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UTILIZATION OF *Moringa oleifera* L. EXTRACT ON THE GROWTH OF *Allium cepa* L. SHOOTS AS A BIOLOGICAL LEARNING RESOURCE

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ABSTRACT: The utilization of *Moringa oleifera* L., leaf extract as a natural plant biostimulant has attracted considerable attention; however, its effect on the early growth of *Allium cepa* L., sprouts remains unclear. This study was conducted to assess the effect of *Moringa oleifera* L., leaf extract on plant growth of *Allium cepa* L., sprouts and to explore its potential as a local-potential-based biology learning resource. This research applied an experimental approach using a completely randomized design with four different concentrations of moringa leaf extract (25%, 50%, 75%, and 100%) with six replications. The observed parameters were leaf number and plant height at 5, 8, 11, and 14 Days After Planting (DAP). Data were analyzed using one-way Analysis of Variance (ANOVA) at a 5% significance level. The results indicated that different concentrations of moringa leaf extract had no significant effect on the number of leaves (F = 0,080; p = 0,970) or plant height (F = 1,114; p = 0,367) of *Allium cepa* L., during the 14-day observation period. Nevertheless, the experimental procedure provides a practical and locally relevant learning resource for teaching plant growth and development concepts as well as scientific inquiry skills in biology education.

Keywords: *Allium cepa* L., Biology Learning Resources, *Moringa oleifera* L.

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INTRODUCTION

Indonesia is one of the world's megabiodiversity countries, possessing a rich diversity of plant species with ecological, nutritional, and educational value (Setiawan, 2022). One such species is *Moringa oleifera* L., a widely distributed tropical plant that grows well in Indonesia and has considerable potential for agricultural, nutritional, and educational applications (Novita et al., 2023; Riastiwi et al., 2018; Saputra et al., 2020). The species falls under to the Moringaceae family and is native to the foothills of the Himalayas in India, Pakistan, Bangladesh, and Afghanistan (Susanti & Nurman, 2022). *Moringa oleifera* L. is commonly acknowledged for its nutritional, medicinal, and agricultural benefits, which have earned it the designation of the "miracle tree" in many regions (Baldisserotto et al., 2018; Britany & Sumarni, 2020; Isnan & Nurhaedah, 2017; Rivai, 2020; Sulasmi et al., 2023).

Moringa plants are widely found in almost all regions of Indonesia. Moringa plants in Indonesia are spread throughout the country, from Aceh to Merauke. However, moringa plants are underutilized. Generally, Indonesians only use

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moringa plants for food, medicine, cosmetics, and traditional cultural rituals (Loaloka et al., 2022; Raslina et al., 2016; Ula et al., 2020). However, if utilized properly, moringa plants can also increase knowledge. One innovation in the employment of moringa as a source of of biological learning for practical activities is the employment of moringa extract to study the growth of *Allium cepa* L., sprouts. Biology learning often fails to optimize the potential of the abundant local plants around us. These plants are often left untouched, even though they offer many benefits that can be utilized in learning, especially moringa (*Moringa Oleifera* L.).

Biology learning resources are anything that comes from nature and the students' local environment that can facilitate the learning process (Alimah, 2019; Falah & Isnawati, 2019). Suryaningsih (2018) and Angio (2020) state that biology learning resources are anything, whether objects or phenomena, which can provide experience in solving several biology problems. Using nature as a source of biological learning can enhance students' knowledge and understanding of the natural phenomena around them (Nurmalasari et al., 2020). In addition, making use of the natural environment as a learning source provides direct experience, increases student engagement, and makes biology lessons more meaningful and interesting because students learn from real phenomena around them (Paggeso, 2018).

