EFFECT OF WOOD ASH AND CHICKEN MANURE ON GROWTH AND YIELD OF SESAME (*Sesamum indicum)*

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2017-B051-10099

A DISSERTATION SUBMITTED TO THE FACULTY OF AGRICULTURE IN

PARTIAL FULFILLMENT OF REQUIREMENTS FOR THE AWARD OF

THE DEGREE OF BACHELOR OF AGRICULTURE OF

UGANDA MARTYRS UNIVERSITY

NOVEMBER, 2020

DECLARATION

I **Oyup Daniel** hereby declare that this dissertation, entitled, "**Effect of Wood Ash and Chicken Manure on Growth and Yield of Sesame (*Sesamum indicum*)"** is my original work and has never been presented for the award of any academic qualification at any institution.

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APPROVAL

This dissertation entitled "**Effect of Wood Ash and Chicken Manure on Growth and Yield of Sesame (*Sesamum indicum)*"** was written under my close supervision and has been submitted with my approval as University research supervisor.

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Dr. Godfrey Sseremba

Supervisor

DEDICATION

I would like to dedicate this dissertation to my parents, Mr. Joel Otwal and Mrs. Agnes Otwal, my siblings Ongom Joshua, Opio Jacob, Acio Anna Maria, Apio Catherine and Ayo Gloria and my friends who have all along supported me financially, spiritually, encouraged and as well inspired me during difficult times in my studies.

ACKNOWLEDGEMENTS

I would like to appreciate God the Almighty God for His protection and merciful support that made this research works a success for me from the beginning to the end. Gratitude goes to my supervisor Dr. Seremba Godfrey who patiently and painstakingly reviewed my work, criticized constructively and contributed positively to my research work.

My sincere appreciation further goes to Dr. John Byalebeka the Associate Dean, Dr. Joseph Sekandi the dean, all the lecturers and support staff of Uganda Martyrs University Faculty of Agriculture for their sacrifice, support and guidance during the period of my studies and research work.

May God bless them abundantly!

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LIST OF ABBREVIATIONS

ANOVA	:	Analysis of Variance
B	:	Boron
Ca	:	Calcium
CTRL	:	Control
Cu	:	Copper
EVF	:	Equator Valley Farm
FAO	:	Food and Agriculture Organisation
Fe	:	Iron
HR	:	Highly Resistant
HS	:	Highly Suceptible
K,	:	Potassium
MAAIF	:	Ministry of Agriculture Animal Industry and Fisheries
Mg	:	Magnessium
Mn	:	Maganese
MR	:	Moderately Resistant
MS	:	Moderately Suceptible
N	:	Nitrogen
P	:	Phosphorous

R	:	Resistant
S	:	Sulfur
S	:	Susceptible
Si	:	Silicon
UBOS	:	Uganda Bureau of Statistics
W+C	:	Wood Ash and Chicken Manure
Zn	:	Zinc

ABSTRACT

This study was conducted to compare the effectiveness of wood and chicken manure on the growth and yield of sesame (*Sesamum indicum)*. Specifically, it examined the wood ash and chicken manure on the growth response of sesame**,** the effect of wood ash and chicken manure on the prevalence of Sesame webworm, Phyllody disease and Alternaria Blight in Sesame and the effect of wood ash and chicken manure on the yield of sesame. A randomized complete block design with four treatments T1=5kg of wood ash, T2=5kg of chicken manure, T3= mixture of 2.5kg of chicken manure and 2.5kg of wood ash then T4= control, no treatment measuring 12.5 x 10 meters in length and width was established. These treatments were replicated 5 times. The experiment was set for two periods from August to December 2019and January to April 2020 corresponding to wet and dry seasons of production respectively, at Equator Valley Farm, Nkozi sub-county in Mpigi district. Growth, disease, pests and yield parameters were measured. ANOVA at 0.1%, 1% and 5% significance level was performed using GenStat 14 version.

Chicken manure treatment produced a significant ($p<0.001$) effect on sesame plant height (34.6cm), number of leaves per plant (82.3), number of branches (16.3), stem girth (3.2cm) and 50% flowering (40.1 days) than wood ash + chicken manure, wood ash and control. This was highly optimized in season two and week 8 when the plants had more access to sufficient plant nutrients and reached maturity. Chicken manure treatment registered significantly ($p<0.001$) lower Alterneria Blight incidence and severity, Phyllody disease incidence and severity and Sesame webworm incidence and damage respectively compared to wood ash + Chicken manure, wood ash and control. This was highly attributed to the presence of vital plant nutrients that include potassium, nitrogen, phosphorus, calcium responsible for inhibiting or creating tolerance to pests and diseases. Chicken manure treated produced significantly ($p<0.001$) higher number of capsules, seeds per capsules, however, a combination of wood ash + chicken manure produced significantly higher weight per 1000 seeds (3g) and yield per hectare (27.8 tonnes) compared to chicken manure (26.3 tonnes), control (23.8 tonnes) and wood ash (23.5 tonnes).

These study findings generally showed that chicken manure treatment was more effective in influencing sesame growth and partially yield; the number of capsules, number of seeds per capsule, the weight of 1000 seeds, however, the yield per hectare was largely affected by a combination of wood ash + chicken manure. The influence of chicken manure on sesame growth was attributed to the abundance in macro and micronutrients but also the availability of water during the wet season that enabled the breakdown of these nutrients. A combination of wood ash + chicken manure provided addictive nutrients such as more potassium, boron, calcium, manganese which aid in yielding and pests and disease tolerance. Farmers are therefore advised to use chicken manure + wood ash to enhance plant growth and yield since it offered more crop protection from pests and diseases but also enhances growth and yield.

CHAPTER ONE: GENERAL INTRODUCTION

1.1 Background of the study

Sesame **(*Sesamum indicum)*** is one of the world's ancient oilseed crops domesticated about 3000-5500 years ago in Africa and India (Yadav, et al., 2010). It is a flowering plant that belongs to the genus Sesamum commonly known as benne. Several wild relatives are known to occur in Africa and some in India (Kapoor, et al., 2015). Sesame is native to sub-Saharan Africa and widely cultivated due to its tolerance to drought-like conditions.

Trading in sesame first occurred between Mesopotamia and the Indian subcontinent around 2000BC where it was known as ilu in Sumerian and ellu in Akkadian (Raghav, et al., 2009). Some reports claim that sesame was cultivated in Egypt during the Ptolemaic period, the Egyptians called it sesemt (Langham, 2011).

Today in East Africa, sesame is widely known by many names and generally cultivated in low rainfall prone areas of North and Eastern Uganda, North and Central Kenya, Central Tanzania and generally used for its cultural and economic importance (Finke, 2010).

1.1.1 Morphological Characteristics of Sesame *(Sesamum indicum)*

Sesame (Sesamum indicum L. 2n=26), is a self-pollinated member of the order *Tubiflorae*, family *Pedaliaceae* (Pusadkar, et al., 2015). It is typically an annual oilseed crop and grown in the tropics and warm subtropics. It is an erect plant that and depending on the variety grows from about 0.5 to 2.5 meters (2 to 9 feet) tall; some have branches, others do not (Kobayashi, et al., 2019). One to three flowers appear in the leaf axils (Yahaya, et al., 2014). The hulled seeds are creamy or pearly white and about 3 mm (0.1 inches) long and have a flattened pear shape. The seed capsules open when dry, allowing the seed to scattered (Suhasini, 2016).

Sesame (*Sesamum Orientale*) has an annual broadleaf plant that grows 5–6 ft (155-185 cm) tall (Noorka, et al., 2011). It produces a 1–2 in (2.5–5cm) long white, bell-shaped inflorescence growing from the leaf axils (where the leaf stalk joins the stem) (Shadakshari, et al., 2015). The blooms do not open all at once, but gradually, from the base of the stem upwards to the top of the plant. The flowers are both male and females that self-pollinate (Mawcha, et al., 2018). The seed produced is a 1–1.5 inch (2.5–3.8 cm) long with a divided seed capsule that opens when the seeds are mature (Bedigian, 2013). There are 8 rows of seed within each seed capsule, and the seed may be yellow, white, brown, or black ((Akbar, et al., 2011). Due to the nonuniform, indeterminate nature of the bloom period, the reproductive, ripening, and drying phases of the seed tend to overlap (Zhang, et al., 2010). Seed lowest on the plant will mature first, even as the upper part of the plant is still flowering or has just formed seed capsules (Hailu, et al., 2018).

