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Comparative Effects of Chicken Manure, Manure Tea, And NPK Fertilizer on The Growth and Yield of Cabbage

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ABSTRACT

The use of chicken manure and its liquid derivative, chicken manure tea, is widespread among horticultural farmers in Kenya due to its perceived rapid stimulation of plant growth compared to synthetic fertilizers. However, these claims lack sufficient scientific backing. Recently, chicken manure tea has gained preference over solid manure, partly due to the presence of wood shavings in the latter. To evaluate their effectiveness, a study was conducted on cabbage (Brassica oleracea var. capitata 'Quiser F1') under polytunnel conditions using four treatments: chicken manure, chicken manure tea, a combination of both, and NPK fertilizer (as a control). Seedlings were transplanted into 10-liter containers in a randomized complete block design with four replications. Data collected included soil and tissue mineral content, soil pH, vegetative growth parameters (stem length, leaf width and length, number of leaves), and marketable head yield. Statistical analysis was performed using R, with means separated via Tukey's test at $\alpha \leq 5\%$. Results showed that all organic treatments, particularly the combination of manure and tea, significantly enhanced early-stage growth, though these effects waned in later stages. Tissue nutrient content was lowest in the combined treatment, possibly due to increased microbial activity and nutrient immobilization from excess organic matter. Despite this, it produced the largest marketable heads. The findings suggest that chicken manure, in all forms, can potentially substitute synthetic fertilizers in cabbage production. However, further field-based studies are needed to confirm these results.

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KEYWORDS: Cabbage nutrition, chicken manure tea, organic fertilizer, marketable yield, Quiser F1, nutrient immobilization.

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INTRODUCTION

Cabbage (*Brassica oleracea* L. var. *capitata*) is one of the most widely cultivated leafy vegetables globally and is especially significant in Kenya, where it serves as a key source of income for smallholder farmers. While its exact historical origin remains debated, recent genetic evidence supports an eastern Mediterranean origin of *B. oleracea*, which later diversified across Europe (Mabry et al., 2021). The crop was introduced to the Kenyan highlands by British settlers in the early 20th century and has since become one of the country's most important vegetables and a significant source of income for smallholder farmers.

Cabbage is cultivated across a wide range of agro-ecological zones and soil types in Kenya. It is consumed raw as a leafy vegetable, cooked, or combined with other vegetables. It is also a rich source of vitamins A, C, and K, as well as essential minerals (Raiola et al., 2018). The consumption of cruciferous vegetables like cabbage has been associated with a reduced risk of several types of cancer due to the presence of glucosinolates and their bioactive derivatives (Jahangir et al., 2009). Furthermore, these vegetables are known to contribute to cardiovascular health (Archana et al., 2018; Raiola et al., 2018).

Despite its economic and nutritional value, cabbage production in Kenya is currently declining, largely due to the depletion of soil fertility. The application of synthetic fertilizers has been limited due to their high cost and negative effects, such as nutrient imbalances, increased soil acidity, organic matter degradation, and the disruption of soil physical properties (Majeed et al., 2021).

Inorganic fertilizers also reduce farm profitability, both through their direct cost and through long-term impacts such as soil acidification and reduced soil mineralization (Bhatt et al., 2018; Bhattacharyya et al., 2015). Consequently, partial or complete substitution of synthetic fertilizers with organic alternatives has been recommended to reduce dependence on agrochemicals and promote sustainable agriculture (Wang et al., 2018).

Chicken manure is often favored as an organic fertilizer for cabbage due to its high concentrations of both macro- and micronutrients and its relative affordability and year-round availability (Naim et al., 2015). Numerous studies have shown that poultry manure enhances nutrient availability, supports microbial activity, and improves soil structure(Hsu and Lai 2022; Majeed et al., ,2021; Ning et al., 2022). The liquid form, commonly known as manure tea, is created by soaking chicken manure in water to extract soluble nutrients and beneficial microbes, and can be applied via fertigation, soil drenching, or foliar spray (Ning et al., 2022). Furthermore, chicken manure is available year-round in large quantities and presents a cost-effective alternative to chemical fertilizers.

Chicken manure can be applied either as solid organic matter incorporated into the soil or as a liquid extract, commonly known as manure tea (Javanmardi and Ghorbani, 2012; Muchiri and Mathenge, 2014). The tea can be administered through fertigation, soil drenching, or foliar spraying. It is prepared by soaking chicken manure in water to extract soluble nutrients and beneficial microorganisms (Javanmardi and Ghorbani, 2012).

