ALGEBRA : JURNAL PENDIDIKAN, SOSIAL DAN SAINS

ISSN : 2807-663X e-ISSN : 2807-629X
Journal Homepage : https://algebra.yana.or.id/index.php/ejournal/index
Volume 6 Number 3 (2026)

MANURE MEDIA AND SOURSOP EXTRACT SHAPE EARLY OIL PALM SEEDLING GROWTH

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ABSTRACT

Sustainable oil palm nurseries require locally available growth media and crop-protection inputs, yet the growth consequences of combining livestock-manure media with soursop (Annona muricata L.) leaf extract remain unclear. This study evaluated three manure-amended media formulations and three extract application volumes for DxP Simalungun oil palm seedlings during the pre-nursery stage. A 3 x 3 factorial randomized complete block design with three blocks comprised 27 plots and 135 seedlings. Media formulations were topsoil amended with cow manure at 150 g/polybag (M0), goat manure at 100 g/polybag (M1), or chicken manure at 100 g/polybag (M2); extract volumes were 0, 50, and 100 mL/polybag. Plant height, stem diameter, leaf area, and leaf number were observed weekly from 5 to 12 weeks after planting (WAP). Reanalysis of plot means showed time-dependent main effects rather than a stable synergistic response. At 12 WAP, media formulation affected leaf area (p = 0.023), with M2 producing the highest mean (4.86 cm2), while extract volume affected leaf number (p = 0.046), with the highest mean at 50 mL (2.67 leaves). No interaction was significant for any 12-WAP endpoint. The novelty lies in the factorial, time-resolved separation of transient and persistent responses: media effects were most consistent for foliage development, whereas soursop extract effects were intermittent and did not replace nutrient provisioning. Chicken-manure-amended topsoil therefore appears promising for leaf expansion, but chemically standardized extract trials that also measure pest suppression are required.

Keywords: botanical pesticide; livestock manure; nursery medium; oil palm; temporal response.

Submited: 04 September 2026	***Accepted: 15 September 2026***	***Published: 27 September 2026***

INTRODUCTION

Oil palm (*Elaeis guineensis* Jacq.) is a strategically important plantation crop in Indonesia, and the quality of planting material established in the nursery influences subsequent field performance. Pre-nursery management is especially important because young seedlings have small root systems, limited buffering capacity, and rapidly changing demands for water, aeration, and nutrients. Sound nursery practice therefore depends on a medium that supports root exploration and stable nutrient supply rather than merely holding the seedling upright (Pahan, 2020; Jeki et al., 2021; Muhammad et al., 2021).

Organic amendments can improve porosity, water retention, cation exchange, and nutrient availability, but their effects depend on feedstock, maturity, application rate, and the properties of the mineral soil (Nurjanah et al., 2020; Sepriani & Triyanto, 2020). Compost-amended media have improved oil palm seedling biomass and nutrient uptake in several nursery studies, although responses are not uniform across formulations (Rosenani et al., 2016; Radin et al., 2018; Salamat et al., 2019). Livestock manures are attractive to small nurseries because they are locally available. Cow, goat, and chicken manures nevertheless differ in decomposition and nutrient-release patterns, and an application that benefits leaf development may not produce an equally rapid response in height or stem diameter (Hartati et al., 2022; Pamungkas et al., 2020; Sipayung et al., 2021).

Botanical pesticides provide another route toward lower-input nursery management. Soursop leaves contain bioactive secondary metabolites and have been investigated as a source of insecticidal and larvicidal material (Haerul et al., 2016; Keewa et al., 2020; Tando, 2018). Botanical products can degrade rapidly and may reduce reliance on persistent synthetic compounds, but biological activity depends strongly on extraction, chemical standardization, target organism, dose, and application timing (Isman, 2020; Kusumawati & Istiqomah, 2022). Consequently, a botanical extract should not be assumed to function as a fertilizer or general growth promoter when pest pressure and chemical composition have not been measured.

