**PERFORMANCE AND QUALITIES OF TWO VARIETIES OF PEPPER (*Capsicum chinense*) UNDER DIFFERENT SOIL AMENDMENTS AND SEASONS**

**A Dissertation Submitted to the**

**Graduate School in Partial Fulfillment of the Requirements for the Degree of**

**MASTER OF SCIENCE**

**BY**

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**DECLARATION**

I, **AFOLAYAN, JOHN OREOLUWA**, an MSc student in the Department of ***Crop and Soil Science****,* Landmark University, Omu-Aran, hereby declare that this thesis entitled “***Performance and Qualities of Two Varieties of Pepper (Capsicum Chinense) Under different Soil Amendments and Seasons***”, submitted by me is based on my original work. Any material(s) obtained from other sources or work done by any other persons or institutions have been duly acknowledged.

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**CERTIFICATION**

This is to certify that this thesis has been read and approved as meeting the requirements of the College of Agricultural Sciences, Department of Crop & Soil Science, Landmark University, Omu-Aran, Nigeria, for the Award of Master of Science (M.Sc Crop Sciences).

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**ABSTRACT**

This research was conducted at the Landmark University Teaching and Research Farm in Omu-Aran, Kwara State. The experiment was carried out to examine the performance and quality of two varieties of pepper (*capsicum chinense*) under different soil amendments and seasons (dry season planting November 2021, wet season planting March 2022). The following amendments were used: Poultry manure (PM), *Tithonia diversifolia* (TD), cattle manure (CM), NPK 15:15:15, and Control (CTRL). Organic amendments were applied at a rate of 20 t ha-1, whereas NPK 15:15:15 was applied at a rate of 180 kg ha-1. The experiment was a 2 x 5 x 2 factorial with three replications laid out in a Randomised Complete Block Design. The following data were collected: plant height, number of leaves, number of primary and secondary branches, shelf-life, yield, and fruit mineral composition. Analysis of variance (ANOVA) was performed on data collected using Genstat software at a 0.05 level of probability. Duncan Multiple Range Test (DMRT) was employed to compare significant treatment means. The results of the study shows plots treated with PM had higher values for the vegetative parameters when compared with other amendments. The highest value for yield (t/ha) was obtained from the Caribbean red variety. The first season (dry season) yield (505,667 t ha-1) performed better than the second season (wet season) yield (270,000 t ha-1). When the values of the various amendments were compared, the PM treated plots produced the best results in term of the vegetative, yield and quality attributes. This concludes that PM application at 20 t ha-1 increased pepper yield and quality parameters in both seasons, and that pepper cultivation can be done more successfully in the dry season than during the wet season.

**DEDICATION**

This project is dedicated to God Almighty, my ever-supportive parents, Mr and Mrs Afolayan, Uncle, Mr Adeleke Adewole and my siblings (Olatunde David and Wuraola Afolayan).

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# CHAPTER ONE

# INTRODUCTION

Peppers, which include both hot and sweet varieties, are an important food crop that originated in the Americas and belong to the Solanaceae family (Bouchard, 2017). Peppers (*Capsicum spp*.) are highly valued for having antioxidants which may provide health advantages and protection against various diseases (Arimboor, Natarajan, Menon, Chandrasekhar, & Moorkoth, 2014).

Although there are roughly 30 different species of capsicum, C. annuum is the most often grown species (Ravishankar, Suresh, Giridhar, Ramachandra Rao, & Sudhakar Johnson, 2003; Csillery, 2006). Among the known species of pepper (Capsicum species) are *Capsicum annuum* Peppers, both spicy and sweet, *Capsicum chinense* (hot pepper, also known as Habanero pepper), *Capsicum frutescens* (finger pepper), *Capsicum baccatum* (Aji), and *Capsicum pubescens* Ruiz and Pav. (rocoto). *Capsicum annum, Capsicum chinense*, and *Capsicum frutescens* are the most widely grown in both tropical and temperate climates (Grubben & Denton, 2004)*.*  *C. chinense* is one of the five domesticated species that thrives well in most parts of Nigeria and is used as a spice for colouring and flavouring a variety of dishes while providing essential vitamins and minerals (Bosland and Votava, 2000).

The Solanaceae class includes the genus Capsicum. *Capsicum chinense* fruits are hollow berries, having between two to four cavities. The mature habanero is typically 2-6 centimetres in length. The crop is cultivated with other vegetables, which may include other Solanaceae relatives, under monoculture or intercropped with other basic crops (Sokona et al., 2013). Kappor (2012) revealed that the unripe fruits of habanero peppers are usually green when they are young and will eventually turn red, orange, or brown when mature.

The lipids, proteins, and minerals in Capsicum fruits are abundant (Park et al., 2006). These nutritional components are crucial for keeping a healthy body, notably fatty acids and amino acids. (Koyuncu, Çetinbaş, & ERDAL, 2020).

Capsicum seeds are thus a low-cost source of nutrional proteins, lipids, and minerals. The nutritional value of capsicum seeds is also affected by variety and ambient factors (Bae, Jayaprakasha, Jifon, & Patil, 2012). Although habanero peppers are the most well-known and popular cultivar of this genus, *Capsicum chinense* also includes a variety of other peppers: Carolina reaper, Bhut jolokia (ghost pepper), Trinidad moruga scorpion, Scotch bonnet, adjuma, goat pepper, and datil are some of the other kinds (Bray, 2016). A ripe habanero is typically 2–6 cm long. Habanero chillies are extremely hot, with Scoville ratings ranging from 100,000 to 350,000. (Filippone, 2020).

The Scotch Bonnet pepper is a *C. chinense* cultivar named for its similarity to the Scottish Tam o' Shanter bonnet. It is one of the hottest peppers, with Scoville Heat Units (SHU) ranging from 100,000 to 350,000. In comparison, a jalapeno pepper has roughly 5,000 SHU on average. At maturity, Typically, the Scotch bonnet pepper comes in either red or yellow. Although, other kinds can mature into colours like orange, yellow, peach, or even chocolate brown. The fruits of habanero the habanero pepper ranges between one and two and a half and one inches in length and diameter, respectively. Its form is hat-like, but flatter and wider than the habanero hence, the name (Mike, 2013).

Most farmland in the tropics has poor soil because it has been farmed continuously for so long without a fallow phase to allow for the restoration of lost fertility. Utilizing both organic and inorganic fertilisers is the best way to overcome the threat of food insecurity that may result from poor soil fertility. Inorganic fertilisers provide nutrients to crop plants more quickly after application. For instance, urea, which contains 46% nitrogen promotes plant vegetative development, is different from NPK fertiliser, which is made up of the essential nutrients that plants need in high quantities: nitrogen, phosphorus, and potassium (Milić, Mrkovački, & Hrustić, 2002). Many studies, (Adeyeye et al., 2019, Ilahi, Hidayat, Adnan, & Toor, 2021), showed the superiority of organic manure over inorganic fertilizers in soil management and sustainable vegetable production. While Organic fertilizer is known as natural fertilizer, inorganic fertilizer is known as chemical or synthetic fertilizer, and these are the two most common fertilizers commonly applied to the soil.