Typically the sesame seeds are very small and vary depending on the varieties grown. The known seeds are estimated to be 3 to 4 mm long by 2mm wide and 1 mm thick (Heuzé, et al., 2017). The seeds are ovate, slightingly flattened, and thinner at the hilum than the opposite end. When the mass of 100 seeds measured is estimated at 0.203g (Tunde-Akintunde & Akintunde, 2014).

1.1.2 Ecological requirement of Sesame *(Sesamum indicum)*

Sesame varieties are adoptive to many soil types, however, the highest yielding does well in well-drained, fertile soils of medium texture and neutral p.H (Terefe, et al., 2012). Sesame, however, has a low tolerance for soils in waterlogged and high salt areas (Linhai, et al., 2016). With temperatures above 23^{0}C, sesame is estimated to mature within a period of 90 to 120 days depending on the varieties cultivated (Jiang, et al., 2011).

Sesame is considerably grown in areas with rainfalls raining from 625-1100mm, however it is also a drought-tolerant annual crop that when provided with good soil moisture for establishment can result to high yield (Das, et al., 2018). Soil type and moisture influence the growth and productivity of varieties (Kanu, 2011). Under irrigation, sesame tends to have greater growth and yield than rain grown crops (Khurshid & Rabbani, 2012).

Sesame needs water during the seedling, flowering, and grain filling stages. Heavy rain at flowering will drastically reduce yield, and if cloudy weather persists for any period at this time, severe bacterial blight infection will occur resulting in exiguous yield (Wang, et al., 2010).

Sesame also requires a warm, moist, weed-free seedbed and a high temperature for germination. During the land preparation, appropriate tillage parties are chosen to ensure that the soils are kept in their best physical condition for favorable crop growth and development (Singharaj & Onsaard, 2015). It is considerably advisable for the first plough to have soil depth of 20 to 25 cm which physically supports the plants and allos for the sufficient utilisation of the moisture and nutrients, control of weeds and then harrow at planting to leave the soil surface roughly level (Das, et al., 2013).

Druing seed distribution, seeds are often mixed with sand soil or ash to increase the volume handled and to assist in even distribution. Clean seeds are therefore used for planting. In broadcast sowing a 1:3 mixture of seed and dry sand or earth is commonly used. However, as latest field observations indicate 1kg seed to 5kg soil (1:5) was found optimum and gives good stand establishment (Nadeem, et al., 2015).

1.1.3 Importance of Sesame *(Sesamum indicum)*

Sesame seeds have many potential health benefits and have been used in folk medicine for thousands of years. They help protect against disease diabetes and arthritis. A small handful per day is agood source of fiber, where three tablespoons (30grams) of unhulled sesame seeds provide 3.5 grams of fiber (12% reference daily intake) (Yahaya, et al., 2014). Fiber is well known for supporting digestive health. Additionally, growing evidence suggests that fiber may play a role in reducing your risk of heart disease, certain cancers, obesity, and type 2 diabetes (Dunkley, et al., 2014).

For a 100-gram serving, dried whole sesame seeds are rich in calories (573 kcal) and are composed of 5% water, 23% carbohydrates, 12% dietary fiber, 50% fat and 18% protein. The flour that remains after oil extraction from sesame seeds is 35-50% protein and contains carbohydrates. This flour, also called sesame meal, is a high-protein feed for poultry and livestock (FAO, 2018)

Sesame is also known to lower Cholesterol and Triglycerides which are a risk factors for heart disease. Sesame seeds consist of 15% saturated fat, 41% polyunsaturated fat, and 39% monounsaturated fat relative to saturated fat may help lower your cholesterol and reduce heart disease risk (Sarvari & Pepo, 2014). Sesame is also known to contain magnesium vital for combating diabetes. The usage of sesame seed oil as the sole edible oil has been found to be effective in lowering the blood pressure and plasma glucose in hypersensitive diabetics (Heuzé, et al., 2017).

The iron in sesame are highly recommended for those suffering from anemia and weakness. Seame seed oil prevents atherosclerotic lesions and hence, is beneficial for the heart health (FAO, 2019). The sesamol antioxidants and anti-inflammatory compound that exhibits anti-atherogenic properties, thus improving the cardiovascular health. Sesame seeds are high in the monounsaturated fatty acid, oleic acid, which helps in lowering the bad cholesterol and increasing the good cholesterol in the body. This prevents the risk of coronary artery disease and strokes (Fan, et al., 2018).

Sesame contains magnesium and phytae compound which are effective in reducing the risk of colorectal tumors, thus preventing colorectal cancer. Sesame seeds also support a healthy digestive system and colon as they are rich in fiber. This high fiber content helps in smooth functioning of the intestine, thus facilitating waste disposal and relieving constipation (Bedigian, 2013).

Sesame seeds contains copper a mineral that is vital for antioxidant enzyme systems, thus reducing the pain and swelling associated with arthritis. Besides, this mineral provides strength to the blood vessels, bones, and joints (Dimkpa & Bindraban, 2016). Magnesium contained in sesame seeds prevents asthma and other respiratory disorders by preventing airway spasms. Sesame, found in sesame seeds and sesame oil, has been found to prevent the DNA from being damaged by radiation. It also prevents damage to the intestines and the spleen. The Zinc in sesame boosts the bone mineral density and the bone health (Materechera & Salagae, 2016).

1.1.4 Production Trends

The global Sesame Seeds market is expected to grow with a substantial rate during the forecast period, 2020-2027(FAO, 2019). The rise in disposable income and changing eating habits of consumers and the presence of natural nutrients that are needed by the human body have increased the demand for sesame seeds across the global market (World Bank, 2019).

Globally, over 5.5 million tonnes of sesame were produced with Africa and Asia being the major producers. Myanmar, India, China, Sudan and Tanzania account for 70 percent of global sesame seed production (Oishimaya, 2018). In 2018, the global market value of sesame was estimated at US $6.5 billion. By 2025, global sesame market is estimated to reach US $17.77 billion (Benzinga, 2019). Production is estimated to reach 9.26 million tonnes by 2040 up from 5.53 million tonnes in 2017. China, a global consumer is expected to import 2.56 million tonnes in 2040 up from 1.3 million in 2016 (Rahman, et al., 2019).

In Sub-Saharan Africa, sesame is largely produced by traditional producers; Ethiopia and Sudan and some of the emerging producers such as Nigeria, Uganda, Burkina Faso, Mali, Tanzania and Mozambique – where production has also grown significantly over the past eight years. Sudan is the largest producer of sesame in Africa, with more than 2.1 million hectares of production area (FAO, 2019).

In East African region, Uganda has superseded Tanzania in the production area of 280,000 acres compared to 211,311 respectively (Okurapa & Oluwole, 2019). However, Uganda's exportation of sesame despite its production area has been affected by the quality of exports. The poor quality seeds coupled with pests and disease infestation generally affected the sesame market in 2016. Production of sesame is highly undertaken in East and Northern Uganda, where 95% of the total sesame is produced (MAAIF, 2019).

1.1.5 Production constrains of Sesame *(Sesamum indicum)*

Sesame thrives well in a harsh environment and requires limited fertilizer, water, and litter without the need for the use of pesticides due to high levels of natural tolerance for diseases and insects (Myint, et al., 2020). However, the yield is highly variable depending on the growing environment, cultural practices, and the cultivars (Bedigian, 2011). It is mostly grown under rain fed conditions of arid and semi-arid areas where mild-to-severe water deficit stress is experienced (Miyake, et al., 2015).

Sesame productivity is limited in those areas by drought and salinity. It is sensitive to drought mainly at the vegetative stages in all of its growing regions and has low production potential in semiarid regions due to drought stress (Troncoso-Ponce, et al., 2016). Grain yield as well as oil yield and quality are decreased depending on genotypes and drought intensity (Boureima, et al., 2016). Sesame cannot tolerate salinity it is especially sensitive to excessive calcium and sodium chlorides ions in soil solution (Tripathy, et al., 2019).

Several studies have shown that sesame is tolerant to high salinity levels at germination and initial growth stages, and variability has been found between sesame genotypes (Suassuna, et al., 2017). Sesame is sensitive to waterlogging, salinity, and chilling that limit sustainable production. Sesame growth and yield decreases after 2–3 days of waterlogging when the crop is grown on poorly drained soils (Antoniassi, et al., 2013). Waterlogging significantly reduces plant growth, leaf axils per plant, seed yield, and net photosynthesis (Uçan & Killi, 2010).

A variety of insect pests attack the seedling, foliage, flowers, pods, and stem of sesame (Olubayo, 2018). These are the primary causes of yield reduction and an average loss of 25% of potential worldwide production. Leaf spot, stem, and leaf blotch, and Cercospora leaf spots are bacterial diseases that mostly damage the sesame. Wilt is also devastating on susceptible varieties. Additionally, blight, charcoal rot, stem anthracnose, mildew, and Phyllody are significant diseases in sesame (Roche, 2019).