Several studies have highlighted the benefits of chicken manure tea in organic crop production. These include balanced nutrient supply, stimulation of plant growth, suppression of plant diseases, and improvements in yield and secondary metabolite production (Javanmardi and Ghorbani, 2012; Muchiri and Mathenge, 2014). Nzoyisaba et al. (2023) reported that chicken manure tea significantly improved tomato yields (up to 45.4 t/ha) and outperformed inorganic fertilizer in both growth and economic return. The present study aims to evaluate the effectiveness of different forms of chicken manure tea in supplying nutrients to cabbage, a crop with high nutrient demands.

MATERIALS AND METHODS

The study was conducted at Taita Taveta University farm located in Kindaya-Ngerenyi ward Mwatate Sub-county of Taita Taveta County. The experimental site is at an altitude of 1600m above sea level within the latitude -03°25' 57" S, and longitude 38°20'36" E. The experiment was set up on pots filled with forest soil (7 kg), and a representative sample was bulked and sent to accredited laboratory for analysis. The forest soil chemical analyses are presented in table 1 below. The soils were potted and randomly assigned to four treatments. The four treatments included:T1: Forest soil + solid chicken manure; T2: Forest soil + chicken manure tea; T3: Forest soil + combination of chicken manure + manure tea; T4: Forest soil + NPK fertilizer (control as the farmers standard practice)

Treatment

Cabbage (*Brassica oleraceae*L.*capitata*) Cv.Quisor F1 seedlings were established in a poly-house; after which the seedlings were transplanted on 19th December, 2019. One seedling per pot was transplanted and each treatment had 12 pots replicated four times to total 48 pots per treatment. The seedlings acclimatized for two weeks before tea and NPK were respectively applied. The experiment was laid out as a Randomized compete block design (RCBD) in a poly-house. The conventional treatment (NPK fertilizer) was applied in three split at two weeks' intervals. NPK (17:17:0) fertilizer was applied to twelve pots at a rate of 2g per pot as a band (115kg N/Ha).Chicken manure (solid) was applied two weeks before transplanting for equilibration. After transplanting, irrigation and manual weeding was done to provide water and control weeds for the cabbage crop.

Chicken manure tea preparation and application

Chicken manure tea was prepared using the non-aerated method (Argun et al., 2017; Shaheen et al., 2018) by soaking/fermenting solid chicken manure for forty five days in water with a ratio of 1:10 (w/v) in a thousand liter tank, then kept in a net shade house. Afterwards, the mixture was filtered before application to remove suspended particles to obtain a debris free solution of chicken manure tea. The liquid chicken manure tea was then diluted before application as a foliar in the ratio of 2:1 (two-part chicken manure tea and 1 part of water). A 1000 ml was applied every three days up to six weeks after transplanting. The nutrient composition of the chicken tea is as shown in table 1.

Vegetative parameters

Two weeks after transplanting, various growth parameters were scored once per week. The data collected included, vegetative parameters such as stem length, leaf width, leaf length and number of leaves until the head formation stage. At the end of the experiment the head weigh and size were determined then the count of marketable heads.

Physiological parameters

The following three physiological parameters were determined:

Leaf Relative leaf water content (LRWC)

Leaf disc from fully expanded leaves were gouged out and used to determine LRWC. The fresh weight of the leaves (FW) was recorded then water-soaked for 24 h at room temperature. After 24 hours, saturated weight (SW) was recorded. Leaves were oven dried for 24 h at 105°C to a constant dry weight (DW). Then LRWC was calculated as:

$$LWRC = \left[{}^{FW - DW}/_{TW - DW}\right] * 100$$

Stomatal conductance (SC)

Stomatal conductance was measured twice per week using an SC-1 Leaf Porometer (Meter Group Inc., Pullman, WA, USA) to assess the gas exchange capacity of the leaves. Measurements were taken during the morning hours (between 09:00 and 11:00 AM) to minimize the influence of midday environmental fluctuations such as temperature and humidity. For each treatment, four randomly selected plants were used. On each plant, readings were taken from the adaxial (upper) surface of three topmost, fully expanded, and healthy leaves to ensure consistency and comparability. The porometer was calibrated before each measurement session following the manufacturer's guidelines to maintain accuracy and reliability of the data.

