RESPONSE OF AMARANTHUS (*Amaranthus cruentus*) TO ORGANIC (COWDUNG) AND INORGANIC(N P K) SOIL AMMENDMENTS.

BY

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CERTIFICATION

This is to certify that this research work has been completed, read through and approved as meeting part of the requirements of the Department of Agricultural Technology, Institute of Applied Sciences, Kwara State Polytechnic in partial fulfilment for the award of National Diploma ND in Agricultural Technology.

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DEDICATION

This project work is dedicated to Almighty God the most beneficent and the most merciful, the creator of the heaven and the earth.

ACKNOWLEGEMENT

All praise, adoration, thanks and glory to Almighty God for bestowing his mercy and blessings upon me throughout my stay in the campus and for the complexion of my National Diploma (ND) programme.

My profound gratitude also goes to my supervisor in person of Mrs Atanda A.O whose supervision and guidance has contributed immensely to the success of the project, Thank you very much, May Almighty God continue to shower his abundant blessings upon you and your family.

And my sincere appreciation goes to my parent **MR & MRS MUHAMMAD** for your love are and support both financially and spiritually, May you live long to reap the fruit of your labour in sound health and abundant blessings. And also to my siblings, thank you very much. And to all the entire family, may Almighty God bestowed his blessing and mercy upon every one of us (Ameen).

ABSTRACT

The scarcity and cost of inorganic fertilizer in the recent time is an issue that need immediate intervention and solution therefore it becomes necessary to provide alternative soil amendment for sustainable crop production to address the global need for food security. This study was carried out at the Kwara State Polytechnic Teaching and Research Farm in the early season of 2025 cropping season. The study is aimed at comparing the effects of cowdung and NPKfertilizer on the growth and yield of Amaranthus cruentus(Efo tete) in a 2x2x3 complete randomised design using certified seeds of obtained from a reputable Agro-seed Outlet in Ilorin.

Data were obtained on plant height, number of leaves per plant, number of branches per plant, fresh weight and dry weight of plant. The results from this study revealed that effect of source of fertilizer was significant on the plant height as cowdung produced the tallest plant (47cm) at 80kgN/ha as well as the number of leaves per plant the rate of application was significant with the highest number of leaves was obtained at 80kgN/ha

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CHAPTER ONE

INTRODUCTION

1.0 Backgroung Information

Green amaranth (*Amaranthus hybridus)* is an annual plant which belongs to the family *Amaranthaceae.*It is a widely distributed species of the genus Amaranthus. Amaranthaceae consist of annual or perennial, hermaphroditic, dioecious, monoecius or polygamous herbs, vines,shrubs or rarely trees. The origin of amaranthus can be traced back to the Central and South America particularly Mexico,Peru and the Andean regions where it was cultivated thousands of years ago for its nutritious seeds and leaves (Sauer, 1967). It consists of approximately 60-75 species globally, although exact counts vary due to taxonomic interpretations and hybridization among species (Sauer 2012). It has been a significant source of food for various civilizations for thousands of years particularly in the Americas, Africa and Asia. Archaeological evidence suggests that species like *Amaranthus caudatus* and *A. hypochondriacus* were important crops among the Aztecs and Incas (Kauffman & Webber,1900)

Today, wild and cultivated species of amaranth are found throughout the North and South America, Africa, Asia, Europe and Oceania. In Africa species like *Amaranthus hybridus* and *A. cruentus* are commonly grown as leafy vegetable while in America grain Amaranth such as *A. cruentus, A. hypochondriancus* are cultivated for their seeds (Brenner et al.;2000 Das, 2016). Over time, the genus diversified and adapted to different climates leading to a wide distribution across tropical and subtropical areas worldwide (Brenner at al.,2000). However, several Amaranthus species have become naturalized weeds outside their native - range, particularly in agricultural fields, disturbed sites and along roadsides (Costea & DeMason 2001).

The increasing popularity of *Amaranthus hybridus* is attributed to its high nutritional content which makes it a valuable component of food security and empowerment strategies in Nigeria. Additionally, *Amaranthus hybridus* has been found to contain substantial amounts of flavonoids, phenolic acids, and betalains, which exhibit strong antioxidant properties that help combat oxidative stress and chronic diseases such as cardiovascular disorders and diabetes (Edeh et al., 2021). The leaves contain significant amounts of vitamin A, vitamin C, vitamin E, iron, calcium, potassium, and dietary fiber, all of which contribute to essential physiological functions in humans (Adekiya et al., 2020). Studies have shown that green amaranth contains higher levels of beta-carotene and antioxidants than many conventional leafy vegetables such as spinach and lettuce (Shukla et al., 2010). The plant's high protein content, particularly in its leaves and seeds, makes it a crucial dietary supplement for communities with protein-deficient diets (Aliyu et al., 2018).

Vegetable production is a significant component of global agriculture, contributing to food security, nutrition, and economic development. According to the Food and Agriculture Organization (FAO), global vegetable production reached approximately 1.1 billion tonnes in 2022. The leading producers include China, which alone accounts for over 50% of global output, followed by India, the United States, and Turkey (FAO, 2023). Nigeria is the leading producer in Africa and the 2^{nd} world largest producer after China with approximately 7.5 million tonnes in 2022(index Box) estimated at S10.3 Billion with estimated projection of 16.4 million metric tonnes by 2028. Studies indicate that organic nitrogen sources, particularly poultry droppings, enhance the accumulation of bioactive compounds in leafy vegetables compared to synthetic fertilizers (Makinde et al., 2020). This is attributed to improved microbial interactions in organically amended soils, which enhance nutrient uptake and metabolic activity (Adekiya et al., 2020). The choice of nitrogen source, therefore, not only affects crop yield but also determines the nutritional and health benefits of *Amaranthus hybridus*. .

1.1 Statement of the problem

The alarming rate of population growth in Nigeria was estimated as 200 million as at year 2000 and increasing at 2.1% yearly as at year 2000. It was projected that the population will be doubled; 400 million by the year 2050,(United Nation 2022).This makes Nigeria the third most populated country globally. The rapid geometric growth calls for high demand for food particularly vegetables which are essential for nutrition and public health. Urbanization and changing dietary preferences further increased demand for vegetables especially Amaranthus among the low-income households (FAO, 2021). This increase in demand for Amaranthus in Nigeria has resulted in scarcity and high cost of quality vegetables for human consumption. Moreso, the change in climate, depleted state of the soil and supply chain gap are some of the challenges aggravating the low supply of vegetables.

