

Growth, production, and nutrients of butterfly (*Centrosema pubescens*) using goat manure fertilization doses and harvest ages

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Abstract: *Centrosema pubescens* is a tropical forage legume valued for its adaptability, protein content, and potential to improve livestock nutrition in low-input systems. However, limited information is available on how organic fertilization and harvest timing affect its productivity and nutritive value. This study evaluated the effects of goat manure fertilization and harvest age on growth traits, forage yield, and nutrient composition of *C. pubescens*. A randomized 2 × 2 factorial design was applied with two manure doses (0 and 300 g plant⁻¹) and two harvest ages (10 and 12 weeks). Measured variables included soil nutrients, plant morphology, chemical composition, and forage production. Manure dose significantly influenced most growth traits and soil properties, but had no effect on forage yield or chemical composition ($p > 0.05$). Harvest age affected most variables, except dry matter, ether extract, and phosphorus content ($p > 0.05$). A significant dose × age interaction was detected: plants fertilized with 300 g plant⁻¹ and harvested at 12 weeks had the greatest leaf number, plant height, stem diameter, branch number, crude protein, and organic matter content. Overall, the combination of 300 g plant⁻¹ goat manure with a 12-week harvest interval improved soil nutrient status, growth performance, and forage nutritive value of *C. pubescens*. These findings suggest that integrating organic fertilization with appropriate harvest management can enhance the agronomic and nutritional potential of this forage legume in tropical systems.

Keywords: Biomass yield, forage quality, soil properties, organic fertilizer.

Abbreviations: CP_crude protein, DM_dry matter, EE_either extract, OM_organic matter, SOC_Soil organic carbon, TN_Total soil nitrogen.

Introduction

Feeding is key to the nutrition of livestock, which is essential for their basic needs, growth, development, production, and reproduction. As demand for animal-derived foods rises globally, improving feed quality is crucial for food security and sustainable livestock production. Ruminants rely on forage for its rich carbohydrates, protein, and fiber, which are vital for their health and productivity. A diet consisting of forage that is abundant in carbohydrates, protein, and fiber is imperative for growth, reproduction, and productivity (Chand et al., 2022). Forage is a legume that is well-suited for livestock production because of its adaptability to diverse environmental conditions and high nutritional content, and the high protein content of these legumes has been demonstrated to improve feed quality, thereby promoting optimal growth and productivity (Suwignyo et al., 2022).

In Indonesia, many legume plants have adapted to their environment, suggesting they can adapt to climate change. Their capacity for adaptation to warm climates has enabled cultivation, resulting in tropical legume varieties that serve as high-quality animal feed (Suwignyo et al., 2023). In this study, Butterfly pea (*C. pubescens*), a legume species, is used as cover crop in tropical plantations. It can serve as an animal feed source. Its capacity for adaptation and acclimatization makes it suited for tropical cultivation, as seen in Indonesia. The productivity and nutritional value of *C. pubescens* are high. It has an ash content of 8.8% and crude protein content of 22.0% (Nworgu and Fasogbon, 2007).

Pastoral practices using fertilizers enhance vegetative growth and yield, increasing forage availability. This optimizes production, enhancing plant growth and yield. Manure application significantly impacts plant growth, yield, and physiological properties (Ullah et al., 2023). Fertilization boosts crop yields and chemical composition (Sariffudin et al., 2021). Harvest age impacts total biomass and nutrient content (Prasojo et al., 2025). *C. pubescens* could be a nutritious livestock feed, increasing productivity. The research is needed to understand its impact on goat manure productivity and

nutrient content, especially based on harvest age. This study will assess how different goat manure fertilization levels and harvest ages affect *C. pubescens* biomass yield and nutrient content. The hypothesis is that both factors influence forage productivity and quality, providing improved management strategies for tropical livestock systems.

