

SHALLOT EXTRACT AND EGGSHELL EFFECTS ON PRE-NURSERY OIL PALM SEEDLINGS

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ABSTRACT

*This study evaluated the individual and combined effects of shallot (*Allium cepa* L.) extract and chicken eggshell powder on the vegetative growth of oil palm (*Elaeis guineensis* Jacq.) seedlings during the pre-nursery stage. The experiment was conducted at the agricultural field of the Faculty of Science and Technology, Universitas Tjut Nyak Dhien, Medan, North Sumatra, from December 2025 to March 2026. A 3 × 3 factorial randomized block design with three replications was used. Shallot extract was applied at 0, 15, and 60 mL plant⁻¹, while eggshell powder was applied at 0, 50, and 150 g plant⁻¹. Plant height, stem diameter, leaf area, and leaf number were recorded from 5 to 12 weeks after planting (WAP) and analyzed by analysis of variance followed by Duncan's Multiple Range Test at the 5% level when treatment effects were significant. Shallot extract significantly affected plant height at 8–12 WAP and leaf number at 9–12 WAP, with 60 mL plant⁻¹ producing the highest values at 12 WAP (20.41 cm and 3.19 leaves). Eggshell powder significantly affected plant height and leaf number only at 12 WAP, with 150 g plant⁻¹ producing 19.44 cm and 3.15 leaves. Neither factor significantly affected stem diameter or leaf area, and the interaction was nonsignificant for all measured traits. The results indicate that the two organic inputs acted mainly as independent, time-dependent growth modifiers rather than as a synergistic treatment during the pre-nursery period.*

Keywords: eggshell powder; oil palm; pre-nursery; shallot extract; vegetative growth.

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INTRODUCTION

Oil palm (*Elaeis guineensis* Jacq.) is a long-lived tropical plantation crop whose field performance depends strongly on the quality of planting material established during nursery stages. In a two-stage nursery system, the pre-nursery is the first period in which germinated seeds develop functional roots and leaves before transfer to the main nursery. Uniform early growth is therefore agronomically important because weak seedlings are more likely to require additional management or to be discarded before field planting. Indonesia remains one of the world's largest oil-palm producers, making efficient seedling management relevant not only to plantation productivity but also to the efficient use of fertilizers and nursery resources (Badan Pusat Statistik, 2024; Corley & Tinker, 2016; Pahan, 2012).

Nutrient management at the pre-nursery stage requires a balance between readily available mineral nutrition and materials that can improve the growing medium over time. Organic amendments can contribute nutrients and modify chemical properties of the medium, but their effects depend on decomposition, particle size, pH, and nutrient release patterns. Studies on oil-palm seedlings show that organic fertilizer can partially substitute mineral fertilizer when nutrient supply is appropriately managed, while other organic composts can improve selected seedling growth traits (Adileksana et al., 2020; Ariyanti et al., 2025). These findings support the evaluation of locally available organic materials, but they also caution against assuming that every organic input will immediately improve all vegetative parameters.

Chicken eggshell is a household and food-industry waste dominated by calcium carbonate. Finely ground eggshell can function as a calcium source and a liming amendment, although the agronomic response is conditioned by its dissolution and the initial chemical properties of the soil or potting medium. Experimental studies have reported increased soil pH and phosphorus availability after eggshell application, while plant responses range from clear improvements to nonsignificant changes depending on crop, dose, and substrate (Ahlina & Supardi, 2023; Faridi & Arabhosseini, 2018; Putri et al., 2023; Reeza, 2025; Sebonela et al., 2024). Calcium is essential for cell-wall stability, membrane function, and growing tissues; however, calcium supply alone does not replace the requirement for balanced nitrogen, phosphorus, potassium, and magnesium nutrition (Marschner, 2012; Thor, 2019; White & Broadley, 2003).

A second low-cost input of interest is shallot extract. Shallot-derived preparations have been studied as natural plant growth regulator (PGR) sources, particularly in vegetative propagation and early plant growth. Their reported effects are consistent with the broader physiological roles of auxin in root formation and cell expansion and of gibberellins in stem elongation and developmental regulation (Hedden & Sponsel, 2015; Zhang et al., 2022). Indonesian experiments have shown that shallot extract can modify rooting or shoot growth, although effective concentrations differ among species and propagation systems (Ayyubi et al., 2019; Irmadhani & Dewi, 2025; Khair et al., 2013; Makrufah et al., 2023). Thus, a concentration that stimulates one crop may be ineffective or excessive for another.

