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Comparative Analysis of Growth and Yield Response of *Cucumis sativus* to Leguminous Prunings (*Gliricidia sepium* and *Leucaena leucocephala*) and Poultry Manure Amendments

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Research Article

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Abstract

Declining soil fertility and heavy dependence on inorganic fertilizers continue to limit cucumber (*Cucumis sativus* L.) productivity in smallholder tropical systems, increasing interest in organic amendments such as poultry manure and leguminous prunings as sustainable alternatives. This study compared the effects of *Gliricidia sepium* and *Leucaena leucocephala* prunings, poultry manure, and their combinations on cucumber growth and yield under field conditions in Mampong, Ashanti Region, Ghana. Using a Randomized Complete Block Design with four replications, seven treatments; sole *Gliricidia*, sole *Leucaena*, sole poultry manure, three paired combinations, and an unamended control—were evaluated for vine length, leaf number, chlorophyll content, and yield traits (fruit length, girth, and weight), with data analysed by ANOVA and LSD separation at $p \leq 0.05$. Chlorophyll content and leaf number did not differ significantly among treatments, but plant height and all yield indicators were significantly affected. Poultry manure consistently produced the tallest plants and heaviest fruits (177.54 g), while *Leucaena* combined with poultry manure gave the greatest fruit length (16.45 cm); sole *Gliricidia* performed poorest across all yield traits. These findings indicate that poultry manure, alone or combined with *Leucaena* prunings, is the most effective organic amendment for enhancing cucumber growth and yield, whereas sole *Gliricidia* application offers limited agronomic benefit.

1. Introduction

Cucumber (*Cucumis sativus* L.) is an important vegetable crop in many tropical and subtropical farming systems because of its dietary value and rising cultivation demand [1]. However, cucumber productivity is often constrained by declining soil fertility, continuous cultivation, and weak nutrient-management practices, especially in smallholder production environments [1–3]. Reliance on inorganic fertilizers alone has also proved insufficient for long-term productivity because it is associated with high cost, nutrient imbalance, soil acidity, and progressive soil degradation under intensive agriculture [3, 4]. These constraints have intensified interest in organic nutrient sources that can support crop growth while improving soil quality and reducing fertilizer dependence [4, 5].

Among organic amendments, poultry manure has consistently shown strong potential for cucumber production because it supplies nutrients, improves soil fertility, and often produces better vegetative growth and yield than competing nutrient sources [1, 3, 6]. In field cucumber studies, poultry manure increased vine length, leaf production, fruit weight, and total yield, and in some cases outperformed NPK fertilizer and other organic materials [6, 7]. Recent field evidence in Ghana similarly found that 10 t ha^{-1} poultry manure produced the longest vines, the highest number of leaves, and the greatest total fruit weight and yield in cucumber [5]. Poultry manure can also improve soil organic matter, total nitrogen, available phosphorus, potassium, aggregate stability, and hydraulic conductivity, indicating benefits that extend beyond immediate crop response [1, 8].

Its agronomic effect, however, depends not only on nutrient content but also on timing and release pattern. Nitrogen from poultry manure is released gradually through mineralization and may not always

match peak crop demand when used alone [1, 9]. In cucumber, earlier poultry-manure application improved vegetative growth and yield more than delayed application, with manure applied at two weeks after planting producing the highest values for leaf number, fruit length, fruit weight, and total yield per plant [2]. Studies on integrated nutrient management further show that combining poultry manure with mineral nitrogen can improve nutrient synchronization, soil fertility, crop growth, yield, and postharvest quality relative to sole applications [1]. More broadly, long-term manure research shows that manure effects can persist well beyond the application period, that nutrient mineralization is shaped by temperature, and that crop nutrient recovery is greater under adequate moisture supply [10, 11].

Alongside animal manures, leguminous prunings have emerged as promising organic inputs because they contribute biomass, biologically fixed nitrogen, and improvements in soil physical and chemical quality [12, 13]. Leguminous green manures can raise soil available nitrogen and phosphorus, increase microbial and labile organic matter pools, and maintain yield even when mineral fertilizer use is reduced [4, 14]. They also tend to improve nitrogen- and phosphorus-use efficiency by increasing crop nutrient uptake and preserving nutrients within the soil–plant system [12]. In longer-term soil processes, leguminous green manure expands both labile and protected soil organic nitrogen pools, enhances soil organic nitrogen retention, and supports greater plant nitrogen uptake than systems relying only on inorganic fertilizer [13, 14]. Complementary evidence from crop-rotation research also indicates that systems with legume inclusion and more diverse residue inputs improve soil nitrogen cycling, particulate organic matter pools, and crop productivity relative to simplified systems [15].

Gliricidia sepium is one of the most widely studied agroforestry legumes for soil improvement. Its leaves and prunings have been reported to enhance soil carbon, nitrogen, phosphorus availability, cation exchange capacity, pH, and soil organic matter across farming systems [15]. Its residues decompose rapidly, release potassium quickly, and have a low carbon-to-nitrogen ratio, features that can favour short-term nutrient supply to crops [15]. Field evidence also indicates that *Gliricidia* green manure can reduce soil bulk density, increase porosity and water retention, and improve vegetable yield, and across other crops it has improved soil fertility and crop performance in maize, ginger, carrot, soybean, and degraded-coconut systems, although rapid decomposition may limit long-term organic matter build-up if biomass inputs are not sustained [15]. *Leucaena leucocephala* has likewise shown strong soil-restorative potential. Incorporated *Leucaena* biomass increased total porosity and soil moisture content in maize systems and produced the highest maize yield among the hedgerow species compared in one recent field study [16]. In degraded mined soils, *Leucaena* also produced the largest gains in soil organic carbon and total nitrogen over time, supporting its value as a fertility-restoration species [17]. Reviews of residue quality further suggest that both *Leucaena leucocephala* and *Gliricidia sepium* can improve soil fertility in the short term through decomposition-driven nutrient release [15].

Despite growing evidence for both poultry manure and legume-derived biomass, direct side-by-side comparisons in cucumber remain limited. Much of the cucumber literature has examined poultry manure alone, its rate, its timing, or its integration with mineral fertilizer rather than its comparative performance against specific leguminous pruning materials [2, 7]. Likewise, although *Gliricidia* and *Leucaena* are well

documented as soil-improving biomass sources in other crops, a recent review specifically identifies the need for further work on crops beyond maize [15]. A recent Ghana cucumber study begins to fill this gap by showing that poultry manure and legume tree prunings both improve cucumber growth and yield, but that responses differ by amendment source and combination: sole poultry manure maximized overall yield, whereas *Leucaena* plus poultry manure enhanced fruit size and length [5].

Against this background, the present study compares the effects of prunings from *Gliricidia sepium* and *Leucaena leucocephala* with poultry manure on the growth and yield of cucumber under field conditions. The study is premised on the view that amendment performance depends on nutrient composition, decomposition pattern, and soil-improving effects, and that a direct comparison is needed to identify the most effective organic option for sustainable cucumber production. Accordingly, the following hypotheses were tested:

H ^{01}: There is no significant difference in the growth performance of cucumber (*Cucumis sativus* L.) when amended with poultry manure, *Gliricidia sepium* prunings, *Leucaena leucocephala* prunings, or their combinations under field conditions.

