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EFFECTS OF ORGANIC AMENDMENTS ON SOIL ORGANIC CARBON, VEGETATIVE GROWTH AND PHYSIOLOGICAL YIELD OF PEPPER (*Capsicum annuum*)

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Abstract

This work investigated the effects of organic amendments on soil carbon, vegetative growth and physiological yield (total protein and chlorophyll) of three varieties of pepper (Capsicum annuum). Preliminary soil physicochemical properties were investigated while soil organic carbon (OC) was determined before and after planting. The experiment was conducted in a factorial experiment consisting of 8 levels of treatments and four replicates in a Randomized Completely Block Design (RCBD). Data analysis was performed using the Genstat application (17.0 version) for Analysis of variance while mean separation (post-hoc) was done using Turkey HSD at 95% confidence limit ($P \leq 0.05$). Results showed that soil OC was significantly lower during the growth of the test plants than in pre-sowing soil samples. Application of 10g cow dung yielded the highest amount of soil OC (0.99%). The Yolo Wonder variety improved soil OC. Test plants witnessed a progressive growth in all vegetative features from week 2 to week 6 ($P<0.05$). Varietal type influenced all vegetative growth parameters except leaf area. Treatment applications had significant effects on all growth parameters ($P<0.05$). Result showed that 10g poultry manure significantly influenced all the growth parameters. Total protein content was influenced by planting duration and varietal type. The Poivron Yolo type of pepper had significantly higher protein contents of 3.5% at week 6 than other types ($P<0.05$). Application of 5g cow dung + 5g goat dung to soil significantly influenced total protein from week 2-6. Total chlorophyll was influenced by plant duration and varietal types. Chlorophyll was higher at week 2 than week 4. In conclusion, the organic treatments applied as soil amendments had positive impacts on growth and physiological yield parameters. Varietal and plant duration factors also exerted positive impacts on the parameters evaluated. Therefore, best performing varieties and soil amendments as highlighted in this report are recommended in the cultivation of pepper for improved plant productivity and carbon sequestration.

Key words: Organic amendments, Pepper, Growth, Yield, Carbon sequestration

Introduction

The genus *Capsicum* (generally known as pepper) belongs to the family Solanaceae. There are five domesticated species: *C. annuum*, *C. frutescens*, *C. chinense*, *C. baccatum* and *C. pubescens* (Aguilar-Melendez *et al*., 2009). Pepper thrives best with liberal quantities of organic matter and a balance of mineral fertilizers (CABI, 2023). It is a major ingredient in most global cuisines with reported health benefits; in addition to being the most widely grown spice in the world, the species has also been used for pharmaceuticals, natural colouring agents and cosmetics, as an ornamental plant and as the active ingredient in self defence repellents (CABI, 2023).

The production of pepper is challenged by lack of arable soil due to impoverished soil conditions. Soil conditioners, also referred to as soil amendments, help improve soil structure by increasing aeration, water holding capacity, and nutrients (Diacono and Montemurro, 2010; Celestina *et al.,* 2019). Soil conditioners include a range of products made from many different materials, both organic and inorganic. Organic (carbon-based) soil conditioners can be made of animal manure, compost from yard waste or food waste, cover crop residue, biosolids, sawdust, ground pine bark, peat moss or other materials (Celestina *et al.,* 2019). Animal wastes in the form of manures are valuable sources of nutrients and organic matter for use in the maintenance of soil fertility and crop production (Wendy *et al.,* 2020). A good number of researches have shown soils amended with animal manures improved soil conditions and crop yields (Iren *et al.,* 2015; Udoh and Iren, 2016; Khaliq *et al.,* 2017). Ayeni and Adetunji (2010) reported that organic fertilizers positively impacted soil nutrient, soil structure, base saturation and bulk density. Moreover, organic manures are rich in organic matter and are a good substrate for the growth of soil microorganisms and they positively affect nutritional balance and the physical properties of soil (Maheshbabu *et al.,* 2018). Soils treated with organic manures have been reported to have significantly improve soil productivity and the yield of maize (John *et al.,* 2013). Iren *et al.,* (2015) reported that organic manures improved the sustained production of water leaf

The production of the pepper is challenged by lack of arable soil due to impoverished soil conditions. Soil degradation due to intensive cultivation occasioned by population pressure and industrialization are challenges to the production of these crops in Nigeria (Udoh and Iren, 2016). The high cost of inorganic fertilizers makes them unaffordable to poor farmers. More so, the continuous use of chemical fertilizers has been reported to result in nutrient imbalance in the soil and a major cause of climate change and aquatic pollution thereby causing inimical effects on the environment (Udoh and Iren, 2016). While there are reports on the single applications of some organic manure on the growth and yield and selected vegetable crops, there are insufficient data on the effects of different organic amendments on soil organic carbon, growth and physiological yields including protein and chlorophyll contents of the existing varieties of pepper in the study area. Thus, data that provide information on the sustainable production of pepper are grossly insufficient. The present study determined the effects of organic amendments on soil carbon, vegetative growth parameters and physiological yield of pepper (*Capsicum annuum*).

Materials and Methods

Study area

The experiment was carried at the Botanical Garden of the Department of Botany, Joseph Sarwuan Tarka University Makurdi, the State Capital of Benue State. Makurdi lies within Longitude $8^{0}30$'E, $8^{0}30$'E and Latitude $7^{0}30$'N, $7^{0}43$'N. It is a 16km radius circle, covering 804km2 land mass (Onah and Omudu, 2016). Makurdi has an estimated population of 500,797 (The World Gazetteer, 2003). Being situated in the Lower Benue Valley, the relief of the Local Government Area (L.G.A) is generally low, with heights ranging between 73 meters and 167 meters above sea level. The soils of Makurdi generally are highly ferruginous tropical soils. Climatically, Production of vegetable crops is high in the study area. Members of some communities are known for cultivating pepper in large quantity.