Moringa plants can serve as a learning resource for practical activities on hormones. The hormones contained in moringa plants are cytokinin and zeatin, which contribute to growth (Ainurvia et al., 2022; Amriyanti & Ajiningrum, 2019; Hartatie & Safira, 2022; Rahman et al., 2017). Furthermore, moringa leaves have been reported to contain high concentrations of nutrients, including nitrogen, phosphorus, and potassium, which are important for plant growth (Rode et al., 2022; Santoso, 2025; Setiawan et al., 2022). Moringa leaf extract acts as a natural biostimulant, stimulating plant growth, production, and quality (Mantja et al., 2023; Suwirmen et al., 2021). Potassium is very significant for supporting plant growth and development, especially in *Allium cepa* L (Aryati & Nirwanto, 2020; R. Sari et al., 2022). *Allium cepa* L., is a bulbous plant that is highly responsive to fertilization, especially potassium fertilizers (Jamaludin et al., 2021). Potassium in red onion plants extends shelf life by increasing bulb content (Aryati & Nirwanto, 2020; Putri et al., 2022; Sukmasari et al., 2020).

Several earlier studies that have utilized moringa leaves (Ainurvia et al., 2022; Harahap et al., 2022; Tomia & Pelia, 2021) report that applying liquid organic moringa leaf fertilizer at concentrations of 35 ml, 150 ml, and 400 ml affects plant height and age. The application of 5% moringa leaf POC, liquid organic moringa leaf fertilizer, and 4% moringa extract can increase onion growth (Ihsan et al., 2021; Mare et al., 2023; Putri et al., 2022; Putri & Usmadi, 2024; Rajiman, 2019). Mantja et al. (2023) stated that increasing the concentration of moringa leaf extract, the more pronounced its effect on onion growth. Therefore, to optimize the utilization of local resources, This study focuses on the effect of *Moringa oleifera* L. leaf extract on the growth of *Allium cepa* L., sprouts and explores its use as a biology learning resources that incorporate local potential. A novel aspect of this study is integrating the experimental application of *Moringa oleifera* L. leaf extract on *Allium cepa* L., sprout growth with the development of biology learning resources according to local potential. Additionally, the study evaluates a broader range of

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extract concentrations (25%, 50%, 75%, and 100%) to identify the most effective concentration for promoting the growth of *Allium cepa* L., sprouts.

Based on previous research on the utilization of *Moringa oleifera* L. and the need for biology learning resources, the research questions of this study are: 1) what is the effect of different concentrations of *Moringa oleifera* L. leaf extract on the growth of *Allium cepa* L., sprouts?; 2) which concentration of *Moringa oleifera* L., leaf extract produces the optimal growth response of *Allium cepa* L., sprouts?; and 3) how can the findings of this study be utilized as a local-potential-based biology learning resource?. The objectives of this study are: 1) to assess how different concentrations of moringa leaf extract affect the growth of *Allium cepa* L., sprouts; 2) to identify the optimal concentration of *Moringa oleifera* L., leaf extract for promoting the growth of *Allium cepa* L., sprouts; and 3) to explore the use of the research findings as a local-potential-based biology learning resource.

METHODS

This study was carried out using a completely randomized design, consisting of four treatments with six replications. The treatments included of *Moringa oleifera* L., leaf extract concentrations of 25%, 50%, 75%, and 100%. The 100% treatment consisted of pure moringa leaf extract, while the lower different concentrations were prepared through dilution of the extract with distilled water. The treatment compositions were as follows: 1) 25% = 25 mL extract + 75 mL distilled water; 2) 50% = 50 mL extract + 50 mL distilled water; 3) 75% = 75 mL extract + 25 mL distilled water; and 4) 100% = 100 mL pure extract. The number of replicates was determined using Federer's formula (Al Barru et al., 2022) as follows:

$$(t-1)\,(n-1) \geq 15$$

Description:
n = Number of repetitions; and
t = Number of treatments.

$$(t-1)\,(n-1) \geq 15$$
$$(4-1)\,(n-1) \geq 15$$
$$(3)\,(n-1) \geq 15$$
$$3n - 3 \geq 15$$
$$3n \geq 15 + 3$$
$$3n \geq 18$$
$$n \geq 18/3$$
$$n \geq 6$$

According to the calculation above, six replications were used for each treatment. Thus, a total of 24 experimental units were established, with each experimental unit consisting of two *Allium cepa* L., bulbs. Therefore, a total of 48 *Allium cepa* L., bulbs were employed in this study. All experimental units were assigned randomly to ensure unbiased treatment allocation. The study design and arrangement of experimental units in the Completely Randomized Design (CRD) are presented in Figure 1.