H ^{02}: There is no significant difference in the yield of cucumber (*Cucumis sativus* L.) when amended with poultry manure, *Gliricidia sepium* prunings, *Leucaena leucocephala* prunings, or their combinations under field conditions.

2. Materials and Methods

2.1. Study Site

The study was conducted on the school farm of the University of Skills Training and Entrepreneurial Development (USTED), Mampong Campus, in the Ashanti Region of Ghana. The experimental plots were established within the central part of the university's coconut plantation, where the canopy provided a semi-shaded environment that helped moderate microclimatic conditions such as temperature and relative humidity. This choice was appropriate because agroforestry systems are known to buffer climatic extremes, create more favourable crop microclimates, and enhance system resilience through tree cover [18, 19].

The Mampong area experiences a tropical wet-semi-equatorial climate characterized by a bimodal rainfall pattern. The major rainy season typically occurs between March and July, while the minor season spans September to November, with an annual rainfall range of 1200–1500 mm. Average daily temperatures range between 21°C and 32°C, with relative humidity often exceeding 70% during the wet season. These conditions are favourable for cucumber growth, as adequate rainfall and moderate temperatures support vegetative development, while supplementary irrigation ensures soil moisture stability during dry spells [20]. Conducting the trial in this agroforestry setting, under the prevailing

rainfall and temperature regime, generated findings that are both scientifically robust and directly relevant to smallholder farmers operating under similar tropical soil-fertility and climatic constraints [21].

2.2. Experimental Design and Treatments

2.2.1. Experimental Design

The experiment was laid out in a Randomized Complete Block Design (RCBD) with four replications. RCBD was chosen because it effectively controls field variability by grouping experimental units into homogeneous blocks, thereby minimizing the influence of soil fertility gradients and other environmental factors on treatment performance [22, 23]. This design is widely recommended in agronomic trials as it reduces bias and increases the reliability of treatment comparisons [24].

2.2.2. Treatments

Seven treatments were applied to evaluate the comparative effects of poultry manure and leguminous prunings on cucumber (*Cucumis sativus* L.) growth and yield, as follows: T1, *Gliricidia sepium* prunings (5 kg per plot); T2, *Leucaena leucocephala* prunings (5 kg per plot); T3, poultry manure (5 kg per plot); T4, *Gliricidia sepium* (2.5 kg) + poultry manure (2.5 kg); T5, *Leucaena leucocephala* (2.5 kg) + poultry manure (2.5 kg); T6, *Gliricidia sepium* (2.5 kg) + *Leucaena leucocephala* (2.5 kg); and T7, an unamended control.

The treatment rates were selected based on previous studies demonstrating the effectiveness of poultry manure in enhancing cucumber growth and yield [5, 6], as well as the soil fertility benefits of *Gliricidia* and *Leucaena* prunings in tropical agroecosystems [15, 17]. Combining poultry manure with leguminous prunings was intended to test whether integrated organic inputs could improve nutrient synchronization, soil fertility, and crop performance beyond sole applications [1].

2.3. Seed Material

The Technisem F1 hybrid cucumber variety was selected as the test crop for this study. Certified seed was purchased from Agriseed, a certified seed distributor in Ghana, ensuring that the planting materials were both viable and genetically pure. The use of certified hybrid seed is critical in agronomic experiments because it guarantees uniformity, reduces genetic variability, and enhances the reliability of experimental outcomes [25]. Technisem hybrid cucumber varieties are widely recognized for their high germination rate, vigorous growth, and adaptability to tropical conditions, making them suitable for field trials in Ghanaian agro-ecological zones [26]. Hybrid cucumber varieties such as this also tend to exhibit superior yield potential, disease resistance, and fruit quality compared with open-pollinated varieties, thereby providing dependable results for comparative studies on soil amendments and nutrient management.

2.4. Preparation of Amendments

2.4.1. Leguminous Prunings

Fresh leaves and fragile stems of *Gliricidia sepium* and *Leucaena leucocephala* were harvested from mature, healthy trees at the USTED Experimental Farm in Asante Mampong. Sampling was performed during the early morning hours (06:00–08:00) to limit diurnal shifts in secondary metabolites. Plant materials were removed from branches, packed in breathable bags, and immediately transported to avert decay. To preserve bioactive compounds, the plucked leaves and delicate stems were air-dried for two weeks at room temperature. After drying, the materials were pulverised into fine powder using a mechanical grinder and stored in airtight containers until incorporation into the soil.

2.4.2. Poultry Manure

Poultry droppings were sourced from Agyingo Poultry Farm at Daaho. The fresh droppings were collected, packed, and transported to the experimental site. Before application, the manure was air-dried under shade to reduce moisture content and minimize ammonia loss, following standard agronomic practice [27, 28]. After drying, the manure was weighed according to treatment requirements (5 kg per plot, or 2.5 kg when combined with leguminous prunings). The measured quantities were thoroughly incorporated into the soil using hoes and hand rakes to ensure uniform mixing. Incorporation was carried out two weeks before planting to allow partial decomposition and nutrient mineralization, synchronizing nutrient release with cucumber growth stages [29, 30]. Plots were watered immediately after incorporation to activate microbial activity and enhance nutrient availability.

2.5. Land Preparation and Planting

The land was prepared manually using hoes and cutlasses to ensure proper soil loosening and weed removal. Each plot measured 2.0 m × 2.5 m (5.0 m^2), and the plots were arranged into four replications, with 1 m left between replicates to minimize interference. In total, seven plots per replicate were established, giving 28 plots across the experiment. Four days after land preparation, the designated treatments were applied, thoroughly mixed into the soil by hand and rake, watered, and left to decompose for two weeks before planting to allow partial mineralization and improve synchronization with cucumber growth stages. Cucumber seeds (*Cucumis sativus* L., Technisem F1) were then planted directly into the prepared plots at a spacing of 0.4 m × 0.5 m. Two seeds were sown per hole, and after two weeks of germination seedlings were thinned to one plant per stand to maintain uniform plant density and reduce competition.

2.6. Cultural and Management Practices

Weed control was carried out manually using hoes, cutlasses, and hand-picking whenever weeds appeared, with *Cyperus rotundus* being the most common species observed. Because rainfall was irregular, supplementary irrigation was provided using watering cans twice daily (morning and evening), with each plot receiving approximately 5–10 L per day (1–2 L m^{-2} day^{-1}), consistent with recommended cucumber water requirements of 10–20 L m^{-2} per week [31]. Consistent irrigation was essential given the shallow root system and high-water demand of cucumber, supporting leaf expansion, nutrient uptake, and fruit quality, since irregular watering or prolonged deficits could reduce fruit set and marketable yield through stress-induced accumulation of cucurbitacins [32]. The field was visited

regularly to monitor pest and disease incidence, with appropriate control measures applied where necessary. By the fourth week after sowing, cucumber vines required support to grow upright, and staking was introduced using the anchor, string, and single-stake methods, which improved light interception, air circulation, and pollination efficiency while reducing risks of fungal infection such as powdery mildew and enhancing fruit uniformity, cleanliness, and ease of harvesting, consistent with previous reports that staked cucumbers produce higher yields and better-quality fruit than unstaked plants [31, 33].