The soil should have high organic matter in order to function properly. This is the primary component of soil improvement and represents the last step of plant and animal decomposition. Organic manure, such as *cattle manure* and poultry manure, gives the soil a spongy texture that enhances the capacity of soil to retain water and provide it the necessary pore space for healthy plant development (Ferreras, Gomez, Toresani, Firpo, & Rotondo, 2006). Organic fertilisers are crucial for soil conservation because they boost soil fertility over the long term and organic matter levels, which affect plant development (Assefa & Tadesse, 2019). According to an experiment's findings, nitrogen administration at a rate of 180 kg ha-1 increased *Capsicum annuum* plants' maximum height, leaf count, branch count, stem thickness, fruit length, seed, and yield measurements. However, little knowledge about the plant's genetic make-up and hereditary features has mostly hindered efforts to enhance the crop. Fruit output is affected by both the quantity of fruits and the weight of each fruit, but considerable improvements need for accurate genetic information and effective breeding techniques.

## 1.1. General Background

In addition to its commercial worth, pepper is an important agricultural crop due to its therapeutic and nutritional properties. Nigeria is the seventh largest pepper grower in the world, with a total harvest area of 99,715 hectares and a total output of 753,116 tons, compared to Spain, which is placed fifth with a total harvest area of 21,4330 hectares and a total output of 1,402,380 tonnes (FAOSTAT, 2019). Due to the increase in the price of inorganic fertilizer and its scarcity, farmers are encouraged to explore other means of supplying nutrients required by plants that are cheap to enhance yield and quality. This study focuses on the differences in vegetative growth, yield, and quality characteristic of two varieties of *Capsicum chinense* when various organic amendments are applied across two seasons.

## 1.2 Justification for the study

Numerous studies have examined how pepper growth and yield respond to both organic and inorganic fertilisers. According to Moneruzzaman Khandaker, Rohani, Dalorima, and Mat's (2017) report, the growth, yield, and quality of pepper plants were considerably impacted by organic fertiliser. Valenzuela-Garca et al. (2019) investigated the effects of manure, vermicompost, and the combination of manure and vermicompost on the yield and quality of jalapeño pepper fruit. Their results revealed that manure alone has the highest yield. Also, in Nepal, the effects of farmyard manure, goat manure, NPK, and a combination of each organic manure with urea were studied with regard to pepper production and growth. The study discovered that goat manure significantly increased pepper output and growth when compared to FYM and vermicompost applied solely (Ghimire, Shakya, & Srivastava, 2013). Knowledge is inadequate on how the minerals and vitamins in pepper are influenced by the seasons or soil amendments. Therefore, to improve knowledge to the study of pepper performance, shelf-life, minerals, and vitamins using organic and inorganic amendments at different seasons, this work is imperative.

## 1.3 Objectives of the study

The primary objective of this study is to evaluate the performance, minerals vitamin C and shelf life of two habanero pepper varieties in response to organic and inorganic fertilisers at two different seasons. The specific objectives of the study are to: -

1. evaluate the vegetative growth and yield performance of two varieties of Habanero pepper under organic and inorganic amendments at two seasons,
2. assess the mineral and vitamin compositions of the two varieties, and
3. determine the effects of amendments and seasons on the shelf life of two Habanero pepper varieties.

# CHAPTER TWO

# LITERATURE REVIEW

## 2.1 Origin, Description and Growth Requirement of *Capsicum chinense*

Capsicum is an herbaceous plant of the Solanaceae family native to Mesoamerica. (Khomendra et al., 2012). The Solanaceae family, also includes tomatoe, potatoe, and eggplant.The five most widely grown species of the Capsicum genus are *Capsicum annuum, Capsicum frutescens, Capsicum chinense, Capsicum baccatum, and Capsicum pubescens* (Antonious and Jarret, 2006). Mexico, Australia, the United Kingdom, America, Sri Lanka, Bangladesh, India, and Africa are home to these plants (Khomendra et al., 2012).  Habanero pepper, belongs to the genus Capsicum. The Guinness Book of Records has identified *Capsicum chinense* as the world's hottest pepper (Khomendra et al., 2012). Agricultural smallholders in emerging nations like Nigeria, Ghana and Sierra Leone have been earning revenue through the production of pepper, enabling chilli to dominate the global spice market, while sweet pepper has become a famous food and cash crop for subsistence farmers (Lin et al., 2013; Kamal, 2018).

*Capsicum Chinese*, has a diverse spectrum of chemical components that benefit human health. The chemical components have anti-cancer, anti-inflammatory, antibacterial, and antioxidant properties include carotenes (provitamin A), flavonoids, capsaicin, minerals, vitamins, and essential oils (Villa-Rivera & Ochoa-Alejo, 2020). Dietary fibre, as one of the nutritional components, is helpful to human health. Elleuch et al., (2011) reported on some data indicating that dietary fibre may help diseases such as colorectal cancer, adiposity, cardiovascular disorders, and diabetes can be averted. Dietary fibre content was connected to polysaccharides with antioxidant activity, as well as the quantitative and qualitative components (Sousa et al., 2014). Human health depends on proteins and amino acids. Amino acids are the building blocks for antibodies, blood cells, hormones, and enzymes. and are necessary for the body's growth, development, regeneration, and repair (Sousa et al., 2014).

The nutrients in the soil have a significant influence in enhancing agricultural production to promote food security and meet the demands of an increasing populace. Soil health are critical to increasing productivity and quality (Neneng, 2020). Therefore, to achieve improve yield, chemical fertilizers should be mixed with organic manure to enrich the soil with important nutrients required by plants to increase the yield per unit area. It is important balance application via proper combination of organic and inorganic fertilizer (Sonam, 2021).

## 2.2 Poultry Manure as a Soil Amendment

It is not unexpected, given the importance of poultry manure, vegetative growth, and yield have responded significantly to an increase in poultry manure (Ikeh et al., 2012). The increased plant height caused by poultry manure was mostly attributable to the increased availability of nutrients throughout the growing season (Ikeh et al., 2012). In the same vein, it was reported by Abdulbaki (2019) that the use of poultry manure enhanced the amount of Fruit produced per plant, fruit length, and fruit quality

Poultry droppings is an excellent fertilizer that may be used instead of chemical fertilizers. Poultry manure application resulted in 53 per cent rise in nitrogen levels in the soil, from 0.09 per cent to 0.14 per cent, as well as an increase in exchangeable cations (Boateng, Zickermann, & Kornahrens, 2009). In the results of Enujeke (2013), plants given 20 t/ha of chicken manure grew taller than other plants, presumably because more concentrated nutrients or minerals were made readily available and easily absorbed by the recipient plants, resulting in quicker growth and development.

## 2.3 Cattle Manure as a Soil Amendment

Utilizing organic manure increases soil physical structure, soil nutrient status, soil microorganisms, soil and crop productivity (Saikai et al., 2019). Cattle manure is the undigested residual of eaten food stuff ejected by bovine species (Gupta, Aneja, & Rana, 2016). An individual bovine animal's diet, water quality, genetic make-up, health, and feed conversion ratio all have an impact on the chemical composition of the animal's faeces, especially when it is kept inside (Powell, Fernández-Rivera, Williams, & Renard, 2016). Most small-scale dairy farms in Africa see cattle manure as a bountiful resource that can be used to raise crop yields and soil fertility (Mahiya, 2018). As a result, manure from small-scale livestock farmer contributes to food security by increasing agricultural output and average income in low-income areas (Lekasi, Tanner, Kimani, & Harris, 2001). When the rate of cattle dung is increased, the vegetative growth and yield parameters rise significantly. As a result, cattle dung contains nutrients that plants require, but at a low concentration and in large quantities (Carlos, 2019). Adekiya, Ojeniyi, and Owonifari (2016) observed that adding cattle manure improved soil temperature, bulk density, and soil dispersion ratio while increasing porosity, moisture content, infiltration rate, growth and yield of Maize.