Seed collection

Seeds of three varieties of sweet pepper (*Capsicum annuum*) awere procured from a licensed Seed Store (Bloomfield Agro-Allied Company Makurdi) in Benue State Nigeria. The varieties are given below: Yolo Wonder (Variety 1), Poivron Yolo (Variety 2) and Chili (Variety 3).

Preliminary physicochemical analysis of experimental soil

Soil was collected at Botanical garden of the Department of Botany, Federal University of Agriculture Makurdi, filtered and put into 240 polythene bags each weighing 20kg (Klotzbucher *et al.,* 2017). Soil particles was distributed into clay, silt and silt using Bouyoucous (1951) hydrometer method as given by Udo *et al.* (2009). Soil pH was determined in the laboratory with a calibrated Suntex TS-2 pH meter. Soil organic matter was determined using the gravimetric procedure by Miyazawa *et al.* (2000). Soil nitrogen was determined using the Kjeldahl digestion method Electrical conductivity and Cation exchange capacity (CEC) were determined with a HACH conductivity meter CO-150 and filtration method respectively (Udoh *et al.,* 2009).

Experimental design

The experiment was conducted separately for each of the crop in a factorial experiment consisting of 3 varieties of each and 8 levels of soil amendments (T1-T7) for pepper. Each treatment level was replicated 4 times in a Randomized Completely Block Design (RCBD structure. Pepper experiment had a factorial combination of 8x4x3 (96 experimental units). Total experimental units = 96+60= 156.

Treatment combinations in pepper experiment

The following treatments were used: T0=5kg of top soil with no manure (control); T1=10g of cow dung; T2 =10g of goat dung; T3=10g poultry manure; T4-5g of goat dung + 5g of poultry manure; T5-5g poultry manure + 5g of cow dung; T6-5g of cow dung + 5g of goat dung; T7= 4g of cow dung + 3g of poultry manure + 3g of goat dung (Olson *et al.,* 2014).

Planting and treatment application

Three seeds were sown in pots filled with 5kg of top soil each. The plants were treated with powdered forms of different soil amendments (T1-T7) by broadcasting around the plant and on the soil Two weeks after germination (Gong *et al.,* 2003).

Plant data collection

Plant data collection took place at week 2, 4 and 6 after planting. Collection of vegetative growth parameters, total protein and total chlorophyll contents followed standard methods (Gong *et al ,* 2003).

Vegetative growth parameters

Growth parameters were evaluated following the methods outlined in Gong *et al.* (2003). They were: Plant height (cm); Stem diameter (mm): Number of leaves; Leaf length (cm); Leaf width (cm) and Leaf area. Plant height was measured using a metre rule to the nearest centimeter (cm) from the stand to the top. Stem diameter was measured using a Vernier caliper to the nearest cm. Number of leaves present on plant stands was counted. Length and width of two largest leaves were measured using the metre rule in centimetre (cm) while leaf area was derived using the formula: LA=Li x Wi x A (where L represent the length of the leaf, W represent the maximum width of the leaf and A is constant)

Determination of total protein

Crude protein content of the fruits was determined. The micro-kjeldahl titration method was used where samples were mixed with 10ml of concentrated tetraoxosulphate (vi) acid in a kjeldahl digestion flask (Simone, 2014). The total nitrogen was calculated and multiplied by a factor 6.25 to obtain the crude protein content as: % Crude protein = %N6.25.

$$\%\ \mathrm{N2} = \frac{(100x)\mathrm{Nx14xVfxT}}{\mathrm{w\ x\ 100\ x\ VA}}$$

Determination of chlorophyll content

Chlorophyll; was extracted from pulverized 10g leaf samples using 50ml acetone (Abdelaal *et al.,* 2020). Chlorophyll content was calculated from standard curve obtained from spectrophotometer reading at 663 nm and 645 nm (Abdelaal *et al.,* 2020).

Data analysis

Data analysis was performed using the Genstat application (17.0 version). Result presentation was done using bar graphs where each bar with error bar represents means ± standard error. Analysis of variance was conducted while mean separation (post-hoc) was done using Tukey HSD. Bars with the same alphabets are not statistically different ($p>0.05$) from each other while bars with different alphabets are statistically significant ($p<0.05$).

Results

Physicochemical properties and organic carbon (OC) of soil samples

Table 1 shows the physic-chemical properties of soil samples prior to the experiment. It was dominated by sand (73.8%) followed by clay (14.2%) and silt (12.0%). It possessed the following properties: pH (6.42-6.43), organic carbon (1.22%), organic matter (2.10%), nitrogen (0.05%) and phosphorus (3.89-4.30 mg/L). Other properties measured in Cmolkg^{-1} were potassium (0.32-0.34), sodium (0.25-0.26) and magnesium (1.84-1.85), calcium (2.90-3.10). Electrical conductivity and cation exchange capacity had maximum values of 1.53 and 7.06 Cmolkg^{-1} respectively. Figure 2 shows that organic carbon content of soil was lower during the growth of pepper than pre-sowing soil samples which contained 1.22% organic carbon. Soils of the three varieties differed significantly in their organic carbon ($P<0.05$) where it was highest in Yolo Wonder variety (0.81%) and lowest in Chili variety (0.65%). In pepper experiment, soil samples under various amendments had significantly different amount of organic carbon. Values were highest in soils treated with 10g cowdung (0.99% OC) followed by soils treated with 10g goat dung (0.95% OC) while the lowest value was recorded in soils treated with a mixture of 5g poultry manure + 5g cow dung. Apart from the latter, all other treatments impacted higher organic carbon in treated soils than the control soil (untreated) that contained 0.6% OC (figure 3).

