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SHORT COMMUNICATION

Inorganic NPK and Foliar Inputs Yield Negligible Growth Benefits in Young 'Siger' Avocado Receiving Basal Organic Amendments

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Abstract

During the juvenile establishment phase, optimizing nutrient management is essential to develop vigorous canopy architecture and establish productive avocado orchards. This study evaluated the vegetative growth responses of one-year-old 'Siger' avocado to compound NPK regimes combined with biofertilizer and foliar inputs under lowland tropical conditions in Jonggol, West Java, Indonesia. The experiment was arranged in a randomized complete block design featuring four fertilization regimes across three replications: an unfertilized control receiving basal organic amendments only, and three supplemental regimes receiving 75, 150, or 300 g per tree of compound NPK (15-15-15) combined with *Azospirillum*-based biofertilizer (100 g per tree) and foliar fertilizer (3 g/L). Each tree received a standard basal application of 20 kg cow manure, rock phosphate, and dolomite. Over the six-month observation period, plant height, stem diameter, and primary branch proliferation increased gradually across all treatments, but no statistically significant differences emerged among the fertilization regimes. These results indicate that the basal organic amendment provided sufficient baseline nutrition to meet the absorption capacity of juvenile root systems, making additional inorganic NPK applications redundant during initial establishment. Therefore, supplemental chemical fertilization for young avocado trees in this location can be deferred during early establishment when adequate basal organic amendments and consistent drip irrigation are provided.

Keywords: avocado, nutrient management, vegetative growth

Introduction

Avocado (*Persea americana* Mill.) is an economically important horticultural crop cultivated worldwide for its nutritional and economic value. In Indonesia, avocado production has increased steadily, driven by expanding domestic markets and growing consumer demand for nutrient-dense foods (Duarte et al., 2016; Hartati et al., 2022). Sustained orchard productivity depends on sound management practices during early vegetative growth, which promote rapid canopy development, vigorous root growth, and early transition to reproductive maturity (Firgiyanto et al., 2023; Widianti et al., 2022).

Early vegetative development in avocado depends on the synchronized availability of macronutrients and soil moisture. Nitrogen (N) drives structural protein synthesis and chlorophyll accumulation, phosphorus (P) coordinates cellular energy transfer and root morphogenesis, and potassium (K) regulates stomatal conductance and enzymatic osmoregulation.

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During the juvenile establishment phase, nutrient deficiencies can retard vegetative development and extend the non-productive juvenile window (Montazar et al., 2025). Consequently, balanced compound NPK fertilizers, supplemented with targeted foliar feeding and biofertilizers, are widely employed to promote seedling vigor and stimulate rhizosphere activity (Baca-Patiño et al., 2025; Kartina et al., 2025; Ramirez-Gil et al., 2023).

Despite extensive research on avocado nutrition, most studies focus on bearing commercial orchards (e.g., 'Hass') under subtropical conditions. Information regarding the nutritional requirements of juvenile trees during field establishment in lowland tropical environments remains scarce, particularly for promising Indonesian cultivars such as 'Siger'. Furthermore, evaluating young perennial trees under field conditions recorded the contribution of basal organic amendments and environmental variability on nutrient availability (Telaumbanua et al., 2023). The shallow nature of the avocado root system indicates that more than 60%–70% of functional feeder roots are concentrated within the upper 30–60 cm of the soil profile, providing the physiological rationale for organic mulching and surface-applied organic matter (Salazar-Garcia et al., 2007). Applying a 15 cm coarse composted pine bark mulch under the avocado tree drip line significantly stimulated feeder root growth at the topsoil/mulch interface, reduced mid-summer heat stress in the root zone, and improved cumulative fruit yield (Moore-Gordon et al., 1995). *Azospirillum* inoculation enhances root nutrient acquisition and shoot accumulation, although yield increases can vary with baseline soil fertility, cultivar differences, and management systems (Boleta et al., 2020; Cruz-Hernández et al., 2022). Therefore, this study aimed to determine whether adding compound NPK (75, 150, and 300 g per tree), combined with biofertilizer containing *Azospirillum* and foliar sprays, can enhance vegetative growth in juvenile 'Siger' avocado, a superior avocado cultivar originating from Lampung, Indonesia.