## 2.4 *Tithonia diversifolia* as a soil amendment

*Tithonia diversifolia* is an annual weed native to South America's part of Mexico that has spread to many parts of Africa along major roads, pathways, and abandoned farmland (Agbede et al., 2013). Several studies have reported on the nutritional properties of *Tithonia diversifolia.* Erdal (2019) discovered that *Tithonia diversifolia* leaves are a good source of plant nutrients. Like other organic materials, Tithonia has an abundance of micronutrients (Reis et al., 2018), making it a complete fertiliser. Tithonia is good for soil rejuvenation as a result of its adaptability and abundance to various conditions, as well as its high vegetative matter turnover and its rapid growth rate (Olabode, Sola, Akanbi, Adesina, & Babajide, 2007). Because of the nutrient value of Tithonia diversifolia, the plant has been employed as mulch and is better for maintaining soil fertility. Similarly, biomass transfer may be accomplished by growing *Tithonia diversifolia* along farm boundaries, harvesting from off-farm places such as roadsides, and utilising its leaves and young stems in the field. (Wanglin et al., 2019). The high nutrient content of *Tithonia diversifolia* has been attributed to its capacity of the proteoid root system to find nutrients in the soil. On the other hand Mucheru-Muna, Mugendi, Kung’u, Mugwe, & Bationo (2007), discovered low amounts of nitrogen and phosphorus nutrients in *Tithonia diversifolia*, and that there are other agroforestry species with higher or similar nutrient content as *Tithonia diversifolia*.

## 2.5 NPK Fertilizer as Soil Amendment

To enhance crop production, it is critical to pay attention to the ideal balance of nutrients consumption through fertilizer application. Solanaceae vegetable crops, in general, take up lot of nutrients from the soil (Mohammad, 2020; Yanling Chen, Cao, & Liu, 2021). Growers and farmers must regulate fertilizer to increase the quality of their fruit yield. In recent years, increased potassium (K) fertilizer amounts have become increasingly important for better nutrient management. Potassium is an essential nutrient for plant growth and development. (Li, Cheng, Wang, & Dong, 2019; El-Badawy, 2019). Potassium (K) is actively involved in a variety of physiological and biochemical functions, including enzyme activation, glucose metabolism, and protein complex metabolism. The most prevalent inorganic molecule that affects plant physiology is potassium (Dreyer, 2021). It's also crucial for the plant's energy status, assimilation of storage, and tissue water connections. K also enhances the size of the fruit by promoting root growth (El-Bassiony, 2006).

Lodhi, Chakravorty, Prasad, & Sangeeta Chandrakar (2019) observed that nutrients and mulching had a significant influence on bell pepper fruiting and fruit quality in a field trial. Dubey et al. (2017) discovered in a field study that the N.P.K. (175:55:45 kg/ha) treatment combination outperformed others in terms of growth indicators of pepper but was poor in terms of both quantity and quality. In terms of yield, N.P.K. (155:55:45 kg/ha) was discovered to be superior, whereas N.P.K. (155:55:55 kg/ha) was discovered to be superior in terms of capsicum quality (fruit length, fruit diameter and fruit shelf life). As a result, optimal NPK dosages for capsicum plant growth, production, and quality were discovered to be extremely beneficial. In a greenhouse experiment, Alhrout (2017) examined plant height (cm), leaf number per plant, days to 50% flowering, fruit number per plant, fruit length, fruit output per plant (kg), and fruit production (t/ha). The NPK treatment produced the highest plant height (cm), leaves per plant, fruits per plant, fruit output per plant (kg), and fruit production per hectare (t/ha). According to Mebratu, Dechassa, Mulualem, & Weldetsadik (2014) nitrogen has a considerable impact on hot pepper (*Capsicum annum*) yield and quality components. The maximum total dry pod yield, marketable yield, pod length, and pod width were obtained when nitrogen was applied at a rate of 100 kg/ha. The physical quality parameters of hot peppers were enhanced by applying nitrogen at a rate of 100 kg/ha.

 Roy, Khan, and Pall (2011) investigated how nitrogen and phosphorus affected the features and productivity of contributing elements to the production of Capsicum. As nitrogen dosages were raised up to 150 kg N ha-1, the length, width, and number of fruits per plant all grew considerably, and the average weight of the fruit content increased dramatically up to 200 kg N ha-1. In their investigation of the effects of nitrogen and phosphorus on the size and productivity of capsicum fruits, Roy, Khan, and Pall (2011) discovered that 200 kg N ha-1 generated the most fruits per plant, whereas the control treatment produced the fewest fruits per plant.

## 2.6 Effects of variety on development and production of *Capsicum chinense*

*Capsicum chinense* varieties differ significantly in terms of their capacity to bloom, Fruit set, prospective production, and other quantitative parameters when grown in different agro climates (Gupta, 2003). Understanding how different varieties perform in different environments is crucial. More than 32.3 million tonnes of fresh fruit are farmed on 1.94 million hectares, throughout the world (FAOSTAT, 2014). Fruit output is related to the number of fruits, the number of seeds per fruit, and the weight of a single fruit, but significant progress requires genetic knowledge and good breeding techniques. However, a lack of appropriate knowledge of the plant's genetic and hereditary characteristics has impeded efforts to enhance the crop performance (productivity). While increasing the number of fruits and single fruit weight has consequences for fruit output, major advances require genetic knowledge and effective breeding procedures. The cultivars' genetics and capacity for environmental adaptation may be responsible for output variations (Tesfaw et al., 2013).

# CHAPTER THREE

# MATERIALS AND METHODS

## 3.1. Description of the experimental site.

The study was conducted at Landmark University's Teaching and Research Farm Omu-Aran, Kwara state (Lat 8' 9' N and Long 5' 61' E) and at elevation of 495 metres above sea level in a derived savanna zone of Nigeria. It gets 600 to 1,200 mm of annual rainfall and has distinct wet and dry season from April to October and November to April respectively.

## 3.2 Soil sampling and analysis

Soil samples were collected randomly from the experimental area and bulked together to create a composite sample. For routine analysis, the composite soil sample was taken to the University Crop and Soil Science Laboratory. Similarly, poultry manure, cattle manure, and fresh *Tithonia diversifolia* leaves were obtained from Landmark University's research farm Omu-Aran and taken to the laboratory for analysis.

## 3.3 Cultural practices

### 3.3.1. Land preparation

The experimental location was cleared of all existing vegetation, and the soil was thoroughly pulverized with a disc plough and a disc harrow. The total land area was 180 m2 and divided into 10 treatment plots per replicate, each plot measure 1 m × 1 m, with a 0.5 m border line in between each replicate and 0.5 m apart to differentiate the treatment plots.

### 3.3.2 Experimental Layout

**Table 1****: Experimental Layout**

|  |  |  |  |
| --- | --- | --- | --- |
| **Treatment** | **Replicate 1** | **Replicate 2** | **Replicate 3** |
| 1 | VI PM | V2 PM | V1 PM |
| 2 | V1 TD | V2 TD | V1 TD |
| 3 | V1 CM | V2 CM | V1 CM |
| 4 | V1 NPK | V2 NPK | V1 NPK |
| 5 | V1 CTRL | V2 CTRL | V1 CTRL |
| 6 | V2 PM | V1 CTRL | V2 PM |
| 7 | V2 TD | V1 PM | V2 TD |
| 8 | V2 CM | V1 NPK | V2 CM |
| 9 | V2 NPK | V1 TD | V2 NPK |
| 10 | V2 CTRL | V1 CTRL | V2 CTRL |

**Key**: PM = poultry manure TD = *Tithornia diversifolia* CM = cattle manure V = Variety CTRL=Control.

### 3.3.4 Experimental design and treatments

The experiment was a 2 x 2 x 5 factorial set up in a Randomised Complete Block Design with three replications (Table 1). The table above shows the experimental layout. Two varieties (Efia and Caribbean red) of *Capsicum chinense,* two seasons (first season planting started in November 2021 while the second season started in March 2022) and five different types of soil amendments were used for the study.