Table 1: Pre-planting physico-chemical analysis of soil samples

Sample ID	pH	% Sand	% Clay	% Silt	% O.C	% O.M	% N	Mgl^{-1} P	Cmolkg^{-1} K	Cmolkg^{-1} Na	Cmolkg^{-1} Mg	Cmolkg^{-1} EC	Cmolkg^{-1} CEC
SIC 1	6.43	73.80	14.20	12.00	1.22	2.10	0.05	4.30	0.34	0.25	1.85	1.51	7.05
SIC 2	6.42	73.80	14.20	12.00	1.22	2.10	0.05	3.89	0.32	0.26	1.84	1.53	6.85
SIC 3	6.43	73.80	14.20	12.00	1.22	2.10	0.05	4.30	0.34	0.26	1.85	1.53	7.06

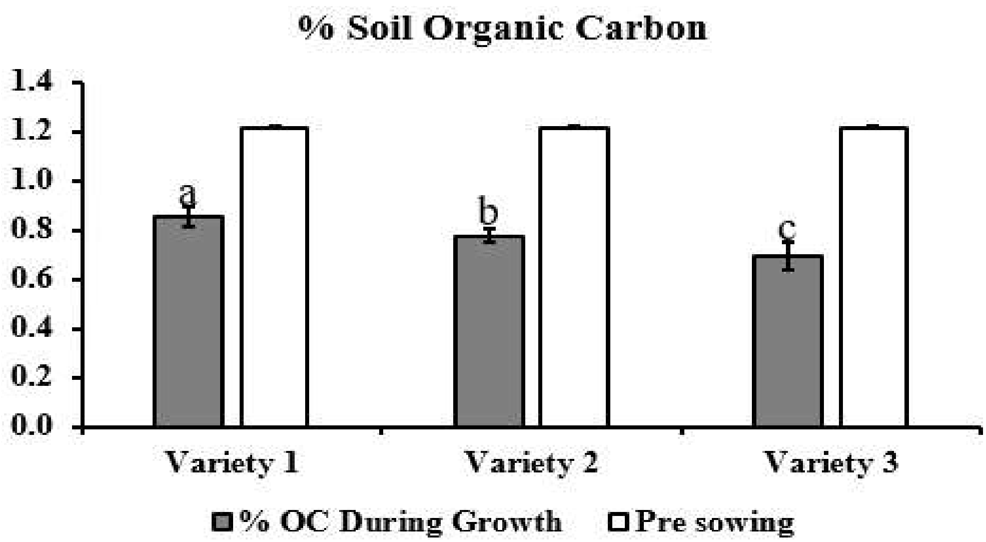

Figure 2: Comparative soil organic carbon at pre-sowing and during growth of pepper varieties

Variety 1= Yolo Wonder; Variety 2= Poivron Yolo; Variety 3= Chili

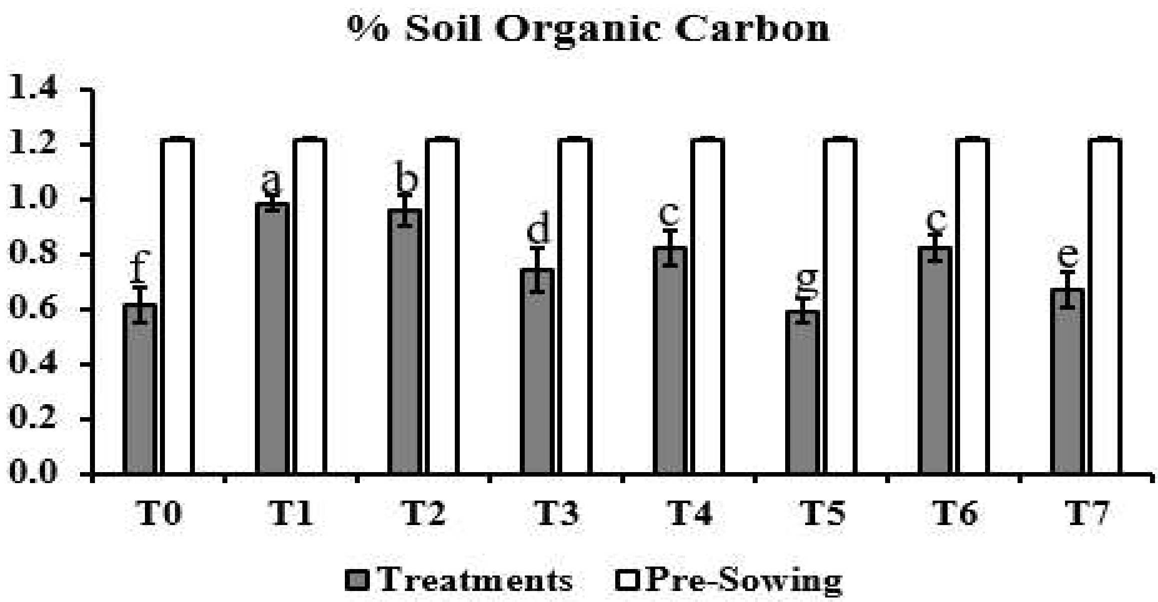

Figure 3: Effects of different amendments on the soil organic carbon at pre-sowing and during growth of pepper