Results and Discussion

Agroclimatic conditions during the experiment

Weather data for Kembang Village (Nanggulan District, Kulon Progo Regency, Yogyakarta Province) were obtained from the Indonesian Meteorological Climatological and Geophysical Agency (2025). During the experimental period, daily temperatures ranged from 25.7 to 29 °C, with an average relative humidity of 85.1%. These values fall within the general optimum range reported for grain legumes (10 – 36% ; Suwignyo et al., 2023). Moderate humidity levels (75-85%) indicate favorable conditions for tropical legume growth (Abay and Tolesa, 2023). Figure 1 depicts a meticulous investigation of environmental agroclimatic conditions. Figure 2 shows the growth development of *C. pubescens* plants during the experiment.

Soil nutrient status

Table 1 summarizes the soil nutrient analysis. Despite its tendency to crack when dry and its low nitrogen content, the grumusol soil at the site supported the growth of *C. pubescens*, consistent with previous reports of its broad adaptability to diverse soils and environments (Nworgu and Ajayi, 2005). The addition of goat manure improved soil quality by increasing organic matter and phosphorus availability and adjusting soil pH, thereby enhancing long-term fertility (Tian et al., 2025). These changes emphasize the role of organic fertilization in sustaining *C. pubescens* productivity under grumusol conditions.

Soil moisture content

Table 1 shows that using 300 g plant⁻¹ increased soil moisture content by 5.22% (5.60% to 10.88%) compared to 0 g plant⁻¹. This shows that goat manure improves soil moisture retention, structure, porosity, water retention, and microbial activity, which supports plant growth and productivity. The addition of organic matter improves aggregate formation and stability, which enhances porosity and water-holding capacity. Furthermore, manure decomposition promotes the release of humic compounds and stimulates microbial activity, processes that increase the soil's ability to retain and store water. These combined physical, chemical, and biological mechanisms explain the higher soil moisture. Manure also improves moisture conservation and soil nutrient cycling (Ullah et al., 2023). Increased soil moisture and fertility from manure contributes to increased agricultural productivity, especially in areas with water scarcity and low fertility (Njoku and Okoro, 2019).

Soil pH

The results (Table 1) showed that the application of 300 g plant⁻¹ of goat manure increased soil pH from 6.78 to 8.00 compared to the control. This rise is mainly explained by the supply of basic cations (Ca²⁺, Mg²⁺, K⁺, Na⁺) present in the manure, which displace H⁺ and Al³⁺ ions from exchange sites, thereby reducing acidity (Abagandura et al., 2023). In addition, the decomposition of organic matter releases carbonates and bicarbonates that further contribute to soil alkalization (Sári et al., 2023). These chemical processes enhance nutrient availability, particularly phosphorus, and support legume growth in acidic soils, highlighting the value of goat manure as an organic amendment in tropical systems (Ferreira et al., 2021)

Soil electrical conductivity (EC)

Data from Table 1 indicate that soil EC decreased from 18.00 μS cm⁻¹ in the control (0 g plant⁻¹) to 13.00 μS cm⁻¹ under the 300 g plant⁻¹ treatment, representing a reduction of 5.00 μS cm⁻¹. This decline reflects the role of goat manure in reducing soil salinity by enhancing ion balance and improving soil structure. Lower EC values mitigate osmotic stress, thereby facilitating water uptake and preventing growth inhibition in legumes (Chadha et al., 2025). Several studies have shown that organic amendments such as compost, manure, biochar, and gypsum can reduce soil salinity while improving nutrient cycling and microbial activity (Sári et al., 2023). In this context, soil EC is a critical indicator for assessing the suitability of soils for legume production (Garcia et al., 2019).