Leaf Relative Chlorophyll content

Relative chlorophyll content was measured once per week using a handheld SPAD meter (SPAD-502 Plus, Konica Minolta Inc., Tokyo, Japan). Measurements were conducted between 09:00 and 11:00 AM to maintain consistency in light and temperature conditions. For each treatment, four representative plants were randomly selected. On each plant, SPAD readings were taken from the adaxial surface of the three topmost fully expanded and healthy leaves. The average of the three readings per plant was used to represent the relative chlorophyll content, and the instrument was calibrated prior to each measurement session according to the manufacturer's instructions.

Chlorophyll Fluorescence

The efficiency of chlorophyll in capturing light energy for photosynthesis was assessed using a Handy PEA Plus chlorophyll fluorometer (Hansatech Instruments Ltd., King's Lynn, Norfolk, UK). Measurements were taken once per week between 10:00 and 11:00 AM under stable ambient conditions. For each treatment, four randomly selected plants were used. On each plant, chlorophyll fluorescence was measured on the three uppermost fully expanded and healthy leaves. Prior to each measurement, leaves were dark-adapted for at least 10 minutes using leaf clips provided with the instrument to ensure accurate determination of maximum quantum efficiency of Photosystem II (Fv/Fm). The average of three readings per plant was calculated to represent the photosynthetic efficiency for analysis.

Tissue nutrients analyses

At the end of each growing season, plant tissue samples were collected for nutrient analysis**.** For each treatment, three replicate composite samples were prepared by collecting leaves from all plants within each replicate plot. The harvested leaf samples were shredded and oven-dried at 70 °C until they reached a constant weight. After drying, the samples were stored in clean, labeled containers to prevent contamination. The oven-dried tissue samples were then properly packaged, clearly labeled by treatment and replicate, and submitted to an accredited national laboratory for nutrient analysis.

Data analysis

The experiment was conducted over two separate growing seasons using a randomized complete block design (RCBD) with three replicates per treatment. Each replicate plot contained 12 plants. Data collected from the study were analyzed using R software (version 3.4.4; released 2018-03-15). Prior to analysis, the data were log-transformed to meet the assumptions of normality and homogeneity of variances. A multivariate analysis of variance (MANOVA) was performed to evaluate the effects of nutrient source as the treatment factor. Where significant differences were detected, treatment means were separated using Tukey's Honest Significant Difference (HSD**) test** at a significance level of **$\alpha \leq 0.05$**.

RESULTS

Nutrients concentration

Soil and chicken manure used in this experiment were sampled before planting and their details of the laboratory analysis are given below (Table 1). From the analysis the soil reaction (pH) was satisfactory for crops' growth. The fertility components of chicken manure (solid) and chicken manure tea is also shown in table 1. From the samples analyzed the solid chicken manure had adequate nutrients to support a good crop.

Table 1: Fertility status of the forest soil, solid chicken manure and chicken manure tea as applied in the treatments used in the study.

Table 1: Laboratory analysis of the forest soil used for the potting, solid chicken manure and chicken manure tea (liquid)

Parameter	Soil	Chicken manure	Chicken Liquid manure
Soil pH	6.22	7.41	7.40
Total Nitrogen %	0.24	2.45	0.93
Total Org. Carbon %	2.55	Not determined	Not determined
Phosphorus ppm %	15	0.37	0.21
Potassium ppm %	0.70	1	0.99

Calcium ppm %	23.9	1.27	0.3
Magnesium ppm %	7.32	0.27	0.04
Manganese ppm %	0.38	535	340
Copper ppm %	0.36	13.3	18.3
Iron ppm	11.9	81.7	41.7
Zinc ppm	8.57	80	48.3
Sodium ppm %	0.4	Not determined	Not determined

Physiological parameters

Physiological parameters—including stomatal conductance, relative chlorophyll content, relative water content, and chlorophyll fluorescence—exhibited similar trends across all treatments. At planting, some plants in each treatment group showed signs of transient wilting, as indicated by the drooping of shoot tips. By seven days after transplanting (DAT), plants recorded their lowest leaf relative water content. All treatments led to a significant increase in LRWC from DAT 7 to DAT 21, after which the values stabilized. Thereafter, leaf relative water content stabilized at approximately 90% for the remainder of the growth period, regardless of treatment (Fig. 1)