Materials and Methods

Site Description

The experimental site had typical lowland tropical microclimatic conditions, with consistent ambient temperatures (27–30 °C) and high relative humidity (74%–79%) (Table 1). Although precipitation was highly variable—punctuated by a distinct dry spell in July and substantial late-season rainfall in September (421 mm)—automated drip irrigation buffered trees against acute drought stress. Consequently, treatment differences reflected nutritional inputs rather than moisture limitations.

The fertilizers included a compound NPK (15-15-15), leaf foliar fertilizer, cow manure, dolomite, rock phosphate, and a biofertilizer, pupuk hayati Emas (PHE), containing *Azospirillum* sp., which we applied as a basal amendment. We monitored pests weekly and applied insecticides as needed. The assigned NPK fertilizer rates were applied once in April 2024. Two weeks after NPK application, we applied PHE at 100 g per tree and foliar fertilizer at 3 g/L to the fertilized treatments.

Plant Material and Experimental Design

The experiment evaluated one-year-old grafted avocado (*P. americana*) seedlings of the local cultivar 'Siger'. The trial used a randomized complete block design with four fertilization regimes and three replications, yielding 12 experimental units. Each unit comprised five trees, for a total of 60 trees.

Before field establishment, all planting holes received a uniform basal soil conditioning package comprising 20 kg of cow manure, dolomite, and rock phosphate to ensure baseline soil structure and biological health. The experimental treatments were control (baseline soil amendments only without supplemental soil NPK, biofertilizer, or foliar fertilizer); 75 g per tree compound NPK (15-15-15) + supplemental package; 150 g per tree compound NPK (15-15-15) + supplemental package; and 300 g per tree compound NPK (15-15-15) + supplemental

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package. Compound NPK was applied as a single ring-placement application in April 2024. Two weeks post-application, these treatments received a uniform supplemental package: 100 g per tree of *Azospirillum*-based biofertilizer and a single foliar micronutrient spray at 3 g/L. Routine orchard sanitation, manual weeding, and pest management were maintained uniformly across all blocks.

Plant Measurements

Vegetative growth parameters were recorded at 30-day intervals over six consecutive months, including plant height (cm): measured from the root collar/soil interface to the apical shoot meristem using a graduated telescopic ruler; stem diameter (mm): recorded 10 cm above the ground line using a digital vernier caliper; and primary branch count: quantified as the total number of lateral architectural branches emerging directly from the primary trunk.

Statistical Analysis

Data were analyzed using SAS (Statistical Analysis System) software. Analysis of variance (ANOVA) was performed according to the randomized complete block design. When the treatment effect was significant ($p < 0.05$), treatment means were separated using Duncan's multiple range test (DMRT) at the 5% significance level. Plant height, stem diameter, and primary branch number were analyzed for each monthly observation.

Results and Discussions

Climatic Conditions During Avocado Young Tree Establishment

The experimental site experienced typical lowland tropical microclimatic conditions, marked by consistent ambient temperatures (27–30 °C) and high relative humidity (74%–79%). Precipitation was highly variable, with a distinct dry spell in July and substantial late-season rainfall in September (421 mm) (Table 1). Automated drip irrigation buffered trees against acute drought stress, so treatment differences reflected nutritional inputs rather than moisture limitations.

Vegetative Growth Responses

Plant height, stem diameter, and the number of primary branches increased steadily across all treatments over the six-month evaluation period (Tables 2–4). However, ANOVA revealed no statistically significant differences ($p > 0.05$) among the fertilization regimes for any vegetative growth trait at any sampling point.

The lack of significant growth differentiation among treatments likely reflects the basal soil amendment applied at planting (20 kg cow manure, rock phosphate, and dolomite per tree). In juvenile, one-year-old avocado trees, absolute nutrient demand is modest because root volume and leaf surface area are limited (Telaumbanua et al., 2023). Decomposed cattle manure provides a sustained release of organic nitrogen, exchangeable potassium, and secondary macronutrients, while rock phosphate satisfies seedling phosphorus requirements. Under these conditions, the basal organic pool likely saturated the juvenile root system's nutritional absorption capacity, making additional chemical NPK inputs (75–300 g per tree) redundant during the initial six-month establishment phase. Furthermore, young avocado roots are sensitive to high localized salt indices; excessive granular fertilizer concentrated in the rhizosphere can cause sub-clinical osmotic stress, preventing accelerated vegetative flushes**.**

Because the fertilized treatments combined soil-applied NPK, *Azospirillum* biofertilizer, and foliar spray into a single package, future investigations should dissociate these components in a factorial design. Evaluating unamended soil controls (without basal manure), monitoring root system architecture, and directly quantifying foliar tissue nutrient concentrations will help identify optimal fertilization protocols for juvenile avocado orchards in tropical lowlands.