T0 =5kg of top soil with no manure (control); T1 =10g of cow dung; T2= 10g of goat dung; T3= 10g poultry manure; T4= 5g of goat dung + 5g of poultry manure; T5= 5g poultry manure + 5g of cow dung; T6= 5g of cow dung + 5g of goat dung; T7= 4g of cow dung + 3g of poultry manure + 3g of goat dung

Effects of organic amendments on vegetative growth of sweet pepper (*C. annuum)*

Figure 4 shows the effects of planting duration (weeks) on vegetative growth of *C. annuum* in amended potted experiments. All vegetative growth parameters increased progressively from week 2-6, thus significant differences were observed in plant morphologies due to plant duration ($P<0.05$). The same trend was observed at week 6 where plant height (14cm), number of leaf (17), leaf length (5cm), leaf width (3cm), leaf area ($8cm^2$) and stem diameter (0.7cm) attained their maximum values (rounded off to the nearest whole number). These values were significantly higher than from those recorded at week 2 and 4. Figure 5 shows the effects of plant varieties on the six vegetative growth parameters of *C. annuum.* Significant differences were observed in plant height, number of leaf, leaf length, leaf width and stem diameter attributed to varietal differences. Only the leaf area showed no significant differences. Poivron Yolo type had the highest plant height and number of leaf while Yolo Wonder type possessed the largest leaf sizes and the widest stem diameter. Figure 6 shows the effects of organic amendments on the growth parameters of *C. annuum*. Treatments had significant effects on all parameters ($P<0.05$). Application of T2 (10g goat dung), T4 (5g goat dung + 5g poultry manure) and T5 (5g poultry manure + 5g cow dung) significantly influenced plant height. Number of leaves in pots treated with T2 (10g goat dung) and T7 (4g cow dung + 3g poultry manure + 3g goat dung) were the highest values obtained. Large leaf sizes and wide stem diameters were observed in pots treated with T4 (5g goat dung + 5g poultry manure) and T5 (5g poultry manure + 5g cow dung) although the overall leaf area had no significant changes in the different amendments.

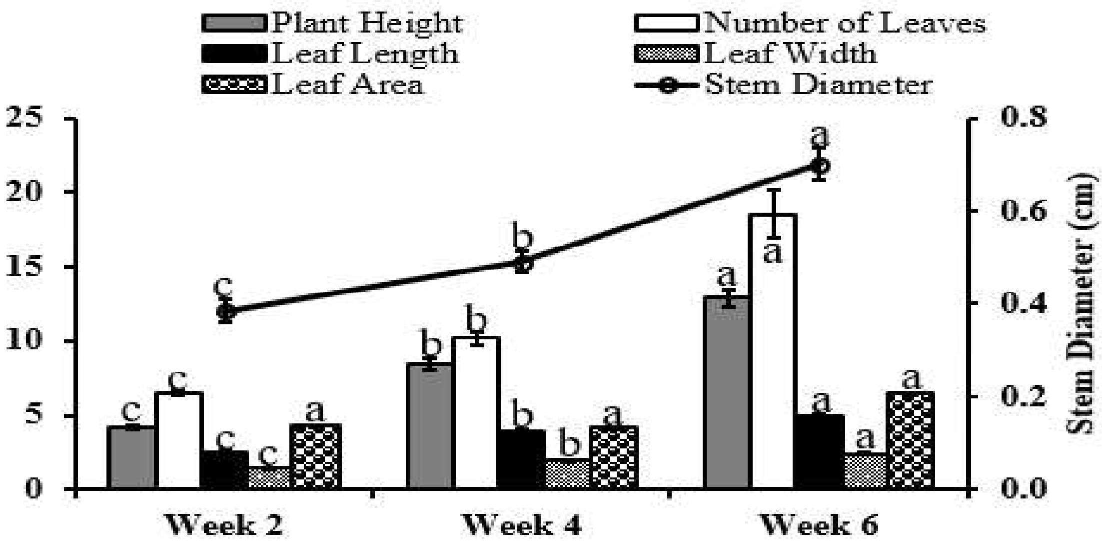

Figure 4: Weekly vegetative growth analysis of pepper plants grown in different soil amendments
Vertical bars represent means; error bars represent ± standard error. Mean separation (post-hoc) was done using Tukey HSD. Bars with the same alphabets are not statistically different ($p>0.05$) from each other while bars with different alphabets are statistically significant ($p<0.05$).

