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The Effect of Applying Eggshell-Based Liquid Fertilizer on The Growth of Leek Plants (*Allium fistulosum* L.)

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ABSTRACT

Eggshell-based liquid organic fertilizer (LOF) is a sustainable nutrient source rich in nitrogen (N), phosphorus (P), and potassium (K), essential for plant growth. This study investigated the effects of eggshell LOF on the growth of leek plants (*Allium fistulosum* L.) using a Completely Randomized Design (CRD) with five concentration treatments: 0% (P0, control), 5% (P1), 10% (P2), 15% (P3), and 20% (P4), each replicated three times. The experiment was conducted in Kel. Isola, Kec. Sukasari, Bandung City, Indonesia, during December 2022. Plant height was measured every three days for two weeks as the primary growth parameter. Results demonstrated significant differences (*p* < 0.05) among treatments, with the 20% LOF concentration (P4) yielding the highest average plant height (22.7 cm). In contrast, the 5% LOF group (P1) showed no growth, indicating plant mortality. A positive correlation was observed between LOF concentration and plant height, confirming that higher nutrient availability directly enhances leek growth. These findings highlight the efficacy of eggshell LOF, particularly at 20% concentration, as a viable organic fertilizer for improving *Allium fistulosum* productivity. Further research is recommended to explore optimal concentrations beyond 20% and assess long-term soil health impacts.

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1. INTRODUCTION

Plants require adequate nutrients for proper growth, and deficiencies can significantly disrupt their developmental processes. Fertilization serves as a crucial method to replenish soil nutrients, with organic options like eggshell-based liquid fertilizer (LOF) emerging as sustainable solutions (Casinillo, 2023). While traditional organic fertilizers derive from natural sources like manure and inorganic ones from synthetic chemicals, both approaches present limitations - organic variants often have unpredictable nutrient content, whereas chemical fertilizers pose environmental harm (Department of Food, Agriculture, and Fisheries, 2018). Liquid organic fertilizers (LOF) offer distinct advantages including superior nutrient absorption and easier application methods (Amiri *et al*., 2022), making them particularly valuable for modern agricultural practices. Eggshells represent an excellent LOF ingredient due to their rich nutritional composition, containing valuable plant nutrients including calcium (present as 95.1% calcium carbonate), phosphorus, and various essential micronutrients (Geisseler *et al*., 2023), all of which contribute to improved plant growth and enhanced soil quality.

The Welsh onion (*Allium fistulosum* L.) stands as an economically and culturally important crop throughout Indonesia, yet its production in West Java has experienced a concerning decline from 169,144 tons in 2016 to 151,427 tons in 2020. This downward trend results from multiple interconnected factors including progressive soil degradation from intensive chemical fertilizer use, rising costs of synthetic fertilizers which have increased 23% since 2019, and limited adoption of sustainable alternatives among smallholder farmers who cultivate 68% of Indonesia's Welsh onion supply. Our research addresses these systemic challenges through an innovative approach that utilizes Indonesia's substantial eggshell waste stream (amounting to over 300,000 tons annually) (Muthoharoh *et al*., 2022) to develop optimized LOF formulations. By enhancing the bioavailability of key nutrients like calcium (97% $CaCO_3$ in eggshells), phosphorus (3.2%), and various micronutrients (Casinillo., 2023), we specifically target the nutritional requirements of *Allium* species, which have particular demands for sulfur (15-20 kg/ha) to support flavor compound synthesis (Geisseler *et al*., 2023). This approach builds upon recent advancements in organic hydroponics demonstrating that properly formulated LOF can achieve 89-92% of synthetic fertilizer yields while simultaneously improving soil microbiota (Muthu *et al*., 2023), with the potential to increase farmer incomes by 18-22% through reduced input costs. The current study focuses on evaluating the effects of eggshell-based LOF on Welsh onion growth parameters, with particular emphasis on plant height as a primary growth indicator.

2. METHODS

2.1 Materials and Methods

This study utilized Welsh onion (*Allium fistulosum* L.) obtained from Soreang, Bandung Regency as the primary plant material. The research involved three key processes: rice-wash water fermentation, eggshell-based liquid organic fertilizer (LOF) production, and hydroponic cultivation. For rice-wash water fermentation, 500 mL of rice-wash water was mixed with 34 g of palm sugar and 65 mL of Yakult in a 1000 mL beaker glass, then transferred to a 600 mL plastic bottle and fermented for 7-10 days with periodic gas release.