Typically, the soils of tropical zones of the world including Nigeria exhibit low fertility especially with regard to macronutrients (N P K) which are crucial for optimal growth and productivity. Report shows that about 72% of the vegetable farmers uses inorganic fertilizer due to its inherent advantage: ease of availability and commendable returns on productivity quick release of nutrients, ease of application high yield and favourable government policy (subsidy).

(Adejobi et al ,2020). However, this require immediate attention and intergrated effort in order to reduce leaching, water pollution, destruction of biodiversity and poor soil health.

Contrarily, the use of organic amendment has not caught enough awareness despite the long term positive effect on the soil health such as improved soil fertility, soil structure and enhanced biological activity. Application of organic manure was reported to increase productivity, soils structure and soil microbial activity. In contrast, inorganic nitrogen fertilizers like urea and synthetic fertilizers provide immediate nitrogen availability but may contribute to leaching and soil degradation (Zhou et al., 2021). Organic fertilizers, such as poultry droppings and cow dung, improve soil structure and enhance microbial biodiversity while releasing nitrogen gradually (Adekiya et al., 2020).

In Nigeria for example, the depleted state of the soil is one of the major challenges militating against the production of many crops including Amaranthus. In addition,most of the areas where Amaranth is cultivated are faced with one challenge or other with respect to the soil nutrient status. The potential of Amaranth with respect to the optimal herbage yield of 10-15 tonnes per hactare and the nutritional status still fall below optimum /standard. According to Taiz et al, (2006) availability of nitrogen significantly influence leaf expansion and biomass accumulation in vegetables such as *Brassica deracean* and Amaranth

Interestingly the availability and the quality of nitrogen has a direct impact on the quantity and quality of the amaranthus harvested. Hence, the yield and quality of *A. hybridus* are strongly influenced by nitrogen fertilization, which affects vegetative growth, chlorophyll content, and phytochemical composition (Sogbedji et al., 2022). Essentially, organic source of nitrogen is crucial in addressing optimal crop production as well as combating some problems associated to soil such as soil acidity, soil alkalinity and nutrient imbalance. Consequently, the effect of source of nitrogen on the yield and the quality of the crop/vegetable demands a deep study to identify the best source of nitrogen for yield without compromising the nutritional quality.

Justification

Given the increasing concerns over soil degradation and environmental sustainability, evaluating different nitrogen sources is crucial for developing fertilization strategies that balance productivity with ecological conservation (Edeh et al., 2021). Macronutrients such as nitrogen (N), phosphorus (P), and potassium (K) are essential for major physiological processes. Micronutrients, although required in smaller amounts, are equally vital in biochemical processes. Empirical studies have shown that integrated application of macro- and micronutrients significantly improves yield, nutritional quality, and stress tolerance in Amaranthus (Ayeni et al., 2014). The review recommends balanced fertilizer application, soil testing, and the use of organic amendments to enhance nutrient uptake and sustain vegetable productivity. By comparing the performance of poultry droppings, cow dung, urea, and synthetic fertilizers, the study aims to generate recommendations that will benefit farmers, agronomists, and policymakers in formulating sustainable nitrogen management practices.

1.3 Objective of the study

The main objective is to identify the Nitrogen source or combination of Nitrogen source that will enhance the productivity of amaranthus in the study area; other objectives are:-

1. To evaluate the growth performance of *Amaranthus creuentus* under different soil amendment
2. To determine the appropriate source and level of application of nitrogen.
3. To assess /evaluate the effects of treatment on shelf of *Amaranthus hybridus*.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Origin and Distribution of Amaranthus

Amaranthus *Amaranthus cruentus* has its origin has it's from the America.The species is believed to have originated in Central and South America, where it was a staple crop of pre-Columbian civilizations such as the Aztecs and Incas (Sauer, 1967). The global distribution of the genus Amaranthus is the result of both natural ecological processes and extensive human activities over centuries. Amaranthus species are diverse and widely distributed today, their spread has been influenced by domestication, trade, migration, agricultural expansion, and the species' innate ecological adaptability.

Historically, Amaranthus species have multiple centers of origin. Grain-producing amaranths such as *A. cruentus*, *A. caudatus*, and *A. hypochondriacus* were domesticated in Central and South America, particularly by ancient civilizations such as the Aztecs and Mayans, who used them for food, rituals, and ceremonies (Sauer, 1967; Brenner et al., 2010). In contrast, leafy vegetable species like *A. tricolor* and *A. dubius* are believed to have originated in Asia and Africa, respectively, where they were independently cultivated for their tender and nutritious leaves (Achigan-Dako et al., 2014).

Human-mediated dispersal has played a central role in the global spread of Amaranthus. During the colonial period, seeds of various Amaranthus species were transported across continents through trade and exploration, often as part of intentional agricultural introductions. In many cases, these seeds were introduced as minor crops or ornamentals and subsequently escaped cultivation to establish in the wild (Costea et al., 2001). Furthermore, diasporic communities and migrants carried Amaranthus seeds to new regions, integrating them into subsistence and kitchen gardens, especially in Africa, Asia, and the Caribbean (Grubben & Denton, 2004).

Today, *A. cruentus* is cultivated globally, especially in sub-Saharan Africa, South Asia, and Latin America. In Africa, it has become naturalized and is widely used in traditional diets across Nigeria, Ghana, Kenya, and Uganda (Achigan-Dako et al., 2014).

Amaranth is believed to have originated in the Americas, particularly in Central and South America. Archaeological evidence suggests that it was domesticated over 6,000 years ago by the Aztecs, Mayans, and Incas, who considered it a staple food and a vital part of their culture and rituals (Sauer, 1967). It was one of the primary crops alongside maize and beans in pre-Columbian civilizations.

The three most commonly cultivated species of amaranth for food purposes are Amaranthus caudatus (originating in the Andean region), Amaranthus cruentus (native to Central America) and Amaranthus hypochondriacus (native to Mexico)

Amaranth was nearly eradicated in the Americas after the Spanish conquest, as the Spanish banned its cultivation due to its association with indigenous religious ceremonies (Tucker, 1986). However, the crop survived in remote areas and later spread globally.