### 3.3.5. Application of amendments

Cured organic manures (cattle dung and poultry manure) were incorporated each at a rate of 20 t ha-1, while *Tithonia diversifolia* was incorporated at 20 t ha-1 two weeks before transplanting for mineralization to take place. According to (Abegunrin, Awe, & Ateniola, 2016), the development of tomato plants was significantly impacted by the application of cattle manure at a rate of 20 t ha-1. According to (Onyegbule, Uwanaka, & Nwosu, 2018) experimental results, 20 t ha-1. The highest growth and output of tomato crops may be achieved with 20 t ha-1 of poultry manure, according to (Usman, 2015). Similar to this, 180 kg N ha-1 of inorganic fertiliser (N-P-K: 15-15-15) was applied to plants two weeks after transplanting using the side placement method.

### 3.3.6 Seed Sowing of the two pepper varieties and Transplanting

The seeds of the two pepper varieties were sown in a shaded nursery for 6 weeks, using a germination tray and sterile soil as the growing medium. Four healthy seedlings were transplanted per bed and were watered regularly.

**3.3.7 Application of Irrigation**

Throughout the dry season, all plots were irrigated until each plot attain field capacity as determined by (Mbah, 2012). Irrigation was performed following the application of the various organic amendments and maintained even after transplanting to guarantee appropriate crop establishment and plant growth. Irrigation was done daily, with the water depth fluctuating according to crop evapotranspiration.

## 3.4 Varieties used and their characteristics

Efia F1 hybrid pepper and Caribbean red habanero were used for this experiment.

1. Efia F1 hybrid pepper seeds were obtained from East-West Seed International, Thailand. They are very productive, with strong plant vigour and high fruit set. Efia F1 is the typical Habanero pepper. It has intermediate resistance to Tm and Cmv (Tobacco and Cucumber Mosaic Virus).
2. Caribbean red habanero is a fiery, fragrant habanero pepper. The Caribbean red habanero pepper thrives best in warm temperatures, though it can also be planted during the wet season.

## 3.5 Data collection

### 3.5.1. Vegetative Parameters

1. **Plant height:** Using a meter rule, the height of two tagged plants per plot was measured at 4, 6, and 8 weeks (WAT) after transplanting from the ground to the growing tip
2. **Number of leaves per plant:** The number of photosynthetically active green leaves per plant was counted, excluding senescent and developing leaves.
3. **Number of primary and secondary branches per plant:** Primary and secondary branches were counted on two different plants at 4, 6, 8, and 10 WAT.

### 3.5.2. Yield Parameters

1. **Number of fruits per plant: -** Fruits harvested were counted and documented from observed plants in each plot.
2. **Fruit weight/plot (Fruit yield): -** Harvested fruits were weighed using an electronic weighing machine with a total potential of 2100 grams treatment-based model from (OHAUS Corporation, USA). The yield per plot was calculated by estimating the weight based on the area covered.

### 3.5.3. Quality Parameters

**Laboratory Analysis of the Fruits:** This was conducted to evaluate the effect of seasons, organic and inorganic amendments on the quality of pepper fruits.

1. **The procedure used in determining mineral compositions in pepper fruit**

The concentrations of copper (Cu) and zinc (Zn) were determined using the Atomic Absorption Spectrophotometer. (AAS Model SP9). Utilizing the complexometric titration technique, Ca and Mg were determined (Thimmappa & Nagabovanalli Basavarajappa, 2021).

1. **Determination of the ascorbic acid in pepper fruit**

The determination of ascorbic acid in the fruit of *Capsicum chinense* was carried out using the Spectrophotometric method according to Keller & Perry (1982). The juice sample was extracted for 45 minutes at room temperature (29°C) with 10 mL of 1% metaphosphoric acid and the extract was then strained through Whatman No. 4 filter paper. One millilitre of the extract was mixed with nine millilitres of 2,6-dichlorophenolindophenol, and the absorbance at 515 nm was measured within 30 minutes against a blank solution. The ascorbic acid content was calculated using a genuine L-ascorbic acid calibration curve. The tests were performed in triplicate, and the findings were represented as ppm of ascorbic acid per 100 mL of sample as the mean value and standard deviation.

1. **Moisture content**

To evaluate the MC, fresh pepper fruits were weighed, longitudinally incised, then put in a Brabender moisture tester Model MT-E drying chamber (Brabender® GmbH & Co., Duisburg, Germany). After the pods had been exposed to 105°C for 24 hours, the MC was calculated (AOAC2000). The moisture content of fresh pepper fruit was calculated using the following formula:

The following formula was used to calculate moisture content/weight losses:

moisture content = \* 100

Where A is the initial weight of fruits (g), and B is the final weight of fruits at every weight (g).

1. **Shelf life of fruits**

Fruit shelf life was measured by calculating the days necessary to reach the last stage of decaying but before the fruits became unfit for ingestion. Freshly picked pepper fruits were kept on an open shelf in the laboratory under ambient conditions for 14 days.

## 3.6. Statistical Analysis

GENSTAT Discovery Software 2003 was employed to analyse the data collected using analysis of variance (ANOVA). Duncan Multiple-Range Test (DMRT) at 5% level of probability was used to identify differences between significant treatment means.

# CHAPTER FOUR

# RESULTS

## 4.1. Initial Soil Properties

The physical features and nutrient status of the experimental soil for the 2021 and 2022 cropping seasons are shown in [Table 1](#Table1). The soil was a sandy loam texture, with a pH of 5.3 in water and 5.2 in CaCl2 and was at the threshold for organic content (1.8%). Total N concentration was 0.14 percent, below the 0.2 percent threshold limit for crop production and available P, exchangeable K, Ca, Mg, and Na values were near to the lower essential limits. that were recommended to be 10.0 mg kg-1, 0.15 mg kg-1, 2.0 mg kg-1, and 0.40 cmol kg-1, respectively (Aboyeji 2021). The results of the soil analysis corroborated with those of Akanbi and Togun (2002), who claimed that weathering, leaching, and intensive farming are the main causes of the critical nutrients’ shortage in most African soils.

**Table 2****: Physical and chemical properties of the initial soil used for the experiment**

|  |  |
| --- | --- |
| **Soil parameters** | **Values** |
| pH in H2O | 5.3 |
| pH in CaCl2 | 5.2 |
| Exchangeable acidity (cmol/ kg) | 2.9 |
| Organic carbon (%) | 1.1 |
| Organic matter (%) | 1.8 |
| Phosphorus (mg/kg) | 7.6 |
| Nitrogen (%) | 0.14 |
| **Exchangeable bases** |  |
| Calcium (cmol/kg) | 3.0 |
| Magnesium (cmol/kg) | 1.3 |
| Sodium (cmol/kg) | 0.1 |
| Potassium (cmol/kg) | 0.12 |
| **Particle size distribution** |  |
| Sand (%) | 81.12 |
| Silt (%) | 7.0 |
| Clay (%) | 11.88 |
| Textural class | Sandy loam |

## 4.2. Chemical composition of the organic amendments used for the study

Table 2 shows the findings of the laboratory analyses of the organic amendments utilised in the research. The analyses revealed that all the amendments provided significant levels of macro and micro-nutrients essential for increased soil fertility and plant development. Poultry manure had higher values for nitrogen, phosphorus, potassium, Calcium, Magnesium, and zinc but lower C: N ratio.