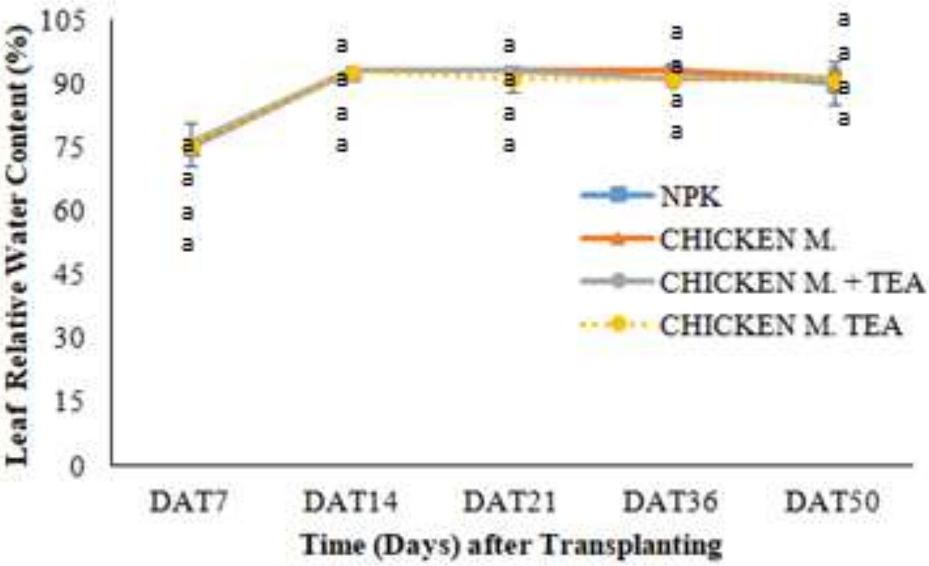

Fig. 1: Leaf Relative Water Content of sampled cabbage leaf discs as influenced by different treatments; similar letters indicates no significance difference among treatments.

Similarly, stomatal conductance was initially low but increased steadily throughout the growing season (Fig. 2). No significant differences were observed among treatments during the entire period.

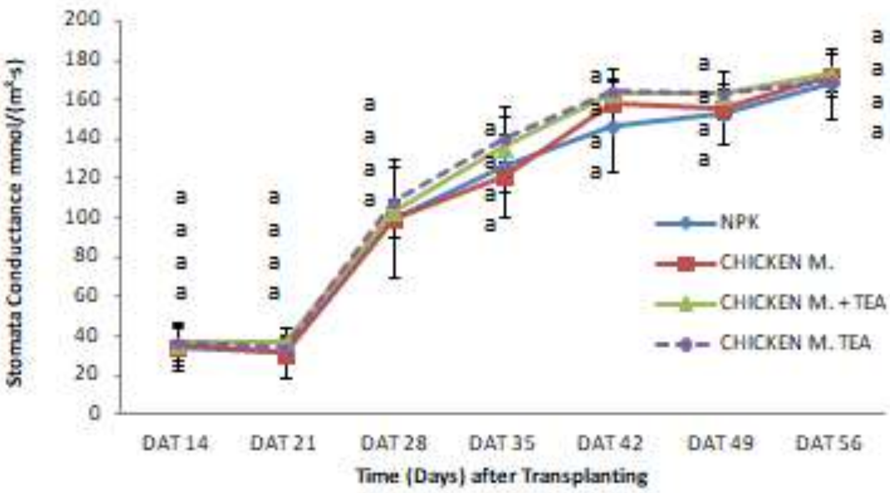

Fig. 2: Leaf stomata conductance of sampled cabbage leaf as influenced by different treatments; similar letters indicates no significance difference among treatments.

Leaf relative chlorophyll content showed a slight increase between 14 and 21 days after transplanting (DAT), after which it remained relatively stable for several weeks before declining slightly as head formation approached (Fig. 3). Across the entire growing season, treatment effects on chlorophyll content were not statistically significant.