Recent agronomic studies published in ALGEBRA also demonstrate that growth-regulator responses are often dose-, method-, and parameter-specific. Gibberellin and humic acid treatments in cherry tomato produced different responses among growth and yield variables, while paclobutrazole concentration and application method altered beet growth and production with significant interactions for several traits (Azhari et al., 2025; Hasibuan et al., 2024). Such evidence reinforces the need to evaluate each PGR-crop combination experimentally rather than infer a uniform response from the presence of a growth-active compound.

The combined use of shallot extract and eggshell powder is conceptually attractive because the former may provide growth-stimulating organic compounds while the latter supplies calcium and can alter medium chemistry. However, their modes and timing of action are different: soluble compounds from shallot extract may act relatively quickly, whereas powdered eggshell is expected to dissolve more gradually. It is therefore uncertain whether simultaneous application will generate an additive or synergistic response in young oil-palm seedlings. The present study aimed to determine the effects of shallot extract, eggshell powder, and their interaction on plant height, stem diameter, leaf area, and leaf number of oil-palm seedlings during the pre-nursery stage. The working hypotheses were that each factor would affect seedling growth and that their combination could produce an interaction response.

RESEARCH METHODS

The experiment was conducted at the agricultural field of the Faculty of Science and Technology, Universitas Tjut Nyak Dhien, Medan, North Sumatra, Indonesia, at approximately 28 m above sea level. The final thesis abstract reports the experimental period as December 2025 to March 2026. Germinated DxP Simalungun oil-palm seeds from PPKS were used as planting material. The principal materials were topsoil, shallots, chicken eggshells, and NPK fertilizer; routine nursery tools included polybags, a digital caliper, measuring equipment, a blender, and a shade net.

A factorial randomized block design was arranged with two treatment factors. Shallot extract (E) consisted of E0 = 0 mL plant⁻¹ (control), E1 = 15 mL plant⁻¹, and E2 = 60 mL plant⁻¹. Eggshell powder (C) consisted of C0 = 0 g plant⁻¹ (control), C1 = 50 g plant⁻¹, and C2 = 150 g plant⁻¹. The 3 × 3 factorial produced nine treatment combinations and was replicated in three blocks, resulting in 27 plots. Each plot contained five seedlings, three of which were designated as sample plants, for a total of 135 seedlings. Plots measured 80 × 80 cm; the thesis specifies 50 cm between plots and 80 cm between blocks.

Shallot extract was prepared from 2 kg of peeled shallots blended with 1 L of water. The mixture was held for 24 h and filtered before use. Application began when seedlings were 14 days old and was repeated once per week according to treatment dose. Eggshells were collected, washed, sun-dried for approximately 1–3 h, ground, and sieved to approximately 80 mesh. The powder was incorporated into the planting medium according to the assigned treatment. Seedlings were maintained through routine watering, consolidation, weeding, fertilization according to the experimental protocol, and pest and disease management under a 65% shade net.

Observations started at approximately 30 days after planting and were repeated weekly. Plant height (cm) was measured from the soil surface to the tip of the youngest unopened leaf. Stem diameter (mm) was measured using a digital caliper. Leaf area (cm²) was estimated from leaf length (L) and maximum width (W) using $A = L \times W \times 0.52$. Leaf number was determined by counting fully formed leaves on each sample seedling. Data were summarized by treatment means for 5–12 weeks after planting (WAP).

The statistical model was $Y_{ijk} = \mu + B_i + E_j + C_k + (EC)_{jk} + e_{ijk}$, where Y_{ijk} is the observation in block i receiving shallot-extract level j and eggshell level k , μ is the grand mean, B_i is the block effect, E_j is the shallot-extract effect, C_k is the eggshell effect, $(EC)_{jk}$ is the interaction effect, and e_{ijk} is experimental error. Data were analyzed by analysis of variance (ANOVA). When a treatment effect was significant, means were separated by Duncan's Multiple Range Test (DMRT) at the 5% level. The manuscript reports significance according to the thesis ANOVA and DMRT outputs and does not infer unreported exact p-values.

RESULTS AND DISCUSSION

The factorial analysis showed a differentiated response across growth variables and seedling age. Shallot extract significantly affected plant height from 8 to 12 WAP and leaf number from 9 to 12 WAP. Eggshell powder affected plant height and leaf number only at 12 WAP. Neither main factor significantly affected stem diameter or leaf area from 5 to 12 WAP, and the $E \times C$ interaction was nonsignificant for all four variables throughout the observation period. Consequently, the most informative treatment contrasts were the late-stage main effects rather than treatment combinations.