**Table 3****: Chemical composition of the organic amendments used for the study**

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameters** | **Cattle dung** | **Poultry**  **manure** | ***Tithonia***  ***diversifolia*** |
| Organic carbon (%) | 25.70a | 22.40b | 14.65c |
| Nitrogen (%) | 1.84b | 2.70a | 1.70b |
| Phosphorus (%) | 0.82b | 1.29a | 0.80b |
| Potassium (%) | 1.98b | 3.62a | 2.98b |
| Calcium (%) | 0.99b | 3.33a | 3.30a |
| Magnesium (%) | 0.54a | 0.60a | 0.13b |
| Zinc (%) | 0.10b | 0.20a | 0.03c |
| C: N | 14.78a | 8.29b | 8.62b |

Values followed by the same letters within the same row are not significantly different at p = 0.05 according to Duncan's multiple range test.

## 4.3. Vegetative parameters

### 4.3.1. Effects of season, organic amendment, and NPK fertilizer on plant height of two varieties of *Capsicum chinense*

Data in Table 4 when compared to the Efia type, Caribbean red has a significant increase in plant height. The effect of the season also shows that the second season significantly increased the plant height. Plant height increased significantly with the application of poultry manure though the value was statistically like the values obtained when *T. diversifolia*, cattle manure, and NPK were applied. The control showed a significant reduction in plant height except at 4 and 6 WAT, where the values are similar to other treatments. The ANOVA response revealed that the effects of varieties and seasons were significant on plant height at all sampling periods except on variety at 10 WAT. In a similar vein, the application of amendments was significant at all sampling periods though not significant 4 WAT. Interaction between varieties and seasons was only significant at 8 and 10 WAT.

**Table 4****: Effects of seasons, organic amendments, and NPK fertilizer on plant height of two varieties of *Capsicum chinense***

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Plant height** | | | | |
| **Treatment** | **4 WAT** | **6 WAT** | **8 WAT** | **10 WAT** |
| **Varieties** |  |  |  |  |
| Efia | 11.828b | 20.744b | 30.794b | 38.322a |
| Caribbean red | 14.856a | 22.900a | 33.992a | 40.767a |
| **Seasons** |  |  |  |  |
| S1 | 8.639b | 16.578b | 29.201b | 37.389b |
| S2 | 16.450a | 24.983a | 34.789a | 41.233a |
| **Amendments** |  |  |  |  |
| Poultry manure | 15.194a | 24.648a | 36.796a | 42.611a |
| *Tithonia diversifolia* | 14.398ab | 22.167ab | 31.741b | 38.667b |
| cattle manure | 13.046ab | 21.935ab | 33.917ab | 40.852ab |
| NPK | 14.074ab | 21.889ab | 33.389b | 41.796ab |
| Control | 12.519b | 20.269b | 28.789c | 35.833c |
| **Anova Response** |  |  |  |  |
| Variety | 0.000 | 0.021 | 0.007 | 0.121 |
| Season | 0.000 | 0.000 | 0.000 | 0.006 |
| Amendment | 0.073 | 0.025 | 0.000 | 0.001 |
| **Interaction** |  |  |  |  |
| V\*S | 0.999 | 0.056 | 0.001 | 0.007 |
| S\*A | 0.915 | 0.983 | 0.997 | 0.675 |
| V\*A | 0.340 | 0.346 | 0.566 | 0.072 |
| V\*A\*S | 1.000 | 1.000 | 0.978 | 0.969 |

Means in a column followed by the same letter(s) are not significantly (P ≤0.05) different according to DMRT. WAT = Weeks after transplanting, V = variety, S = season, A = amendment

### 4.3.2. Effects of seasons, organic amendments, and NPK fertilizer on the number of leaves of two varieties of *Capsicum chinense*

Table 4 shows that Caribbean red produced more leaves, though not significant at 8 and 10 WAT. The effect of seasons also revealed that the second season significantly increased the number of leaves. The application of amendment showed that Poultry manure greatly enhanced the number of plant leaves, followed by NPK, cattle manure, and *Tithonia diversifolia.* Poultry faeces increased the number of plant leaves significantly, followed by NPK, cattle manure, and *Tithonia diversifolia* with the control having the fewest leaves. The ANOVA response revealed that the effects of seasons and amendments were significant at all sampling periods on leaf production. Similarly, variety was only significant at 4 and 6 WAT. Except at 6 WAT across varieties and seasons, there was no interaction between the treatments.

**Table 5****: Effects of seasons, organic amendments and NPK fertilizer on the number of leaves of two varieties of *Capsicum chinense***

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Number of leaves** | | | | |
| **Treatment** | **4 WAT** | **6 WAT** | **8 WAT** | **10 WAT** |
| **Varieties** |  |  |  |  |
| Efia | 12.833b | 30.900b | 51.500a | 71.606a |
| Caribbean red | 15.122a | 34.722a | 53.322a | 71.850a |
| **Seasons** |  |  |  |  |
| S1 | 7.700b | 29.611b | 45.744b | 65.6778b |
| S2 | 17.689a | 35.367a | 56.200a | 74.689a |
| **Amendments** |  |  |  |  |
| Poultry manure | 16.333a | 37.926a | 60.389a | 83.333a |
| *Tithonia diversifolia* | 15.185ab | 33.333b | 51.296b | 71.019b |
| cattle manure | 13.315b | 33.870ab | 53.185b | 71.407b |
| NPK | 14.333ab | 33.926ab | 53.704b | 72.537b |
| Control | 12.630c | 28.185c | 45.000c | 60.130c |
| **ANOVA Response** |  |  |  |  |
| Variety | 0.036 | 0.020 | 0.506 | 0.994 |
| Season | 0.000 | 0.000 | 0.000 | 0.001 |
| Amendment | 0.044 | 0.000 | 0.000 | 0.000 |
| **Interaction** |  |  |  |  |
| V\*S | 0.936 | 0.003 | 0.604 | 0.946 |
| S\*A | 0.997 | 0.502 | 0.360 | 0.017 |
| V\*A | 0.956 | 0.659 | 0.177 | 0.572 |
| V\*A\*S | 1.000 | 0.994 | 0.998 | 0.998 |

Means in a column followed by the same letter(s) are not significantly (P ≤0.05) different according to DMRT. WAT = Weeks after transplanting, V = variety, S = season, A = amendment

### 4.3.3. Effects of seasons, organic amendments, and NPK fertilizer on the number of primary branches of two varieties of *Capsicum chinense*

A higher number of primary branches were produced in the Caribbean red variety though the value was not significant when compared with the Efia variety (Table 5). Seasons had no influence on the number of primary branches except at 6 WAT with season 2 having higher values for the number of primary branches. The outcome of the application of amendments revealed that the number of primary branches at 4 WAT did not differ significantly. However, at 6, 8, and 10 WAT, the application of poultry manure enhanced the number of primary branches in a statistically significant way that was comparable to the values observed when NPK was treated. When compared to other treatment, the control treatment provided the least significant value for the number of primary branches. The effect of season was significant on number of branches at 6 WAT whereas the impact of amendment on the number of branches was significant at 6, 8 and 10 WAT as indicated in the ANOVA response. None of the interactions were significant.