2.2 Distribution of Amaranth

Global Distribution

Today, amaranth is grown worldwide, particularly in tropical and subtropical regions. Its distribution spans across the Americas, Africa, Asia, and parts of Europe. The adaptability of amaranth to various climatic and soil conditions has allowed it to thrive in different ecological zones.

In Mexico, Guatemala, and Peru, amaranth is still cultivated for traditional uses. The United States has seen a resurgence in amaranth production, particularly among health-conscious consumers. In South America, countries like Bolivia, Argentina, and Ecuador grow amaranth as part of indigenous agricultural systems. Amaranth was introduced to Africa through trade routes and colonial interactions. It has become an important leafy vegetable and grain crop in many African countries, including Nigeria, Kenya, and Uganda, where it is a major leafy green consumed widely. Ethiopia and South Africa, where it is cultivated for both food and ornamental purposes. Many species, such as *Amaranthus blitum* and *Amaranthus dubius*, are grown as vegetables in African subsistence farming systems (Grubben & Denton, 2004).

Amaranth is extensively cultivated in South and Southeast Asia .In India, amaranth (locally known as "rajgira") is used in traditional foods and Ayurvedic medicine.In China, it is grown for both its leaves and seeds.In Nepal, Bangladesh, and Sri Lanka, amaranth is part of local diets and agricultural systems.Amaranth was introduced to Europe during the colonial era and is mainly grown in small quantities for health food markets. Countries such as Russia, Ukraine, and Poland have seen increasing interest in amaranth grain cultivation due to its gluten-free properties and high protein content (Kauffman & Weber, 1990).

PRODUCTION

According to FAO (2021), the total global vegetable production reached approximately 1.15 billion tonnes in 2020, marking a 68% growth compared to the year 2000 (FAOSTAT, 2021). This rise has been driven largely by expanding production in Asia, which remains the largest contributor to global vegetable output. Major vegetable producers include China, India, the United States, and Turkey. China alone accounts for over 50% of global vegetable production, cultivating major crops such as tomatoes, cabbage, and green onions (FAOSTAT, 2022). The increase in mechanization, irrigation infrastructure, and hybrid seed varieties has further fueled production growth in these countries. Africa contributes only a modest share to global vegetable output, with the continent producing about 88.52 million tonnes of vegetables in 2022 (Statista, 2023). Despite having 60% of the world's uncultivated arable land, much of the region's agricultural systems remain underdeveloped, with challenges such as poor storage, weak value chains, limited irrigation, and low fertilizer use (World Bank, 2022).Nonetheless, vegetable farming remains an important livelihood source, especially in East and West Africa, where crops like tomatoes, onions, leafy greens (Amaranthus, Corchorus, Telfairia), and okra are commonly cultivated. Egypt, Nigeria, and Ethiopia are among the leading vegetable producers on the continent.

Nigeria is a leading producer of vegetables in sub-Saharan Africa. According to FAO estimates, the country produced approximately 7.5 million tonnes of vegetables in 2022 (FAOSTAT, 2023). In earlier records from the FAO 2013 Statistical Yearbook, Nigeria cultivated around 1.84 million hectares of vegetables at a yield of 64 tonnes per hectare, resulting in 11.83 million tonnes of total production (FAO, 2013). The discrepancy between years may be due to different classification methods, crop inclusion, and climatic variability.Key vegetable crops produced in Nigeria include:Tomatoes: 3.9 million tonnes (2022), though postharvest losses are high due to poor cold storage infrastructure (FAOSTAT, 2023).Okra: 2 million tonnes, placing Nigeria among the top producers globally (FAOSTAT, 2023).Onion: 938,000 tonnes (2022).Green pepper: 747,000 tonnes (2022). In addition, Nigeria also dominates in root and tuber production, which, though not vegetables by strict classification, are relevant to broader horticultural and dietary analysis:

The increasing popularity of *Amaranthus cruentus* is attributed to its high nutritional content, which makes it a valuable component of food security and empowerment strategies in Nigeria. Nigeria is the leading producer in Africa and the 2^{nd} world largest producer after China. However, with the sudden the increasing demand for amaranth by the seeming populating there is need to boost production with the latest technology especially with the global climate challenge. According to Montero et al 2009, the sophisticated and simple green house and even screen house with a passive control of the environmental conditions are currently coexisting in worldwide horticulture. Also, the nutritional quality of vegetables is becoming increasingly important while the market demands an immaculate product which is safe to consume (Gruda 2005, 2019:Gruda et al 2018) Moreover ,the raising of amaranth in a well-protected and controlled environment ensures minimal input such as water,fertilizer ,herbicides pesticides and even labour with optimal output in terms of herbage and seeds.

Amaranthus cruentus, commonly referred to as green amaranth, is a fast-growing leafy vegetable with high economic and nutritional value (Shukla et al., 2010). It is rich in vitamins A, C, and E, minerals such as calcium and iron, and phytochemicals including flavonoids and antioxidants (Akanbi et al., 2005). In developing countries of the world cultivation of amaranth is feasible and common among the most vulnerable sector of the population that is the women and the children as it avails them enormous socioeconomic benefit in terms of food security, employment as well as income generation as a means of livelihood.

In Nigeria, *Amaranthus cruentus* is widely cultivated due to its adaptability to different agro ecological zones, short life cycle, and ability to produce high yields under varying soil fertility conditions (Ewulo et al., 2019). However, the nitrogen requirement of the crop varies depending on the soil nutrient status and environmental conditions, making nitrogen fertilization a crucial determinant of its productivity

Precise global figures for Amaranthus production are limited. However, several countries are recognized as major producers China, Russia, Bolivia, Ecuador, and Peru cultivate both grain amaranths and leafy species, with grain yields often exceeding 1 t/ha due to efficient C4 photosynthesis pathways. Leatherleaf Amaranths (e.g., A. cruentus, A. blitum, A. dubius) are important in Africa, albeit at relatively lower productivity levels. Leafy amaranths used as vegetables generally yield:4–14 t/ha fresh weight under common cultivation. Up to 40 t/ha has been achieved under optimized conditions. Grain yields of amaranth average around 0.9 t/ha, though improved varieties and practices (e.g. in Mesoamerican regions) can surpass this.