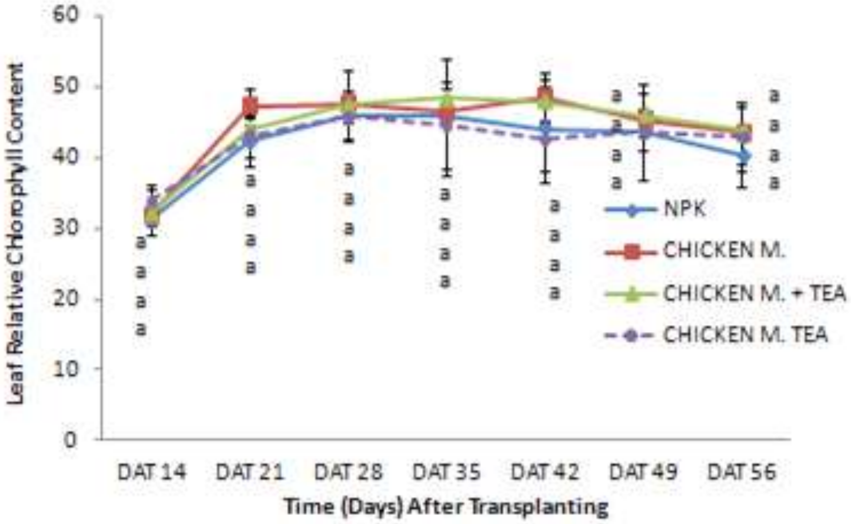

Fig. 3: Leaf Relative Chlorophyll content of sampled cabbage leaf as influenced by different treatments; similar letters indicates no significance difference among treatments.

The maximum quantum yield of Photosystem II (Fv/Fm) remained consistently high, with values averaging approximately 0.80 throughout the experimental period, indicating no detectable photo-inhibition. No statistically significant differences in Fv/Fm were observed among the treatment groups (Fig. 4), suggesting that all treatments maintained comparable photosynthetic efficiency under the given conditions

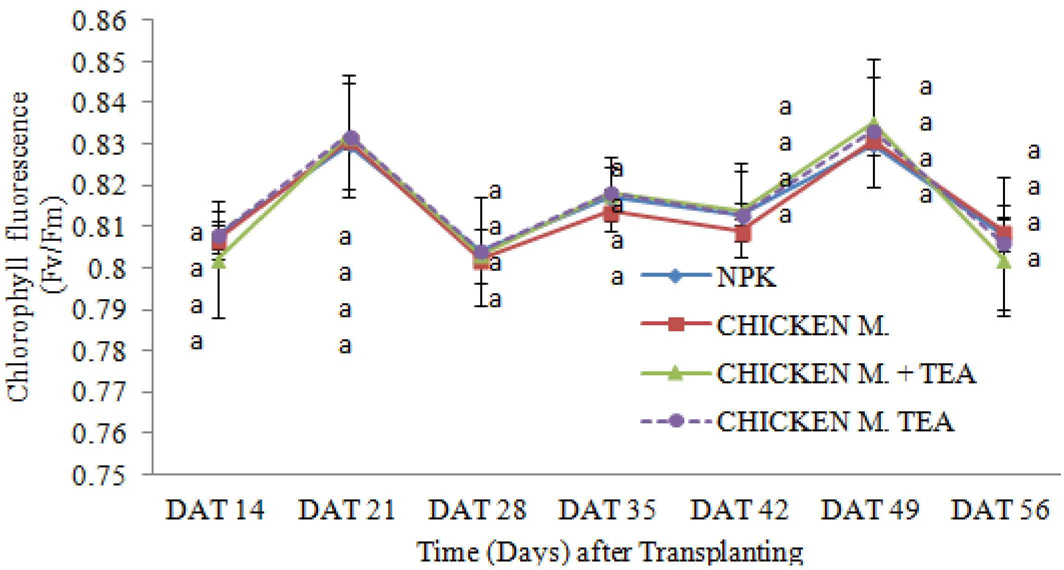

Fig. 4: Chlorophyll fluorescence of sampled cabbage leaf as influenced by different treatments; similar letters indicates no significance difference among treatments.

Growth parameters

At transplanting, all the plants had similar characteristics in terms of height, root collar diameter, number of leaves and responded similarly towards transplanting shock recovery supported by the physiological data above in the early phase of establishment**.**

The application of different fertilizer treatments—NPK, Chicken Manure (CHICKEN-M), Chicken Manure + TEA (CHICKEN-M.+TEA), and Chicken Manure – TEA (CHICKEN-M.-TEA)—resulted in varying effects on cabbage growth parameters across the growing period.