Soil organic carbon (SOC)

Application of 300 g plant⁻¹ of goat manure markedly increased SOC content to 16.14% compared with 1.60% in the control, representing a net gain of 14.54%. This improvement surpasses the increase of 12.4% reported in soybean systems by Zhang et al. (2024). The higher SOC reflects the input of organic matter from manure, which contributes to the stabilization of soil aggregates, enhances water-holding capacity, and promotes microbial activity (Abagandura et al., 2023). Beyond improving soil properties, SOC plays a central role in the carbon cycle and is a key driver of soil fertility and agroecosystem sustainability (Cardinael et al., 2022). These findings emphasize the potential of goat manure as an effective organic amendment for supporting the growth and productivity of *C. pubescens*.

Total soil nitrogen (TN)

Goat manure application increased total TN availability in the soil. At 300 g plant⁻¹, TN reached 0.84% compared with 0.15% in the control, representing an increase of 0.69%. This effect is attributed to the combined input of organic and mineral fractions from manure, which enhance nitrogen mineralization rates by 4.55–8.31 times relative to unfertilized soils (Wang et al., 2023). By enriching soil organic matter and improving nutrient turnover, manure application supports biological nitrogen fixation and enhances nutrient use efficiency, thereby promoting the growth of legumes such as (Ullah et al., 2023).

Table 1. Soil nutrient at the location.

No	Parameter	Manure fertilizer doses (300 g plant ⁻¹)	
		Before	After
1	Moisture content (%)	5.6	10.88
2	pH (H ₂ O)	6.78	8
3	Soil electrical conductivity (μS cm ⁻¹)	18	13
4	Organic carbon (%)	1.6	16.14
5	Total nitrogen (%)	0.15	0.84
6	C/N Ratio	10.67	19.21
7	Phosphorus (mg kg ⁻¹)	39	80

Table 2. Morphological of *C. pubescens* due to treatments.

Treatments		Leaf number	Plant length (cm)	Stem diameter (cm)	Number of branches	Leaf length (cm)	Leaf width (cm)
Goat manure fertilization doses (K)	Harvest ages (H)						
K1	H1	325 ^a	185 ^a	0.68	22.12 ^a	4.54	2.84
K1	H2	776 ^c	213 ^{bc}	0.86	33.81 ^b	6.17	3.91
K2	H1	597 ^b	192 ^b	0.91	31.75 ^b	6.22	3.97
K2	H2	1150 ^d	269 ^c	1.13	51.17 ^c	7.02	4.65
K		*	*	*	*	*	*
H		*	*	*	*	*	*
K*H		*	*	ns	*	ns	ns
CV (%)		16.11	7.93	2.17	10.54	6.85	7.19

Different letters (a, b, c,) in the same column and lines showed significant effects ($p < 0.05$), K1: 0 g plant⁻¹, K2 : 300 g plant⁻¹ H1 : 10 week, H2 : 12 week K*H : goat manure fertilization level and harvest ages.

Soil nitrogen/nitrogen (C/N) ratio

The C/N ratio is a key indicator of soil nutrient dynamics, reflecting the balance between organic carbon and nitrogen, which regulates organic matter decomposition and nitrogen availability (Ullah et al., 2023). At 300 g plant⁻¹, the C/N ratio increased to 19.21 compared with 10.67 in the control, representing a difference of 8.54. This higher ratio suggests greater carbon retention relative to nitrogen, contributing to improved soil fertility and supporting the growth of *C. pubescens* (Nworgu and Ajayi, 2005). A balanced C/N ratio also favors microbial activity and enhances the efficiency of biological nitrogen fixation (Bakacsi et al., 2020). Moreover, the combined application of manure and mineral fertilizers has been shown to further increase the C/N ratio and organic carbon reserves, both of which are essential for the long-term sustainability of legume-based systems (Abagandura et al., 2023).

Soil phosphorus

Soil phosphorus plays a central role in legume nutrition, being essential for root development, nodulation, and biological nitrogen fixation (FBN) (Ullah et al., 2023). Despite its importance, most soil P occurs in insoluble or organic forms, strongly adsorbed to mineral surfaces, which restricts plant uptake (Abagandura et al., 2023). Organic amendments, such as goat manure, can increase available P (up to 80 mg kg⁻¹), thereby improving growth and nutritional quality of crops (Ferreira et al., 2021). Phosphate fertilizers boost chickpea yields and nutritional content (Suwignyo et al., 2023). Legumes, like *C. pubescens*, mobilize phosphorus through their roots, increasing availability (Francis et al., 2023).