Nigeria relies heavily on leafy Amaranthus, particularly A. cruentus, as a vegetable staple. Production data shows strong responses to agronomic practices. Leaf yields in Nigeria range from 30 to 40 t/ha under favorable conditions—comparable to sub-Saharan performance (e.g., Benin at

30 t/ha, Tanzania at 40 t/ha, and peak reports of 82.8 t/ha across regions). Domestic projects such as the Fadama I irrigation initiative in Edo State significantly increased yields, with many smallholder farmers producing over 400 kg per harvest, evidencing a clear benefit of irrigation. In Sokoto State, optimal seed rate (3 kg/ha) and drilling led to highest fresh/dry biomass .In Adamawa State, applying 120 kg N/ha and 40 cm spacing achieved ~126 g fresh weight per plant Fertilizer studies in Kwara State show low adoption of practices like manure and chemical fertilizer despite known benefits .

Botany and Morphology of Amaranth

Amaranthus species are mostly annual or short-lived perennial herbs. They exhibit erect, spreading, or prostrate growth habits. The plant has a taproot system, often with a well-developed primary root. Some species have a reddish-colored root .The stem is herbaceous, erect, and sometimes branched. It may be smooth or covered with fine hairs. The leaves are simple, alternate, and exstipulate (without stipules).They are ovate, lanceolate, or rhombic in shape. The margin is entire, and the surface is smooth or slightly hairy. Leaves have prominent veins and a petiole that varies in length.The flowers are borne in dense spikes or panicles, either terminal or axillary. Inflorescences may be erect or drooping. The flowers are small, unisexual or bisexual, and often inconspicuous. Amaranthus is mostly monoecious (having both male and female flowers on the same plant) or dioecious (separate male and female plants).Flowers lack true petals but have green, red, or purplish bracts and sepals. Staminate (male) flowers have 3–5 stamens. Pistillate (female) flowers have one ovary with a single ovule and 2–3 stigmas. The fruit is a capsule (utricle), which may be dehiscent (splitting open) or indehiscent (remaining closed).It contains numerous tiny lenticular or reniform (kidney-shaped) seeds.Seeds are small, shiny, and come in black, brown, or reddish colors.They are highly prolific and enable rapid propagation.

Many Amaranthus species are known for their C4 photosynthesis, which helps them thrive in hot and dry conditions. Some species exhibit red or purplish pigmentation due to anthocyanins. *Amaranthus cruentus* L., commonly known as smooth pigweed, is a fast-growing annual herb in the family Amaranthaceae. It is widely distributed across North America, South America, Africa, and Asia, thriving in disturbed soils, agricultural fields, and wastelands (Costea et al., 2001). This species is well known for its high adaptability, C4 photosynthetic efficiency, and ability to thrive under harsh conditions. It is cultivated for its edible leaves and seeds, but it is also considered a weed in many cropping systems due to its high reproductive capacity and herbicide resistance (Horak & Loughin, 2000).

The genus Amaranthus consists of approximately 75 species, with some being important food crops and others regarded as agricultural weeds (Mosyakin & Robertson, 2003). The name Amaranthus is derived from the Greek word "amarantos," meaning "unfading", which refers to its long-lasting flowers (Sauer, 1955). Amaranthus cruentus is an erect, annual herb that typically grows between 0.5 to 2 meters tall (Costea & Tardif, 2003). The plant has a branched or unbranched stem, depending on environmental conditions (Horak & Loughin, 2000).It has a taproot system that is well-developed and deeply penetrating the soil (Mosyakin & Robertson, 2003).The root is often reddish and aids in drought tolerance (Ehleringer et al., 1997).The stem is herbaceous, ribbed, and glabrous (hairless) or slightly pubescent (Costea et al., 2001).It is usually green or reddish, depending on environmental conditions (Sauer, 1955).Leaves are simple, alternate, and exstipulate (without stipules) (Mosyakin & Robertson, 2003).They are ovate to lanceolate, with a smooth surface and entire margins (Costea & Tardif, 2003).Each leaf has a long petiole and measures between 5 to 15 cm in length (Horak & Loughin, 2000).The plant produces dense, greenish terminal panicles and axillary spikes (Costea et al., 2001).Inflorescences may be erect or slightly drooping, depending on the growth conditions (Sauer, 1955).Amaranthus cruentus is monoecious, meaning it bears separate male and female flowers on the same plant (Mosyakin & Robertson, 2003).Flowers are small, green, and inconspicuous, lacking true petals but enclosed within green sepals (Horak & Loughin, 2000).

Male flowers contain five stamens, while female flowers have three feathery stigmas (Costea & Tardif, 2003). The fruit is a small, dry, indehiscent capsule (utricle) that encloses the seeds (Mosyakin & Robertson, 2003). It measures less than 2 mm in diameter and does not split open at maturity (Horak & Loughin, 2000). Seeds are tiny (about 1 mm in diameter), black, shiny, and lenticular (lens-shaped) (Ehleringer et al., 1997).They have a hard seed coat, allowing for long-term dormancy and viability (Costea et al., 2001).A single plant can produce up to 200,000 seeds, contributing to its aggressive spread (Horak & Loughin, 2000). Amaranthus cruentus reproduces exclusively by seeds, which are dispersed via wind, water, animals, and human activities (Costea & Tardif, 2003).The seeds can remain dormant for years, leading to persistent infestations (Mosyakin & Robertson, 2003).Amaranthus cruentus follows the C4 photosynthetic pathway, which enhances its efficiency in high-temperature and drought conditions (Ehleringer et al., 1997).The plant exhibits rapid growth, allowing it to outcompete other species for light, nutrients, and water (Costea et al., 2001). It is a cosmopolitan weed found in temperate, subtropical, and tropical regions (Horak & Loughin, 2000). It commonly grows in agricultural fields, roadsides, gardens, and disturbed lands (Costea & Tardif, 2003).Amaranthus cruentus is a highly adaptable plant with both economic and agricultural significance. While it serves as an important nutritional and medicinal plant, it also poses challenges as an invasive weed. Effective management strategies must balance its utilization and control.

HEALTH BENEFITS OF AMARANTHUS

The increasing popularity of *Amaranthus cruentus* is attributed to its high nutritional content, which makes it a valuable component of food security and empowerment strategies. Amaranthus species, particularly *Amaranthus cruentus*, are known for their rich antioxidant profile, which plays a significant role in mitigating oxidative stress. The antioxidative capacity of this plant is primarily due to its high levels of phenolic compounds, flavonoids, betalains, and essential vitamins such as C and E (Nsimba et al., 2008; Kalinova & Dadakova, 2009). These phytochemicals work synergistically to scavenge reactive oxygen species (ROS) and inhibit lipid peroxidation, thus protecting cellular structures from oxidative damage.