Table 1. Main effects of shallot extract and eggshell powder on plant height (cm)

Treatment	8 WAP	9 WAP	10 WAP	11 WAP	12 WAP
Shallot extract					
E0: 0 mL plant ⁻¹	11.35 b	12.86 c	14.32 b	15.88 c	18.01 c
E1: 15 mL plant ⁻¹	11.03 c	12.90 b	14.16 c	15.89 b	18.39 b
E2: 60 mL plant ⁻¹	12.56 a	14.57 a	16.27 a	18.26 a	20.41 a
Eggshell powder					
C0: 0 g plant ⁻¹	11.31	12.86	14.06	15.81	18.16 c
C1: 50 g plant ⁻¹	11.73	13.81	15.56	17.18	19.21 b
C2: 150 g plant ⁻¹	11.90	13.66	15.13	17.04	19.44 a

Means within the same factor and column followed by different letters differ according to DMRT at 5%. Columns without letters indicate a nonsignificant main effect for that factor. $E \times C$ interaction was nonsignificant at all observation times.

At 12 WAP, the E2 treatment (60 mL plant⁻¹) reached 20.41 cm, compared with 18.01 cm under E0. The response became detectable from 8 WAP onward, indicating that the benefit of shallot extract was age-dependent rather than immediate. The same temporal pattern was observed for leaf

production. A plausible interpretation is that young seedlings initially relied heavily on seed reserves and establishment processes, while later vegetative growth became more responsive to externally supplied growth-active compounds. Auxin regulates root architecture and cell expansion, whereas gibberellins contribute to stem elongation and developmental transitions; therefore, a PGR-rich natural extract may produce stronger visible effects once roots and shoots are physiologically active (Hedden & Sponsel, 2015; Zhang et al., 2022). The result is also consistent with studies in which shallot extract affected rooting or vegetative growth in other crops, although the optimal concentration varied widely (Ayyubi et al., 2019; Irmadhani & Dewi, 2025; Khair et al., 2013; Makrufah et al., 2023).

Eggshell powder did not significantly alter plant height until 12 WAP, when C2 (150 g plant⁻¹) produced 19.44 cm compared with 18.16 cm in the control. The delayed response is compatible with the chemistry of powdered eggshell: calcium carbonate is not a rapidly soluble complete fertilizer, and its effects depend on particle size, medium acidity, moisture, and residence time. Eggshell-derived amendments can raise soil pH and increase calcium availability, but this does not guarantee an immediate growth response in every crop (Faridi & Arabhosseini, 2018; Reeza, 2025; Sebonela et al., 2024). In physiological terms, calcium is indispensable for cell walls, membrane stability, and meristematic tissues, yet a response to additional calcium will remain constrained if other nutrients are limiting or if the medium already supplies adequate Ca (Marschner, 2012; Thor, 2019; White & Broadley, 2003).

Table 2. Stem diameter and leaf area at 12 WAP

Treatment	Stem diameter (mm)	Leaf area (cm ²)
Shallot extract		
E0: 0 mL plant ⁻¹	7.42	16.61
E1: 15 mL plant ⁻¹	7.27	12.53
E2: 60 mL plant ⁻¹	7.54	16.34
Eggshell powder		
C0: 0 g plant ⁻¹	7.09	14.04
C1: 50 g plant ⁻¹	7.52	15.10
C2: 150 g plant ⁻¹	7.62	16.35

ANOVA indicated no significant main effect of shallot extract or eggshell powder on stem diameter or leaf area from 5–12 WAP. The E × C interaction was also nonsignificant throughout the observation period.

The absence of significant effects on stem diameter and leaf area is important because it shows that the positive responses were trait-specific. Numerical increases alone should not be interpreted as treatment effects when ANOVA is nonsignificant. For example, eggshell C2 had the highest 12-WAP stem diameter mean (7.62 mm) and leaf area mean (16.35 cm²), but these values were not statistically different from the other eggshell levels. Similarly, E2 produced a 12-WAP stem diameter of 7.54 mm, yet the shallot-extract main effect remained nonsignificant. This pattern suggests that treatment-driven changes in vertical growth and leaf initiation occurred earlier or more consistently than changes in radial stem growth or individual leaf expansion. Comparable parameter-specific responses are common in PGR and organic-input studies, where a treatment can significantly affect one growth component without altering all measured traits (Azhari et al., 2025; Hasibuan et al., 2024; Putri et al., 2023).