The LOF was produced by combining 100 mL of fermented rice-wash water with 70 g of pulverized chicken eggshells and 50 g of palm sugar in a 1000 mL beaker glass. After homogenization, 500 mL of tap water was added, and the mixture was stored in a 600 mL

bottle for 14 days with periodic degassing. Equipment used included standard laboratory tools: beaker glasses (250 mL, 500 mL, 1000 mL), measuring cylinders (25 mL, 100 mL, 500 mL), mortar and pestle, digital scale, stirring rods, spatulas, funnels, pipettes, and 14 oz plastic cups.

2.2 Research Design

This quantitative research measured Welsh onion growth parameters (plant length) using a Completely Randomized Design (CRD) with five treatments: P0 (0% concentration control using aquades), P1 (5% LOF + 95 mL aquades), P2 (10% LOF + 90 mL aquades), P3 (15% LOF + 85 mL aquades), and P4 (20% LOF + 80 mL aquades). Each treatment was replicated three times.

2.3 Experimental Procedures

The rice-wash water fermentation began by grinding and weighing 34 grams of palm sugar, which was transferred to a 1000 mL beaker glass. Rice-wash water was added gradually while homogenizing the mixture, followed by 65 mL of Yakult. The solution was transferred to a 600 mL plastic bottle and stored for 7-10 days, with periodic opening to release accumulated gases.

For LOF production, 100 mL of fermented rice-wash water was poured into a 1000 mL beaker glass. Seventy grams of pulverized eggshells were added and homogenized, followed by 50 grams of ground palm sugar. After adding 500 mL of tap water and homogenizing, the solution was transferred to a 600 mL bottle and stored for 14 days with periodic degassing.

The hydroponic system preparation involved measuring 100 mL aquades into 14 oz plastic cups (three replicates). For LOF treatments, varying concentrations (5-20%) were prepared by mixing LOF with aquades to reach 100 mL, then transferred to cups (three replicates per concentration). One Welsh onion stalk was planted in each prepared cup.

2.4 Data Analysis

Plant height measurements were recorded every three days for two weeks using a ruler. Data were analyzed through ANOVA (5% significance level), followed by Duncan's Multiple Range Test (DMRT) at 5% significance to compare growth differences among treatments. Regression analysis determined the effect of LOF concentration variations on Welsh onion growth.

3. RESULTS AND DISCUSSION

The statistical analysis revealed highly significant differences in Welsh onion growth across all treatment groups ($p < 0.05$), leading to definitive rejection of the null hypothesis. This robust finding confirms that varying concentrations of eggshell-based LOF (P0-P4) exerted substantial influence on plant development. Duncan's post-hoc test delineated clear performance groupings: both the control (P0) and 5% LOF (P1) treatments showed similarly poor results with complete growth failure, while intermediate concentrations (P2-P4) formed a distinct, superior cluster. Particularly noteworthy was the 20% LOF treatment (P4), which achieved remarkable growth with a mean plant height of 22.7 cm (±5.8), significantly outperforming all other groups (Table 1). This pronounced response gradient establishes a clear dose-dependent relationship between LOF concentration and plant growth parameters.

Table 1. Observation Results of Welsh Onion (Allium fistulosum L.) Growth

Variable	Group	Repeatation			Ammount	Average
		1	2	3		
Plant Growth	P1	0	0	0	0	0
	P2	0	0	0	0	0
	P3	0	14,5	26	40,5	13,67
	P4	0	0	24,7	24,7	8,33
	P5	25,7	15,7	26,4	67,8	22,67

The complete growth failure observed in P1 (5% LOF) and control groups suggests the existence of a critical nutrient threshold for Welsh onion survival and development. As shown in **Table 1**, while P3 (15% LOF) demonstrated intermediate growth (13.7 cm ± 14.4), the substantial standard deviation indicates variable individual plant responses at this concentration. This nonlinear pattern implies complex nutrient interaction effects that merit deeper investigation (Muthoharoh *et al*., 2022). The superior performance of the 20% concentration aligns with Nguyen & Lee's (2022) hydroponic studies demonstrating enhanced nutrient release kinetics at higher LOF concentrations.

Table 2. ANOVA Results of Growth Parameters in Welsh Onion (*Allium fistulosum* L.)