Morphological of *C. pubescens*

Table 2 shows that the application of goat manure at 300 g plant⁻¹ increased the growth of *C. pubescens* compared to the control (0 g plant⁻¹), particularly at 12 weeks. The highest mean values for number of leaves, plant length, stem diameter, number of branches, and leaf length and width were recorded at this treatment level. The interaction between fertilizer dose and harvest age indicated optimal responses at the highest dose and later harvest.

Number of leaves

As shown in Table 2, the application of goat manure and the harvest age significantly influenced leaf production, with the 300 g plant⁻¹ treatment showing the highest values at 10 and 12 weeks. The increase in leaf number is attributed to the improved nutrient supply and soil conditions provided by manure. In particular, potassium has been reported as an important factor in enhancing leaf development, consistent with other studies on goat manure (Haris et al., 2022). Overall, manure application improves soil quality, supports plant development, and results in a higher leaf count (Dahlin et al., 2021).

Table 3. The percentage of chemical composition of *C. pubescens*.

Treatments		Dry Matter	Organic Matter	Crude Protein	Ether Extract	Calcium	Phosphorus
Goat manure fertilization doses (K)	Harvest ages (H)						
K1	H1	22.15	88.02 ^b	16.28 ^a	1.43	1.10	0.39
K1	H2	22.43	88.17 ^b	17.43 ^b	1.32	0.87	0.36
K2	H1	21.99	89.55 ^b	16.74 ^{ab}	1.39	1.06	0.39
K2	H2	22.97	87.74 ^a	16.69 ^{ab}	1.47	0.90	0.39
K		ns	ns	ns	ns	ns	ns
H		ns	*	*	ns	*	ns
K *H		ns	*	*	ns	ns	ns
CV (%)		5.45	0.63	2.98	10.33	4.55	4.14

Different letters (a, b, c,) in the same column and lines showed significant effects ($p < 0.05$), K1 : 0 g plant⁻¹, K2 : 300 g plant⁻¹ H1 : 10 week, H2 : 12 week K*H: goat manure fertilization level and harvest ages

Moreover, the significant interaction between fertilizer dose and harvest age indicates that longer harvest periods exert a stronger effect on leaf production in plants receiving higher manure doses.

Plant length

Plant length was significantly influenced by both fertilizer treatment and harvest age, with a clear interaction between the two factors (Table 2). The highest value, 269 cm, was recorded under the 300 g plant⁻¹ treatment at 12 weeks. This response is attributed to the nutrient supply provided by goat manure, which enhances soil fertility by increasing soil organic carbon, nitrogen, phosphorus, and potassium (Tian et al., 2025). Consistent evidence indicates that manure application improves soil fertility and crop performance, contributing to greater plant length (Francis et al., 2023). The interaction effect further suggests that extended harvest age exerts a stronger influence on plant length in plants receiving higher manure doses. Determining the optimal harvest time is therefore essential to maximize plant length and nutrient content (Dahlin et al., 2021).

Stem diameter

Stem diameter was significantly affected by both fertilizer treatment and harvest age, with an interaction observed between the two factors (Table 2). The largest value (1.13 cm) was recorded under the 300 g plant⁻¹ treatment at 12 weeks. This increase may reflect tissue accumulation during the vegetative phase, supported by the nutrient supply from manure. Enhanced cambial cell division and differentiation likely contributed to stem thickening, as manure nutrients stimulate hormonal activity, including auxins and cytokinins, which promote cambial activity and cell formation (Francis et al., 2023). Previous studies have also reported that goat manure application substantially increases stem diameter (Tian et al., 2025). The interaction between manure dosage and harvest age indicates that optimal stem diameter is achieved when adequate fertilization is combined with an appropriate harvest time, as similarly reported for lempoyang (Munawar and Shahari, 2019).