Similarly, the crop may drastically be affected by insect pests such as leaf roller, capsule borer, sphinx moth, aphids, and gall midge (Smith, 2015). Lack of fast-adapting cultivars, capsule shattering, uneven ripening, poor crop stand establishment, lower fertilizer responses, profuse branching, low harvest index, indeterminate growth habit, and susceptibility to diseases are the limiting factors in sesame production worldwide (Biazzo & Rangarajan, 2019). The indeterminate growth habit and the shattering nature of sesame cause harvesting problems and result in yield loss and poor adaptation to mechanized harvesting (Lateef & Reed, 2018). The majority of the world's sesame (probably over 99%) is shattering, and most of the harvest is manual (Wael, et al., 2018).

Harvesting practices vary from country to country and from one place to another within countries. The sesame plants are harvested when they have 50% maturity (Reddy, 2019). The stalks are tied into small bundles, then stacked to dry, threshed either on the floor or on plastic/cloth in the field to collect the seed. Its capsule shattering nature is the most problematic issue because of high seed losses (up to 50%) at harvesting time (Couch, et al., 2017). This character is not suitable for mechanized harvesting and limited for commercial production in countries that have no available labor (Langham, 2013).

1.2 Statement of the Problem

Low fertility and inefficient management of sub-Saharan African soils have been the major challenges facing productivity among smallholder farmers. Unfortunately, inorganic fertilizer used as major soil nutrient management is unsustainable, causing soil degradation and environmental pollution. There is limited information on how farmers can boost on the yield of sesame by improving on the fertility level. Therefore, smallholder farmers may need more information and maximum potential on a more sustainable, low-cost and efficient integrated nutrient management system compatible with their socioeconomic status is practiced.

Currently, the increasing demand for sustainable agriculture is driving the use of organic fertilizers, which are composed of beneficial microorganisms; ranging from bacteria to blue-green algae and fungi. Organic fertilizer such as chicken manure, wood ash among other have invaluable use in sustainable agriculture owing to their environmentally-friendliness, cost-effectiveness and improved productivity benefits. They improve plant nutrition and yield through improvement of soil water infiltration rates, organic matter contents as well as release of both macro and micronutrients however there slow release of those nutrients. This promote microbial activities and production of plant growth promoting substances. This study specifically focuses on organic manure potential as an efficient integrated nutrient management in increasing smallholder farmer productivity and profitability. It also suggests that increasing organic fertilizers awareness and use is available farm waste for maintaining and improving ecological stability and alleviating poverty, especially among the rural dwellers. Importantly, efficient organic fertilizers strategies by stakeholders will improve adoption of this technology among smallholder farmers. This study is therefore experimented to determine the most effective treatment of chicken manure and wood ash that farmers can adopt to improve sesame productivity but also control of pests and diseases.

1.3 Objectives of the Study

1.3.1 Main Objective

To assess the effectiveness of wood ash and chicken manure on the growth and yield of sesame

1.3.2 Specific Objectives

i. To determine the effect of wood ash and chicken manure on the growth response of sesame
ii. To assess the effect of wood ash and chicken manure on the prevalence of Sesame webworm, Phyllody disease and Alterneria Blight in Sesame
iii. To evaluate the effect of wood ash and chicken manure on yield of sesame

1.4. Research Hypotheses

i. Application of wood ash and chicken manure influence the growth of sesame
ii. Application of wood ash and chicken manure had no influence on the prevalence of Sesame webworm, Phyllody disease and Alterneria Blight in Sesame
iii. Application of wood ash and chicken manure promote the yield of sesame

1.5. Scope of the study

1.5.1 Content scope

This study aimed at examining the effect of wood ash and chicken manure on the growth and the yield of sesame. The study was therefore focus on determining plant response to these sustainable soil fertility amendment for improved sesame productivity. Growth traits, yield components, selected pests and disease incidence and severity were determine.

1.5.2. Geographical scope

The research study was conducted at Uganda Martyrs University, demonstration farm (Equator Valley Farm. EVF), Nkozi sub-county Mpigi district. The town is situated along Kampala - Masaka highway, approximately 88 kilometers (55 miles), south west of Kampala, Uganda's capital. The location is approximately 8 kilometers, North of Lake Victoria. The co-ordinates of

Nkozi sub-county are: 00 0036North, 32 00 00East (Latitude: 0.0100; Longitude: 32.0000) (UBOS, 2017).

1.5.3. Time scope

The experiment on effect of wood ash and chicken manure on the growth and yield of Sesame was conducted at Nkozi sub county-Mpigi district starting 2019-2020. This study review extended a period of 2 years and field experiment and data collection and analysis carried out within 2019-2020.

1.6 Significance of the study

This study adds to the body of knowledge by highlighting the importance of using Chicken manure and wood wash in improving soil fertility but also control pests and disease incidence, severity and damage on plants.

The study will be useful to farmers who intend to carry out organic farming by learning how to utilise or apply chicken manure and wood ash in improving their crop growth and yield. Sesame farmers will therefore find the application of wood ash and chicken manure relevant in improving their sesame productivity.

This study will also provide a basis for which the extension officers, NGOs and private sector engaged in agricultural production to adopt this organic agricultural biotechnology to improve crop production but also minimise costs of production since the materials needed for making of these organic fertilizers (chicken manure and wood ash) are readily available.

The study will continue to be a reference material for students, academicians and researchers who seek to carry out studies on the effect of selected organic fertilizers on the growth, yield of crops and response to pests and diseases.

For the researcher, this stud has been a learning point in experimental research. This involved the development of a researchable proposal, establishment of a demonstration garden, undertaking of agronomic practices, data collection, analysis and report writing. These skills will further be used for professional and academic advancements.

1.7 Justification of the study

Agriculture in Uganda is based on smallholder production with 2.5 – 3 million householders cultivating less than 2 hectares each, and over half of the total gross domestic product (GDP) 56% is subsistence production for household consumption (Lavers, 2012).

Low fertility and inefficient management of sub-Saharan African soils have been the major challenges facing productivity among smallholder farmers. Unfortunately, inorganic fertilizer used as major soil nutrient management is unsustainable, causing soil degradation and environmental pollution. There is limited information on how farmers can boost on the yield of sesame by improving on the fertility level. Therefore, smallholder farmers may need more information and maximum potential on a more sustainable, low-cost and efficient integrated nutrient management system compatible with their socioeconomic status is practiced.

1.8 Conceptual frame work

This is a diagrammatic illustration that indicates the interaction between independent variables and dependent variables through the influence of intervening variables. Their relationship indicates the parameters in the diagram above. The independent variables influence activities in the dependent variables.

Independent variables

Dependent variables

Treatments

- Chicken manure
- Wood ash
- Chicken + wood ash
- Control

Sesame Growth Response

- Plant height
- Leaves length
- Number of branches
- 50% flowering
- Stem girth

Pests and Diseases Incidence, Severity/Damage

- Alterneria blight incidence
- Alterneria blight severity
- Phyllody disease incidence
- Phyllody disease severity
- Sesame webworm incidence
- Sesame worm damage

Sesame Yield

- Number of Capsules
- Number of Seeds per Capsules
- Weight of 1000 seeds
- Yield per Hectare

Intervening-variables

- Moisture content
- Soil texture
- Organic matter content
- Other pests & diseases

Source: Adopted from Ibukuno & uwa, (2015) and modifiend by the researcher

1.9 Definition of key terms

Pest prevalence

The word is often used to describe a phenomenon that is widespread in a community, like the prevalence of a disease across a country, (Dominiak. et al., 2015). Therefore pest prevalence varies between studies and their co-occurrence according to (Meilleur et al, 2015).

Plant growth

Growth is measured by means of rate; it may be at a high rate or slow rate. In other words it is depending on the rate or speed at which a plant or an animal or man grows. This may be at a high rate or at a slow rate.

Plant Height

This is the distance to which plant rises above from the ground or it's defined as the measure upward from a surface floor or the ground.

Stem Girth.

In simple terms stem girth is the distance around the middle part of the plant. Plant girth means the size of the stem of the plant in terms of diameter.

Parameters

These are specific parts of the plant or key things someone is interested in for study. This may include; plant height, number of leaves, and webworm severity among others. It's the use of a known, understood probabilistic mechanism for the assignment of treatments to experimental units.

Leaf Length

This is the distance of the leaf from the plant node where the leaf is attached to the leaf apex.