**Table 6****: Effects of seasons, organic amendments and NPK fertilizer on number of primary branches of two varieties of *Capsicum chinense***

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Number of primary branches | | | | |
| **Treatment** | **4 WAT** | **6 WAT** | **8 WAT** | **10 WAT** |
| **Varieties** |  |  |  |  |
| Efia | 1.333a | 3.189a | 3.489a | 3.622a |
| Caribbean red | 1.356a | 3.300a | 3.878a | 3.967a |
| **Seasons** |  |  |  |  |
| S1 | 1.311a | 2.411b | 4.078a | 4.044a |
| S2 | 1.367a | 3.689a | 3.733a | 3.855a |
| **Amendments** |  |  |  |  |
| Poultry manure | 1.574a | 3.833a | 4.315a | 4.315a |
| *Tithonia diversifolia* | 1.167a | 3.333b | 3.889ab | 4.037ab |
| cattle manure | 1.259a | 2.944b | 3.463ab | 3.574b |
| NPK | 1.704a | 3.537ab | 4.278a | 4.296a |
| Control | 1.037a | 2.27c | 2.596c | 2.7704c |
| **ANOVA Response** |  |  |  |  |
| Variety | 0.995 | 0.880 | 0.917 | 0.763 |
| Season | 0.967 | 0.000 | 0.278 | 0.631 |
| Amendment | 0.193 | 0.005 | 0.004 | 0.003 |
| **Interaction** |  |  |  |  |
| V\*S | 0.956 | 0.859 | 0.815 | 0.958 |
| S\*A | 0.912 | 0.533 | 0.991 | 0.971 |
| V\*A | 0.836 | 0.486 | 0.819 | 0.618 |
| V\*A\*S | 0.994 | 1.000 | 1.000 | 1.000 |

Means in a column followed by the same letter(s) are not significantly (P ≤0.05) different according to DMRT. WAT = Weeks after transplanting, V = variety, S = season, A = amendment

### 4.3.4. Effects of seasons, organic amendments, and NPK fertilizer on the number of secondary branches of two varieties of *Capsicum chinense*

The main and interaction effects of seasons, organic amendments, and NPK fertilizer on the number of secondary branches of two varieties of *C. chinense* are shown in Table 6. At all weeks after transplanting, the effects of variety were only significant at 6 WAT. Seasonal effects showed that the number of secondary branches on the plants increased significantly during the second season. The application of NPK significantly increased the number of secondary branches at 6 WAT, though the value was statistically similar to the value obtained with the application of poultry manure. At 8 and 10 WAT, treatments with poultry manure increased the number of secondary branches, followed by NPK, *T. diversifolia,* and cattle manure, respectively. Values obtained from the control plots showed a significant reduction in the number of secondary branches. The ANOVA response revealed that the effects of seasons and amendments were significant at all weeks after transplanting. Similarly, varieties were significant only at 6 WAT. Interaction between varieties and seasons was only significant at 6 WAT.

**Table 7****: Effects of seasons, organic amendments, and NPK fertilizer on number of secondary branches of two varieties of *Capsicum chinense***

|  |  |  |  |
| --- | --- | --- | --- |
| **Number of secondary branches** | | | |
| **Treatment** | **6 WAT** | **8 WAT** | **10 WAT** |
| **Varieties** |  |  |  |
| Efia | 1.578b | 7.278a | 10.789a |
| Caribbean red | 2.089a | 7.600a | 11.322a |
| **Seasons** |  |  |  |
| S1 | 1.244b | 5.411b | 7.922b |
| S2 | 2.256a | 8.533a | 12.756a |
| **Amendments** |  |  |  |
| Poultry manure | 2.185ab | 8.685a | 13.111a |
| *Tithonia diversifolia* | 2.000b | 7.556bc | 11.444bc |
| cattle manure | 1.481c | 7.130c | 10.629c |
| NPK | 2.556a | 8.296ab | 12.630ab |
| Control | 1.370c | 5.796d | 7.907d |
| **ANOVA Response** |  |  |  |
| Variety | 0.008 | 0.657 | 0.493 |
| Season | 0.000 | 0.000 | 0.000 |
| Amendment | 0.000 | 0.000 | 0.000 |
| **Interaction** |  |  |  |
| V\*S | 0.000 | 0.189 | 0.048 |
| S\*A | 0.790 | 0.584 | 0.559 |
| V\*A | 0.730 | 0.816 | 0.532 |
| V\*A\*S | 0.989 | 1.000 | 0.999 |

Means in a column followed by the same letter(s) are not significantly (P ≤0.05) different according to DMRT. WAT = Weeks after transplanting, V = variety, S = season, A = amendment.

## 4.4. Effects of seasons, organic amendments, and NPK fertilizer on the yield of two varieties of *Capsicum chinense*

The analysis of variance revealed that there was no significant (p<0.001) interaction effect of the treatments on the number and weight of fruits, as shown in Table 7. A higher number and weight of fruits were observed with the Caribbean red though not significant when compared with the Efia variety. The effect of seasons on the number and weight of fruits was significant, with the first season having a much larger number and weight of fruits. Higher number and fruit weight was observed with the of application of poultry manure though not significant fresh fruit weight. The least value for the two parameters were recorded in the control plots. The effect of seasons and amendments were significant on the number and weight of fruits as indicated in the ANOVA response.

**Table 8****: Effects of seasons, organic amendments, and NPK fertilizer on the yield of two varieties of *Capsicum chinense***

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatments** | Number of fruits/plot | Fruit fresh weight /plot (g) | Number of fruits/hectare | Fruit fresh weight /hectare (kg) |
| **Varieties** |  |  |  |  |
| Efia | 60.69a | 391.38a | 303,444a | 1,956.9a |
| Caribbean red | 74.22a | 534.02a | 371,111 a | 2,670.1 a |
| **Seasons** |  |  |  |  |
| S1 | 101.13a | 657.07a | 505,667a | 3,285.3a |
| S2 | 54.00b | 401.18b | 270,000 b | 2,005.9b |
| **Amendments** |  |  |  |  |
| Poultry manure | 83.04a | 632.11a | 415,185a | 3,160.55a |
| *Tithonia diversifolia* | 67.00b | 495.44ab | 335,000b | 2,678.40b |
| cattle manure | 65.22b | 535.48ab | 326,100b | 2,477.20b |
| NPK | 75.04ab | 478.19ab | 375,100ab | 2,390.95bc |
| Control | 48.26c | 301.15c | 241,300c | 1,505.75d |
| **ANOVA Response** |  |  |  |  |
| Variety | 0.41 | 0.09 | 0.41 | 0.09 |
| Season | 0.001 | 0.000 | 0.001 | 0.000 |
| Amendment | 0.000 | 0.000 | 0.000 | 0.000 |
| **Interaction** |  |  |  |  |
| V\*S | 1.00 | 0.91 | 1.00 | 0.91 |
| S\*A | 0.9 | 0.85 | 0.96 | 0.85 |
| V\*A | 0.67 | 0.56 | 0.67 | 0.56 |
| V\*A\*S | 0.95 | 0.98 | 0.95 | 0.98 |

Means in a column followed by the same letter(s) are not significantly (P ≤0.05) different according to DMRT. WAT = Weeks after transplanting, V = variety, S = season, A = amendment.