Number of branches

Branch number was significantly influenced by both fertilizer dose and harvest age, with a strong interaction observed between the two factors (Table 2). The highest value (51.2) was recorded under the 300 g plant⁻¹ treatment at 12 weeks. Branch number increased progressively with higher manure application and longer harvest age. The interaction indicates that manure supply enhances the positive effect of extended growth periods on branching. Goat manure improves soil structure and stimulates biological activity, thereby supporting plant development (Munawar and Shahari, 2019). Previous studies have shown similar effects, reporting increased bud initiation and branching in species such as *Cosmos sulphureus* under organic fertilization (Saleh et al., 2024). While harvest age extension favors new branch emergence, the branching response appears to depend primarily on nutrient availability rather than age alone (Dahlin et al., 2021).

Leaf length

Leaf length was significantly affected by both manure application and harvest age (Table 2). The maximum value (7.02 cm) was observed at 300 g plant⁻¹ and 12 weeks, compared to 4.54 cm under 100 g plant⁻¹ at 10 weeks. The increase in leaf length reflects the plant's response to nutrient supply, as organic amendments improve morphophysiological traits that indirectly stimulate leaf expansion (Tian et al., 2025). Goat manure provides a balanced source of nutrients, while organic fertilizers in general have been shown to enhance leaf elongation (Bharathy et al., 2024). The interaction between fertilizer dose and harvest age approached significance, suggesting a potential synergistic effect. Such synergy between organic inputs and growth duration may optimize leaf length by sustaining leaf health and delaying senescence (Zhang et al., 2024).

Leaf width

Leaf width was significantly affected by both manure application and harvest age, with each factor exerting an independent influence (Table 2). The widest leaves (12 weeks, 300 g plant⁻¹) were associated with nutrient accumulation and enhanced

Table 4. Forage production of *C. pubescens*.

Treatments		Fresh Weight (t ha ⁻¹)	Dry Matter	Organic Matter	Crude Protein
Goat manure fertilization doses (K)	Harvest ages (H)				
K1	H1	4.34 ^a	0.94 ^a	3.82 ^a	0.70 ^a
K1	H2	7.81 ^{ab}	1.76 ^{ab}	6.89 ^{ab}	1.36 ^{ab}
K2	H1	4.99 ^a	1.08 ^a	4.46 ^a	0.84 ^a
K2	H2	12.63 ^b	2.88 ^b	11.10 ^b	2.08 ^b
K		ns	ns	ns	ns
H		*	*	*	*
K*H		*	*	*	*
CV (%)		49.24	48.63	49.18	47.10

Different letters (a, b, c) in the same column and lines showed significant effects ($p < 0.05$), K1 : 0 g plant⁻¹, K2 : 300 g plant⁻¹ H1 : 10 week, H2 : 12 week K*H: goat manure fertilization level and harvest ages.

cell division during the vegetative phase. Previous studies confirm that goat manure improves vegetative growth and leaf expansion across different plant species (Bharathy et al., 2024). Similarly, longer harvest durations increased leaf width due to higher growth rates and sustained elongation (Tian et al., 2025). However, no interaction between manure dose and harvest age was detected, indicating that these factors act independently in influencing leaf width.

Chemical composition of *C. pubescens*

The chemical composition of *C. pubescens* was significantly influenced by both manure application and harvest age (Table 3). At 12 weeks, crude protein concentration increased, whereas calcium content declined. The application of 300 g plant⁻¹ of goat manure also enhanced organic matter and ether extract, suggesting that nutrient inputs from organic sources shape the chemical profile of the forage. These shifts highlight the complex interactions between organic fertilization and plant physiological responses, with potential implications for optimizing fertilization strategies and improving forage quality.