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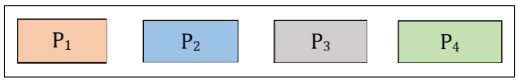
1. P_4t_1	2. P_1t_2	3. P_3t_2	4. P_2t_4
5. P_3t_4	6. P_4t_6	7. P_2t_1	8. P_1t_5
9. P_1t_1	10. P_3t_5	11. P_2t_4	12. P_4t_3
13. P_2t_2	14. P_1t_3	15. P_4t_5	16. P_3t_6
17. P_4t_2	18. P_3t_1	19. P_1t_6	20. P_2t_5
21. P_2t_3	22. P_4t_4	23. P_3t_3	24. P_2t_6

Figure 1. Research Design.

Description:
P_{1-4} = Treatment;
t_{1-6} = Repetition; and
1-24 = Experiment number.



Forty-eight onion bulbs (*Allium cepa* L.) of relatively uniform size and developmental stage were selected as experimental materials to minimize variation among treatments. In this study, the tools and materials used are presented in Table 1 and Table 2.

Table 1. Research Tools.

No.	Toll Name	Amount	Specification
1	Polybag	24	Size 15 x 15 cm
2	Measuring Cup	1	Size 500 ml
3	Ruler	1	30 cm
4	Blender	1	-
5	Sieve	1	-
6	Cell Phone Camera	1	-
7	Writing Instruments	1	-

Table 2. Research Materials.

No.	Tool Name	Amount	Specification
1	*Allium cepa* L.	48 pieces	The size is the same
2	Moringa Leaves	3.5 kg	-
3	Clean Water	3.5 liter	-
4	Soil	14 kg	-
5	Manure	10 kg	-
6	Label	24 pieces	Size 5 x 10 cm

Procedure

Moringa Leaf Extraction

The prepared moringa leaves are washed with clean water. The leaves are then extracted by blending them with clean water in a 1:1 ratio (1 kg of moringa leaves added to 1 liter of clean water), then the mixture is pressed and filtered. The filtered moringa leaf extract is used as a 100% solution (Abdullah *et al.*, 2019).

Preparation of Planting Media and Planting

The planting media used is soil mixed with manure at a ratio of 14 kg of soil to 10 kg of manure, then placed in polybags with a soil capacity of 1 kg. Two *Allium cepa* L., seedlings are planted 10 cm apart.

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Moringa Extract Application

Moringa extract was applied daily for 14 days by spraying the extract solution at the predetermined concentration for each treatment. Plant growth observations were conducted periodically on the 5th, 8th, 11th, and 14th Days After Planting (DAP). The measured parameters included plant height and leaf number and visual documentation of *Allium cepa* L., growth throughout the study. The height of the data on plants were collected from the soil surface to the end of the longest leaf length was measured using a ruler. and recorded in centimeters (cm). Leaf count was obtained by counting the total number of fully emerged leaves on each plant. Visual documentation was conducted periodically to record the growth and morphological changes of *Allium cepa* L., during the experimental period. The observation period was limited to 14 days because this study was designed to develop practical activities for high school students. This duration was considered sufficient to demonstrate the initial growth response of *Allium cepa* L., to moringa extract treatment while ensuring that the practical activities remained efficient and compatible with the allocated classroom learning time.