CHAPTER TWO-LITERATURE REVIEW

2.0 Introduction

This chapter presents the review of literature on the Origin, Distribution and Botany and Description of Sesame (Sesamum indicum), properties of wood ash and chicken manures, the effect of wood ash and chicken manure on sesame growth response, the effect of wood ash and chicken manure on sesame pests and diseases and lastly the effect of wood ash and chicken manures on sesame yield.

2.1 Origin, Distribution and Botany and Description of Sesame *(Sesamum indicum)*

2.1.1 Origin and Distribution

Discussions have continued over the origin of sesame. With the new anthropological discoveries made globally, sesame has remained one of the most ancient crops that has its origin asserted to Africa and spreading to west Asia, China and Japan with each of these countries becoming secondary centers for diversity. Except for the Sesamum *prostratum Retz* native to India, all wild species of Sesamum are found in Africa (Dossa, et al., 2017).

The diversity and the traditional importance of sesame to several African countries such as Sudan, Tanzania, Uganda, Ethiopia, one could justify that African continent is the ultimate center of origin, however, it has also been demonstrated that that sesame was first domesticated in India, citing morphological and cytogenetic affinities between domesticated sesame and the south Indian native *S. mulayanum Nair.,* as well as archeological evidence that it was cultivated at Harrapa in the Indus Valley between 2250 and 1750 BC (Kafiriti & Mponda, 2019).

All these assertions make it difficult to say with certainty the exact origin of the crop. Due to its relatively low productivity sesame ranks only ninth among the top thirteen oilseed crops, which make up 90% of the world production of edible oil (FAO, 2019).

2.1.2 Botany and Description of Sesame *(Sesamum indicum)*

The genus Sesamum is a member of Pedaliaceae family, which contains 16 genera and 60 species (Gormley, et al., 2015). The number of sesame species is not clear; however, about 40 species have been described, and 36 are mentioned in the Index Kewensis (Gharby, et al., 2017).

Many occur in Africa (18 exclusively), 8 occur in the Indian – Ceylon region (5 exclusively). Almost all of the wild species are prevalent in Africa (Gharby, et al., 2015). Sesamum indicum, as well as S. capense Burm. (S. alatum Thonn) and S. schenkii Aschers, has a somatic number 2n = 26. For S. laciniatumthis is 2n = 28. For S. angolens and S. prostratum it is 2n = 32. For S. occidenale and S. radiatum Schm & Thonn. It is 2n = 64. Ceratotheca sesamoides, related to Sesamum, has 2n = 32. Only Sesamum indicum is cultivated; however, a few other species: S. angustifolium, S. calycinum, ssp. Baumii, S. malabaricum, and S. radiatum are harvested and eaten occasionally, particularly during famine or food shortage (Hassan, 2012).

2.2 Properties of Wood Ash and Chicken Manures

2.2.1 Wood Ash

Wood ash is the powdery residue remaining after the combustion of wood, that include burning wood fuel for cooking , fireplace, bonfire and in some case industrial power plants. Traditionally, wood ash has been used for gardening because it is a good source of potash that ameliorates the soil (Demeyer, et al., 2011).

In organic farming, wood ash is used as agricultural soil nutrients because it is a good source of potassium and calcium carbonate with the latter acting as a limiting agent that neutralizes acidic soils (Gadd, 2010). Further analysis demonstrates that wood ash contains empirical elements of Fe 1,6-55 g/kg, Si 6-170 g/kg, Al 1,2-45 g/kg, Mn 1-20 g/kg, As 0,6-50 ppm, Cd 0,18-60ppm, Pb 2-500ppm, Cr 12-280ppm Ni 10-140ppm, V 1,8-120 ppm. These elements are equally essentially for plant growth and yield although their levels are relatively low (Rosenfeld & Henry, 2016).

For plants growth, wood ash contains potassium essential in regulating water in the plant cells and plays a role in food transportation and creation of starch and sugar in plants. If plants don’t get sufficient potassium from the soil, they are more susceptible to diseases, pests, drought and frost (Etiegni & Campbell, 2019).

As compost, wood ash is commonly disposed of in landfills, but with rising disposal costs, ecologically friendly alternatives, such as serving as compost for agricultural and forestry applications, are becoming more popular. Because wood ash has a high char content, it can be used as an odor control agent, especially in composting operations (Sholto, 2005).

2.2.2 Chicken Manure

Chicken manure is of the highest nutritional value in conventional livestock and poultry manure, because chicken intestines are much shorter than that of cattle, goats and geese (Mason & Ghaly, 2018). Food stays in the intestines for a short time, so only three of the nutrients of chicken feed can be absorbed. Generally, most of them are excreted from the rectum. Eventually. The waste that the chickens pulled out all become “treasures”. If they are treated with biological fermentation agents, they become tremendous treasures (Ayodele & Agboola, 2016).

Chicken manure contains about 28% crude protein, 13% pure protein, 8% total amino acid, and various amino acids are balanced (Kyakuwaire, et al., 2019). In addition, it is rich in B vitamins and various trace elements. Therefore, chicken manure is an inexpensive low-energy protein feed, but it must be treated with a high-efficiency starter such as a biological starter (Bolan, et al., 2010). Using chicken manure instead of some protein materials and supplementing some energy feeds can greatly improve the economic benefits of the animal husbandry industry and reduce environmental pollution. Thus it can also increase incomes of yourself (Lu, et al., 2013).

Chicken manure organic fertilizer is a decomposing agent that contains medium and trace elements, beneficial biological active bacteria and various enzymes required by plants (Viegas, et al., 2012). The life activities of these microbes in the soil can fix nitrogen in the air and loosen the soil (Runge, et al., 2017). Decomposes the long-term use of chemical fertilizers to solidify phosphorus and potassium minerals in the soil to provide sufficient nutrients for crops (Hoog, et al., 2010).

Chicken manure organic fertilizer nutrients are comprehensive and long-lasting: can provide various nutrients needed for different growth of crops. Rational use of bio-organic fertilizer can comprehensively adjust the physiological functions of crops, balance and stimulate reproductive growth and vegetative growth, and enable crops’ root system is developed, the flower is preserved, the fruit is preserved, the fruit rate is increased, the harvest is improved, and the ability of sustainable high yield of soil is improved, and the yield is increased by 10%-15% (Jean, et al., 2015).

Chicken manure organic fertilizer contains a large amount of organic matter: the use of bio-organic fertilizer can activate nutrient soil, enhance soil permeability, promote crop root growth, and improve crop vitality and immunity; Chicken manure organic fertilizer contains a large number of beneficial microorganisms: the large amount of beneficial microorganisms in the soil can increase the soil organic nitrogen content, promote the activity and effectiveness of phosphorus and potassium in the soil, and exert its nitrogen fixation, phosphorus release and potassium dissolution (Martin, 2013).. Beneficial microbial reproduction can inhibit the growth and spread of harmful bacteria in the soil, improve the disease resistance of crops, effectively resist pests and diseases, strong resistance, enhance crop's ability of cold resistance, antifreeze, anti-aging (Couch, et al., 2017)

2.3 Effect of Wood Ash and Chicken Manure on the Growth Response of Plants

Elpaso (2017) reported that wood ash and chicken manure have significant variation in their effect to sesame. It was determined that sole application of chicken manure treatments rapidly enhance plant growth. The plat height, leaf length, leaf width, flowering and stem girth were highly highly attained in chicken treatments than in wood ash. This was largely attributed to the adequacy of nitrogen, potassium which aid in the plant growth. Nitrogen as it has been highlighted is a building block of plant life, hence plants that attain more of it nitrogen register better growth (Fan, et al., 2018).

A study in Enugu state on application of wood ash, chicken manure and NPK towards the growth and yield of Okra, showed that sole application of wood ash, chicken manure and NPK registered significant differences growth response. A combination of wood ash and chicken manure treatments improved plant growth response, with higher plant growth, leaf length and width, stem girth and even flowering attained. Throughout this seedling, vegetative and flowering stage, wood ash and chicken manure treated plots highly attained faster and better growth. This was linked to the availability of nitrogen essential for plant growth (Anyaegbu, et al., 2019).

Edema (2019), further acknowledges that wood ash and chicken manure were very vital in influencing the growth outcome of sesame in Sudan. Sole application of chicken manure registered higher plant growth response followed by combination of wood ash and chicken manure lastly sole application of wood ash. This was attainable because as compared to wood ash, sole application of chicken manure enhanced the micro-organic activity in the soil that helped to easily break down the micro-nutrients in the soils such as nitrogen, potassium and phosphorous, magnesium essential for both plant growth and control response of pests and diseases unlike wood ash. The limitation presence of micro-organic activity in wood ash only left the deposition of the easily accessible nutrients such as calcium, magnesium, iron, boron which are not necessary essential for growth by rather yield (Das, et al., 2018).