2.7. Data Collection

Five plants per plot were randomly selected and tagged from the three central rows to avoid border effects. These plants were consistently used for recording phenological, growth, and yield parameters, following the sampling approach recommended in cucumber field trials [34].

2.7.1. Growth Parameters

Vine length

Plant height was measured weekly, starting two weeks after sowing (WAS), using a manual meter rule placed vertically at the base of each tagged plant to record the distance from the soil surface to the tip of the main vine; the mean vine length per plot was then calculated, following procedures widely applied in cucumber growth studies [35, 36].

Number of leaves

The total number of fully expanded leaves on each tagged plant was counted weekly by manual inspection and averaged per plot, a standard indicator of vegetative growth used in cucumber experiments to assess treatment effects [37].

Chlorophyll content: Leaf chlorophyll content was measured biweekly using a portable SPAD chlorophyll meter, clipped onto the midpoint of the third fully expanded leaf from the apex of each tagged plant, with three readings per leaf averaged. Measurements were conducted between 08:00 and 10:00, when stomata are open and leaf water status is stable, reducing variability from midday heat stress, diurnal fluctuations in photosynthetic activity, and evening declines in chlorophyll fluorescence; morning readings are reported to be more reliable and consistent, reflecting true physiological status without interference from transient stress factors [38, 39].

2.7.2. Yield Parameters

Fruit length

Measured from the stem end to the blossom end of each fruit from the tagged plants using a tape measure, with mean values computed per plot, following methods validated in cucumber yield studies [40].

Fruit girth

Fruit diameter was measured at the widest point of each fruit using a manual vernier calliper, with readings averaged per plot [41].

Average fruit weight per plant

Fruits harvested from tagged plants were weighed individually on a digital scale (0.01 g precision), summed, and divided by the number of plants to obtain the average fruit weight per plant, consistent with cucumber yield evaluation protocols [42].

2.8. Statistical Analysis

All experimental data were analysed using R statistical software. Descriptive statistics (means) were computed for all growth and yield parameters. Inferential statistics were performed using analysis of variance (ANOVA) under the RCBD framework to test treatment effects at each sampling interval. Where ANOVA indicated significant differences, treatment means were separated using the Least Significant Difference (LSD) test at a 5% significance level ($p \leq 0.05$).

3. Results

3.1. Chlorophyll Content

Mean chlorophyll content across treatments and sampling dates is presented in Table 1 and Fig. 1. At 14 days after planting (DAP), chlorophyll content was highest overall, ranging from 46.66 SPAD units (control) to 50.35 (LL treatment); GS (50.15), LL + PM (50.27) and PM (49.62) also recorded relatively high values. Chlorophyll content then declined progressively with plant age at each subsequent sampling date, reaching its lowest values by 56 DAP (36.98–42.03 SPAD units). Treatments involving poultry manure (PM, GS + PM, LL + PM) tended to retain relatively higher chlorophyll levels at later growth stages than sole GS or the control, although GS also maintained comparatively high early values.

Analysis of variance (Table 2) showed that treatment effects on chlorophyll content were not statistically significant at any sampling date (14 DAP: $F = 2.11$, $p = 0.103$; 28 DAP: $F = 1.57$, $p = 0.212$; 42 DAP: $F = 1.51$, $p = 0.231$; 56 DAP: $F = 1.22$, $p = 0.340$), indicating that the type of organic amendment did not significantly influence leaf chlorophyll concentration under the conditions of this study.

Table 1
Mean chlorophyll content (SPAD units) of cucumber leaves under different organic amendments at 14, 28, 42 and 56 days after planting (DAP).

Treatment	14 DAP	28 DAP	42 DAP	56 DAP
GS	50.15	47.58	40.45	36.98
LL	50.35	47.33	42.84	41.23
PM	49.62	45.68	43.13	40.39
GS + LL	48.83	44.74	42.95	37.13
GS + PM	47.91	45.76	44.32	42.03
LL + PM	50.27	46.13	42.82	41.69
Control	46.66	44.98	44.14	40.17

Table 2
Analysis of variance (F- and p-values) for chlorophyll content, number of leaves and plant height of cucumber under different organic amendments at 14, 28, 42 and 56 days after planting.

Growth parameter	14 DAP	28 DAP	42 DAP	56 DAP
Chlorophyll content (F)	2.11	1.57	1.51	1.22
Chlorophyll content (p)	0.103	0.212	0.231	0.340
Number of leaves (F)	1.09	1.14	1.63	1.72
Number of leaves (p)	0.405	0.380	0.197	0.175
Plant height (F)	11.75	5.34	3.15	5.26
Plant height (p)	0.000	0.003	0.027	0.003

3.2. Number of Leaves

The mean number of leaves per plant increased from 14 to 42 DAP across all treatments before declining slightly by 56 DAP, reflecting natural leaf senescence in the later reproductive stage (Table 3; Fig. 2). Notably, plants under the unamended control produced more leaves than the sole GS, sole LL, and GS + LL treatments across all sampling dates, and from 28 DAP onward the control also exceeded GS + PM and LL + PM. Poultry manure alone (PM) recorded the highest leaf numbers overall, reaching 38.60 at 42 DAP. This pattern, in which vegetative leaf proliferation did not consistently track amendment type, is broadly consistent with wider evidence that maize and other cereal crops show variable, resource-specific vegetative responses to organic and inorganic soil-fertility amendments, including less commonly used organic materials, such that greater biomass input does not always translate into proportionally greater vegetative growth [43, 44].

The ANOVA (Table 2) confirmed that these differences among treatments were not statistically significant at any sampling date (14 DAP: p = 0.405; 28 DAP: p = 0.380; 42 DAP: p = 0.197; 56 DAP: p = 0.175), indicating that leaf number was comparatively insensitive to the organic amendments tested, in agreement with the broader observation that not all organic and inorganic soil-fertility inputs translate into statistically detectable gains in crop vegetative parameters [43].

Table 3
Mean number of leaves per cucumber plant under different organic amendments at 14, 28, 42 and 56 days after planting (DAP).

Treatment	14 DAP	28 DAP	42 DAP	56 DAP
Control	4.425	7.750	31.100	27.925
GS	3.850	6.100	15.050	13.275
GS + LL	4.100	6.400	21.650	19.325
GS + PM	4.450	7.350	28.325	25.550
LL	3.850	7.250	26.650	24.400
LL + PM	9.250	7.450	27.350	24.500
PM	5.150	9.400	38.600	35.480

3.3. Plant Height

Unlike chlorophyll content and leaf number, cucumber plant height differed significantly among treatments at every sampling date (Table 2; 14 DAP: F = 11.75, p < 0.001; 28 DAP: F = 5.34, p = 0.003; 42 DAP: F = 3.15, p = 0.027; 56 DAP: F = 5.26, p = 0.003). At 14 DAP, poultry manure (PM) produced the tallest plants (14.945 cm), significantly exceeding all other treatments, while LL + PM (12.280 cm) and GS + PM (11.750 cm) formed an intermediate group and GS, LL, GS + LL and the control did not differ significantly from one another (Table 4). This early divergence points to the more rapid nutrient release of poultry manure relative to the sole leguminous prunings, consistent with reports that *Leucaena* tends to produce a stronger early growth response than *Gliricidia* when the two residues are compared directly under similar decomposition conditions [45].