The data were tested for normality and homogeneity prior to statistical analysis to ensure that the assumptions of ANOVA were met. Data that satisfied these assumptions were tested using one-way ANOVA was performed to analyze the effect of different concentration levels of *Moringa oleifera* L. leaf extract on the growth parameters of *Allium cepa* L. If significant differences were detected, DNMRT at a 5% significance level was performed to determine differences among treatments. Statistical analyses were carried out with SPSS version 27.

RESULTS AND DISCUSSION

The research data are presented in Tables 3 and 4, which show the average number of leaves and average height of *Allium cepa* L., plants as a result of using moringa leaf extract (*Moringa Oleifera* L.). These data provide an overview of the effect of different concentrations of moringa leaf extract on the vegetative growth of *Allium cepa* L. plants.

Table 3. Average Number of Leaves of *Allium cepa* L. After Application of Moringa Leaf Extract (Mean ± SD).

Concentration of Moringa Extract (%)	Day After Planting (DAP)			
	5	8	11	14
25%	9.2 ± 1.16	14.6 ± 0.69	18.4 ± 2.03	23.2 ± 2.12
50%	10.83 ± 1.88	16 ± 1.12	18.2 ± 0.83	22.8 ± 1.91
75%	11.2 ± 1.19	15.6 ± 2.48	17.8 ± 2.90	21.4 ± 3.27
100%	11.66 ± 2.18	15.33 ± 2.60	17.5 ± 2.43	31.25 ± 4.37

Table 4. Average Plant Height of *Allium cepa* L. After Application of Moringa Leaf Extract (Mean ± SD).

Concentration of Moringa Extract (%)	Day After Planting (DAP)			
	5	8	11	14
25%	4.20 ± 1.08	9.33 ± 1.66	15.41 ± 1.32	21.75 ± 1.32
50%	5.08 ± 0.94	12.03 ± 1.02	16.73 ± 1.59	22.61 ± 0.96
75%	5 ± 0.47	11.08 ± 0.49	16.1 ± 0.74	20.66 ± 1.35
100%	5.7 ± 0.93	11.03 ± 0.79	14.6 ± 2.19	20.58 ± 1.54

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The findings of the data analysis on the impact of moringa leaf extract (*Moringa oleifera* L.) on plant growth, using the observation parameters leaf number and plant height, are presented in the following table.

Table 5. Results of ANOVA Analysis of *Allium cepa* L. Leaf Count.

Number of Leaves	Sum of Squares	df	Mean Square	F	Sig
Between Groups	.948	3	.316	.80	.970
Within Groups	79.094	20	3.955		
Total	80.42	23			

The ANOVA results indicated that the significance value for the number of *Allium cepa* L., leaves was 0.970, which exceeded the significance level of 0.05. This result suggests that the application of different concentrations of *Moringa oleifera* leaf extract did not significantly influence the number of *Allium cepa* L., leaves. Therefore, no statistically significant differences were found among the treatments after analysis treatments in terms of leaf number.

Table 6. Results of ANOVA Analysis of *Allium cepa* L. Plant Height.

Tall *Allium cepa* L.	Sum of Squares	df	Mean Square	F	Sig
Between Groups	4.501	3	1.500	1.114	.367
Within Groups	26.940	20	1.347		
Total	31.441	23			

The ANOVA results indicated that the significance value for the height of *Allium cepa* L., plants was 0.367, which exceeded the significance level of 0.05. This result suggests that the application of different concentrations of *Moringa oleifera*/Leaf extract showed no significant effect on the height of *Allium cepa* L., plants. Therefore, Statistical analysis revealed no significant differences among the treatments with regard to of plant height.