Research has demonstrated that both aqueous and methanolic extracts of Amaranthus leaves exhibit strong free radical scavenging activity in vitro, comparable to standard antioxidants like ascorbic acid and BHT (Barba de la Rosa et al., 2009). Betalains, in particular, are unique to Amaranthus and contribute significantly to its antioxidant potential, alongside flavonoids such as quercetin and rutin (Sarker & Oba, 2020). These compounds support the plant's role in preventing chronic diseases related to oxidative stress, including cardiovascular disease, diabetes, and certain cancers (Ndayishimiye & Ajayi, 2021). Overall, the antioxidative properties of Amaranthus not only underscore its nutritional value but also suggest promising therapeutic applications in functional foods and nutraceuticals in Nigeria. The leaves contain significant amounts of vitamin A, vitamin C, vitamin E, iron, calcium, potassium, and dietary fiber, all of which contribute to essential physiological functions in humans (Adekiya et al., 2020). Studies have shown that green amaranth contains higher levels of beta-carotene and antioxidants than many conventional leafy vegetables such as spinach and lettuce (Shukla et al., 2010).

Additionally, *Amaranthus cruentus* has been found to contain substantial amounts of flavonoids, phenolic acids, and betalains, which exhibit strong antioxidant properties that help combat oxidative stress and chronic diseases such as cardiovascular disorders and diabetes (Edeh et al., 2021). The plant's high protein content, particularly in its leaves and seeds, makes it a crucial dietary supplement for communities with protein-deficient diets (Aliyu et al., 2018).

Nutrient composition of Amaranth Leaves and Seeds.

Typically 100g of raw amaranth leaves contains ~23 kcal energy, Protein: 2.5g,Carbohydrates: 4.0g,Fiber: 2.2g,Fats: 0.3g,Vitamins & Minerals, Vitamin A: 2917 IU (High in beta-carotene),Vitamin C: 43.3 mg (Powerful antioxidant),Vitamin K: 1140 µg (Supports bone health & blood clotting),Folate: 85 µg (Important for DNA synthesis),Calcium: 215 mg (Good for bones & teeth),Iron: 2.3 mg (Helps in oxygen transport),Magnesium: 55 mg (Supports muscle and nerve function),Potassium: 611 mg (Essential for heart health) 100g raw seeds contain 371 kcal of energy,Protein: 13.6g (Rich in lysine, an essential amino acid),Carbohydrates: 65.3g,Fiber: 6.7g,Fats: 7.0g (Contains healthy unsaturated fats),Vitamins & Minerals:,Calcium: 159 mg,Iron: 7.6 mg,Magnesium: 248 mg ,Phosphorus: 557 mg,Potassium: 508 mg,Zinc: 2.9 mg. (delete nutritional composition)

2.4 Effect of Soil Nutrient Status on the Nutritional Quality of Amaranth

Soil nutrient status plays a crucial role in determining the nutritional composition of Amaranth (Amaranthus spp.). The availability of essential soil nutrients directly influences the concentration of vitamins, minerals, and bioactive compounds in the leaves and grains of the plant. Several studies have demonstrated how soil fertility affects the protein content, mineral composition, and antioxidant properties of amaranth.

2.4.1. Effect of Soil Macronutrients (Nitrogen, Phosphorus, and Potassium) on Amaranth Nutrition

Nitrogen (N): Nitrogen is a critical nutrient for protein synthesis in plants. Studies have shown that increasing nitrogen fertilization improves the protein content and amino acid profile of amaranth leaves and seeds (Onyango et al., 2020). Additionally, nitrogen enhances chlorophyll production, leading to higher levels of carotenoids and vitamin C.

Soil nutrient status plays a crucial role in determining the nutritional composition of Amaranth (Amaranthus spp.). The availability of essential soil nutrients directly influences the concentration of vitamins, minerals, and bioactive compounds in the leaves and grains of the plant. Several studies have demonstrated how soil fertility affects the protein content, mineral composition, and antioxidant properties of amaranth.

2.6. Effect of Soil Micronutrients on Amaranth Nutritional Quality

Iron (Fe): Iron is essential for chlorophyll synthesis and electron transport in photosynthesis. Deficiency in iron results in low iron accumulation in leaves, reducing the nutritional value of amaranth as a dietary iron source (Mibei et al., 2017).Zinc (Zn): Zinc is crucial for enzyme function and protein synthesis. Low soil zinc leads to reduced zinc content in edible leaves, affecting its potential for combating zinc deficiency in human diets (Noulas et al., 2018).Magnesium (Mg): As a central element in chlorophyll, magnesium deficiency can result in lower chlorophyll and carotenoid content, reducing the antioxidant capacity of amaranth leaves (Kamran et al., 2021).

Soils rich in organic matter and beneficial microbial communities improve nutrient cycling, leading to higher mineral absorption by amaranth plants (Kumar et al., 2020).Organic amendments such as compost and manure have been shown to enhance the vitamin and mineral content of leafy vegetables, including amaranth (Ghosh et al., 2022).

Soil pH affects the availability of essential nutrients. Amaranth grows best in slightly acidic to neutral soils (pH 5.5 – 7.0) (Singh et al., 2019).In acidic soils, iron and aluminum toxicity may reduce nutrient uptake, leading to poor nutritional quality of amaranth leaves. Alkaline soils can limit the availability of phosphorus, zinc, and manganese, negatively impacting plant nutrition. Phosphorus is essential for energy transfer and root development. Adequate phosphorus supply improves the uptake of other minerals like iron (Fe) and zinc (Zn), which are vital for human nutrition (Shukla et al., 2018). Potassium (K): Potassium influences the water balance and enzyme activity in plants. A sufficient potassium supply has been linked to increased antioxidant activity and improved carbohydrate metabolism, enhancing the nutritional value of amaranth leaves (Adeyemi et al., 2019)

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2.7 Climate and Soil Requirements

2.7.1. Climate

Amaranthus thrives in warm climates with temperatures ranging from 25–35°C. It is drought-tolerant but performs best with moderate rainfall (Palada & Crossman, 1999).It requires well-drained loamy soil with good organic content. Soil pH of 6.0–7.5 is ideal for optimum growth. Land Preparation; clearing and tilling are very important, remove weeds and previous crop residues. Plough and harrow to a fine tilth to enhance root penetration. Soil Enrichment: Apply 10–15 tons/ha of organic manure before planting (Oluoch et al., 2009). Enhance soil fertility with compost or farmy yard manure. Seed Selection and Sowing: Amaranthus is propagated by seeds, which can be directly sown or raised in nurseries. Spacing is done 30 cm apart, thinning to 10 cm between plants. They have no significant dormancy period and germinate quickly under suitable conditions. However, to enhance germination, soaking seeds in water for 2–4 hours can improve germination speed.