## 4.5. Effects of seasons, organic amendments, and NPK fertilizer on the fruit pericarp

## thickness and moisture content of two varieties of *Capsicum chinense*

The analysis of variance revealed that there was no significant interaction effect between variety, seasons and amendments on the fruit pericarp thickness, fruit fresh weight, fruit dry weight, and the percentage moisture content, though Variety has a tremendous effect on fruit pericarp thickness. Efia variety produced thicker pericarp as compared with the Caribbean red (Table 8). The season had no significant effect on fruit pericarp thickness. A thicker pericarp was observed with the application of *Tithonia diversifolia* which was not significant when other amendments were applied.Effects of varieties and seasons were not significant on the percentage moisture content of the fruit but the application of *Tithonia diversifolia* among other treatments increased the moisture content.

**Table 9****: Effects of seasons, organic amendments, and NPK fertilizer on the fruit wall thickness and moisture content of two varieties of *Capsicum chinense***

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatment** | Fruit pericarp Thickness (mm) | Fresh fruit weight (g) | Dried fruit weight (g) | Moisture content (%) |
| **Varieties** |  |  |  |  |
| Efia | 6.63a | 22.69a | 2.92a | 87.13a |
| Caribbean red | 4.34b | 17.92a | 2.50a | 86.05a |
| **Seasons** |  |  |  |  |
| S1 | 5.31a | 20.77a | 2.81a | 87.47a |
| S2 | 5.01a | 18.89a | 2.55a | 86.45a |
| **Amendments** |  |  |  |  |
| Poultry manure | 4.54a | 15.94b | 2.07b | 87.01b |
| *Tithonia diversifolia* | 6.34a | 24.02a | 3.33a | 86.09a |
| cattle manure | 5.33a | 21.99ab | 2.79ab | 87.27ab |
| NPK | 4.82a | 17.83ab | 2.62ab | 85.31ab |
| Control | 4.50a | 17.78ab | 2.38ab | 86.56ab |
| **ANOVA response** |  |  |  |  |
| Variety | 0.00 | 0.14 | 0.52 | 0.11 |
| Season | 0.88 | 0.73 | 0.78 | 0.73 |
| Amendment | 0.23 | 0.14 | 0.20 | 0.14 |
| **Interaction** |  |  |  |  |
| V\*S | 0.45 | 0.31 | 0.59 | 0.28 |
| S\*A | 0.57 | 0.56 | 0.90 | 0.48 |
| V\*A | 0.31 | 0.38 | 0.65 | 0.35 |
| V\*A\*S | 0.72 | 0.84 | 1.00 | 0.75 |

Means in a column followed by the same letter(s) are not significantly (P ≤0.05) different according to DMRT. WAT = Weeks after transplanting, V = variety, S = season, A = amendment.

## 4.6. Pooled analysis of seasons 1 and 2 of the effects of organic amendments, and NPK fertilizer on the shelf life of two varieties of *Capsicum chinense*

The pooled analysis for the two seasons on shelf life of two varieties of *Capsicum chinense* varied significantly with different varieties, application of organic amendments and NPK fertilizer (Figure 1). Application of poultry manure and *Tithonia diversifolia* significantly(p<0.05)produced longer shelf life for *Capsicum chinense* with Caribbean red having more numbers of days. In both varieties, plots treated with NPK fertilizer and control had the lowest value for shelf life, though fruit harvested from the control plot had a longer shelf life than fruit harvested from NPK fertilizer plots.

**Figure 1****:** Effects of organic amendments and NPK fertilizer on the shelf life of two varieties of *Capsicum chinense* (Pooled analysis of seasons 1 and 2).

PM = Poultry manure, CM = Cattle manure, TD = *Tithonia diversifolia* NPK = Inorganic fertilizer, CTRL = Control

## 4.7. Pooled analysis of seasons (1 and 2), soil amendments and effects in the mineral composition of two varieties of *Capsicum chinense*

The pooled analysis for the two seasons of the laboratory determination of mineral (Ca, Cu, Zn, and Mg) composition of *Capsicum chinense* varied significantly with different varieties and application of organic amendments and NPK fertilizer (Figures 2, 3, 4, and 5). Application of poultry manure produced higher values for Ca composition which was similar to the values obtained with the application of *Tithonia divesifolia* followed by the application of cattle manure for the two varieties. Least and similar values for Ca were obtained with the application of NPK fertilizer and control (Figure 2).

There was a significant difference (p > 0.05) in the Cu concentration of the fruits among the different amendments used for the study. A significantly higher values for Cu were obtained in the application of poultry manure, *Tithonia divesifolia* and cattle manure on the Caribbean red variety. Other amendments gave varying but similar values for the two varieties with the control having a significantly lower Cu value (Figures 3). Plots applied with poultry manures significantly increased Zn content of Caribbean red, as compared with the Efia variety. The application of other amendment also increased Zn value of Caribbean red though the differences in the Zn values was not significant. The value for Mg for the two varieties were higher and statistically similar with the application of poultry manure. There was no significant difference in the Mg values for the two varieties when *Tithonia divesifolia* and cattle manure were applied. The least value for Mg was obtained on the control plots for the two varieties.

**Figure 2****:** Effects of organic amendments and NPK fertilizer on calcium composition of two varieties of *Capsicum chinense* (Pooled analysis of seasons 1 and 2)

PM = Poultry manure, CM = Cattle manure, TD = *Tithonia diversifolia* NPK = Inorganic fertilizer, CTRL = Control

**Figure 3****:** Effects of organic amendments and NPK fertilizer on copper composition of two varieties of *Capsicum chinense* (Pooled analysis of seasons 1 and 2)

PM = Poultry manure, CM = Cattle manure, TD = *Tithonia diversifolia* NPK = Inorganic fertilizer, CTRL = Control

**Figure 4****:** Effects of organic amendments and NPK fertilizer on zinc composition of two varieties of *Capsicum chinense* (Pooled analysis of seasons 1 and 2).  
PM = Poultry manure, CM = Cattle manure, TD = *Tithonia diversifolia* NPK = Inorganic fertilizer, CTRL = Control

**Figure 5****:** Effects of organic amendments and NPK fertilizer on magnesium composition of two varieties of *Capsicum chinense* (Pooled analysis of seasons 1 and 2).

PM = Poultry manure, CM = Cattle manure, TD = *Tithonia diversifolia* NPK = Inorganic fertilizer, CTRL = Control

## 4.8. Effects of seasons, organic amendments, and NPK fertilizer on vitamin C contents of two varieties of *Capsicum chinense*

The vitamin C concentration of two varieties of *Capsicum chinense* varied significantly depending on variety, season, and treatment. The season had a significant effect on the vitamin C level of the two kinds, with the second season having greater vitamin C content than the first season. The use of poultry manure and *Tithonia diversifolia* generated the maximum vitamin C value for *capsicum chinense*, with the Efia variety having higher vitamin C. In all seasons, NPK fertiliser and control plots had the lowest fruit content of vitamin C, however fruits collected from NPK fertiliser plots had somewhat higher vitamin C than those obtained from control plots.

**Figure 6****:** Effects of seasons, organic amendments, and NPK fertilizer on vitamin c content of two varieties of *Capsicum chinense*V1 = Efia, V2 = Caribbean red, PM = Poultry manure, CM = Cattle manure, NPK = Inorganic fertilizer, CTRL = Control

## 4.9 Discussion

Growth, yield and quality parameters of *C. chinense* varieties differed under organic and inorganic soil amendments. This variety's differential performance might be linked to genetic diversity and hence physiological traits. Similar results were found by Bergefurd et al., (2011) where the authors found that variations in responses by diverse varieties of bell pepper may be linked to differences in the genetic attributes and environmental conditions.