Effect of Moringa Leaf Extract on Leaf Number

According to Table 3 and the outcomes of the ANOVA analysis in Table 5, the application of *Moringa oleifera* L. leaf extract at various concentrations did not significantly affect the number of *Allium cepa* L., leaves. The significance value obtained was 0.970 ($p > 0.05$), which indicates that the treatments did not differ significantly from each other. The average values, presented as average ± Standard Deviation (SD), indicate the degree of variation in the data across replicates for each treatment. In general, the SD values in this study were classified as low to moderate, indicating that the growth response of *Allium cepa* L., between replicates was relatively consistent. Standard deviation serves to measure the dispersion of data relative to the average, where a smaller SD value indicates a lower level of data variability and better data homogeneity (Andrade, 2020).

The insignificant ffect of moringa leaf extract on leaf number is believed to be related to the relatively short observation period and the fact that the plants were still in the early vegetative growth stage. At this stage, the root system of *Allium cepa* L., had not yet developed optimally. Hence, the plants' capability of absorbing nutrients and bioactive compounds from the moringa leaf extract was still limited. Mashamaite et al. (2022) state that natural biostimulants generally produce more pronounced effects when applied over a longer period of time because their active

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compounds work gradually through plant metabolic processes. Therefore, extending the duration of the experiment may allow the biostimulant effects of moringa leaf extract to become more evident in terms of leaf production.

Moringa leaf extract has been reported to contain cytokinins., particularly zeatin, which contribute to stimulating cell division, shoot formation, and leaf development (Maishanu et al., 2017). The importance of cytokinins in supporting vegetative growth is further explained by Sadak et al. (2024), who state that these hormones contribute to the formation of vegetative organs by increasing cell division activity. In addition, moringa leaf extract also contains macronutrients, such as Nitrogen (N), Phosphorus (P), and Potassium (K), as well as various other bioactive compounds that function as natural biostimulants (Mantja et al., 2023). The present results match those reported by Yuniati et al. (2022), reported that the efficacy of moringa leaf extract as a natural growth promoter is affected due to several factors, such as concentration, application method, and environmental conditions, and therefore does not always result in a marked increase in vegetative growth parameters.

Effect of Moringa Leaf Extract on Plant Height

According to Table 4 and the findings of the ANOVA analysis in Table 6, the application of moringa leaf extract at various concentrations showed no statistically significant effect on the plant height of *Allium cepa* L. The significance value obtained was 0.367 ($p > 0,05$), indicating that statistical analysis showed no significant differences among the treatments. The mean ± Standard Deviation (SD) values indicate that the within-replication variability of plant growth for each treatment was low to moderate. This suggests that the growth response of *Allium cepa* L., was relatively uniform across replications and that the observational data exhibited a good degree of homogeneity (Ciarleglio, 2021).

The insignificant effect of moringa leaf extract on plant height is believed to be associated with the plant's suboptimal capacity to absorb active compounds during the early growth phase. At this stage, the root system of *Allium cepa* L., is still developing, so the absorption of water, nutrients, and growth regulators from the moringa leaf extract has not yet reached its maximum potential. Incomplete root development may limit the plant's ability to utilize the administered compounds, resulting in a growth response that is not yet clearly evident. This result is in line with the findings of Jia et al. (2022), who noted that root system development supporting nutrient uptake and regulating plant growth responses to various environmental factors.

The growth in plant height is influenced by the activity of auxin and gibberellin hormones, which play a role in cell division, elongation, and enlargement (Sosnowski & Truba, 2023). State that auxin increases cell wall plasticity, thereby enabling cell elongation, whereas gibberellin is involved in promoting cell division and elongation. In addition to hormonal factors, environmental stress can also affect plant growth responses. Sansan et al. (2025) reported that stress conditions can reduce photosynthetic activity and increase the formation of reactive oxygen species that inhibit plant tissue growth. Sivasamy et al. (2022) also stated that high salinity and nutrient imbalances can disrupt metabolism and the activity of protective enzymes, resulting in suboptimal

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vegetative growth of plants. Therefore, optimal plant height is determined by the interaction between endogenous hormonal regulation and favorable environmental conditions that support normal physiological processes.