By 28 DAP, PM remained tallest (36.220 cm), with LL + PM (29.305 cm) showing strong growth, while GS + PM and GS + LL occupied intermediate positions and GS, LL and the control remained lowest. At 42 and 56 DAP, the superiority of PM became more pronounced, reaching 103.69 and 115.71 cm, respectively, with LL + PM and GS + PM consistently following and significantly exceeding sole GS (53.00–53.96 cm) and sole LL (61.04–63.19 cm). The consistently greater height increment observed under LL + PM relative to GS + PM at later stages is in line with earlier comparisons reporting a stronger height response to *Leucaena* than to *Gliricidia* residues [45]. Overall, these results indicate that poultry manure was the most effective single amendment for promoting cucumber vine elongation, and that its

integration with either leguminous species further enhanced growth relative to the sole leguminous prunings.

Table 4
Mean plant height (cm) of cucumber under different organic amendments at 14, 28, 42 and 56 days after planting (DAP). Means within a column followed by the same letter are not significantly different at $p \leq 0.05$ (LSD test).

Treatment	14 DAP	28 DAP	42 DAP	56 DAP
GS	8.105 c	16.840 cd	53.00 d	53.96 d
LL	7.230 c	13.460 d	61.04 cd	63.19 cd
PM	14.945 a	36.220 a	103.69 a	115.71 a
GS + LL	7.225 c	19.195 bcd	71.30 bcd	73.23 bcd
GS + PM	11.750 b	24.175 bc	91.34 abc	93.45 ab
LL + PM	12.280 b	29.305 ab	94.27 ab	95.87 ab
Control	8.642 c	18.313 cd	84.20 abc	85.45 bc

3.4. Yield Indicators

Mean values for fruit length, girth and weight under the different organic treatments are presented in Table 5. Poultry manure (PM) produced the highest fruit weight (177.54 g) and a high fruit length (15.02 cm) and girth (4.35 cm), while the LL + PM combination produced the greatest fruit length overall (16.45 cm) together with a substantial fruit weight (164.54 g). GS + PM and GS + LL produced intermediate fruit lengths (12.67 and 13.03 cm) and weights (122.25 and 131.42 g). By contrast, sole GS produced the smallest fruits across all three indicators (4.21 cm length, 1.23 cm girth, 45.28 g weight), performing below even the unamended control (8.50 cm, 2.22 cm, 114.92 g).

ANOVA confirmed highly significant treatment effects for all three yield indicators (Table 6): fruit length ($F = 13.44$, $p < 0.001$), fruit girth ($F = 18.57$, $p < 0.001$) and fruit weight ($F = 8.46$, $p < 0.001$). Mean separation by LSD (Table 7) showed that LL + PM (16.450 cm) produced significantly longer fruits than most other treatments, while PM (15.017 cm), LL (12.745 cm), GS + LL (13.025 cm) and GS + PM (12.673 cm) formed a statistically similar intermediate group, and GS (4.210 cm) and the control (8.500 cm) were significantly shorter. For fruit girth, GS + PM (4.553 cm) recorded the numerically largest mean but did not differ significantly from PM, LL + PM, LL and GS + LL, whereas the control (2.220 cm) and especially GS (1.228 cm) were significantly narrower. For fruit weight, PM (177.54 g) was significantly heavier than the control and GS, and was statistically comparable to LL (168.04 g) and LL + PM (164.54 g), while GS + LL and GS + PM showed intermediate weights and GS (45.28 g) remained the lowest.

Taken together, these results show that treatments involving poultry manure and *Leucaena* prunings, either individually or in combination, consistently improved fruit length, girth and weight relative to the

unfertilized control, whereas sole *Gliricidia* was the least effective amendment across all yield indicators. The LL + PM combination in particular optimized fruit length, suggesting a complementary effect between the readily available nutrients in poultry manure and the biomass and nutrient-release characteristics of *Leucaena* prunings.

Table 5
Mean fruit length, girth and weight of cucumber under different organic amendments.

Treatment	Fruit length (cm)	Fruit girth (cm)	Fruit weight (g)
GS	4.21	1.23	45.28
LL	12.75	4.12	168.04
PM	15.02	4.35	177.54
GS + LL	13.03	4.11	131.42
GS + PM	12.67	4.55	122.25
LL + PM	16.45	4.26	164.54
Control	8.50	2.22	114.92

Table 6
Analysis of variance for cucumber fruit length, girth and weight under different organic amendments.

Yield indicator	df (Treatment)	MS (Treatment)	F	p
Fruit length	6	69.09	13.44	0.000
Fruit girth	6	6.63	18.57	0.000
Fruit weight	6	8224.91	8.46	0.000

Table 7
Mean comparison of cucumber fruit length, girth and weight under different organic amendments. Means within a row followed by the same letter are not significantly different at $p \leq 0.05$ (LSD test).

Indicator	GS	LL	PM	GS + LL	GS + PM	LL + PM	Control
Fruit length (cm)	4.210 d	12.745 b	15.017 ab	13.025 b	12.673 b	16.450 a	8.500 c
Fruit girth (cm)	1.228 c	4.120 a	4.350 a	4.101 a	4.553 a	4.260 a	2.220 b
Fruit weight (g)	45.28 d	168.04 ab	177.54 a	131.42 abc	122.25 bc	164.54 ab	114.92 c

4. Discussion

This study set out to compare the effects of *Gliricidia sepium* and *Leucaena leucocephala* prunings, poultry manure, and their combinations on cucumber growth and yield, and the results allow both hypotheses to be evaluated directly. For chlorophyll content and leaf number, the null hypothesis of no significant difference among treatments (H^{01}) could not be rejected, whereas for plant height and all three yield indicators, H^{01} and H^{02} were both rejected, since treatment effects were highly significant. This divergence between vegetative-physiological indicators and structural growth/yield indicators is an important finding in its own right and warrants closer interpretation.

The absence of significant treatment effects on chlorophyll content contrasts with expectations from the wider organic-amendment literature, where poultry manure and leguminous residues are generally reported to improve nitrogen availability and, by extension, leaf pigment concentration [1, 4, 12, 14]. One plausible explanation is that, under the semi-shaded, agroforestry-buffered microclimate of the trial site, all treatments—including the control—retained sufficient residual soil fertility and moisture stability to sustain comparable chlorophyll synthesis, particularly given that SPAD readings were taken under controlled morning conditions to minimize measurement noise [38, 39]. The consistent decline in chlorophyll content from 14 to 56 DAP across all treatments alike further suggests that this pattern was driven primarily by leaf physiological ageing rather than by nutrient supply, since a genuine amendment effect would be expected to widen, rather than preserve, the gap between treatments as the season progressed. A similar decoupling was observed for leaf number, where the unamended control unexpectedly matched or exceeded several amended treatments; while this runs counter to typical reports that organic residues stimulate leaf proliferation [6, 7], it is consistent with prior observations that vegetative branching responses to sole leguminous prunings can be inconsistent relative to unamended plots [43, 44], and it underscores that vegetative indicators such as leaf count do not necessarily scale with reproductive or structural growth outcomes.