Factorial agronomic experiments are useful because they distinguish independent main effects from true synergy. Studies published in Algebra have used factorial randomized block designs to demonstrate that plant responses to growth regulators and soil-related inputs can vary with observation time and response variable (Azhari et al., 2025; Hasibuan et al., 2024). In oil palm pre-nurseries, however, manure-amended media and soursop leaf extract are more often discussed separately. It remains uncertain whether the medium alters the seedling growth response to the extract and whether any observed response persists until the end of the pre-nursery observation period.

This study addressed that gap by evaluating three manure-amended topsoil formulations together with three application volumes of aqueous soursop leaf extract in DxP Simalungun seedlings. Its novelty is not a claim that either input is universally superior; rather, it is the factorial and time-resolved identification of when media, extract, and their interaction influence distinct growth components from 5 to 12 WAP. The study tested three hypotheses: media formulation affects seedling growth, extract application volume affects seedling growth, and the two factors interact. The practical objective was to identify a locally feasible formulation while separating persistent endpoint performance from short-lived early responses.

RESEARCH METHODS

Study site and experimental material

The experiment was conducted from December 2025 to February 2026 at Jalan Terompet, Padang Bulan, Medan, Indonesia, at approximately 28 m above sea level. Germinated DxP Simalungun oil palm seeds supplied by the Indonesian Oil Palm Research Institute were planted individually in 15 x 27 cm polybags. The nursery was protected with 65% shade netting. Routine maintenance included watering, plot consolidation, weed control, and treatment application. The observation unit used in the statistical analysis was the plot mean.

Experimental design and treatments

A 3 x 3 factorial randomized complete block design was used with three blocks. The first factor was manure-amended media formulation: M0, topsoil plus 150 g cow manure per polybag; M1, topsoil plus 100 g goat manure per polybag; and M2, topsoil plus 100 g chicken manure per polybag. Because the manure rates were not equal, this factor represents complete media formulations and does not isolate manure species from dose. The second factor was the application volume of aqueous soursop leaf extract: E0, 0 mL/polybag; E1, 50 mL/polybag; and E2, 100 mL/polybag. The

combination produced nine treatments in each block, 27 plots in total. Each plot contained five seedlings, of which three were sampled, giving 135 seedlings overall.

Extract preparation and application

One hundred soursop leaves were blended with 1 L water. The suspension was held for 24 h and filtered through cloth to obtain the stock extract. Application began when seedlings were 14 days old and followed the assigned volume. The source thesis did not report chemical profiling of the extract, so the stated treatments should be interpreted as stock-solution application volumes rather than standardized concentrations of acetogenins or other active compounds.

Growth measurements

Plant height was measured from the medium surface to the tip of the youngest incompletely opened leaf. Stem diameter was measured with a digital caliper. Leaf area was estimated from leaf length multiplied by leaf width and a correction factor of 0.52. Fully formed leaves were counted. Measurements were recorded weekly from 5 through 12 WAP. No pest abundance, feeding damage, disease severity, or pesticide-efficacy outcome was recorded; the dependent variables were therefore restricted to vegetative growth.

Statistical analysis

Plot means reported for the three blocks were reanalyzed for this article using the factorial randomized block model Yijk = mu + Bk + Mi + Ej + (ME)ij + errorijk, where B is block, M is media formulation, E is extract volume, and ME is their interaction. Separate analyses of variance were performed for each response at each observation week using alpha = 0.05 and 16 residual degrees of freedom. This approach reproduces the design used in the thesis while correcting inconsistent significance labels in several appendix tables. Because the same plots were observed repeatedly, the week-specific tests are interpreted as descriptive evidence of timing; the 12-WAP endpoint is emphasized for the primary agronomic conclusion. Means are presented without new post-hoc letter groupings where pairwise tests were unavailable.

RESULTS AND DISCUSSION

Endpoint performance at 12 weeks after planting

At 12 WAP, the clearest media response occurred in leaf area. Media formulation had a significant main effect, $F(2, 16) = 4.82$, $p = 0.023$, and M2 had the highest observed mean (4.86 cm2). The extract main effect on leaf area was not significant, $F(2, 16) = 0.09$, $p = 0.910$, and the interaction was also nonsignificant, $F(4, 16) = 0.37$, $p = 0.828$. Thus, the leaf-area advantage at the endpoint was associated with the media formulation rather than a synergistic combination with soursop extract.