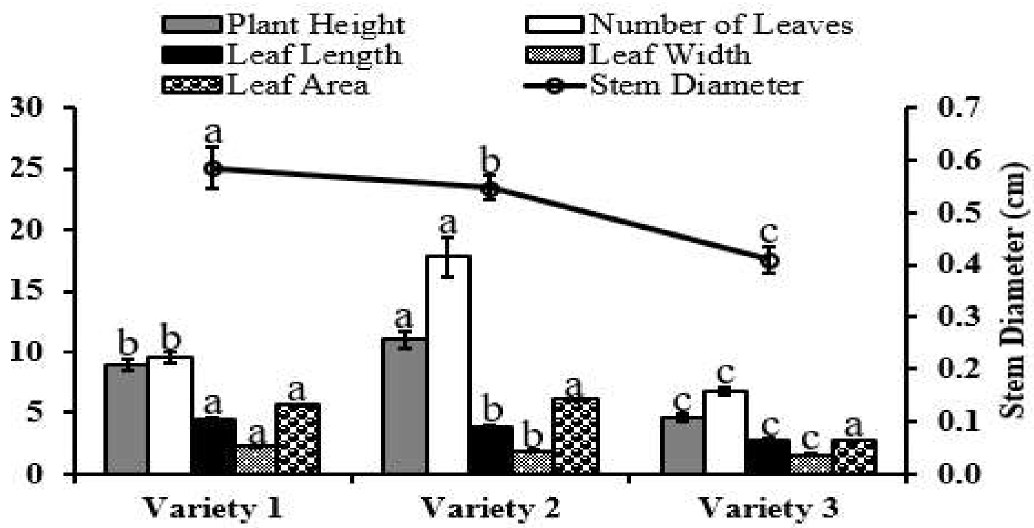

Figure 5: Effect of soil amendments on vegetative growth of three varieties of pepper
Vertical bars represent means; error bars represent ± standard error. Mean separation (post-hoc) was done using Tukey HSD. Bars with the same alphabets are not statistically different (p>0.05) from each other while bars with different alphabets are statistically significant (p<0.05).
Variety 1= Yolo Wonder**;** Variety 2= Poivron Yolo**;** Variety 3= Chili

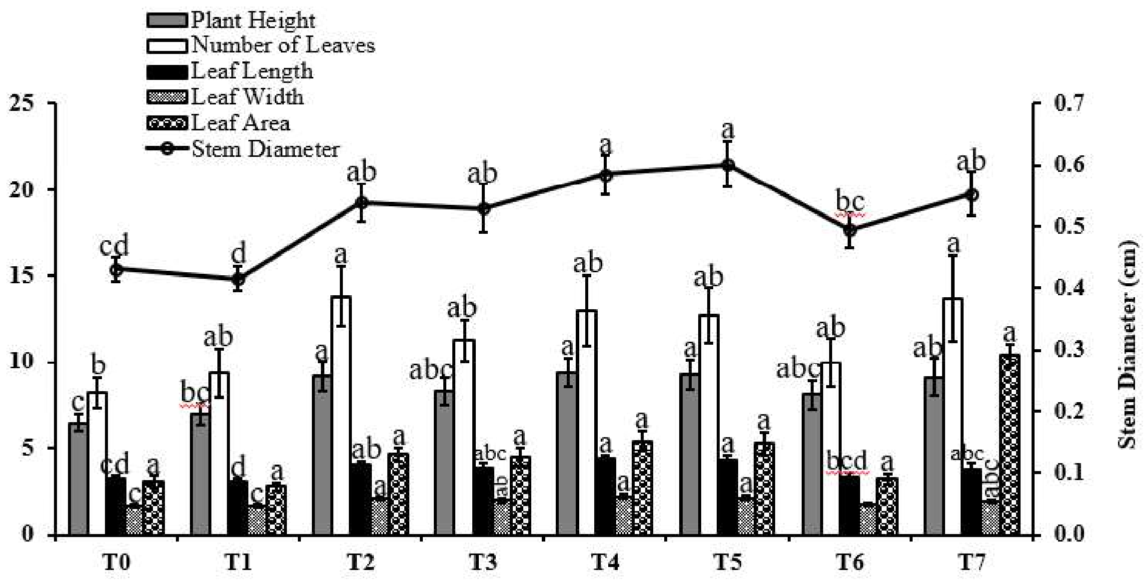

Figure 6: Effect of different soil amendments on vegetative growth of pepper
Vertical bars represent means; error bars represent ± standard error. Mean separation (post-hoc) was done using Tukey HSD. Bars with the same alphabets are not statistically different (p>0.05) from each other while bars with different alphabets are statistically significant (p<0.05). T0 =5kg of top soil with no manure (control); T1 =10g of cow dung; T2= 10g of goat dung; T3= 10g poultry manure; T4= 5g of goat dung + 5g of poultry manure; T5= 5g poultry manure + 5g of cow dung; T6= 5g of cow dung + 5g of goat dung; T7= 4g of cow dung + 3g of poultry manure + 3g of goat dung

Effects of organic amendments on total protein content of sweet pepper (*C. annuum*)

Figure 7 shows the effects of planting duration (weeks) on total protein content of the three varieties of *C. annuum*. Total protein fluctuated within the two factors (duration and varieties). It was a function of both variety and duration. The Poivron Yolo type (variety 2) had significantly higher protein contents (from week 2-6) than other types (P<0.05) within the same time frame. This variety had its highest protein contents of 3.5% at week 2 and week 6 with a slight reduction (3.0%) at week 4. Increase in protein content (3.5%) was also recorded in the Chili type at week 6. Figure 8 shows the effects of organic amendments on total protein content of the three varieties of *C. annuum* from week 2 to 6. Treatments had significant effects on total protein across the plant duration (P<0.05). Application of T6 (5g cow dung + 5g goat dung) significantly influenced total protein from week 2-6. At week 6, total protein (3.5%) was more pronounced in T6 (5g cow dung + 5g goat dung) and T4 (5g goat dung + 5g poultry manure) than in other treatments including the control.