By contrast, plant height and yield indicators responded strongly and consistently to amendment type, with poultry manure, alone or combined with *Leucaena*, consistently outperforming sole *Gliricidia* and, in most cases, the control. This pattern is consistent with the broader literature showing that poultry manure supplies readily available nutrients that support rapid vegetative growth and yield formation in cucumber [1, 5, 6, 7], and it reinforces earlier Ghanaian field evidence that sole poultry manure maximizes overall cucumber yield while *Leucaena* combined with poultry manure enhances specific fruit traits such as length [5]—a pattern closely mirrored in the present results, where LL + PM produced the greatest fruit length while PM alone produced the greatest fruit weight. The comparatively poor performance of sole *Gliricidia* across virtually all growth and yield indicators is a notable point of divergence from studies conducted in other cropping systems, where *Gliricidia* has been reported to improve soil fertility and crop performance in maize, ginger, carrot, soybean and degraded-coconut systems [15]. This discrepancy may be explained by the rapid decomposition and low carbon-to-nitrogen ratio of *Gliricidia* residues, which favour a short, early pulse of nutrient release that may not persist through the full cucumber growth cycle if biomass inputs are not sustained [15], particularly at the

moderate single application rate (5 kg per plot) used here relative to the higher legume-tree biomass rates reported to improve soil physical properties and yield in other trials [16].

The synergistic performance of the poultry manure–legume combinations, particularly LL + PM, is consistent with the broader rationale for integrated organic nutrient management, in which combining a fast-mineralizing, high-nutrient-content material such as poultry manure with a biomass source that contributes organic matter and slower-release nitrogen can improve nutrient synchronization with crop demand relative to either input alone [1, 9]. This is compatible with evidence that leguminous green manures raise soil available nitrogen and phosphorus and preserve nutrients within the soil–plant system when integrated with other organic or mineral sources [4, 12, 13, 14], and it suggests that the benefit of *Leucaena* in this trial operated less through its sole-application effect—which was itself limited—and more through its combination with a readily mineralizable nutrient source. The stronger height and fruit-length responses associated with *Leucaena* relative to *Gliricidia* combinations also align with prior direct comparisons of the two hedgerow species reporting a greater growth response to *Leucaena* [45], reinforcing that the two legume species are not interchangeable as organic amendments despite their shared classification as nitrogen-fixing prunings.

These findings should be interpreted in light of several limitations. First, the trial was conducted over a single growing season at one site, so the results reflect the specific soil, climatic and agroforestry-shading conditions of the USTED Mampong campus and may not extrapolate directly to open-field, non-agroforestry, or multi-season cucumber production systems. Second, soil nutrient dynamics (e.g., mineral nitrogen release curves, microbial biomass, or soil organic carbon change) were not directly measured, which limits the ability to attribute the observed height and yield differences unambiguously to specific nutrient-release mechanisms rather than to other correlated soil or microclimatic factors. Third, because the two leguminous species were applied at a single rate and only in combination with poultry manure rather than across a range of application rates, the trial cannot determine whether a higher rate of sole *Gliricidia* application would have narrowed the performance gap observed here. Future work that couples soil nutrient monitoring with a wider range of application rates, and that extends the comparison across seasons and sites, would help clarify whether the patterns observed here reflect genuine differences in decomposition and nutrient-release dynamics between *Gliricidia* and *Leucaena* or are specific to the conditions of this trial.

5. Conclusions

Under the field conditions of this study, organic amendment type had no significant effect on cucumber chlorophyll content or leaf number, but significantly influenced plant height and all three yield indicators (fruit length, girth and weight), leading to rejection of H^{02} and partial rejection of H^{01}. Poultry manure, applied alone or in combination with *Leucaena leucocephala* prunings, consistently produced the tallest plants and the best overall yield performance, with sole poultry manure maximizing fruit weight and the *Leucaena*–poultry manure combination maximizing fruit length. Sole *Gliricidia sepium* prunings, by contrast, were the least effective amendment across all growth and yield indicators, performing at or

below the level of the unamended control. These findings suggest that, among the organic options evaluated, poultry manure remains the most reliable single amendment for cucumber production in similar agroforestry-shaded, smallholder tropical settings, and that integrating it with *Leucaena* prunings can further optimize specific fruit-quality traits. Where poultry manure supply is constrained, sole *Gliricidia* application at the rate tested here cannot be recommended as an adequate substitute, and further research is needed to establish whether higher application rates, repeated seasonal inputs, or combination with other nutrient sources would improve its agronomic performance.

Abbreviations

The following abbreviations are used in this manuscript:

DAP	Days After Planting
GS	*Gliricidia sepium*
LL	*Leucaena Leucocephala*
PM	Poultry Manure
GS + LL	*Gliricidia sepium + Leucaena Leucocephala*
LL + PM	*Leucaena Leucocephala +* Poultry Manure
GS +PM	*Gliricidia sepium +* Poultry Manure

Declarations

Conflicts of Interest

The authors declare that they have no conflicts of interest, whether financial or personal, that could have influenced the conduct, analysis, or reporting of this study.

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Author Contributions

Richard Ntumi brought the conceptualization and the design of the research protocol. Richard Ntumi wrote the first and final draft of the manuscript. Data structuring and analysis was done by Prince

Asenso and Isaac Kwame Boafo. Doris Osei Asuming reviewed and revised the manuscript. All authors read and approved the final draft of the manuscript.

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Data Availability Statement

All data used for the study are available upon a reasonable request.

References

1. Zahid N, Ahmed MJ, Tahir MM, Maqbool M, Shah SZA, Hussain SJ, Khaliq A, Rehmani MIA Integrated effect of urea and poultry manure on growth, yield and postharvest quality of cucumber (Cucumis sativus L.)
2. Onuorah N, Umeh O Effect of poultry manure application timing on cucumber (Cucumis sativus L.) growth and yield in Ifite-Ogwari, Anambra State, Nigeria
3. Orluchukwu J, Confidence A (2022) Effect of organic and inorganic fertilizers on the growth and yield of cucumber (Cucumis sativa L.) in South-South Nigeria. Int J Agric Policy Res 10:31
4. Zhang J, He W, Wei Z, Chen Y, Gao W (2025) Integrating green manure and fertilizer reduction strategies to enhance soil carbon sequestration and crop yield: evidence from a two-season pot experiment. Front Sustain Food Syst 8:1514409
5. Boateng OE, Agyarko K, Essilfie ME, Ntekor I, Michael O, Richard N (2025) Effects of Poultry Manure and Legume Tree Prunings on Soil Properties, Growth and Yield of Cucumber (Cucumis sativus L.) under Field Conditions in Ghana. J Exp Agric Int 47:659–676
6. Kehinde-Fadare A, Olufunke OO, Olayemi A (2022) Effect of organic and inorganic fertilizer on growth, yield and nutritional quality of cucumber (Cucumis sativus). Asian J Agric Hortic Res 9:1–8
7. Oke O, Jatto K, Oyaniyi T, Adewumi O, Adara C, Marizu J, Ogunbela A, Adebayo G (2020) Responses of different poultry manure levels on the growth and yield of cucumber (Cucumis sativus Linn.) in Ibadan, Nigeria. J Res Wildl Environ 12:206–215
8. Tijani F, Oyedele D, Agomoh I (2024) Improving the hydraulic and mechanical properties of a degraded paleustult: Potential of combined application of poultry manure and Portland cement. Ife J Sci 26:367–380
9. Bhardwaj AK, Rajwar D, Yadav RK, Chaudhari SK, Sharma DK (2021) Nitrogen availability and use efficiency in wheat crop as influenced by the organic-input quality under major integrated nutrient