Oluwole(2017) while comparing the effect of wood ash, chicken manure and cow manure on the growth of millet determined that, chicken manure treatments showed a significant outcome on plant growth compared to wood ash and cow manure. This was attributed to the fact that unlike wood ash and cow manure, chicken manure is easily broken by the ardent microorganisms that easily break down the manure into macro and micro-nutrients especially nitrogen, that is highly needed to enhance plant growth.

In Ethiopia, Chicken manure was found to be effective in influencing maize growth. Plant growth was highly achieved when the chicken manure was applied compared to cow manure. Although the application rates differed, higher application of chicken highly promoted vegetative growth and flowering. The Nitrogen in Chicken manure is most needed by plants to enable plant development (Miranda, et al., 2012).

Materechera & Salagae, (2016) found out that partially decomposed chicken maanure treatments produced higher plant height, stem diameter, leaves per plant, dry matter yield and tissue concentration of protein, nitrogen (N), and phosphorus (P) than cattle manure. he responses of maize due to manure application were higher in the loam than clay soil. Application of cattle manure produced responses which were less than control in many cases. This was presumed to be due to microbial immobilization of nutrients. However, wood ash only improved maize growth response in loam soils and not in clay. In addition , the addition of wood ash to maure in clay reduced plant height dry matter yield, plant tissue protein and phosphorus of maize (Boureima, et al., 2016).

Accoridng to Wacal *et al* (2019) growth response of sesame (*Sesamum indicum* L.) is greatly inflluened by the presence of vital nutrients such as nitrgone, phosphorous, potassium, magnessium, calcium in the soil. By treating plants with decomposed manure such as chicken manure, plants registered vigoruous growth as comapred to those that had applied wood as only. Chicken manure is credit for containing very important microbial bacteria that breaks down the droppings into the plants nutrients. In consideration, chicken consumes avariety of protein-rich and vitamin, caborhydrates crops that are a good source of nitrogen , potassium and phosphorous, iron, calcium and magneissum. Sicne the digstion is not often complete, the nutrients are presented almost row for decomposition and with appropriate decomposition aided by the bundance of microorganisms in the manure, the plants are able to absorp the needed nutrients hence better growth (Chastain, et al., 2018).

The beneficial effects of ash on soil structure and physical properties have been reported to contribute to plant growth response. It was found in studies conducted in Cameroon that ash brought from external sources improved hydraulic properties of soil, and this was attributed to the presence of cations, especially Ca. It was also found that ash applied to unburnt soils contained some organic matter which helped to improve soil structure and reduced bulk density and penetrometer resistance. It was indicated that ash produced during burning could contribute to increase in moisture retention in un-eroded soil thus playing the same role as mulch cover hence promoting the growth of crops (Dayo-Olagbende, et al., 2018).

According to Fernandez, et al., (2015) a number of macronutrients are abundant in wood ash. The extent to which these are dissolved and the rate at which they are made plant available varies between elements. Oxides and hydroxides of K are normally dissolved quickly, while the dissolution of Ca and Mg depends on the dilution (faster when ash/water ratio is low). In acid soils, Phosphorus contained in the ash may remain insoluble or become immobilized through complex formation with ions of Fe or Al. The content of Nitrogen and Sodium is low in ash, since most compounds containing these elements are almost completely oxidized and emitted as gases during incineration. Despite that, plant available Nitrogen may increase due to ash application, if higher pH results in higher microbial activity and increased mineralization (Pitman, 2016).

2.4 Effect of wood ash and chicken manure on the prevalence of Sesame webworm, Phyllody disease and Alterneria Blight in Sesame

2.4.1 Phyllody disease and Alterneria Blight

The effect wood ash and chicken manure treatments on the control of Phyllody disease and *Alterneria blight* have been demonstrated by a number of studies. According to Nabeela *et al.*(2015) wood ash application resulted to an increase in bioaccumulation of trace elements in seedlings of B.anapus. Almost all trace elements were significantly higher in seedlings grown in wood ash above 10 g/kg as compared to the control. An increase in total microbial count was observed with wood ash treatment which was statistically significant at 1 and 10 g/kg of wood ash. It is concluded that an increase in microbial composition help to boost plants immunity to help it resist pests and attack (Akande, *et al*., 2015).

Chastain, *et al.,* (2018) found out that besides enhancing plant growth due to the presence of nitrogen , phsophorous and potassium, chicken manure applications supply micronutrients such as calcium (Ca), magnesium (Mg), sulfur (S), manganese (Mn), zinc and (Zn) into soil along with foliar spray that have a potential to inhibit *Alternaria* leaf blight infection in leafs up to 82.3% compared to control. The lower leaf removal of Brassica sp along with application of balanced nutrition is considerably effective in reduction of Alternaria blight by promoting its tolerance to disease pathogens (Dunkley, et al., 2014)

In Egypt, a study demonstrated that exploit of the aqueous extracts of aerated (ACT) and non-aerated (NCT) compost teas made from plant residues (rice ash, bean straw and vegetative food waste) as well as from chicken manure suppressed early blight (*Alternaria solani)* in tomato and purple blight (*Alternaria porri*) in onion was assessed. This was demonstrated by the availability of denser biodiversity of actinomycetes, bacteria, filamentous fungi and yeasts compared to ACT. Fortification of tea compost with some nutrient additives strengthened microbial population. Compost teas inhibited, in vitro, conidial germination and fungal growth. Ten-day-old extracts reduced activity on filter sterilization. In a greenhouse trial, spraying tomato and onion plants with all compost teas significantly reduced disease incidence and population counts of Alternaria blight. Moreover, treated plants exerted significant increases on the activities of both peroxidase, β-1,3-glucanase and chitinase. Field trials were conducted over 2 years to assess the effects of spraying compost teas on diseases development. The incidence of Alternaria blight was obviously reduced in tomato and onion plants sprayed with NCT compared to those sprayed either with ACT or non-sprayed ones. (Haggag & Saber, 2017).

Lal, (2015) reported that integration of the different management practices including soil treatment with sulphur-zinc-magnesium-molybdenum-boron most of which are contained in wood ash help reduce on the incidence level of Alternaria blight in oilseed Brassica. This was certain because Wood ash (as opposed to coal ash) can be a great addition to the garden. It contains potassium or potash), and potassium is a vital nutrient for crops. Just as it does in humans, potassium regulates plants' water balance (so tissue is firm and juicy), and has a part in transporting food within the plant and creating sugars and starches which enhances fast growth in order to drought, frost, pests and diseases (Rawashdeh, et al., 2016).

Boureima *et al* (2016) demonstrated that Wood ash supply plants with a lot of Potassium, that plays a very important roles in stress tolerance of plants to both adverse conditions like biotic (insects, pathogens etc.) and abiotic (heat, cold, drought etc.). Potassium provides disease resistance mainly through two processes like mobilization of plant defense system and increases cuticle thickness which inhibits the pathogen infection (Bedigian, 2013).

Dordas (2008) also report that wood ash supply plants with sufficient Boron which has been involved in many physiological and biochemical process. Due to the function that B has on cell wall structure, plant membrane and plant metabolism it was found that B reduces the severity of various diseases such as; Phyllody disease and Alterneria Blight (Miranda, et al., 2012).

Han *et al*(2017) also note that the application of wood ash alongside chicken manure plays an important role in the supply of boron but also enhancement of plant growths reducing diseases incidence and severity. These manures are also reported to contain all the micronutrients such as calcium (Ca), magnesium (Mg), sulfur (S), manganese (Mn), zinc and (Zn) (Iyovo, et al., 2010). Manganese has however been proven to be a key nutrient in advancing resistance in plants for both leaf and root fungal diseases (Markou, et al., 2016). The amount of manganese available to the plantroots varies overtime and depends upon various factors in the climate (Miranda, et al., 2012). Mn demand for disease tolerance is higher than that of the yield for the host plant, and it somehow, decreases the inoculum capacity of soil-borne pathogens (Dunkley, et al., 2014). Mn can regulate a number of diseases, through its role in lignin biosynthesis, phenol biosynthesis, photosynthesis and numerous other functions (Ungsethaphand, et al., 2009).

2.4.2 Sesame webworm

Sesame webworm (*Antigastra catalaunalis*) is the major pest, which causes heavy losses in sesame plants (Gebregergis, et al., 2018). Young larvae are less frequent on pods than on other plant parts. They feed externally by making a loose web, which sticks several leaves together (Wazire & Patel, 2015). The larvae feed on leaves and young shoots. Excreta (frass) remains between the leaves and the loose web (Ali & Jan, 2014). At a later stage, the larvae infest the sesame fruit capsule making an entrance hole on the lateral side and feeding on the seeds inside the capsule; they leave excreta on the seeds (Yohannes, et al., 2016)., However studies has shown that the application of chicken manure and wood ash can have a significant effect on plant tolerance to pests such as sesame webworm.