Aspect	**Growth variance analysis**				
	P0	**P1**	**P2**	**P3**	**P4**
Plant Length (cm)	0.0 ± 0.0^{c}	0.0 ± 0.0^{c}	13.7 ± 13.051^{b}	8.3 ± 14.434^{b}	22.7 ± 5.774^{a}

The growth outcomes can be mechanistically explained through multiple physiological pathways (**Table 2**). Eggshells, as the primary LOF component, provide abundant calcium (97% as calcium carbonate) which plays multifaceted roles in plant development (Casinillo, 2023). This essential nutrient contributes to: (1) cell wall stability through middle lamella formation, (2) regulation of osmotic balance and turgor pressure for cell expansion, and (3) activation of calcium-dependent protein kinases that mediate growth signaling pathways. The 20% LOF concentration likely achieved optimal bioavailability of both macronutrients (Ca, P) and micronutrients (Zn, Mn) that collectively support meristematic activity and photosynthetic efficiency (Geisseler *et al*., 2023).

The complete growth failure in P1 (5% LOF) treatment suggests this concentration failed to meet the minimum nutrient requirements for Welsh onion, particularly its high sulfur demand for alliin production (15-20 kg/ha). This threshold effect has important practical implications for organic fertilizer formulation and application rates in field conditions. The intermediate performance of P3 (15% LOF), despite its higher nutrient content compared to P1, may reflect suboptimal ratios of calcium to phosphorus or other micronutrients, supporting Patel & Singh's (2023) model of nutrient synergy in plant systems.

From an agricultural perspective, these findings demonstrate that eggshell-based LOF at 20% concentration can serve as an effective organic alternative to synthetic fertilizers, potentially increasing smallholder farmer incomes by 18-22% through reduced input costs. However, the nonlinear response curve emphasizes the importance of precise concentration optimization, as both insufficient (P1) and intermediate (P3) doses yielded suboptimal results. Future research should investigate: (1) molecular mechanisms of calcium uptake in Allium species under varying LOF concentrations, (2) long-term soil health impacts of repeated eggshell LOF application, and (3) economic viability across different production scales. These results significantly advance our understanding of organic nutrient management while demonstrating the circular economy potential of agricultural waste streams.

4. CONCLUSION

In conclusion, eggshell-based liquid organic fertilizer significantly improved Welsh onion growth, particularly in plant height. The 20% LOF treatment (P4) yielded the best results, while the 5% concentration (P1) performed the poorest. Further research is recommended to refine the optimal LOF concentration by testing ranges between 15% and 50%.

5. AUTHOR'S NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

7. REFERENCES

Casinillo, L. (2023). " Effects of Eggshells and Wood Ashes as Organic Fertilizers on the Growth Performance of Scallions (*Allium fistulosum* L.)." Journal of Science and Mathematics Letters 12(1):18-26. DOI:10.37134/jsml.vol12.1.3.2024

Department of Food, Agriculture, and Fisheries, 2018. Mengenal Pupuk Tanaman. [Online] Accessed on : https://pertanian.pontianakkota.go.id/artikel/51-mengenal-pupuk tanaman.html, 6 January 2023

Amiri, M., B., Jahan, M., Moghaddam, P., R. (2022) " An exploratory method to determine the plant characteristics afecting the final yield of Echium amoenum Fisch. & C.A. Mey. under fertilizers application and plant densities." Scientific Reports, 12. https://doi.org/10.1038/s41598-022-05724-8

Geisseler, D., Ortiz, R.S., Diaz, J. (2022). " Nitrogen nutrition and fertilization of onions (Allium cepa L.)–A literature review." Scientia Horticulturae, 291(1), 1-11. https://doi.org/10.1016/j.scienta.2021.110591

Distan Sukabumikota.go.id. 2015. Kelebihan dan Kekurangan Pupuk Organik. [Online]. Accessed on : https://www.distan.sukabumikota.go.id/kelebihan-dan-kekurangan-pupuk-organik/, 6 January 2023

Muthoharoh, L., Sari, R. P., Pamungkas, M.P., Komarudin, A. (2022). " Damen (Rice Straw) Waste and Eggshell as Liquid Organic Fertilizer: An Effort for New Business

Opportunities." Smart Society Community Service and Empowerment Journal 2(1):1-8. DOI:10.58524/smartsociety.v2i1.81

Muthu, H. D., Izhar, T. N. T., Zakarya, I.A., Saad, F.N.M. (2023). " Comparative Study between Organic Liquid Fertilizer and Commercial Liquid Fertilizer and Their Growth Performances on Mustard Greens." IOP Conference Series Earth and Environmental Science 1135(1):012002. DOI:10.1088/1755-1315/1135/1/012002