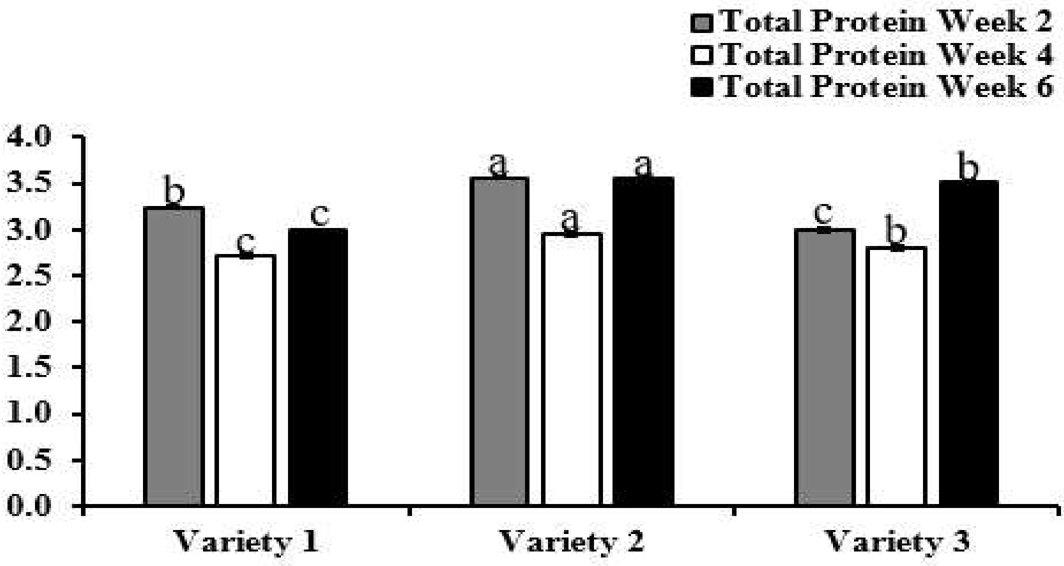

Figure 7: Effect of soil amendments on total protein of three varieties of pepper

Vertical bars represent means; error bars represent ± standard error. Mean separation (post-hoc) was done using Tukey HSD. Bars with the same alphabets are not statistically different (p>0.05) from each other while bars with different alphabets are statistically significant (p<0.05).

Variety 1= Yolo Wonder; Variety 2= Poivron Yolo; Variety 3= Chili

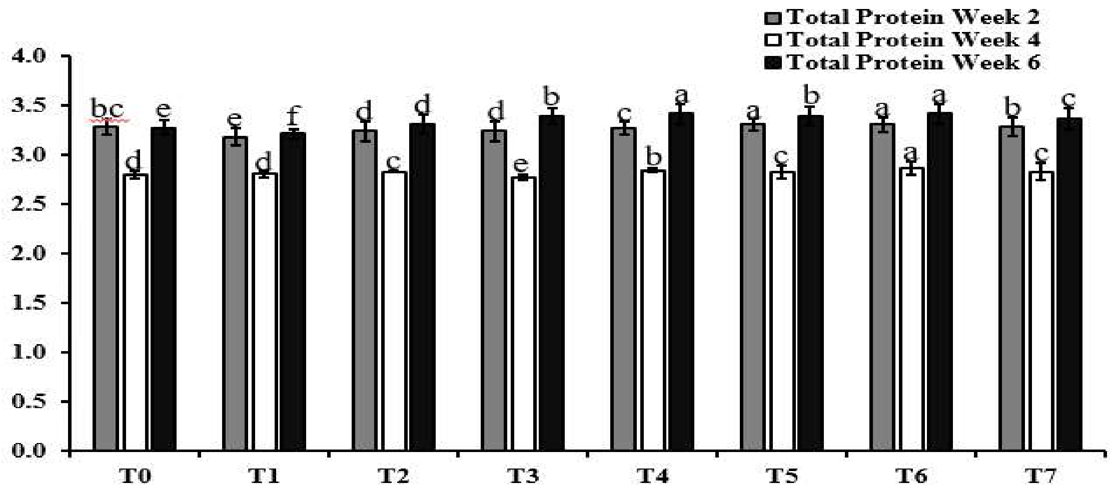

Figure 8: Effect of different soil amendments on total protein of pepper
Vertical bars represent means; error bars represent ± standard error. Mean separation (post-hoc) was done using Tukey HSD. Bars with the same alphabets are not statistically different (p>0.05) from each other while bars with different alphabets are statistically significant (p<0.05). T0 =5kg of top soil with no manure (control); T1 =10g of cow dung; T2= 10g of goat dung; T3= 10g poultry manure; T4= 5g of goat dung + 5g of poultry manure; T5= 5g poultry manure + 5g of cow dung; T6= 5g of cow dung + 5g of goat dung; T7= 4g of cow dung + 3g of poultry manure + 3g of goat dung

Effects of organic amendments on total chlorophyll content of sweet pepper (*C. annuum*)

Figure 9 shows the effects of planting duration (weeks) on total chlorophyll content of the three varieties of *C. annuum*. Total chlorophyll fluctuated within the two factors (duration and varieties). It was a function of both variety and duration. Chlorophyll content in plants was higher at week 2 than at week 4 while week 6 contained the highest amount. The Yolo Wonder type (variety 1) had significantly higher chlorophyll content (7.0%) at 6 than other types (P<0.05) although its chlorophyll content was the lowest recorded at week 2 and 4. Figure 10 shows the effects of organic amendments on total chlorophyll content of the three varieties of *C. annuum* from week 2 to 6. Treatments had significant effects on total chlorophyll across the plant duration (P<0.05). Application of T7 (4g of cow dung + 3g of poultry manure + 3g of goat dung) most significantly influenced total chlorophyll at week 4 and 6 while T6 (5g cow dung + 5g goat dung) had a pronounced effect at week 2. Cholophyll contents in plants growing in amended pots were higher than those growing in control pots. \