Dry matter

Table 3 shows that goat manure dose and harvest age had no significant effect on dry matter content. Values ranged from 21.9% to 22.9%, which are lower than those previously reported for *C. pubescens* (26.36%; Prihandini et al., 2024) and for plants cultivated on peatlands (24.3%; Ali et al., 2013). In comparison, *Centrosema bundey* treated with goat manure exhibited dry matter contents between 27.30% and 31.71% (Haris et al., 2022). The absence of a significant interaction between manure application and harvest age suggests that both factors influenced dry matter content independently.

Organic matter

Table 3 shows that goat manure dose had no significant effect on organic matter content ($p > 0.05$). Values ranged from 87.7% to 89.6% across treatments, which are lower than those previously reported for *C. pubescens* (90.67%; Prihandini et al., 2024). In comparison, *Centrosema bundey* treated with goat manure showed organic matter contents between 92.22% and 93.35% (Haris et al., 2022). A significant interaction between manure dose and harvest age was detected, indicating that both factors influence organic matter. The combined effect of adequate manure application and optimal harvest timing can enhance growth, yield, and nutritional quality of *C. pubescens* (Harwanto et al., 2025).

Crude protein

Table 3 shows that goat manure dose and harvest age had no significant effect on crude protein, with values ranging from 16.3% to 17.4% across treatments. These results are lower than the 18.02% reported for *C. pubescens* (Prihandini et al., 2024), and within the range of 14.77–18.97% observed in two seasons by Nworgu and Ajayi (2005). Plants fertilized with NPK showed higher crude protein levels (18.04 – 19.32% ; Harwanto et al., 2025), while other studies reported values up to 22.0% (Nworgu and Fasogbon, 2007). In *Centrosema bundey*, goat manure application resulted in 13.41–16.98% crude protein (Haris et al., 2022). A significant interaction was observed between manure dose and harvest age, suggesting that appropriate fertilization combined with optimal harvest timing can increase crude protein concentration in *C. pubescens* (Harwanto et al., 2025).

Ether extract

According to Table 3, manure dose and harvest age did not significantly affect ether extract ($p > 0.05$). Yields ranged between 1.32% and 1.47%, which are lower than those previously reported for *C. pubescens* (4.42 – 4.98% ; Nworgu and Ajayi 2005). No significant interaction between fertilization and harvest age was detected, indicating that both factors independently influenced ether extract levels.

Calcium

Table 3 indicates that goat manure dose had no significant effect on calcium content, whereas harvest age showed a substantial influence. Calcium ranged from 0.87% to 1.10%, slightly higher than values reported for *C. pubescens* across two seasons (0.91 – 0.98% ; Nworgu and Ajayi 2005). The absence of a significant interaction between fertilization and harvest age suggests that both factors acted independently in determining calcium concentration.

Phosphorus

Table 3 shows that goat manure dose and harvest age did not significantly influence phosphorus content, although harvest timing alone had a noticeable effect. Values ranged from 0.36% to 0.39%, which are slightly higher than those previously reported for *C. pubescens* (0.34 - 0.37% ; Nworgu and Ajayi, 2005). No interaction was observed between manure dose and harvest age, confirming that these factors acted independently.

Forage production of *C. pubescens*

Table 4 shows that goat manure fertilization (0 vs. 300 g plant⁻¹) and harvest age (10 vs. 12 weeks) affected *C. pubescens* productivity, particularly in dry weight, green weight, organic matter, and crude protein. The highest productivity was obtained at 12 weeks with 300 g plant⁻¹, reaching 12.6 t ha⁻¹ dry weight and 2.08 t ha⁻¹ crude protein. A significant interaction was detected between manure dose and harvest age ($p < 0.05$), whereas the main effect of manure dose alone was not significant.