Amaranthus seeds are light-sensitive and germinate best when sown near the soil surface (not deeply buried).Optimal germination occurs at 25–30°C with adequate moisture can also hasten the germination rate. Proper seedbed preparation and moisture management ensure uniform germination. Seeds germinate within 3–7 days under optimal moisture conditions. Regular watering is needed to maintain moisture for seedling establishment.

Fertilization: Apply NPK 15:15:15 (200–300 kg/ha) at planting to enhance growth. Top-dressing with urea (50–100 kg/ha) after two weeks promotes leaf production. Regular but light irrigation is required, especially in dry conditions. Overwatering should be avoided to prevent fungal diseases. Manual weeding is recommended every 2–3 weeks. Pre-emergence herbicides (e.g., glyphosate) can be applied before planting.

Common pests include aphids and caterpillars. Control using neem extract or approved insecticides. Common diseases include leaf spot, damping-off, and root rot. Proper spacing and use of fungicides help in disease prevention.

Leaves are harvested 3–4 weeks after planting for vegetable use. Continuous or selective harvesting promotes more leaf production while grain varieties mature within 60–90 days. Harvested seeds are dried, threshed, and stored in airtight containers.

2.9 Response of *Amaranthus cruentus* to Different Nitrogen Sources

Nitrogen (N) is a vital macronutrient required for plant growth and productivity, influencing physiological processes such as photosynthesis, protein synthesis, and enzymatic activity (Marschner, 2012). The efficiency of nitrogen utilization in crops depends on the source, form, and method of application (Singh et al., 2019). Both organic and inorganic nitrogen sources contribute differently to soil fertility, microbial activity, and crop performance (Adekiya et al., 2020).

2.9.1 Inorganic Nitrogen Sources and Crop Performance

Inorganic nitrogen fertilizers, such as urea and NPK formulations, are widely used to enhance crop growth due to their rapid nutrient release and high nitrogen content (Aliyu et al., 2018). Studies have shown that the application of urea significantly improves vegetative growth, leaf expansion, and biomass accumulation in leafy vegetables, including *Amaranthus cruentus* (Makinde et al., 2020). Urea provides an immediate nitrogen supply, which boosts chlorophyll synthesis and photosynthetic efficiency (Singh et al., 2019). However, excessive application can lead to nitrogen leaching, soil acidification, and environmental pollution, particularly in high-rainfall regions like the Guinea savanna (Edeh et al., 2021).

The use of synthetic fertilizers such as NPK (15:15:15) has also been reported to enhance the yield and marketability of *Amaranthus cruentus* (Adekiya et al., 2020). The balanced combination of nitrogen, phosphorus, and potassium improves root development, leaf expansion, and overall biomass production (Ewulo et al., 2019). However, prolonged dependence on synthetic fertilizers can degrade soil structure and microbial diversity, necessitating sustainable nitrogen management strategies.

2.9.2 Organic Nitrogen Sources and Crop Performance

Organic fertilizers, including poultry droppings and cow dung, are gaining popularity as sustainable alternatives to synthetic fertilizers (Akanbi et al., 2005). Poultry manure is particularly rich in nitrogen, phosphorus, and potassium, promoting vigorous plant growth and increased leaf yield in *Amaranthus cruentus* (Olowoake & Ojo, 2016). The slow-release nature of organic fertilizers enhances soil fertility by improving microbial activity, organic matter content, and cation exchange capacity (Adekiya et al., 2020).

Cow dung, though lower in nitrogen compared to poultry droppings, has been reported to enhance soil moisture retention, root development, and gradual nitrogen release, resulting in sustained crop growth (Edeh et al., 2021). Organic fertilizers improve soil health and enhance nutrient availability over time, but their effectiveness depends on decomposition rates, application timing, and environmental conditions (Makinde et al., 2020).

Comparative studies have shown that while inorganic fertilizers provide immediate growth stimulation, organic fertilizers contribute to long-term soil health and sustainability (Aliyu et al., 2018). In the Guinea savanna, where soil fertility is often low, the integration of organic and inorganic nitrogen sources may offer the best approach for optimizing *Amaranthus cruentus* production.

2.10 Phytochemical Composition and Antioxidant Properties

Amaranthus species, particularly Amaranthus hybridus, are known for their rich antioxidant profile, which plays a significant role in mitigating oxidative stress. The antioxidative capacity of this plant is primarily due to its high levels of phenolic compounds, flavonoids, betalains, and essential vitamins such as C and E (Nsimba et al., 2008; Kalinova & Dadakova, 2009). These phytochemicals work synergistically to scavenge reactive oxygen species (ROS) and inhibit lipid peroxidation, thus protecting cellular structures from oxidative damage.

Research has demonstrated that both aqueous and methanolic extracts of Amaranthus leaves exhibit strong free radical scavenging activity in vitro, comparable to standard antioxidants like ascorbic acid and BHT (Barba de la Rosa et al., 2009). Betalains, in particular, are unique to Amaranthus and contribute significantly to its antioxidant potential, alongside flavonoids such as quercetin and rutin (Sarker & Oba, 2020). These compounds support the plant's role in preventing chronic diseases related to oxidative stress, including cardiovascular disease, diabetes, and certain cancers (Ndayishimiye & Ajayi, 2021).

Overall, the antioxidative properties of Amaranthus not only underscore its nutritional value but also suggest promising therapeutic applications in functional foods and nutraceuticals.

The phytochemical profile of *Amaranthus cruentus* is influenced by nitrogen fertilization, with significant variations in antioxidant properties, flavonoid content, and phenolic compounds

(Shukla et al., 2010). Nitrogen application affects the synthesis of secondary metabolites, which contribute to the plant's medicinal and nutritional value (Edeh et al., 2021).