Table 1. Main-effect means for oil palm seedling growth at 12 WAP

Treatment	Height (cm)	Stem diameter (mm)	Leaf area (cm2)	Leaves (no.)
M0: cow manure, 150 g	14.86	2.97	4.33	2.48
M1: goat manure, 100 g	14.15	3.14	4.70	2.56
M2: chicken manure, 100 g	15.38	3.10	4.86	2.48
E0: extract, 0 mL	14.88	2.98	4.66	2.22
E1: extract, 50 mL	14.86	3.11	4.59	2.67
E2: extract, 100 mL	14.65	3.11	4.63	2.63

Neither height nor stem diameter showed a significant 12-WAP response. For height, p values were 0.278 for media, 0.942 for extract, and 0.158 for the interaction. For stem diameter, the corresponding p values were 0.234, 0.334, and 0.519. Leaf number showed a significant extract main effect, $F(2, 16) = 3.77$, $p = 0.046$; E1 produced the highest observed mean (2.67 leaves), closely followed by E2 (2.63 leaves), whereas E0 averaged 2.22 leaves. The media main effect and media-by-extract interaction for leaf number were nonsignificant ($p = 0.890$ and $p = 0.284$, respectively). Without pairwise contrasts, the overall extract test should not be interpreted as proof that every treated mean differed from the untreated mean.

Time-dependent treatment effects

The weekly analyses revealed that several effects were transient. Media formulation affected leaf area at every observation from 5 to 12 WAP (all $p < 0.024$), whereas the extract affected leaf area at 5-8 and 10 WAP but not at 9, 11, or 12 WAP. Media affected stem diameter from 5 to 11 WAP, but not at the endpoint; extract effects on diameter were confined to 5-9 WAP. Height responded to both factors only at 5-7 WAP. These patterns indicate temporal dissociation: early seedling dimensions

were responsive to initial treatment conditions, but the responses did not necessarily persist as seedlings developed.

Table 2. Observation weeks with significant factorial ANOVA effects

Response	Media formulation	Soursop extract	M x E interaction
Leaf area	5-12 WAP (all p < .024)	5-8, 10 WAP (all p < .024)	None
Stem diameter	5-11 WAP (all p < .038)	5-9 WAP (all p < .034)	5 WAP (p = .048)
Plant height	5-7 WAP (all p < .001)	5-7 WAP (all p < .001)	6-7 WAP (p = .019-.025)
Leaf number	8 WAP (p = .020)	10 and 12 WAP (p = .039-.046)	11 WAP (p = .009)

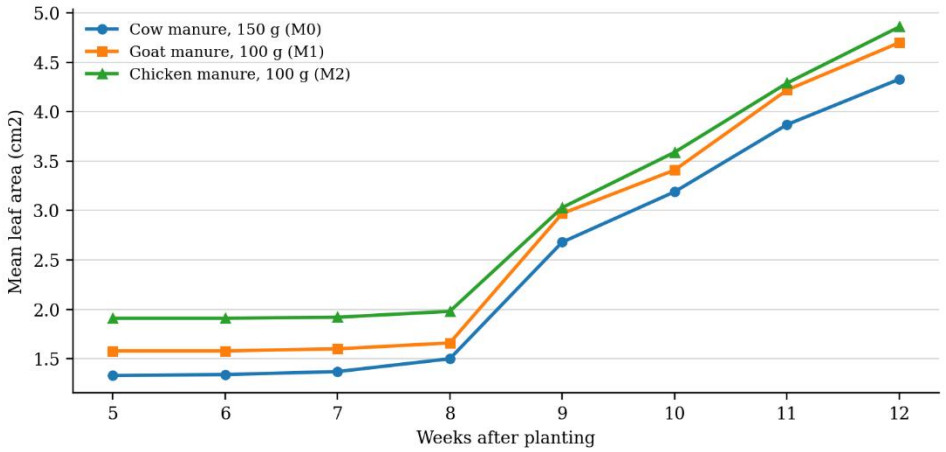


Figure 1. Leaf-area trajectories under the three manure-amended media formulations

Figure 1 shows that M2 maintained the highest numerical leaf area throughout the observation period, while differences among media narrowed and widened as leaves expanded. The consistency of the overall media test across weeks supports a foliage-development effect, even though the unequal manure rates prevent the response from being attributed solely to manure species. Chicken manure can release nutrients relatively rapidly, while amendment effects also arise through changes in water retention, aeration, and biological activity. Previous nursery research likewise shows that compost or manure incorporation can improve oil palm growth, but the response depends on the amendment-medium combination (Rosenani et al., 2016; Salamat et al., 2019; Sipayung et al., 2021). The present result therefore supports M2 as a promising formulation rather than establishing 100 g chicken manure as a universal optimum.