Height:
Plant height increased progressively over time across all treatments. By day 50, the tallest plants were observed under the CHICKEN-M.-TEA treatment (9.6 ± 0.3 cm), followed by CHICKEN-M.+TEA (9.3 ± 0.3 cm), and CHICKEN-M (8.8 ± 1.0 cm). The NPK treatment resulted in the lowest height (8.9 ± 0.6 cm). However, differences among treatments were relatively minor.
Leaf Width:
Leaf width increased steadily over the growing period, with CHICKEN-M and CHICKEN-M.+TEA treatments resulting in broader leaves by day 50 (25.4 ± 0.9 cm and 24.8 ± 4.5 cm, respectively) compared to NPK (24.5 ± 0.9 cm). CHICKEN-M.-TEA yielded the narrowest leaves (22.7 ± 0.7 cm).
Leaf Length:
Similar to width, leaf length was greatest under the CHICKEN-M.+TEA treatment throughout the growth period. By day 50, CHICKEN-M.+TEA had the longest leaves (35.8 ± 3.5 cm), followed by CHICKEN-M.-TEA (31.9 ± 4.2 cm). The NPK treatment consistently resulted in the shortest leaves across all time points.
Number of Leaves:
Cabbage plants under CHICKEN-M.-TEA had the highest number of leaves by day 50 (22 ± 1.3), slightly more than those under CHICKEN-M .+TEA (21 ± 1.2). NPK-treated plants had the fewest leaves (20 ± 1.0), suggesting that organic treatments may better promote foliar development.

Table 2: The influence of different treatments on selected cabbage growth parameters determine at different intervals of the growing period; Different letters indicates significance difference among treatments

		Treatment			
Parameter	Time	NPK	CHICKEN M.	CHICKEN M. + TEA	CHICKEN M. TEA
	DAY 21	4 ± 1.0a	5.2 ± 0.8b	5.1 ± 1.2b	5.7 ± 1.0b
Height	DAY 36	8 ± 1.0a	8.2 ± 1.1a	8.1 ± 1a	7.9 ± 1.2a
	DAY 50	8.9 ± 0.6a	8.8 ± 1.0a	9.3 ± 0.8a	8.8 ± 1.0a
	DAY 21	14.7 ± 1.8a	19 ± 1.9b	19.6 ± 1.8b	16.6 ± 2.1ab
Leaf width	DAY 36	22.2 ± 1.3ab	21.2 ± 0.9ab	23.6 ± 1.0b	20 ± 1.1a
	DAY 50	24.5 ± 0.9a	22.5 ± 4.3a	24.8 ± 4.5a	22.7 ± 0.7a
	DAY 21	21.8 ± 1.4a	27.2 ± 3.3b	26.3 ± 3b	25.4 ± 2.2b
Leaf length	DAY 36	32.5 ± 1.8a	31.9 ± 3.5a	34.4 ± 3.1a	29.7 ± 2.2a
	DAY 50	34.7 ± 1.9ab	33.5 ± 3.5ab	35.8 ± 2.9b	31.9 ± 2.4a
	DAY 21	11 ± 1.5a	13 ± 1.3b	13 ± 1.3b	12 ± 1.1ab
Number of leaves	DAY 36	17 ± 1.6a	18 ± 1.4a	18 ± 1.5a	18 ± 1.4a
	DAY 50	24 ± 1.3a	23 ± 1.1a	25 ± 1.6a	24 ± 1.3a
Stem Diameter	Day 74	1.5 ± 0.2a	1.5 ± 0.2a	1.6 ± 0.2b	1.5 ± 0.2a
cabbage head wt.		2.7 ± 0.5ab	2.6 ± 0.7a	2.8 ± 0.6b	2.6 ± 0.5a

Stem Diameter:
Stem diameter measurements taken on day 74 showed minimal variation among treatments, ranging from 1.5 ± 0.2 cm to 1.6 ± 0.2 cm, indicating no significant treatment effect on stem thickening at maturity.
Cabbage Head Weight:
The heaviest cabbage heads were recorded in plants treated with CHICKEN-M.+TEA (2.8 ± 0.6 kg), followed closely by NPK (2.7 ± 0.5 kg). Organic treatments alone (CHICKEN-M and CHICKEN-M.-TEA) yielded slightly lighter heads (2.6 ± 0.7 kg and 2.6 ± 0.5 kg, respectively).

Tissue nutrient analyses

Table 3: The influence of different treatments on nutrient concentration of Cabbage leaves at the end of growing season; Different letters indicates significance difference among treatments.