Studies indicate that organic nitrogen sources, particularly poultry droppings, enhance the accumulation of bioactive compounds in leafy vegetables compared to synthetic fertilizers (Makinde et al., 2020). This is attributed to improved microbial interactions in organically amended soils, which enhance nutrient uptake and metabolic activity (Adekiya et al., 2020). The choice of nitrogen source, therefore, not only affects crop yield but also determines the nutritional and health benefits of *Amaranthus cruentus*.

2.8 Uses and Economic Importance of Amaranthus

Amaranthus is a source of income for small-scale farmers because of the fast growing cycle, it is form of poverty alleviation in developing countries for the vulnerable group; women and children. It is used in local and international markets as fresh vegetables and grains. It is used in food, industry, and medicine. It is used to treat a number of ailments in the traditional medicine across the globe. Leaves cooked as vegetables, seeds used in porridges and baking, and grain flour used in food processing.

Amaranthus is an important crop with significant nutritional, economic, and health benefits. It is gluten-free, this make it preferred over other grain and cereals. It is a perfect source of protein for the vegetarians since it contains lysine and squalene Proper agronomic practices, including fertilization, irrigation, and pest control, enhance its productivity. Given its potential in food security and income generation, promoting Amaranthus cultivation can contribute to sustainable agriculture and improved nutrition globally.

Nitrogen Use Efficiency in Guinea Savanna Ecology

The Guinea savanna ecology is characterized by moderate to high temperatures, variable rainfall, and low soil organic matter content, necessitating efficient nitrogen management practices (Aliyu et al., 2018). In this region, excessive nitrogen application can lead to nutrient leaching, while insufficient nitrogen supply results in reduced vegetative growth and yield (Ewulo et al., 2019).

Research suggests that the combined application of organic and inorganic nitrogen sources enhances nitrogen use efficiency, balancing immediate nutrient availability with long-term soil fertility (Edeh et al., 2021). Integrated soil fertility management approaches, such as combining poultry manure with urea or NPK fertilizers, have been shown to optimize *Amaranthus cruentus* growth and productivity under Guinea savanna conditions (Makinde et al., 2020).

2.9 Diseases of Amaranthus.

Amaranthus species, although considered relatively hardy and tolerant to various stress conditions, are susceptible to several diseases that can significantly affect their growth, yield, and quality. Among the most prevalent diseases are foliar infections, root rots, and damping-off, many of which are caused by fungal and bacterial pathogens.

One of the most common and widespread diseases affecting Amaranthus is leaf spot, primarily caused by species of Cercospora, particularly Cercospora beticola and C. cruenta. The disease manifests as small brown to dark brown circular or irregular spots on the leaves, which may coalesce to form larger necrotic areas. In severe cases, the infection leads to extensive defoliation and stunted growth. The pathogen thrives in humid and warm environments, conditions typical of many tropical and subtropical regions where Amaranthus is cultivated. Effective management strategies include crop rotation, proper field sanitation, and the use of fungicides such as mancozeb and chlorothalonil. The adoption of resistant varieties has also shown promise in reducing disease incidence (Zewdie & Bosland, 2000).

Another significant disease is damping-off, primarily caused by soil-borne fungi such as Pythium spp. and Rhizoctonia solani. This disease typically affects seedlings, causing them to rot at the base and collapse shortly after emergence. Damping-off is especially problematic in poorly drained or over-irrigated soils. Prevention can be achieved by ensuring good drainage, using sterilized soil or seedbeds, and treating seeds with appropriate fungicides (Kumar et al., 2015).

In addition, root rot, caused by pathogens like Fusarium spp. and Phytophthora spp., has been observed in Amaranthus fields, especially under conditions of high soil moisture and poor aeration. Infected plants exhibit wilting, yellowing of leaves, and browning of root tissues. Management of root rot involves improving soil drainage, avoiding waterlogging, and applying soil fungicides where necessary (Muthukumar & Vasanthi, 2014).

Bacterial infections such as bacterial leaf blight, caused by Xanthomonas campestris pv. amaranthicola, have alscrop rotation, and copper-based bactericides are commonly recommended control measures (Mali et al., 2018).

Viral diseases, though not as common, can occasionally affect Amaranthus crops. Amaranthus mosaic virus (AMV), for instance, causes mosaic patterns, leaf curling, and general chlorosis. Control is largely dependent on vector management—especially of aphids—and the use of virus-free planting materials (Varma & Malathi, 2003).

CHAPTER THREE

3.1 Description of Study Site

The study was carried out at the Teaching and Research far of the of the Department of Agricultural Technology, Kwara State Polytechnic Ilorin, a Southern Guinea Savannah Ecological Zone with latitude (Latitude 8^0 29'N, Longitude 4^0 35'E), and about 301m above the sea level(Google 2016 Data map) The rainfall patterns is bimordal and the daily average temperature is 27C

3.2 Experimental design

The experiment was Completely Randomized Design with 2 treatments (Cowdung and NPK) at 3 levels. The N PK was applied at 3 different rates of T 1 control - 0kg/ha T2-100kg/ha and T3-150kg/ha while Cowdung was applied at T1 (control) - 0t/ha T2-100t/ha and T3 150t/ha.

3.3 Analysis of Soil and cowdung

Pre-planting Laboratory analysis of the cowdung was carried out to determine the major nutrients present Also, physical characterization of the soil was carried out.

3.4 Source of Planting Material

The plants were propagated by seeds. Seeds were purchased from Premier Seed Company. Seeds were grown on seedbeds. However, cowdung was obtained from a Fulani cattle farm near oke ose and the N P K were obtained from a retail Agro outlet

3.5 General Agronomic Practices

Agronomic practices carried out included Planting of the seeds, adequate watering, weeding, fertilization and other crop protection and management practices. Weeds were control manually by hand pulling and hoeing of the surroundings of the pots. Cypermenthrin insecticide was used to spray the plants twice before harvesting to kill leaf defoliator and other destructive insects on the field.

3.6 Data Collection

Growth and yield parameters collected on the crop include: plant height, leaf number, number of branches and fresh and dry weight per plants after harvesting using tape measure and censor scale with precision and minimal error.