management systems. Front. Plant Sci 12:634448

10. Agomoh I, Hao X, Zvomuya F (2018) Phytoextraction of nitrogen and phosphorus by crops grown in a heavily manured Dark Brown Chernozem under contrasting soil moisture conditions. Int J Phytorem 20:27–34
11. Agomoh IV (2017) Nutrient dynamics and phytoextraction in soils receiving long-term manure application. Ph.D. Thesis, [university not stated in source]
12. Gao X, He Y, Chen Y, Wang M (2024) Leguminous green manure amendments improve maize yield by increasing N and P fertilizer use efficiency in yellow soil of the Yunnan-Guizhou Plateau. Front Sustain Food Syst 8:1369571
13. Yao Z, Xu Q, Chen Y, Liu N, Li Y, Zhang S, Cao W, Zhai B, Wang Z, Zhang D (2021) Leguminous green manure enhances the soil organic nitrogen pool of cropland via disproportionate increase of nitrogen in particulate organic matter fractions. CATENA 207:105574
14. Gan H, Drinkwater LE (2025) Leguminous green manure promotes N accrual in labile and persistent soil organic matter pools. Plant Soil 507:763–781
15. Alamu EO, Adesokan M, Fawole S, Maziya-Dixon B, Mehreteab T, Chikoye D (2023) Gliricidia sepium (Jacq.) Walp applications for enhancing soil fertility and crop nutritional qualities: a review. Forests 14:635
16. Kugedera AT, Mandumbu R, Nyamadzawo G (2022) Rainwater harvesting and Leucaena leucocephala biomass rates effects on soil moisture, water use efficiency and Sorghum bicolor [(L.) Moench] productivity in a semi-arid area in Zimbabwe. J Sci Food Agric 102:6443–6453
17. Opoku E, Dzomeku BM, Opata J, Adam AM, Rasche F (2026) Perennial legumes Pueraria phaseoloides and Leucaena leucocephala exhibit high potential for fertility restoration of degraded mined soils in Ghana. J. Plant Nutr. Soil Sci
18. Grandez-Alberca MA, Cotrina-Sanchez A, Silva-Melendez TB, Huamán-Pilco ÁF, Puscan-Rojas J, Coronel-Alcalde MN, Medina-Medina AJ, Zabaleta-Santisteban JA, Tuesta-Trauco KM, Rivera-Fernandez AS (2026) Agronomic and economic characterization in agroforestry systems with cocoa (Theobroma cacao L.) in the Utcubamba Valley. Peru Agrofor Syst 100:103
19. Niether W, Jacobi J, Blaser WJ, Andres C, Armengot L (2020) Cocoa agroforestry systems versus monocultures: a multi-dimensional meta-analysis. Environ Res Lett 15:104085
20. Asibey MO, Agyeman KO, Amponsah O, Ansah T (2020) Patterns of land use, crop and forest cover change in the Ashanti region. Ghana J Sustain For 39:35–60
21. Chavez J, Nijman V, Sukmadewi DKT, Sadnyana MD, Manson S, Campera M (2024) Impact of farm management on soil fertility in agroforestry systems in Bali. Indonesia Sustain 16:7874
22. Salinas Ruíz J, Montesinos López OA, Crossa J (2024) Randomized complete block design. Introduction to Experimental Designs with PROC GLIMMIX of SAS: Applications in Food Science and Agricultural Science. Springer, Cham, Switzerland, pp 75–98
23. Thomas CG (2021) Experimental research. Research Methodology and Scientific Writing. Springer, Cham, Switzerland, pp 93–133

24. Marini RP (2024) Experimental designs and statistical analyses for rootstock trials. Agronomy 14:2312
25. Kumar S, Lamichaney A, Sripathy K, Dinni S, Kamble UR (2025) Modern molecular techniques to support hybrid seed industry in crop plants. Hybrid Seed Production for Boosting Crop Yields: Applications, Challenges and Opportunities. Springer, Singapore, pp 535–557
26. Niikura S (2017) F1 hybrid breeding using genome information. The Radish Genome. Springer, Cham, Switzerland, pp 199–216
27. Agbede TM (2026) Effects of biochar and poultry manure on soil properties, growth and yield of yam in degraded tropical Alfisol in Southwestern Nigeria (2023–2024). Eurasian J Soil Sci 15:195–208
28. Omar L, Ahmed OH, Boyie Jalloh M (2021) Abdul Majid, N.M. Rice husk compost production and use in mitigating ammonia volatilization from urea. Sustainability 13:1832
29. Bergstrand K-J, Löfkvist K, Asp H (2020) Dynamics of nutrient availability in tomato production with organic fertilisers. Biol Agric Hortic 36:200–212
30. Nnabuihe E (2026) Effects of Poultry Manure, NPK Fertilizer and their Integrated Application on Soil Fertility and Cucumber (Cucumis sativus L.) Yield in Awka, Southeastern Nigeria. Acta Agric Sci
31. Asamoah CE (2022) Effect of different methods of staking on the growth and yield of cucumber (Cucumis sativus). Master's Thesis, University of Education, Winneba, Ghana
32. Fanourakis D, Makraki T, Spyrou GP, Karavidas I, Tsaniklidis G, Ntatsi G (2025) Environmental drivers of fruit quality and shelf life in greenhouse vegetables: Species-specific insights. Agronomy 16:48
33. Masrie B, Girma T (2023) Effect of stem pruning and staking time on growth and yield of tomato (Lycopersicon esculentum Mill. var. Mersa) at Mersa, North Wollo. Ethiopia Vegetos 36:1080–1088
34. Smiti K, Mina U, Verma M (2026) Field-based assessment of sowing date-induced temperature stress on growth, sensitivity, and yield of four cucurbit species. Adv Hortic Sci 40:193–208
35. Duncanson L, Armston J, Disney M, Avitabile V, Barbier N, Calders K, Carter S, Chave J, Herold M, MacBean N (2021) Aboveground woody biomass product validation good practices protocol. [Report, publisher not stated in source]
36. Perez-Harguindeguy N, Diaz S, Garnier E, Lavorel S, Poorter H, Jaureguiberry P, Bret-Harte MS, Cornwell WK, Craine JM, Gurvich DE (2016) Corrigendum to: New handbook for standardised measurement of plant functional traits worldwide. Aust J Bot 64:715–716
37. Chrysargyris A, Xylia P, Stavrinides M, Tzortzakis N (2025) Evaluating a natural-based solution for its stimulation in Cucumis sativus plants and fruits. Horticulturae 11:499
38. Aasen H, Van Wittenberghe S, Sabater Medina N, Damm A, Goulas Y, Wieneke S, Hueni A, Malenovský Z, Alonso L, Pacheco-Labrador J (2019) Sun-induced chlorophyll fluorescence II: Review of passive measurement setups, protocols, and their application at the leaf to canopy level. Remote Sens 11:927
39. Xue R, Zhang C, Yan H, Li J, Ren J, Akhlaq M, Hameed MU, Disasa KN (2023) Physiological response of tomato and cucumber plants to micro-spray in high-temperature environment: a scientific and