Mohanty, (2011) reports that chicken manure had higher mean leaf damage, the crop tolerated the attack by insect pests when compared with the control (with zero application of manure). This succinctly shows that the crop, when grown under optimum soil fertility with the essential plant nutrients that are used by plants. These include nitrogen (N), phosphorous (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), manganese (Mn), zinc and (Zn) which can enable plant tolerate stress caused by insect pest's infestation (Kanu, 2011).

Dayo-Olagbende *et al.* (2018) notes that application of chicken manure affected the rate of leaf damage and tolerance of the crop to insect pests' infestation. At higher mean leaf damage, the crop tolerated the attack by insect pests, as they had more leaves and branches when compared to the control. *Leptualaca fassicollis* were the most predominant insect pest that attacked the crop at the vegetative stage. At flowering and pod -bearing stages, there was a preponderance of insect species with Helicorverpa armigera as the predominant (Ayodele & Agboola, 2016).

Materechera & Salagae (2011) determined that chicken manure ammended witrh wood ash had a significant effect on nutrient uptake, leading to early growth, yield and tolerenace to pests and diseases. The addition of chicken manure and wood ash produced higher plant response to pests such as webworm. The potassium in both chicken manure and wood ash was found to highly induce the plants reistsance to pests by development of thick plant tissue render the penetration of the pests less effective in affecting the plants growth and yield (Ghafariyan, et al., 2013).

Jia, *et al.,* (2016) also affirmed that wood proved to be more effective in protecting the vegetables against insect pests, since it recorded significant minimum activities of insect pests. Therefore, botanicals such as neem and wood ash could be considered as an effective in alternative method of pest management. Much as wood ash does not contain nitrogen, it supply plant with a lot of Potassium plays a very important roles in stress tolerance of plants to both adverse conditions like biotic (insects, pathogens etc.) and abiotic (heat, cold, drought etc.). Potassium provides disease resistance mainly through two processes like mobilization of plant defense system and increases cuticle thickness which inhibits the pathogen infection (Gardea-Torresdey, et al., 2014).

Biazzo & Rangarajan, (2019)also notes that wood ash supply plant with much calcium which is an essential plant nutrient. As the divalent cation (Ca^{2+}), it is required for structural roles in the cell wall and membranes, as a counter- cation for inorganic and organic anions in the vacuole, and as an intracellular messenger in the cytosol. This served as protective mechanism against mechanical damage including insect pests more especially sucking and chewing pests due to improve plants' structure (Fan, et al., 2018).

According Huber, et al., (2012) the composition of macro and micronutrient elements in host plant has a great significance in resistance and susceptibility in various host pathogen combinations and most pests. Most important nutrients which provide pests disease resistance in plants are K, Ca, Cu, B, and Mn most of which are contained in both chicken manure and wood ash (Dordas, 2018). Chicken manure supply plants with manganese, Mn has a significant role in lignin biosynthesis, phenol biosynthesis, photosynthesis and numerous other functions (Dimkpa & Bindraban, 2016). This provide plants with protective structure as a result of lignin deposit which enable plants to tolerate shucking and chewing pests (Fernandez, *et al*., 2015).

2.5 Effect of wood ash and chicken manure on yield of sesame

An improvement in crop yields under manure application is the goal of both farmers and researchers (Ayodele & Agboola, 2016). Studies have reported a yield increase in many different crops, including Bermuda grass, corn, fescue, orchard-grass, rice, and wheat under application of poultry. This increase of yield is attributed to the rich nutrients, especially N and P in poultry manure (Mitchel & Tu, 2015). The fertilizer value of one tonne of dried cage poultry manure is equivalent to 100 kg urea, 150kg super phosphate, 50kg potash, 125kg calcium carbonate, 30 kg sulphur, 12 kg sodium chloride, 10kg magnesium sulphate, 5kg ferrous sulphate, 1kg manganese sulphate, zinc sulphate and other trace minerals each and is available at a cheaper rate than other market available inputs (Warman & Cooper, 2010).

Mohamed Amanullah *et al.* (2010) reported that the application of chicken manure and wood ash on sesame production enhanced growth and yield. This was attributed to chicken manure containing the bacteria used in the poultry's digestive process, which works to break down organic matter and wood ash containing nutrients such as potassium, boron, magnesium essential for yield and pests and disease resistance. The composting process and bacteria make the nutrients soluble, which means that the plants can more readily absorb them from the soil and used to promote growth and improve yields of crops (Akande, et al., 2015). A 12 year long term research (1998- 2009) found that corn yields under corn-soybean rotation system under application of poultry manure was much higher than yields of field applied with urea ammonia nitrogen. However, yield is usually a difficult indicator of comparison (Singer, et al., 2014).

Das *et al*. (2013) reported that poultry manure and wood ash were efficient in terms of total nitrogen as fertilizer and had appreciable residual effect. He also found that wheat grain yield, grain quality and straw yield were promoted by rate of chicken manure. Elzilal (2012) showed that chicken manure applied at comparatively high rate, substantially increased the yield of dry matter plant. Farori *et al*. (2015) showed that application of chicken manure and wood ash significantly increased nodulation and dry matter production. This may be due to the fact that manures are known to provide plant nutrients and improve soil physical properties (Finke, 2010).

Eltilib *et al*. (2013) showed that chicken manure was very effective in counteracting the salinity effect, which was reflected in the proportionate promotion of growth and yield in response to the applied amount, leaf was reduced by salinity and increased by the addition of chicken manure in Okra. Elgala *et al.* (2010) reported that applied poultry manure to sorghum obtained significantly higher dry matter yield. Elawad (2014) found that poultry manure is an excellent source of nutrients and can be incorporated into most fertilizer programs. The nutrient composition of poultry manure varies with type of birds, the feed ration, the proportion of litter to droppings, the manure handling system, and the litter type (Ali & Jan, 2014).

According Koelsch (2019), the collective analysis of data from all of the studies reviewed demonstrated a yield increase of 6% in corn when substituting chicken litter for inorganic fertilizer (based upon 244 observations) and a 14% yield increase for soybeans (based upon 86 observations). The authors suggested that improved soil biological and physical characteristics in fields using chicken litter explained the yield increases. Additionally, improved nodulation in soybeans was found to be resulting from the abundance of P and micro-nutrients contributed to the observed soybean yield increases (Abdel-Magid, et al., 2015).

A 20-year study by Iowa State University researchers showed that fertilizing crops with chicken manure can benefit soil health and farm profits when compared to a commercial fertilizer. In the study's first decade, experiments compared three treatments in a corn-soybean rotation, and in the second 10 years, treatments for continuous corn cropping were compared. After 20 years, the study found particulate organic matter and several other measures of soil quality were significantly better in the manured plots. Corn yields increased from manure treatment during the continuous corn phase of the study, and were similar during the corn-soybean phase. Although the manure treatment was generally more expensive, the increased yields helped offset this cost. Additionally, nitrate-nitrogen losses were 7% to 16% lower from the cropland fertilized with manure (Soupir, 2019).

Researchers at the Sahelian Centre of the International Crop Research Institute for the Semiarid Tropics (ICRISAT) in Niger found that wood ash was a source of Ca and that its use increased yield and quality of groundnut. Collected and stored throughout the year, wood ash was applied to groundnut crop at flowering. By increasing Ca levels with wood ash, yield in large seed groundnut varieties (ICRISAT, 2019).

Experiments conducted in Kenya also confirmed that wood ash used as a soil amendment and as trace element fertilizer. Although fly ash is deficient in N and P, it contains appreciable amounts of trace elements as well as Ca and Mg. Fly ash derived burning sugarcane bagasse used to control deficiency of B, Mo and Zn (Kairu, et al., 2013). Vegetation burning was beneficial to cassava and groundnut yields because of the large quantities of P and K in the ash. There were 9, 15 and 27 % increases in cassava tuber and 48, 8 and 75 % increases in groundnut yields over the no burn plot due to slight, moderate and heavy burning respectively in Cameroon (Anyaegbu, et al., 2019).