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Table 1

Monthly Rainfall, Average Temperature, and Relative Humidity Recorded at the IPB–Cargill Oil Palm Teaching and Research Plantation, Jonggol, from January to December 2024

Month	Rainfall (mm per month)	Average temperature (°C)	Relative humidity (%)
January	433	29	79
February	267	29	79
March	162	29	79
April	181	29	79
May	13	29	79
June	145	29	79
July	0	29	79
August	128	29	79
September	421	29	79
October	74	28.5	74
November	95	28	76
December	158	27	74
Total	2077	-	-
Average	173	28.7	78

Source. Meteorological, Climatological, and Geophysical Agency of Indonesia (BMKG), as compiled in the 2024 climatic records of the IPB-Cargill Oil Palm Teaching and Research Plantation, Jonggol.

Table 2

Effect of Different NPK Compound Fertilizer and Foliar Fertilizer Combinations on Monthly Plant Height (cm) of One-year-old Avocado cv. 'Siger' over Six Months of Observation

Treatment (g per tree)	Plant height (cm)					
	1	2	3	4	5	6
Control	56.95	59.38	62.83	64.50	75.07	77.60
75	59.87	67.11	69.24	76.90	79.07	83.23
150	58.42	62.24	65.11	70.30	74.27	82.47
300	54.67	58.87	61.12	65.15	68.57	77.53
p value	0.48	0.31	0.37	0.28	0.56	0.84
CV (%)	6.93	8.7	8.38	11.35	11.66	12.49

Notes. CV = coefficient of variation. Values represent mean plant height per treatment group across replicates.

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Table 3

Effect of Different NPK Compound Fertilizer and Foliar Fertilizer Combinations on Monthly Stem Diameter (mm) of One-year-old Avocado cv. 'Siger' over Six Months of Observation

Treatment (g per tree)	Stem Diameter (mm) – (months after fertilizer application)					
	1	2	3	4	5	6
Control	2.41	2.56	2.80	3.10	3.47	3.63
75	2.65	2.70	2.85	2.99	3.08	3.23
150	2.57	2.77	2.84	2.96	3.28	3.65
300	2.49	2.51	2.77	2.86	3.07	3.43
p value	0.28	0.31	0.91	0.61	0.33	0.71
CV (%)	5.63^{T}	6.49^{T}	4.98^{T}	7.06^{T}	8.53^{T}	14.04^{T}

Notes. CV = Coefficient of variation. T indicates square-root-transformed data $(x+0.5)^{1/2}$.

Table 4

Effect of Different NPK Compound Fertilizer and Foliar Fertilizer Combinations on the Number of Primary Branches in One-year-old Avocado cv. 'Siger' over Six Months of Observation

Treatment (g per tree)	Number of Primary Branches (months after fertilizer application)					
	1	2	3	4	5	6
Control	1.91	2.09	2.38	2.46	2.71	3.02
75	1.88	1.95	2.00	2.00	2.10	2.25
150	1.95	1.99	2.06	2.14	2.25	2.39
300	1.97	2.06	2.15	2.22	2.33	2.49
p value	0.16	0.55	0.47	0.63	0.75	0.60
CV (%)	4.71^{T}	11.10^{T}	14.26^{T}	15.10^{T}	15.04^{T}	19.84^{T}

Notes. CV = Coefficient of variation. T = transformed data results $(x+3)^{1/2}$.

Conclusions

Supplemental fertilization regimes combining compound NPK (75–300 g per tree), *Azospirillum* biofertilizer, and foliar spray did not significantly increase plant height, stem diameter, or branch production in one-year-old 'Siger' avocado trees over six months. The heavy basal application of 20 kg cow manure and rock phosphate per planting hole appeared sufficient to meet the nutritional requirements of juvenile trees, rendering additional chemical NPK applications redundant during early establishment at this location. For establishing young avocado orchards on amended soils, modest organic fertilization combined with consistent drip irrigation is sufficient, and additional inorganic NPK applications can be deferred until trees enter active canopy expansion and reproductive bearing stages.

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