3.6.1 Growth Parameters

Plant height PHT (cm): This was measured from the ground level to the tip of the last leaf of two selected sample plants from each pot using a tape measure .

Number of leaves number per plant (NLPP): Number of leaf from sampled plants were counted and recorded from 2weeks after emergence at three consecutive intervals, 2,3 and 4 WAP

Number of branches per plant: (NBPP): Branches of each sampled plants were counted and recorded at regular assessment periods 2,3 and 4 WAP.

3.7 Data Analysis

All data collected were subjected to Analysis of Variance using Genstat Discovery 4th Edition. Significant means were separated where appropriate by the least significant difference at 5% probability level.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

Table 4.1: Mean squares from the analysis of variance for number of branches and leaves per plant

Source of variation		**NPK**		**Cowdung**			
	d f	**2**	**3**	**4**	**2**	**3**	**4**
Rep	3	1.0907	2.1881	1.694	6.865	12.708	35.031
Source	1	2.0689ns	0.7759ns	5.232ns	to.531ns	12.500ns	16.531ns
Error (a)	3	1.8226	1.2604	1.042	0.865	3.250	3.448
Level	3	1.6200ns	6.9522**	6.699**	3.115ns	8.542ns	15.115ns
Source x level	3	0.0598ns	0.1432ns	1.582ns	1.281ns	3.250ns	2.198ns
Error (b)	12	0.3081	0.7313	1.029	to.503	5.229	9.601
Total							

*, ** and *** denote effect significant at 5, 1 and 0.1 percent probability level, respectively

Ns denotes effects not significant

Mean squares from the analysis of variance for fresh and dry weight per plant

Source of variation	**NPK**				**Cowdung**		
	d f	**2**	**3**	**4**	**2**	**3**	**4**
Rep	3	1.0907	2.1881	1.694	6.865	12.708	35.031
Source	1	2.0689ns	0.7759ns	5.232ns	to.531ns	12.500ns	16.531ns
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Total							

*, ** and *** denote effect significant at 5, 1 and 0.1 percent probability level, respectively

Ns denotes effects not significant

Mean squares from the analysis of variance for number of leaves and branches per plant

Source of variation	**Cowdung**				**Poultry droppings**		
	d f	**2**	**3**	**4**	**2**	**3**	**4**
Rep	3	1.0907	2.1881	1.694	6.865	12.708	35.031
Source	1	2.0689ns	0.7759ns	5.232ns	to.531ns	12.500ns	16.531ns
Error (a)	3	1.8226	1.2604	1.042	0.865	3.250	3.448
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Error (b)	12	0.3081	0.7313	1.029	to.503	5.229	9.601
Total							

*, ** and *** denote effect significant at 5, 1 and 0.1 percent probability level, respectively

Ns denotes effects not significant

CHAPTER FIVE

5.1 CONCLUSION AND RECOMMENDATIONS

The study carried out to evaluate and compare the effect of two soil amendments on growth and yield of *amaranthus* revealed that the use of use of cowdung proved to be appreciably better with better growth rate and yield. This could be due to the fact that cowdung are usually higher in nitrogen content after decomposing in the soil hence there was an upward strike of vegetative growth of Amaranthus from week3 up to the harvest time.

Similarly, crop from the cowdung plots were noticed to have longer and better shelf life hence they maintain their nutritional quality. The farmer stand better economic and financial chance as no crop wastage is expected,

Therefore the government should provide enabling environment and machinery so that cowdung can be produced in patent form to enable farmers have access to it as a form of soil amendment since the use of organic manure even improves physical and chemical characteristics of the soil and even the quality of the crop.

REFERENCES

Devendra, C. (1992). Comparative aspects of digestive physiology and nutrition in goats and sheep. Small Ruminant Research, 7(2), 91–110.

Kiepe, P. (1995). No runoff, no soil loss: Soil and water conservation in hedgerow barrier systems. ILEIA Newsletter, 11(4), 20–21.

Kirtikar, K. R., & Basu, B. D. (2001). Indian medicinal plants (Vols. 1–4). Oriental Enterprises.

Oboh, G., Akinyemi, A. J., & Ademiluyi, A. O. (2007). Antioxidant and inhibitory effect of red amaranth on key enzymes linked to type 2 diabetes and hypertension. African Journal of Traditional, Complementary and Alternative Medicines, 4(3), 288–294.

Rastogi, A., & Shukla, S. (2013). Amaranth: A new millennium crop of nutraceutical values. Critical Reviews in Food Science and Nutrition, 53(2), 109–125.

Shukla, S., Bhargava, A., Chatterjee, A., Srivastava, A., & Singh, S. P. (2006). Mineral profile and variability in vegetable amaranth (Amaranthus tricolor). Plant Foods for Human Nutrition, 61, 23–28.

Bressani, R. (1994). Composition and nutritional properties of amaranth. In Amaranth: Biology, Chemistry, and Technology. CRC Press.

Brenner, D. M., Baltensperger, D. D., Kulakow, P. A., Lehmann, J. W., Myers, R. L., Slabbert, M. M., & Sleugh, B. B. (2000). Genetic resources and breeding of Amaranthus. Plant Breeding Reviews, 19, 227–285.

Castellanos-Bolaños, T., Villegas-Silva, R., González-Castañeda, J., & Guzmán-Maldonado, S. H. (1996). Amaranth: A pseudo-cereal of nutraceutical interest. Agrociencia, 30(3), 247–255.

Early, A. (2006). Amaranth: A rediscovered food crop. Journal of Agricultural History, 80(2), 179–204.

Jarošová, M., Vítová, M., & Jaroš, J. (2010). Amaranth oil - Composition, properties, and uses. Czech Journal of Food Sciences, 28(6), 541–549.

Martínez-Cruz, O., Paredes-López, O., & Reyes-Moreno, C. (2014). Amaranth: Nutritional properties and its potential as a functional food. Comprehensive Reviews in Food Science and Food Safety, 13(4), 431–444.

Rastogi, R. P., & Mehrotra, B. N. (1991). Compendium of Indian Medicinal Plants. CDRI, Lucknow and PID, New Delhi, India.

Shukla, S., Bhargava, A., Chatterjee, A., Srivastava, A., & Singh, S. P. (2006). Screening of green leafy vegetables for their nutraceutical properties. Indian Journal of Agricultural Sciences, 76(9), 547–550.