In addition, a study on orchids showed that moringa leaf LOF combined with coconut water did not always significantly affect the time of shoot emergence or the number of shoots (Bandang et al., 2021).

Growing-medium conditions and moisture may also influence the success of stem cuttings. Research on roses has shown that growing-medium characteristics are associated with root formation and vegetative growth (Kim et al., 2018; Megawati & Tambing, 2021). Based on the observation records, the use of relatively small polybags and excessively wet growing-medium conditions was suspected of causing basal stem rot, which may have inhibited shoot formation. This possibility should be confirmed in future studies by measuring growing-medium moisture content, pH, electrical conductivity, and the nutrient content of the LOF.

Thus, the non-significant effect of moringa leaf LOF on the number of shoots does not necessarily indicate that moringa leaves have no potential as a biostimulant. Rather, the findings indicate that the concentrations, formulation, growing medium, and application techniques used in this study did not produce a consistent response in rose cuttings.

Leaf Development in Rose Plants (*Rosa hybrida L.*)

The highest number of leaves was recorded in the control treatment, P0 (25 leaves), followed by P2 (19 leaves), P1 (14 leaves), and P3, P4, and P5, each of which produced only 4 leaves. The one-way ANOVA yielded $p = 0.667$, indicating no significant differences

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among concentrations. The low leaf numbers in P3-P5 indicate that increasing the LOF concentration did not necessarily improve growth. A non-linear concentration response has also been reported for moringa leaf extract, particularly when high concentrations produce an inhibitory effect (Perveen et al., 2021).

These results differ from those of studies on vegetable-waste LOF in roses, which reported an effect on leaf number (Mulyanti, 2018), banana-peel LOF in roses (Butar-Butar, 2024), and moringa leaf extract in lettuce (Ainurvia et al., 2022). Differences in response may be caused by plant characteristics, LOF raw materials, nutrient and phytohormone contents, concentration, growing medium, and application technique. The literature indicates that the benefits of moringa leaf extract are strongly influenced by material composition and the appropriateness of the application dose (Yuniati et al., 2022; Mashamaite et al., 2022).

Based on field notes, the lower portions of the rose stems showed signs of decay, and several fully expanded leaves wilted. These conditions were suspected to be associated with an excessively wet growing medium, limited medium volume, and watering frequency. Growing-medium characteristics are important factors in the rooting and growth of rose cuttings (Kim et al., 2018; Megawati & Tambing, 2021). The findings are also consistent with Cahyono and Asngad (2016), who showed that fertilizer concentration and watering interval did not always significantly affect the number of leaves in young plants. Future studies should standardize cutting age, container size, growing-medium composition, and watering volume and should analyze the LOF composition before application.

CONCLUSION

Based on the results of the study, the following conclusions were drawn:

1) Variation in moringa leaf LOF concentration did not significantly affect the number of shoots ($p = 0.286$) or the number of leaves ($p = 0.667$) produced by rose cuttings.
2) Descriptively, the highest number of shoots was recorded in P1 (10%), with 10 shoots, whereas the highest number of leaves was recorded in the control treatment, P0 (0%), with 25 leaves. Because the ANOVA results were not significant, the most effective moringa leaf LOF concentration could not be established from this study.

RECOMMENDATIONS

Future studies should use rose cuttings that are uniform, healthy, and sufficiently mature; larger polybags and a more porous growing medium, such as a mixture of soil, compost, and carbonized rice husk; controlled watering volumes and intervals to prevent the growing medium from becoming excessively wet; pretreatment of the cuttings when necessary; and analyses of the pH, electrical conductivity, and nutrient content of the moringa leaf LOF before application.

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