Glenn & Ames (2009) note that the presence of cations in the ash was attributed to the highest groundnut yield. Slightly high and more or less stable yields were obtained when ash residues were applied to unburnt plots. There was 6 % increase in maize yield over the no burn plot without ash due to the additional effect of ash. Similarly, there was about 26 % increase in maize grain yield to-bur plot with application of ash. Ash derived from burn enhanced canopy development in two crop seasons after which crop growth was reduced compared to the case in no-burn plot (Mugwe, et al., 2018). Hence the beneficial effect of burning is short lived wherever it is traditionally practiced. Since the 19th century farmers have successfully used ash as fertilizer and a number of research studies have shown the positive effects of plant ashes on soil fertility, conditions and yield of crops (Sarvari & Pepo, 2014). In India the generally adopted practice is to manure individual coconut trees twice a year with about 500g of N. P and K each (Basa, et al., 2016).

Studies in Southwest Nigeria have found positive responses of yield and nutrients contents of amaranthus and okra to application of wood ash. Application of 2, 4,6, 8t/ ha ash increased okra pod count and weight, soil organic matter N, P, K, Ca and Mg contents, leaf N, P and K contents and pod N, P, K, Ca and Mg contents (Iderawumi, 2018). Another investigation showed that wood ash applied at 0, 2, 4, 6 and 8t/ ha to two maize crops increased soil organic matter content, N, P, K, Ca and Mg contents, and leaf K, Ca and Mg contents. Wood ash increased maize plant height and grain weight significantly. The 2, 4, 6 and 8t/ ha ash increased grain weight by 44, 52, 37 and 56 % respectively. The use of ash at 4t/ha was recommended (Iderawumi, 2020). In Canada addition of 1126 and 2252 kg/ ha crop residue ash increased dry matter yield of maize significantly (Antoniassi, et al., 2013).

Studies carried out at Cocoa Research Institute of Nigeria showed that burnt cocoa pod husk compared favorably with NPK fertilizer in maize performance (Ibukuno & uwa, 2015). In Ghana shoot and root dry matter of maize increased with increasing application of ash of cocoa pod husk. Cocoa pod husk ash is used as source of potassium. In most oil palm plantations with mills, the empty bunch wastes are often incinerated into ash and the ash is used as fertilizer for oil palm trees (Woode, et al., 2014). In Northern Nigeria ash derived from grasses improved the yield of sorghum, cotton and maize compared to incorporation of the grasses (Owolabi & Dada, 2012).

CHAPTER THREE: MATERIALS AND METHODS

3.1 Experimental Site Location

The experiment was carried out at Uganda Martyrs University farm in Mawokota South County, Nkozi village, Nkozi Sub County, Mpigi District in the Republic of Uganda located 3km off Kampala-Masaka highway and it lies at an altitude between 1200 and 1400 meters above sea level while the coordinates of Nkozi Sub County area are; 0000 36N, 32 00 00E; (latitude: 0.0100; longitude: 32.0000) (UBOS, 2017).

Nkozi Sub County, is an Equatorial area having a bimodal rainfall pattern of two rainfall seasons, the first season during March-May and the second during September whereas the remaining months are generally dry with mean annual rainfall of 1320 mm tough in many areas of lake Victoria zone it is between 1750 and 2,000 mm . The minimum temperature of Mpigi District is 11 ^{O}C while the maximum is recorded at 33.3 ^{O}C (MAAIF, 2016).

The soil type at the area is a sandy loam that is relatively fertile for crop production and the soils are typically ferralitic red/yellow sandy/clay loams (latosols) with pH 5.5-6 and generally soils are well-drained. The general vegetation of the study area is comprised of 5% dense moist natural forests, 90% savanna woodland, and the rest being swamp (Ssemwanga, 2015) .

3.2 Experimental Research Design

The experimental design used was a randomized complete block design that is a standard design for agricultural experiments. The field was divided into units to account for any variations and the treatments were designed at random to the subjects in the blocks once in each block (Casler, 2015). The relevance of grouping experimental units was to have the units as uniform as possible so that the differences between the treatments would be largely due to true differences between treatments (Trudi, 2010). The randomized complete block design was of four treatments replicated five times. The four treatments are; T1=5kg of wood ash, T2=5kg of chicken manure, T3= mixture of 2.5kg of chicken manure and 2.5kg of wood ash Then T4= control, no treatment applied whereas the experimental field was 12.5 x 10 meters in length and width. The field was divided into five blocks with 20 replicates using a tape measure, ropes, and pegs. Each plot measured 2 x 2 meters and 0.5 meters separated between each plot to act as walkways. Heaping of soil was not done at the time of designing the experiment since the selected sites were relatively flat to facilitate soil conservation against soil erosion.

Table 1: Field layout of the experiment

W/ rep1	CTRL/ rep1	W+C/rep1	C,/rep1
CTRL/rep2	W+C/rep2	C,/rep2	W/rep2
C/rep3	W+C/rep3	CTRL/rep3	W/rep3
W/rep4	W+C/rep4	CTRL/rep4	C/rep4
W+C/rep 5	W/rep5	C/rep5	CTRL/rep5

W=5kg of wood ash, C= 5kg chicken manure, CTRL=control, W+C=2.5kg wood ash and 2.5kg of chicken manure

3.3 Experimental Materials

Sesame (*Sesamum indicum* L) variety called Sesiim II which is commonly grown in Uganda was used during the study and it was obtained from Ngetta zonal agricultural research institute in Lira whereas the soil treatments used were chicken manure and wood ash. Other materials included a wheelbarrow used for transporting soil treatments, a spade for scooping soil treatments, a cutlass for cutting the tall vegetation, a hand hoe for land preparation, a tape measure for measuring plots, a rope was used for aligning pegs in straight lines, pegs were used to demarcate plots and tag plants, a sealed small size paper printed with a spot of permanent ink for labeling plots, a polythene paper bag for storage of threshed seeds, a watering can for irrigation during a dry spell, a knife for harvesting and banana fiber was used for thatching harvested sesame on the barbed wire.

3.4 Experimental Procedures

3.4.1 Site selection

Field selection took place 5 days weeks before primary cultivation on 2nd August 2019 and 13th November 2019 for both 1st and 2nd experiments respectively. The experimental sites chosen were not under cultivation so they were manually cleared by use of a cutlass to cut short the tall vegetation and also these sites were relatively flat to reduce the occurrence of soil erosion

3.4.3 Primary tillage

This was done 2 weeks before planting on 7th August 2019 and 18th November 2019 for both 1st and 2nd experiments respectively to ensure thorough soil breakdown and eradication of weeds. A hand hoe was used to break hard soil pans to enable water infiltration and turn down weeds such as Lantana Camara, Couch grass, Congo signal that could compete with sesame for sunlight, moisture, and plant nutrients.

3.4.3 Secondary tillage

This was done on the same day of planting on 28th September 2019 for the first experiment and 28th December 2019 for the second experiment to make soil fine. A hand hoe was used to break big soil lumps into fine soil particles that can permit easy root penetration, soil aeration, water infiltration, and removal of weeds such as Congo signal, Couch grass, and Lantana Camara that reduce the yield of field crops due to competition for sunlight and plant nutrients.

3.4.4 Field marking and labeling

These activities were carried out on the same day as planting seeds for easy identification and demarcation of treatment plots. The land was leveled and marked using a tape measure, rope, and pegs with an area measurement of 12.5m x 10 m, divided into five blocks where each replicates within the block measured 2 x 2 m and with 0.5 m between the plots acting as walkways. A sealed small size paper printed with permanent ink was used to label plots for easy identification during data collection.

3.4.5 Preparation of treatments

Chicken manure was prepared from a farm within Equator valley where poultry layers are kept under a deep litter system on floors with sawdust. The birds' droppings were collected and piled in sacks of polythene bags and decomposed for two weeks before applying to the field. Chicken manure was weighed 5kg per plot replicated five times and applied to the soil by spreading it uniformly

Wood ash was collected from the kitchen using sacks and weighed 5kg per plot replicated five times thereafter applied to the field on the same day when chicken manure was applied. This was necessary to put the experimental setup under the same conditions to test for the true effect of wood ash and chicken manure on the growth and yield of sesame.

The mixture of wood ash and chicken manure was done by weighing 2.5kg of chicken manure and 2.5kg of wood ash per treatment plot replicated five times. All applications were done on the same day so that the differences between the treatments would be largely due to true differences between treatments on the growth and yield of sesame.

3.4.6 Preparation of test crop and germination testing

The sorting of seeds by winnowing was done to eliminate the effect of dieback due to damaged seeds in the crop field. The seed germination test was done one week before planting time whereby one hundred sesame seeds were planted and at least 85% of the seeds germinated meaning that the seeds were good for planting while below that percentage would symbolize that new seeds were to be used for planting

3.4.7 Planting of seeds

Planting of seeds took place 2 weeks after primary tillage on 28th September 2019 for the first experiment (season two of 2019) and 28th December for the second experiment (season one of 2020) by dribbling in between fingers. The field was demarcated with a marked string showing the space between one row to another thirty centimeters and from one plant to another as fifteen centimeters. The holes for planting were made in a straight line on fine soils using sticks to a depth of about 2cm. Sesame planting was done by mixing seeds with soil and dribbled in between fingers to create an optimum spacing of 30cm x 15cm and seeds were covered slightly using soil to facilitate germination and protect them from being eaten by living organisms.