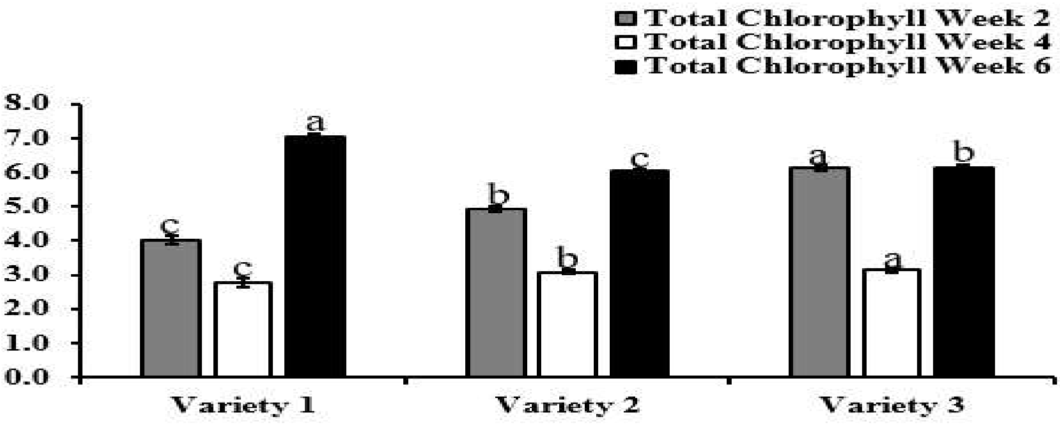

Figure 9: Effect of soil amendments on chlorophyll content of three varieties of pepper
Vertical bars represent means; error bars represent ± standard error. Mean separation (post-hoc) was done using Tukey HSD. Bars with the same alphabets are not statistically different (p>0.05) from each other while bars with different alphabets are statistically significant (p<0.05).
Variety 1= Yolo Wonder**;** Variety 2= Poivron Yolo**;** Variety 3= Chili

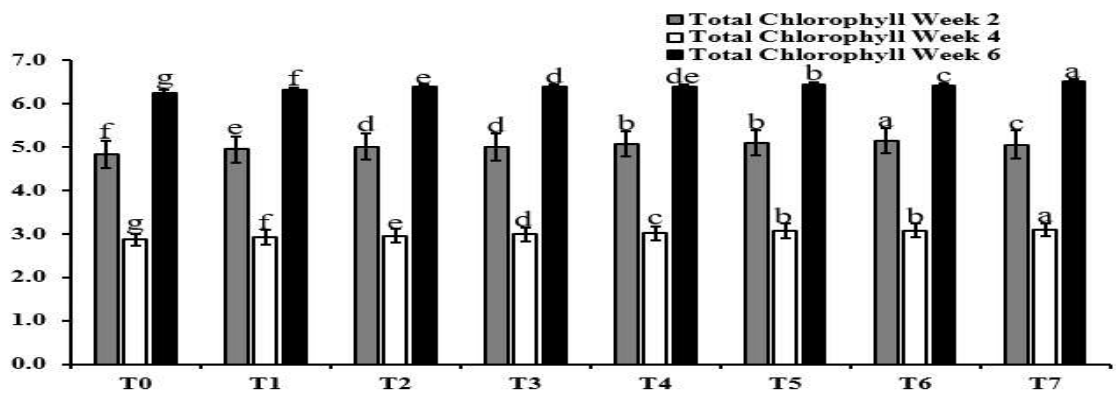

Figure 17: Effect of different soil amendments on total chlorophyll of pepper
Vertical bars represent means; error bars represent ± standard error. Mean separation (post-hoc) was done using Tukey HSD. Bars with the same alphabets are not statistically different (p>0.05) from each other while bars with different alphabets are statistically significant (p<0.05). T0 =5kg of top soil with no manure (control); T1 =10g of cow dung; T2= 10g of goat dung; T3= 10g poultry manure; T4= 5g of goat dung + 5g of poultry manure; T5= 5g poultry manure + 5g of cow dung; T6= 5g of cow dung + 5g of goat dung; T7= 4g of cow dung + 3g of poultry manure + 3g of goat dung

Discussion

The outcome of pre-soil analysis revealed the suitability of the test soil for pepper production. The soil was arable although deficient in organic matter and organic carbon possible due to limited number of trees and fallen leaf litters that could add to to the organic matter of the soil at the Botanical garden. Hence microbial activities are probably limited. Although macrofauna population was not investigated at the experimental site, the area is characterized by presence of earthworms and their casts which might have contributed to the good soil structure and other suitable physico-chemical properties observed. These include suitable pH, cation exchange capacity and electrical conductivity found within normal range for arable land. The above findings agree with some reports on the use of soil conditioners or amendments in the alteration of soil structure (Celestina *et al*, 2019). Some authors also reported that the soil conditioners do not change soil texture, which refers to the proportions of sand, silt, and clay in the soil (Celestina *et al*, 2019). It is however possible that the use of organic soil amendments might have greatly increased the cation exchange capacity (CEC) of soils. This refers to the relative ability of soils to store nutrients in the form of positively charged particles called cations. The higher the CEC, the more cations that can be held and exchanged with plant roots, providing them with the nutrients they need (Gilbert *et al*. 2020).