effective means of alleviating crop heat stress. Agronomy 13:2798

40. Akrimi R, Mhamdi M, Abid G, Ezzeddine H, Nouiri I (2025) Magnetic-water-enhanced tomato yield and antioxidant response under arid conditions of South Tunisia. Horticulturae 11:301
41. Kareem M (2023) Irrigation regimes and growth media effects on growth and yield of greenhouse cucumber (Cucumis sativus L.). Master's Thesis, [university not stated in source]
42. Ahmed I, Rohman MM, Hossain MA, Molla MR, Azam MG, Hasan MM, Gaber A, Albogami B, Hossain (2022) A. A study on the phenotypic variation of 103 cucumber (Cucumis sativus L.) landraces for the development of desirable cultivars suitable for the changing climate. Life 12:1235
43. Agyeman K, Afuakwa JJ, Owusu-Danquah E (2012) Improving soil fertility for maize (Zea mays L.) production using inorganic and organic fertilizer
44. Partey ST, Thevathasan NV, Zougmoré RB, Preziosi RF (2018) Improving maize production through nitrogen supply from ten rarely-used organic resources in Ghana. Agrofor Syst 92:375–387
45. Opoku E, Dzomeku BM, Opata J, Adam AM, Rasche F (2026) Restoring productivity of degraded mined soils using legume leaf residues as organic amendments. Sci Rep 16:12429

Figures

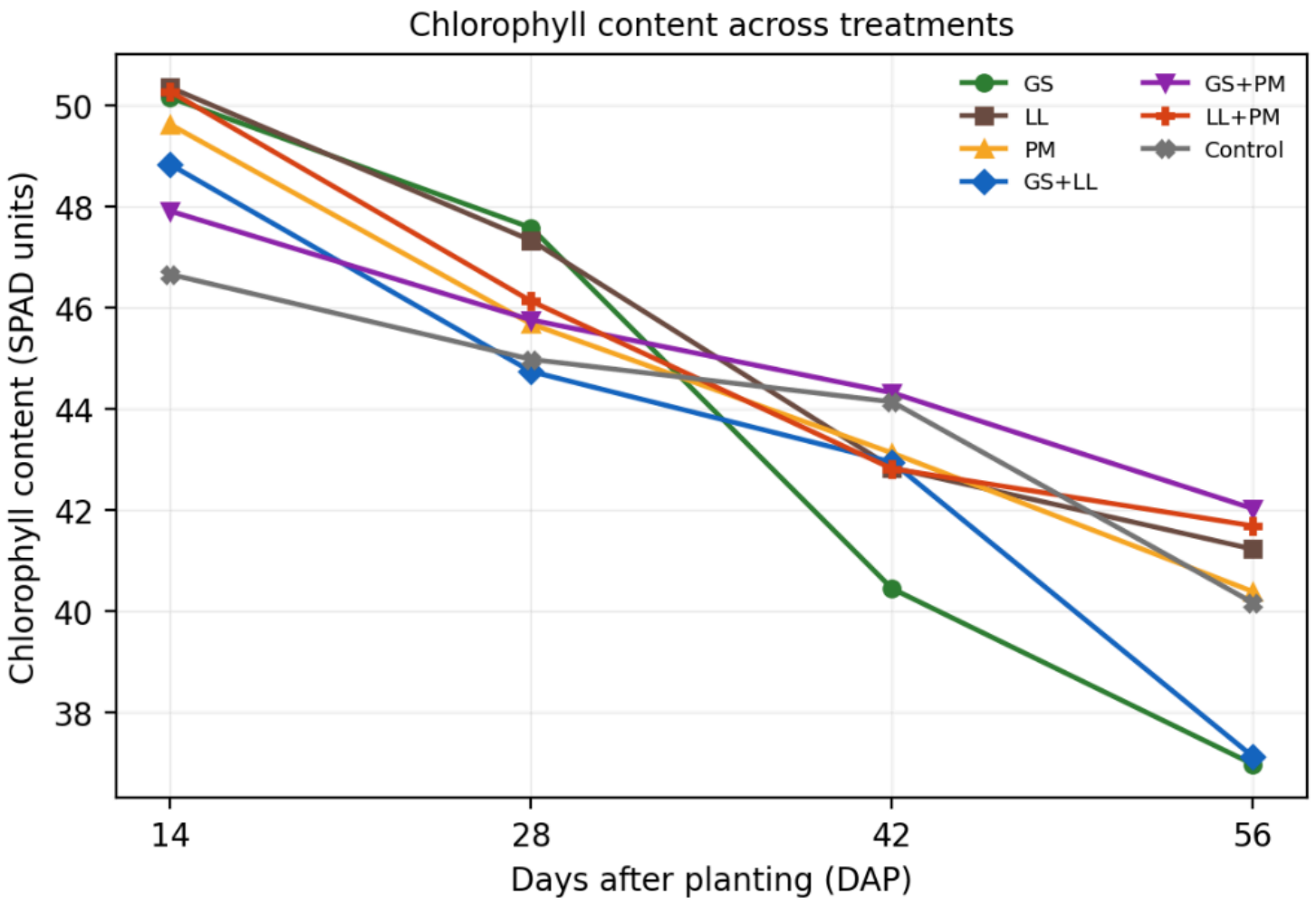


Figure 1

Chlorophyll content (SPAD units) of cucumber leaves under different organic amendments at 14, 28, 42 and 56 days after planting.