Table 3. Main effects of shallot extract and eggshell powder on leaf number

Treatment	9 WAP	10 WAP	11 WAP	12 WAP
Shallot extract				
E0: 0 mL plant ⁻¹	2.04 b	2.07 b	2.15 c	2.93 b
E1: 15 mL plant ⁻¹	2.11 b	2.26 a	2.37 b	3.04 a
E2: 60 mL plant ⁻¹	2.37 a	2.41 a	2.56 a	3.19 a
Eggshell powder				
C0: 0 g plant ⁻¹	2.07	2.22	2.33	2.96 b
C1: 50 g plant ⁻¹	2.11	2.15	2.26	3.04 b
C2: 150 g plant ⁻¹	2.33	2.37	2.48	3.15 a

Means within the same factor and column followed by different letters differ according to DMRT at 5%. Eggshell effects were nonsignificant at 9–11 WAP and significant at 12 WAP. E × C interaction was nonsignificant at all ages.

Leaf number showed the clearest late-stage response to shallot extract. E2 increased leaf number to 2.37 at 9 WAP and 3.19 at 12 WAP, whereas E0 produced 2.04 and 2.93 leaves at the same ages. The magnitude of the difference was modest, but the effect was consistent enough to be significant across 9–12 WAP. New leaf initiation depends on meristem activity and assimilate supply,

both of which can respond to changes in hormonal balance and root function. Studies of natural PGRs have similarly reported that shallot-based treatments can stimulate root or shoot formation when concentration and crop sensitivity are appropriate (Irmadhani & Dewi, 2025; Makrufah et al., 2023). These results support shallot extract as a potential low-cost PGR input, but they do not establish that higher doses beyond 60 mL plant⁻¹ would provide additional benefits.

Eggshell effects on leaf number appeared only at 12 WAP. C2 produced 3.15 leaves, compared with 2.96 under C0 and 3.04 under C1. This delayed response parallels the plant-height result and supports the interpretation that eggshell powder required time to interact with the growing medium before a measurable seedling response emerged. Similar crop studies show that eggshell amendments can improve growth when the substrate and dose permit useful calcium release, yet responses are not universal (Ahlina & Supardi, 2023; Putri et al., 2023; Reeza, 2025). The role of eggshell powder should therefore be described as a supplemental calcium/soil-amendment input rather than as a complete fertilizer.

No significant E × C interaction was detected for plant height, stem diameter, leaf area, or leaf number at any age from 5 to 12 WAP. This means that the response to shallot extract did not statistically depend on eggshell dose, and vice versa, within the tested treatment range. The absence of interaction is biologically plausible because the two inputs have contrasting mechanisms and release kinetics. Shallot extract supplies soluble organic constituents that may act relatively rapidly, while eggshell calcium carbonate dissolves gradually. A synchronised synergistic response would require the timing and magnitude of both effects to overlap. The present data do not support such synergy during the pre-nursery period. This is also consistent with the general principle that organic amendments and PGRs can produce independent, crop-specific responses rather than predictable additive effects (Adileksana et al., 2020; Ariyanti et al., 2025).

From a practical nursery perspective, E2 (60 mL plant⁻¹) was the most consistently favourable shallot treatment for height and leaf number, while C2 (150 g plant⁻¹) produced the best significant eggshell responses at 12 WAP. However, because stem diameter and leaf area were unaffected and there was no interaction, these treatments should not be interpreted as a complete replacement for balanced nursery fertilization. Further work should assess soil pH, exchangeable calcium, nutrient status, root traits, and a longer observation period extending into the main nursery. Measuring these intermediate variables would help distinguish a true nutrient-mediated eggshell effect from changes caused by pH or other medium properties, and would clarify whether the shallot response is primarily associated with rooting, hormonal activity, or improved nutrient acquisition.

CONCLUSIONS

Shallot extract affected selected vegetative traits of pre-nursery oil-palm seedlings in an age-dependent manner. Significant effects occurred on plant height at 8–12 WAP and leaf number at 9–12 WAP, with 60 mL plant⁻¹ (E2) producing the highest 12-WAP plant height (20.41 cm) and leaf number (3.19). Eggshell powder affected plant height and leaf number only at 12 WAP, when 150 g plant⁻¹ (C2) produced 19.44 cm and 3.15 leaves. Neither shallot extract nor eggshell powder significantly affected stem diameter or leaf area during 5–12 WAP. The interaction between shallot extract and eggshell powder was nonsignificant for all measured variables throughout the study. Accordingly, the two materials behaved as independent inputs under the tested conditions, and the data do not support a synergistic effect during the pre-nursery period. Future studies should evaluate a wider dose range, medium pH and nutrient dynamics, root responses, and carry-over effects into the main-nursery stage before practical fertilizer-substitution recommendations are made.

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