Results have shown that soil OC was significantly lower during the growth of the test plant than in pre-sowing soil samples. Application of 10g cowdung yielded the highest amount of OC in soil. The pepper Yolo Wonder variety improved soil OC. Organic amendments are often reported to influence crop performance through the amelioration of soil constraints (i.e. improving soil physical, chemical and biological properties and restoring degraded soils) and/or through plant nutrients contained in the amendments (Celestina *et al*, 2019) Soil is an important reservoir of carbon, storing more than the atmosphere and terrestrial vegetation combined.(Gilbert *et al*. 2020) In terrestrial ecosystem, different studies have reported that the main factors influencing the soil OC were soil types, climate, topography, land use patterns, tillage practices, and fertilizer application (Zhang *et al.,* 2020). This study shows that animal wastes in the form of manures are valuable sources of nutrients and organic matter for use in the maintenance of soil fertility and crop production. This agrees with the view of Wendy *et al.* (2020) that soil conditioners generally help improve the soil structure to enable plants to better utilize nutrients.

In this work, test plants witnessed a progressive growth in all vegetative features from week 2 to week 6. The outcome of this investigation showed that the plant's vegetative features grew progressively along the growth cycle from seedlings to maturity stages. This might result from cellular and tissue differentiation during plant development most especially at week 6 that recorded the best plant growth. The progressive increase in vegetative parameter with number of weeks might probably due to an enhanced nutrient uptake potential by the plants as the week progresses (Chen *et al.,* 2011; Saud *et al.,* 2014). In pepper, varietal type influenced all vegetative growth parameters. Varietal differences and impacts on growth and physiological yields may be due to genetic factors or an interplay of genes and environment, a view that was upheld in other studies (Kovacs *et al.,* 2022).

It was discovered that different treatment applications had significant effects on all growth parameters of pepper where each of the amendment positively influenced one or more growth parameter. The increase in number of leaves per plant with organic fertilizer application stressed its importance during the vegetative growth of crop plants (CABI, 2023). This work aligned with the suggestions given by Sanwal *et al.* (2017) who attributed the increase in number of branches of okra to poultry manure application. The authors argued that easy solubilization of nutrients might have released plant nutrient leading to improved nutrient status and water holding capacity of the soil. These differences in plant morphometric characteristics as observed in this study may be due to the different application manure obtained from different sources including poultry dung, cow dung and goat wastes used in single and combined forms at different mixes. This finding aligns with the view of authors who observed the influence of soil conditioners on growth of rice (Réthoré *et al.,* 2020), finger millet (Suma and Urooj, 2012), and soybean (Lee *et al.,* 2019; Okoh *et al.,* 2023). Similar reports were given by Amin *et al.* (2016) who found improved performances of cereal crops in different soil amendments A good number of researches have shown soils amended with animal manures improved soil conditions and crop growth and yields (Iren *et al.,* 2015; Udoh *et al.,* 2016; Khaliq *et al.,* 2017). Ayeni and Adetunji (2010) reported that organic fertilizers positively impacted soil nutrient, soil structure, base saturation and bulk density. Moreover, organic manures are rich in organic matter and are a good substrate for the growth of soil microorganisms and they positively affect nutritional balance and the physical properties of soil (Maheshbabu *et al.,* 2018).

Total protein content lants significantly depend on both durations of plant and variety. The Poivron Yolo type of pepper had significantly higher protein contents of 3.5% at week 6 than other types. Treatment application had significant effects on total protein of the two test plants In pepper, application of 5g cow dung + 5g goat dung to soil significantly influenced total protein from week 2-6. This effect may be attributed to the ability of amendments to prevent transpiration rate and improve many physiological and biochemical processes in plants including protein yield (Kovacs *et al.,* 2022). The outcomes were in tandem with other numerous studies that suggested possible effects of fertilization by inorganic amendments in crop productivity as it affects the physiological properties of plants in terms of production of biomass and biochemical (Ahmad *et al.,* 2015; Kowalska *et al.,* 2020). Total chlorophyll was influenced by plant duration and varietal types in the two test plants. In pepper, chlorophyll was higher at week 2 than week 4 while week 6 contained the highest amount t. The Yolo Wonder type of pepper had significantly higher chlorophyll content (7.0%) at week 6 than other types. Treatment applications had significant effects on total chlorophyll across the plant duration ($P<0.05$) where amendment using 4g of cow dung + 3g of poultry manure + 3g of goat dung most significantly influenced total chlorophyll at week 4 and 6. In maize and wheat plants, inorganic silica amendments was found to improve leaf chlorophyll index (Galindo *et al.,* 2021).

The organic manures used are good sources of nutrients. All plants require a ready supply of macro and micronutrients within their growth medium in order to accomplish their standard physiological functions. The presence of appropriate concentrations of nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), sulfur (S), magnesium (Mg) and iron (Fe) have all been recognised as essential for optimum plant growth, chlorophyll synthesis and overall productivity (Abdelaal *et al.,* 2020). A depletion in overall leaf chlorophyll content reduces the amount of solar radiation that can be absorbed which in turn limits the efficiency of corresponding photosynthetic processes thus lowering primary photosynthetic production (Abdelaal *et al.,* 2020).

Conclusion

In conclusion, the organic treatments applied as soil amendments had positive impacts on all growth of pepper. Application of 5g cow dung + 5g goat dung to soil significantly influenced total protein from week 2-6 while 4g cow dung + 3g poultry manure + 3g goat dung increased total chlorophyll. Application of 5g cow dung + 5g goat dung to soil significantly influenced total protein from week 2-6 while 4g cow dung + 3g poultry manure + 3g goat dung increased total chlorophyll. Varietal and plant duration factors also exerted positive impacts on the parameters evaluated. Therefore, the best performing varieties and soil amendments as highlighted in this report are recommended in the cultivation of pepper for improved plant productivity and carbon sequestration.

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