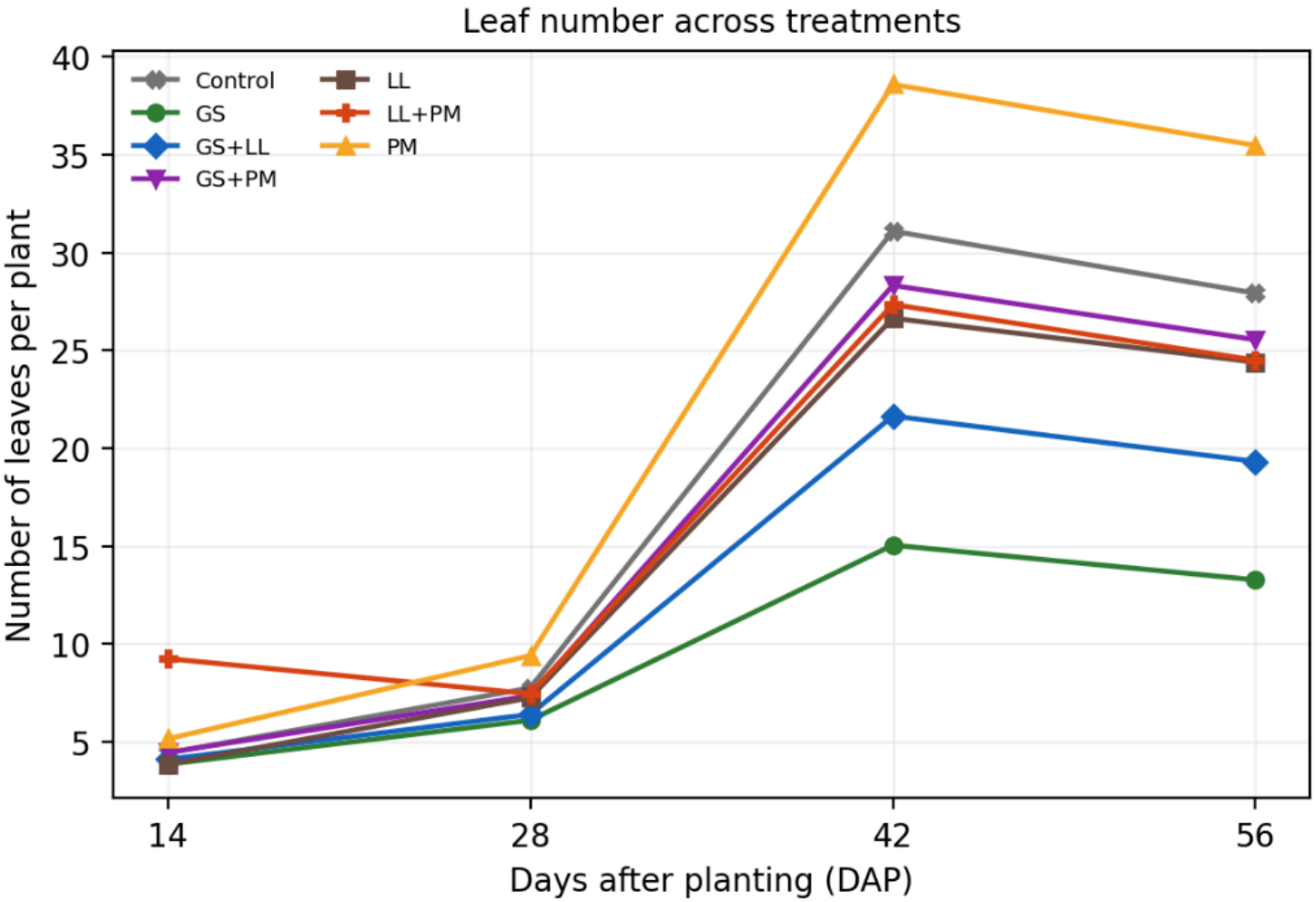


Figure 2

Mean number of leaves per cucumber plant under different organic amendments at 14, 28, 42 and 56 days after planting.

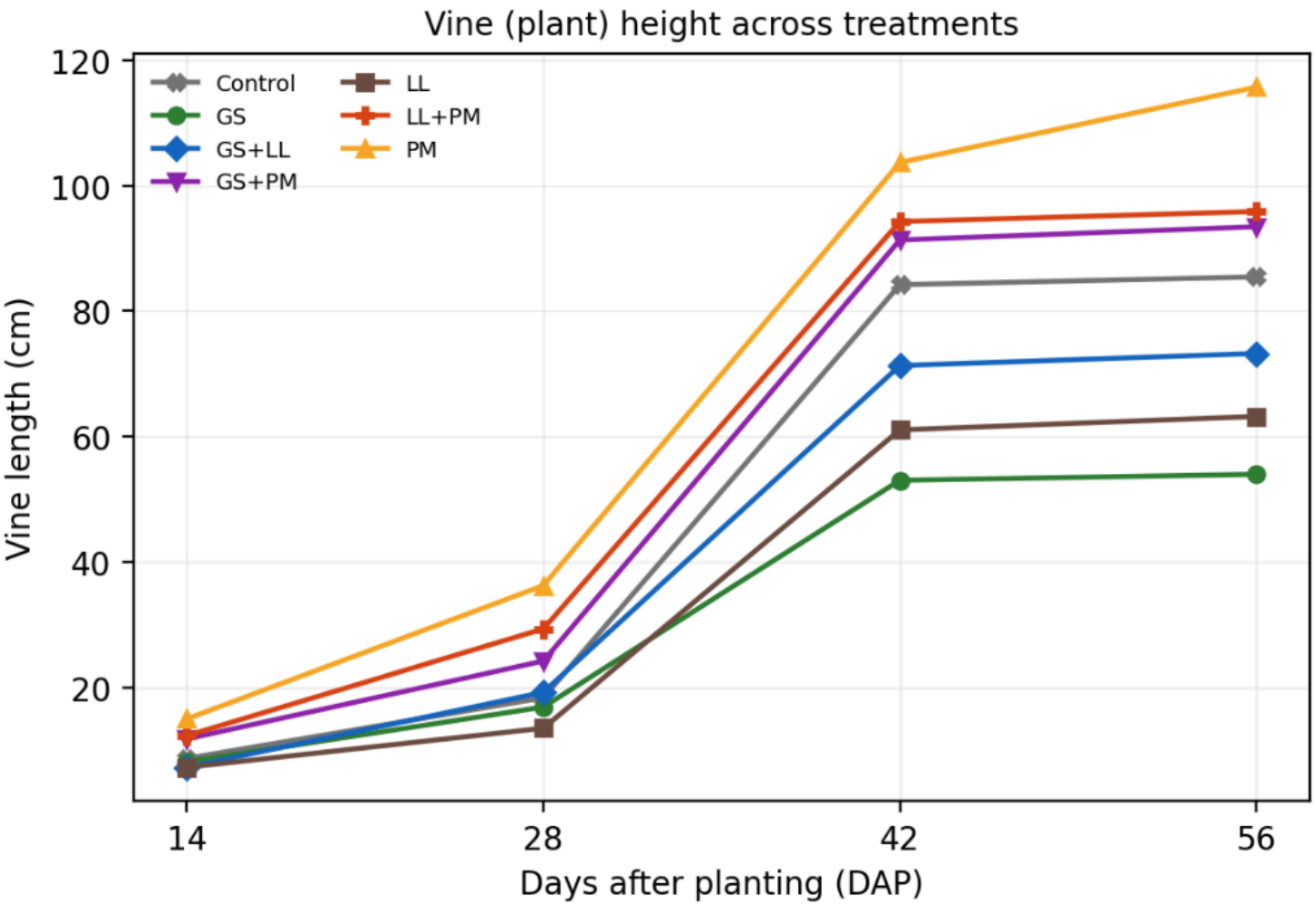


Figure 3

Mean plant (vine) height of cucumber under different organic amendments at 14, 28, 42 and 56 days after planting.