Fresh and dry matter biomass

According to Table 4, biomass yield was influenced by harvest age and manure application. The highest value (12.6 t ha⁻¹) was obtained at 300 g plant⁻¹ after 12 weeks, exceeding the 9.56 t ha⁻¹ reported under NPK fertilization (Harwanto et al., 2025). Goat manure alone did not significantly affect biomass, but its effect increased with plant age, consistent with patterns described for the age–biomass relationship (Saleh et al., 2024; Seeiso and Materechera, 2012). Dry matter increased substantially with harvest age, ranging from 0.94 to 2.89 t ha⁻¹ across treatments, surpassing some reported values (Harwanto et al., 2025) and approaching the 3–7.5 t ha⁻¹ range described by Nworgu and Ajayi (2005). The significant interaction between fertilization and harvest age indicates that goat manure is more effective at 12 weeks in enhancing dry matter production.

Organic matter biomass

Organic matter biomass was mainly influenced by harvest age (Table 4). Production increased from 3.82 t ha⁻¹ (0 g plant⁻¹, 10 weeks) to 11.1 t ha⁻¹ at later harvests. The higher production at 12 weeks can be attributed to the accumulation of lignocellulosic components in plant tissues. While the manure dose alone had no significant effect, a significant interaction with harvest age suggests that the effectiveness of goat manure in increasing organic matter biomass depends on harvest timing (Suhartanto et al., 2020).

Crude protein weight biomass

Table 4 shows that crude protein biomass increased with harvest age, although manure dose alone was not significant. The combined treatment of 300 g plant⁻¹ and 12-week harvest yielded the highest crude protein biomass (2.08 t ha⁻¹). This indicates that goat manure contributes to protein accumulation when combined with adequate harvest timing. Protein yield is influenced by plant lifespan, nutrient availability, and environmental conditions (Ali et al., 2013). The interaction between dose and age highlights that extending harvest time is essential to maximize the effect of goat manure on protein biomass.

Materials and Methods

Study and experimental design

The experiment was conducted from March to June 2025 in Kembang Village, Nanggulan District, Kulon Progo Regency, Yogyakarta Province. A factorial experiment arranged in a completely randomized design (CRD) was used with two factors: goat manure dose (0 and 300 g plant⁻¹) and harvest age (10 and 12 weeks after planting, WAP). This generated four treatments (2×2), each with four replicates (16 experimental units). Each experimental unit comprised 4 plants (total 64 plants). Plant spacing was 1.00 m × 0.50 m.

Agroclimatic conditions

The secondary data set included humidity and temperature measurements collected at the Kembang Village site in Nanggulan District, Kulon Progo Regency, Yogyakarta Province. These data were obtained from the Meteorology, Climatology, and Geophysics Agency Geophysics Station (Indonesian Meteorological Climatological and Geophysical Agency, 2025). The regency is situated between 7° 38' 42" and 7° 59' 3" south latitude, and 110° 1' 37" and 110° 16' 26" east longitude.

Planting preparations of *C. pubescens*

Goat manure was collected from a local farm in Nanggulan (Kulon Progo), and *C. pubescens* seeds were obtained from the Forage Laboratory of Animal Feed and Pasture, Universitas Gadjah Mada. Prior to sowing, seeds were immersed in water, and only those that sank were selected for germination. The selected seeds were raised in a nursery for four weeks before transplanting. Seedlings were transplanted to the field at a spacing of 1.00 m × 0.50 m, with planting holes of 10 cm depth.