The outcomes of this present study is consistent with those of Sustr et al. (2019), who stated that the effectiveness of moringa leaf extract in promoting plant growth is influenced by dosage, application method, and growing conditions, so that plant responses to the treatment may vary. Variations in these factors are believed to be the reason why the effect of moringa leaf extract on the plant height of *Allium cepa* L., was not significant in this study.

Potential of the Research as a Biology Learning Resource

The findings of this study may provide beneficial implications, particularly in biology education as a learning resource for topics related to plant growth and development. Although statistically, the administration of moringa leaf extract has not shown a statistically significant effect on onion growth, this research process remains educational because it allows students to directly observe plant responses to different treatments, analyze growth data, and draw conclusions based on their observations. The use of research results as a learning resource is consistent with the view of Andarias et al. (2022), who reported that the environment and local potential can serve as a source of biological learning to help students contextually understand concepts.

On the other hand, practical activities using moringa leaf extract and *Allium cepa* L., also provide students with opportunities to understand the concepts of plant hormones, the roles of nutrients, and the environmental factors that affect plant growth. The study provides potential material for developing biology learning resources. In addition, using moringa leaf extract as a biology learning resource the utilization of local potential can enhance students' science process skills, such as observing, measuring, classifying, and interpreting experimental data. Simarmata et al. (2022) emphasize that using local potential-based learning resources can increase student engagement and science process skills in biology learning.

The findings of the present study also show that although the administration of moringa leaf extract has not had a statistically significant effect, the variation in growth responses observed still reflects biological dynamics that can be used as a source of meaningful biological learning. This variation provides opportunities for students to study the interactions between internal plant factors (such as plant hormones) and external factors (including nutrient availability and environmental conditions), and how these factors affect *Allium cepa* L., sprout growth. In experiment-based learning activities, students can directly observe, analyze, and draw conclusions from the data obtained, thereby understanding biological concepts not only theoretically but also through valid scientific empirical experience (Sari et al., 2019).

One constraint of this study is the relatively short observation period 14 days which was set to align with the time typically allocated for biology lab activities in high schools. Consequently, this study focused only on the initial growth response of *Allium cepa* L., to the administration of moringa leaf extract and does not fully describe The long-term impact of this treatment on plant growth and development. Although the results of this study have not yet shown a statistically significant

effect, this laboratory activity still has the potential to be applied in biology education. Through this activity, students can understand the concepts of plant growth and development more concretely while developing scientific process skills through hands-on learning experiences, such as observing, measuring, recording data, and drawing conclusions based on experimental results.

CONCLUSION

The outcomes of this study showed that the application of *Moringa oleifera* L., leaf extract at concentrations of 25%, 50%, 75%, and 100% did not significantly affect the growth of *Allium cepa* L., as indicated by leaf number and plant height observations over 14 days. Despite the absence of statistically significant differences detected among treatments, the 50% concentration tended to produce higher average values for both growth parameters than the other concentrations. These findings suggest that moringa leaf extract may have growth-promoting potential, although its effects were not sufficiently strong to produce significant differences under the conditions of this study.

From an educational perspective, this study provides potential material for developing contextual biology learning resources based on local potential. Practical activities involving moringa leaf extract and *Allium cepa* L., can help students understand plant growth and development concepts while enhancing science process skills such as observation, measurement, data recording, and data interpretation. Future studies should include a control treatment, longer observation periods, and additional growth parameters to further assessthe effectiveness of moringa leaf extract and strengthen its application in biology learning.

RECOMMENDATION

Recommendations for future research include conducting further studies using different concentrations of *Moringa oleifera* leaf extract and varying treatment durations to obtain more comprehensive results regarding shallot growth. Additionally, future research could also involve different plant species or environmental conditions to expand the use of moringa leaf extract in plants growth studies. Furthermore, the educational resources developed from this study could be designed to be more interactive and innovative to enhance students' interest and understanding in biology learning.

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