There were variations in the total fruit yield among the two varieties. In contrast to the Efia variety, the Caribbean red variety produced more primary and secondary branches, which increased the ability of pods bearing buds, and leaf area, and increases photosynthetic capacity and assimilate production of fruits. These factors may be the cause of the Caribbean red variety's higher total fruit yield. Vegetative growth has a beneficial influence on hot pepper yield and yield components, according to findings of Godfrey-Sam-Aggrey and Bereke-Tsehai Tuku's (2013) and Benson, Obadofin, & Adesina (2013) found that bell pepper primary and secondary branches served as the sites of fruit buds and the starting points for the creation of new fruit buds. Varietal difference in yield could also be that Caribbean red had higher nutrient utilization efficiency than the Efia variety (Abdelhamid, Horiuchi, & Oba, 2020).

The differences in mineral contents of the two varieties of pepper can be attributed to variety and different genetic make-up. Peterson, Johnson, and Mattern (1982) discovered great difference in mineral concentration in wheat by genotype and found that the genotype effect was significantly greater than the influence of other environmental variables.

Cropping of pepper in season 1 (2021) had lower vitamin C contents of pepper fruit relative to season 2 (2022). This could be adduced to better soil moisture in season 2 relative to season 1. The better soil moisture would have made more nutrient available for pepper uptake. The concentration of minerals in plants is greatly influenced by climatic conditions. Climate changes have been observed to alter the chemical make-up of plants (Weston & Barth, 1997; Lefsrud, Kopsell, Kopsell, & Curran-Celentano, 2005).

The inherent physiological and morphological features of plants are some of the factors that determine fruit growth, development, and maturation. When compared to the Efia variety, Caribbean red's, yield component differed the various seasons evaluated. The yield increase might be as a result of optimum and adequate environmental factors. Chatterjee and Mahanta (2013) reported that the development and production of broccoli are positively influenced by the presence of ideal temperature, humidity, and light intensity. The differences in yield between the seasons could be attributed to varying differences in response to environmental conditions. The results of this study are comparable to those of Erickson & Markhart (2001) who observed that plant growth and production were influenced by the soil and weather conditions. Efia's yield drop in the second season could be attributed to environmental stress (heavy rainfall) during blooming and fruit set, which results in blossoms and flower abortion. High temperatures reduce fruit set and, as a result, yield in sweet pepper. The sweet pepper needs a temperature between 20 and 25 °C to thrive and produce at its best. Temperature above 32°C or below 15°C negatively growth and yield of sweet pepper (Saha, Hossain, Rahman, Kuo, & Abdullah, 1970).

The study also revealed that during the first season trial, yield increased significantly as compared to the second season trial. This could be attributed to the onset of flowering of the two varieties which coincided with favourable environmental condition and subsequent transition to fruit for maximum yield (Nahardani, Sinaki, & Firouzabadi, 2013).

The application of organic and inorganic fertilizers enhanced vegetative growth of *C. chinense*. In both seasons, values obtained for plant height in the control plot were lower compared to other treatments.

Among the amendments, the increasing order of pepper yield were control < NPK fertilizer < cattle manure < *Tithonia* < PM. The increase in the yield of pepper due to the application of the amendments relative to the control was due to the enhancement of soil fertility status (Table 1). When manures are decomposed, they enhance macro-nutrients and micro-nutrients while also improving the physiochemical characteristics of the soil, which improves pepper growth and production. Pepper grown on poultry manure yielded more compared with other sources of organic soil organic amendment and NPK fertilizer. It can be attributed to its high nutritional value and minimal C:N ratio of the PM used in this experiment. The observed lower C:N ratio of PM will result in earlier nutrient release due to quick mineralization for the pepper. The C: N ratio of organic materials, according to Wolf and Snyder (2005), has a major influence on the pace of decomposition and the mineralization of N because N governs the proliferation and turnover of the micro-organisms that mineralize organic carbon. Although *Tithonia* in this study has statistically similar values of C: N ratio with PM, but *Tithonia* has an inferior nutrient content relative to PM which make the differences in yield. NPK fertilizer though has higher nutrient content but has inferior yield relative to other organic amendments due to possible leaching of its nutrient especially during heavy rainfall. The organic amendments like PM apart from increasing the nutrient content of the soil helps enhance soil structure thereby preventing the leaching of nutrient in this amendment. This is consistent with Adekiya et al., (2020) also reported that okra grown under organic soil amendment performed better.

The enhanced nutrient availability in soil as a result of manure mineralization, which led to better absorption by pepper plants, was attributed to soil amendments increasing pepper mineral and vitamin C contents as compared to the control.

When compared to control and NPK fertiliser, pepper grown with organic amendments (poultry manure, *Tithonia*, and cattle manure) has higher fruit quality (Ca, Cu, Zn, Mg, and vitamin C). This is due to the fact that organic manures, as opposed to NPK fertiliser, which only includes N, P, and K, contain other (micro and macro nutrients) Ragab El-Mergawi & Khalid Naser Al-Redhaiman, (2010) also, reported that vegetables grown organically were of greater quality than those grown conventionally.

Contrary to cattle that only browse on forages with lower deposition of these minerals, poultry are fed high concentrate feed, which may account for the higher contents of some of these nutrients in PM treatment. They may also be added to poultry feeds to control disease, promote rapid growth, and improve feed efficiency.

Organic amendments boosted the vitamin C content of Capsicum chinense fruits, which is explainable by the fact that fruits obtained from organically treated plots had higher amounts of phenolic compounds and antioxidant capacity than inorganic samples. This is consistent with the findings of Magkos, Arvaniti, and Zampelas (2003) and Aboyeji et al. (2017), who found that the compared to lettuce cultivated in a conventional production system had lower Vit-C content compared to lettuce grown in an organic production system.

# CHAPTER FIVE

# DISCUSSION AND CONCLUSION

## 5.1. Conclusion

The result of this study indicate that the Caribbean red variety of *Capsicum chinense* (Habanero pepper) had the best for the vegetative attributes. Pepper sown (March, 2022) in the second season had the best values for plant height and number of leaves. However, plants in the first season (November, 2022) had higher values for the number of primary and secondary branches. Plots treated with poultry manure had higher values for the vegetative parameters. The highest value for yield (t/ha) was obtained from the Caribbean red variety. The first season performed better than the second season with respect to yield (505,667 t/ha) harvested. When the values of the various amendments were compared, the poultry manure treated plots produced the best results in term of the vegetative,yield and quality attributes.

When the influence of pepper variety on shelf life was investigated, it was discovered that the Caribbean red variety performed best, while plots treated with NPK fertiliser had the lowest shelf-life (days) compared with the control treatment and plots treated with organic amendments. In terms of minerals (Cu, Zn, Ca, Mg, and vitamin C contents), both pepper varieties performed similar. The effect of soil amendments on mineral content, on the other hand, revealed that pepper fruits harvested from plots treated with organic amendments such as cattle manure, poultry manure, and *Tithonia diversifolia* had the highest mineral and vitamin C contents. Though season had no effect on the mineral content of pepper, pepper plants in the second season had a higher vitamin C contents compare with first season.

## 5.2 Recommendation

The Caribbean red pepper Habanero variety can be grown in the study area, and dry season is an ideal time to cultivate pepper. To increase yield and improve fruit quality, organic fertilizers such as *Tithonia diversifolia*, cattle manure, and poultry manure should be used instead of NPK fertilizer.

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