Interpretation of the soursop-extract response

The extract produced intermittent growth signals, including an overall leaf-number effect at 12 WAP, but it did not generate a persistent increase across all growth variables. This is biologically plausible because soursop leaf extract is primarily proposed as a botanical pesticide, not a balanced nutrient solution. Acetogenins, alkaloids, flavonoids, tannins, and other secondary metabolites may affect insects or microorganisms, yet their concentration and non-target physiological effects vary with plant material and preparation (Tando, 2018; Isman, 2020). The absence of chemical profiling in the present experiment makes application volume a poor proxy for active dose. A future trial should quantify marker compounds, record pH and electrical conductivity, and include pest-density and feeding-damage outcomes before recommending the extract for nursery protection.

The highest endpoint leaf-number mean occurred at 50 mL rather than 100 mL, while endpoint leaf area was statistically unchanged by extract volume. This non-monotonic pattern does not support a simple dose-response interpretation. It may reflect sampling variation, changing seedling sensitivity, or unmeasured biological pressure. Similar time-specific responses have been reported when plant growth regulators and soil amendments were assessed factorially in beet and cherry tomato experiments (Hasibuan et al., 2024; Azhari et al., 2025). The appropriate practical conclusion is therefore conditional: the extract may influence particular growth observations, but its value as a botanical pesticide must be demonstrated through direct protection outcomes.

Interaction, contribution, and limitations

No media-by-extract interaction was significant for any 12-WAP endpoint. Isolated interactions appeared for stem diameter at 5 WAP, plant height at 6-7 WAP, and leaf number at 11 WAP, but none persisted. This is the central contribution of the time-resolved analysis: a single significant observation can overstate synergy if persistence is not examined. Under the tested conditions, media

and extract acted largely independently, with media exerting the more consistent influence on leaf expansion. The data therefore do not justify recommending a specific combined treatment as superior.

Four limitations define the scope of inference. First, manure source was confounded with dose, so a balanced comparison requires equal dry-matter or nutrient-equivalent rates. Second, the aqueous extract was not chemically standardized. Third, pest pressure and protection efficacy were not measured. Fourth, the same plots were measured repeatedly, while the available thesis tables supported only week-specific randomized-block analyses rather than a full longitudinal mixed model. A follow-up study should use equal nutrient inputs, characterize media chemistry and extract composition, measure pest and growth outcomes together, and analyze repeated measurements with plot-level random effects. Multi-site or multi-season validation would further test whether the observed foliage response is robust under different nursery environments (Listia & Syukur, 2021; Lau et al., 2024).

CONCLUSIONS

Manure-amended media formulation influenced oil palm seedling foliage more consistently than aqueous soursop leaf extract. At 12 WAP, the chicken-manure formulation (100 g/polybag) produced the highest observed leaf area (4.86 cm2), and the media main effect was significant ($p = 0.023$). Extract volume affected leaf number at the endpoint ($p = 0.046$), but the response was non-monotonic and did not extend to height, stem diameter, or leaf area. No media-by-extract interaction persisted to 12 WAP. The article's novelty lies in demonstrating that treatment effects were component-specific and time-dependent: transient early significance did not equal durable agronomic synergy. The chicken-manure formulation is a useful candidate for further testing, while soursop extract should be evaluated as a standardized crop-protection input with direct pest measurements rather than assumed to be a general growth enhancer.

ACKNOWLEDGEMENTS

The author thanks Ir. Razali, M.P., and Ahmad Nadhira, S.P., M.Si., for academic guidance during the undergraduate research, and Universitas Tjut Nyak Dhien for supporting the study.

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