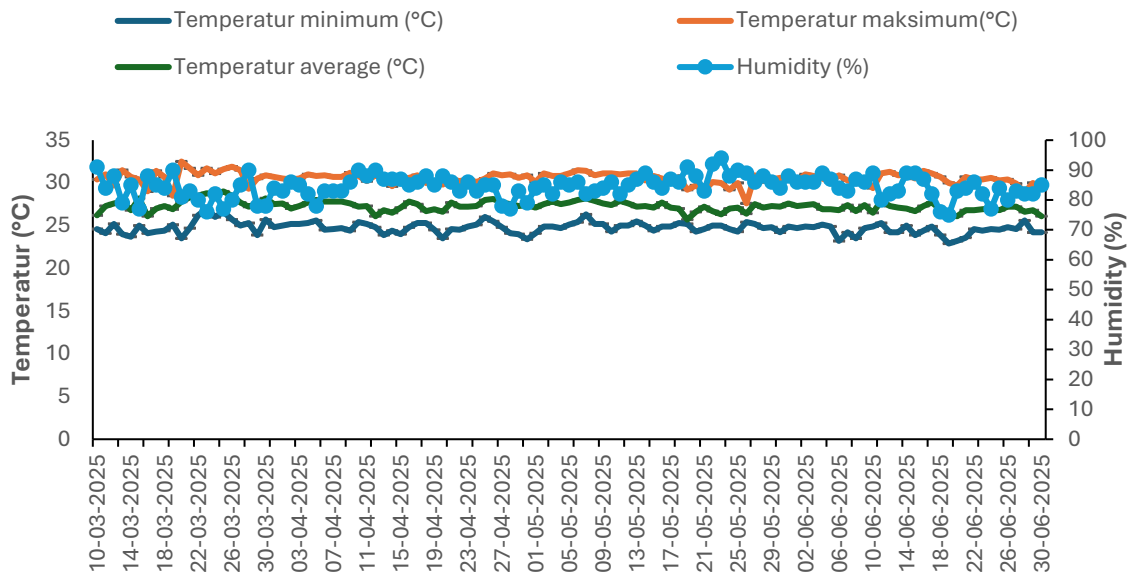


Figure 1. Temperature and humidity conditions at the location.



Figure 2. Growth of *C. pubescens* in on-site experiments.

Fertilization

Two goat manure treatments were evaluated : 0 and 300 g plant⁻¹. The manure was applied as a basal dressing, evenly distributed around each plant, once a week for seven consecutive weeks after planting.

Soil nutrient analysis

Soil samples were collected at the experimental site before planting and after fertilization, at a depth of 0–20 cm, from plots corresponding to both fertilizer treatments (0 and 300 g plant⁻¹). Composite samples were prepared from five subsamples per plot. The following parameters were analyzed : soil moisture content (%), pH (H₂O), electrical conductivity (μS cm⁻¹), organic carbon (%), total nitrogen (%), C/N ratio, and available phosphorus (mg kg⁻¹). Standard methods were employed for each analysis (Walkley–Black for organic C, Kjeldahl for total N, and Bray I for available P) (Najdenko et al., 2024).

Observation of morphology

Plant morphology measurement are taken weekly. All plants were observed and recorded systematically. Parameter observations included length, diameter, width, length of leaves, number of branches, and leaves.

Forage production analysis

Forage weight at harvest (g plant⁻¹) is converted into tons/ha, then multiplied by the percentage of dry matter. Production (dry matter, organic matter, and crude protein) is calculated by multiplying the percentage of its content by the production of fresh weight. Biomass products are determined by converting fresh weight to ton DM ha⁻¹ (Astuti et al., 2020).

Chemical analysis

Chemical composition analyses were performed on samples of *C. pubescens*. The parameters included dry matter, organic matter, crude protein, and ether extract (AOAC, 2012).

Statistical analysis

The treatment's effect was analyzed with RStudio (Rathod and Kumar, 2023) version 2024.12.0+467 (RStudio : Integrated Development for R. Posit PBC, Boston, MA) and the "agricolae" module from the CRAN package (R Core Team, 2022). Subsequent analyses employed Duncan's new multiple range test (DMRT) to identify additional significant results.

Conclusions

The application of goat manure and the harvest age have shown favorable change in the chemical composition of *C. pubescens*. The 300 g plant⁻¹ over 12 weeks has shown to enhance soil nutrients, productivity, and nutritional quality. Future research implications could test different and more extensive doses of organic fertilizer, different harvest intervals, or long-term field trials

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