Treatment	cabbage heads Mineral concentration								
	N	P	K	Ca	Mg	Fe	Cu	Mn	Zn
CHICKEN M.	2.2 b	0.28 b	1.19 d	0.22 a	0.11 a	66.7 c	10a	48.3 a	38.3 a
CHICKEN M. + TEA	1.4 a	0.07 a	0.89 b	0.29 b	0.16 b	33.3 a	11.7 b	50 b	40 b
CHICKEN M. TEA	2.3 b	0.39 c	0.93 c	0.18 c	0.28 c	38.3 b	11.7 b	55 c	48.3 c
NPK	2.4 b	0.45 d	0.66 a	0.28 b	0.16 a	38.3 b	10 a	90 d	61.7 d

Nutrient concentrations in cabbage heads varied significantly among treatments, indicating differential uptake and accumulation patterns in response to the fertilizer regimes.

The highest nitrogen concentration was observed in the NPK treatment (2.4%), significantly higher than in all organic treatments. Chicken Manure (CHICKEN M) and CHICKEN M + TEA showed intermediate nitrogen levels (2.2% and 1.4%, respectively), while CHICKEN M TEA had the lowest (1.3%).

Phosphorus levels were highest in NPK-treated plants (0.45%) and lowest in CHICKEN M + TEA (0.07%). Both CHICKEN M and CHICKEN M TEA had similar moderate P concentrations (0.28% and 0.39%, respectively).

Cabbage heads treated with CHICKEN M accumulated the most potassium (1.19%), followed by CHICKEN M TEA (0.93%). The lowest K concentration was found in CHICKEN M + TEA (0.89%) and NPK (0.66%).

Calcium content was highest under CHICKEN M + TEA (0.29%), followed closely by NPK (0.28%). Organic-only treatments showed slightly lower Ca values, with CHICKEN M at 0.22% and CHICKEN M TEA at 0.18%.

The CHICKEN M TEA treatment yielded the highest Mg concentration (0.28%), while CHICKEN M recorded the lowest (0.11%). NPK and CHICKEN M + TEA had intermediate values (0.16%).

On considering the micronutrients, the CHICKEN M treatment led to the highest Fe accumulation (66.7 mg/kg), which was substantially greater than in all other treatments (~33.3–38.3 mg/kg). This suggests improved Fe availability or uptake with chicken manure alone.

CHICKEN M + TEA and CHICKEN M TEA both recorded the highest Cu concentrations (11.7 mg/kg), while CHICKEN M and NPK had the lowest (10 mg/kg).

The NPK treatment resulted in the highest Mn concentration (90 mg/kg), whereas the lowest value was recorded under CHICKEN M (48.3 mg/kg). TEA treatments showed moderate Mn accumulation (~50–55 mg/kg).

Zinc accumulation followed a similar trend to Mn, with the NPK treatment showing the highest Zn concentration (61.7 mg/kg), and CHICKEN M the lowest (38.3 mg/kg). Zinc levels increased under CHICKEN M + TEA and CHICKEN M TEA (40–48.3 mg/kg), suggesting that TEA may enhance Zn availability.

DISCUSSION

Cabbage (*Brassica oleracea* var. *capitata*) is recognized as a heavy feeder with high nutrient demands, particularly for nitrogen, phosphorus, and potassium, to support optimal growth, productivity, and market quality (Yeshiwas, 2017). Baseline soil chemical analysis from this study (Table 1) indicated low nutrient levels, especially in nitrogen—a major growth-limiting element. This justified the application of organic and inorganic amendments to enhance nutrient availability and plant development.

The fertilizer regimes used in this study represented conventional (NPK), organic (chicken manure), and modified organic (chicken manure tea and their combination) nutrient sources. These organic-based strategies aim to replace conventional practices associated with soil degradation, such as acidification and nutrient leaching under high rainfall or irrigation (Bhatt, Labanya, and Joshi, 2019).

Baseline soil analysis (Table 1) depicted forest soil with low total nitrogen (0.24 %), low potassium (0.70 ppm), moderate organic carbon (2.55 %), and slightly acidic pH (6.22). These characteristics underscore the inherently nutrient-poor nature of the growing medium and justify the need for effective fertilization to support cabbage growth.

Solid chicken manure displayed high nutrient levels—total N: 2.45 %, manganese: 535 ppm, iron: 81.7 ppm, and zinc: 80 ppm—while chicken manure tea offered substantial albeit lower soluble nutrient concentrations (e.g. total N: 0.93 %, Mn: 340 ppm, Fe: 41.7 ppm) (Table 1). These nutrient profiles likely contributed to observed crop responses: early vegetative vigor was strongest under chicken manure and its tea combinations (Table 2), supporting reports that poultry manure-based organic amendments can meaningfully enhance nitrogen availability and growth parameters in vegetables (Arslanoglu, 2022; Li et al., 2017).

At Day 21, **NPK-treated plants** exhibited significantly shorter height and smaller leaves (Table 2), likely reflecting nutrient losses due to high solubility and early leaching—common limitations associated with synthetic fertilizers in rain-fed or irrigated systems (Nzoyisaba et al., 2023). In contrast, organic treatments—especially **CHICKEN M + TEA**—supported rapid early growth, consistent with literature highlighting the benefits of organic amendments for sustained nutrient release and microbial-mediated (Dikinya and Mufwanzala, 2010).

By Day 36, differences in plant height and leaf dimensions among treatments diminished (Table 2), indicating compensatory growth in NPK-treated plants and supporting the notion that nutrient use efficiency and timing can influence growth convergence across treatments (Hoover et al., 2019). The slower nutrient release from chicken manure, while delaying early growth slightly, may offer a more stable supply beneficial over the growing cycle.

Physiological metrics—including leaf relative water content, stomatal conductance, and chlorophyll content—remained statistically comparable across treatments (Figures 1–3). LRWC exceeded 90% from Day 14 onward, while stomatal conductance and chlorophyll levels equalized similarly across treatments, indicating that all nutrient regimes sufficiently supported photosynthetic capacity and tissue hydration. These results align with studies showing that organic amendments can support plant physiological performance comparable to synthetic inputs when adequately balanced (Arslanoglu 2022; Nzoyisaba et al., 2023)

Chlorophyll fluorescence (Fv/Fm, Figure 4) remained high (~0.83) regardless of treatment, indicating no photo-inhibition and confirming that both organic and inorganic practices maintained optimal Photosystem II performance—a pattern consistent with non-stress growth conditions across nutrient regimes (Nzoyisaba et al., 2023).

Nutrient concentration in cabbage heads (Table 3) revealed that NPK enhanced N, P, Mn, and Zn levels, reflecting the rapid uptake of soluble inorganic sources. Conversely, CHICKEN M and CHICKEN M + TEA treatments enhanced soil availability of K and Fe, likely tied to improved cation exchange and microbial mobilization from organic (Arslanoglu, 2022). Most importantly, CHICKEN M + TEA produced the heaviest cabbage heads (Table 2), suggesting that combining soluble organic tea with solid manure optimizes nutrient timing—supporting yield outcomes comparable to or better than synthetic fertilizer (Nzoyisaba et al., 2023).

CONCLUSION

Integration of **chicken manure and manure tea** provides a sustainable and effective alternative to conventional NPK fertilization for cabbage production. These organic treatments supported early morphological development, maintained physiological stability, improved micronutrient accumulation (e.g., Fe, K), and delivered highest yield under **CHICKEN M + TEA**, while also buffering soil pH and potentially enhancing long-term fertility.

RECOMMENDATIONS

The combined application of chicken manure and manure tea (CHICKEN M + TEA) should be promoted in cabbage cultivation, particularly on nutrient-deficient and acidic soils, due to its superior performance in enhancing plant growth and yield. To ensure widespread adoption and effective implementation, extension services and farmer training programs should prioritize integrated organic nutrient management practices, emphasizing the importance of aligning application timing and dosage with specific soil and environmental conditions. Additionally, further research is necessary to investigate the long-term effects of these organic amendments on soil fertility, microbial activity, and crop productivity across diverse agro-ecological zones and multiple growing seasons.

LIMITATIONS

This study was conducted at a single site during one growing season, which limits the generalization of the findings across diverse environmental conditions. Additionally, the chemical and microbial composition of the chicken manure tea was not characterized, restricting a deeper understanding of its specific mechanisms of action. Furthermore, important soil biological indicators—such as microbial biomass, earthworm activity, and changes in soil organic matter—were not assessed, thereby limiting insights into the broader impacts of the organic amendments on soil health and long-term fertility**.**

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