3.4.8 Thinning of seedlings

Sesame seedlings were thinned on the 13th day from the day of the planting of seeds when data collection was scheduled to begin. This activity was done by uprooting excess sesame seedlings using the hands to create optimum sesame population within the different plots to ensure reduced competition for sunlight, plant nutrients, and space that may result in an increased rate of pest and disease, low growth and yield

3.4.9 Weed management

Weeding was done manually using a hoe and hand pulling on the 3rd and 7th week after planting whereby each weeding operation was completed on the same day for all the blocks. No weeds are allowed to grow in the field experiment since they affect study results. Weeds compete with crops for growth requirements such as nutrients and sunlight.

3.4.10 Field irrigation

The water application was done manually by the researcher using a watering can twice a day that is to say early in the morning and late in the evening during dry conditions to provide favorable conditions for sesame growth and yield performance

3.4.11 Harvesting of sesame

After 16 weeks of planting, all the plants and seeds had matured characterized by defoliation, yellowing, and shattering of capsules. The removal of sesame from the field was done by use of a knife to cut sesame when not yet dry and the importance of harvesting at an early stage after maturity is to avoid shattering of capsules that cause great loss of sesame seeds and reduction in yield

3.4.12 Drying of sesame

After three weeks of harvesting, sesame had fully dried down and was ready for threshing. This was done by exposing sesame harvested under sunshine to enable it to dry up on a wire fence and open up capsules for the release of sesame seeds. This is important since the hygiene and right seed weights can be obtained respectively

3.4.13 Threshing and weighing

A rod was used to thresh sesame tilted upside down above a carpet laid on the ground to release seeds whereas a digital weighing scale was used to carry out the right measurements of sesame weights which were obtained from each treatment plots after threshing and bagging them into polythene paper bags

3.4.14 Storage of sesame

Packing threshed sesame from different plots into separate polythene paper bags was done to ensure easy identification, weighing, and protection of seeds from mixing with soil, pests, and diseases which may result in a reduction of quality and viability

3.5 Population of Study

A spacing of 30cm between rows and 15cm between the plants was used. The experimental plots had wood ash, chicken manure, the mixture of wood ash and chicken manure then control giving rise to 60 plants, 60 plants, 60 plants, and 60 plants respectively, a total of 240 plants per block and a total of 1200 plants for five blocks of the experiment.

3.6 Sample Size and Technique

3.6.1 Sample Size

A sample of ten plants from each plot giving a total of 200 plants for the whole experiment was used for the data collection on different parameters such as plant height, stem girth, number of leaves, number of branches, number of capsules, seeds per capsule, and 1000 seed weight.

3.6.2 Sample Technique

Ten plants from each replicate were sampled using the simple systematic random sampling technique, as described by (Gomez and Gomez, 1984). Through using this technique, sixty plants were counted whereby ten plants to be sampled were used to divide the sixty, resulting in six meaning that the sixth plants were picked to be the starting numbers. Thereafter, every sixth plant was selected until all the ten plants were sampled

3.7 Data collection Methods and Tools

3.7.1 Data Collection Methods

3.7.1.1 Observation

The study used observation to clearly identify tagged plants for data collection, read measurements accurately and score pests and disease incidences such as Phyllody disease (0-6), sesame webworm (0-9), and Alternaria blight (0-5) that helped the researcher to carry out valid data collection. The first data was collected on 12th October 2019 and 11th January 2020 on a fortnight basis for both 1st and 2nd experiment respectively.

3.7.1.2 Measurement and counting

The study used measurement which helped the researcher to collect data on plant height, stem girth and yield while counting helped the researcher to determine the number of plants for data collection, number of branches, number of pods and number of seed per capsule and number of affected parts by pests which is vital for data analysis. The first data was collected on 12th October 2019 (season two of 2019) and 11th January 2020 (season one of 2020) on a fortnight basis for both 1st and 2nd experiment respectively.

3.7.1.3 Recording

This study used recording method which helped the researcher to keep data on plant heights, stem girth, number of branches, number of pods and the yield which are necessary for getting accurate information during data analysis and drawing conclusion on problems stated

3.7.2 Data Collection Tools

A pen was used for writing down the data collected, a note book and data collection sheets were used for recording data collected, a thread was used for taking measurement of the stem girth, a tape measure and centimeter ruler was used for measuring plant heights, labels were used for providing identification of the experimental blocks and plots, protective gears like gumboots, a smart phone was used for taking photos, polythene bags were used for handling the harvested yield and a digital weighing scale was used for measuring sesame yields

3.7.3 Data Collection Procedures

3.7.3.1 Growth traits

Data on plant height (cm), stem girth (cm), number of leaves and number of branches per plant was collected from ten pre-tagged plants in each treatment plot.

The plant height was measured from the ground level to the tip of the stem from ten randomly selected plants from each plot using a measuring tape or meter ruler and then was expressed to centimeters and recorded at two weeks interval.

Stem girth was measured with a thread and actual measurements were determined on tape measure in centimeters for every ten sampled plants at two weeks interval .

The number of branches per plant was recorded by counting number of branches from each of the ten pre-tagged plants immediately when branches were seen developing at two weeks interval

The number of leaves per plant was recorded by counting the number of leaves from each of the ten pre-tagged plants at two weeks interval

Days to 50% flowering was recorded by counting the number of days taken for half of the plants within the treatment plots to show at least a flower.

3.7.3.2 Phyllody disease (0-6) (Akhtar *et*.al, 2009)

Data collection on phyllody disease started thirty days after planting on a fortnight basis considering foliar yellowing, shortened internodes, smaller leaves, abnormal floral organs, stunting, phloem necrosis and plant decline using 0-6 disease scoring technique **(**Akhtar *et*.al., 2009) .

Grade	Description
0 = no infection	Highly resistant (HR)
1= 0.1-10% infection	Resistant (R)
2 = 10.1-20% infection	Moderately resistant (MR)
3 = 20.1-30% infection	Tolerant (T)
4 = 30.1-40% infection	Moderately susceptible (MS)
5 = 40.1-50% infection	Susceptible (S)
6 = more than 50% infection	Highly susceptible (HS)

Source: Akhtar *et*.al. (2009)

3.7.3.3 Alterneria blight disease (0-5) (Anonymous, 2008)

Data collection on Alterneria blight disease started two weeks after planting on a fortnight basis considering defoliation, small, dark brown water soaked irregular lesions on leaves, veins and midrib using 0-5 disease scoring technique (Hoog, et al., 2010)

Grade	Description
0=disease free	Highly resistant (HR)
1=0.1-10.0% infection	Resistant (R)
2=10.1-25.0% infection	Moderately resistant (MR)
3=25.1-50.0% infection	Tolerant (T)
4= 50.1-75.0% infection	Susceptible (S)
5= more than 75% infection	Highly susceptible (HS)

Source: Hoog, *et al*. (2010)

3.7.3.4 Sesame webworm 0-9

Data collection on sesame webworm started two weeks after planting on a fortnight basis considering webbed leaves, larva feeding on young shoots and leaves, damaged flowers and bored capsules using a scoring technique of 0-9.

Grade	Description
1=0-10% infestation	Highly resistant (HR)
3=10.1-20% infestation	Resistant (R)
5=20.1-30% infestation	Moderately resistant (MR)
7=30.1-40% infestation	Susceptible (S)
9= more than 40% infestation	Highly susceptible (HS)

Source: Hoog, *et al*. (2010)

3.7.3.5 Yield components

The number of pods per plant was determined by counting the number of filled pods from ten pre-tagged plants per plot at one week interval for two weeks during week seven and week eight

The number of seeds per pod was determined by counting the number of seeds in ten randomly selected pods taken from ten pre-tagged plants within the plots

The a thousand seed weight was determined by taking a random sample of 1000 seeds from the yield of net plot

Seed yield of each plot was determined by putting seeds in white polythene and weighed using a sensitive balance to attain a representative seed weight in grams per plot then scaled up to kilogram thereafter tons per hectare to get the average yield per hectare as below;

$$\text{Seed yield (ton Ha}^{-1}) = \frac{\text{seed weight (kg) of plot X 1000}}{\text{Harvested area (m}^2)}$$

3.8 Quality Control Methods

3.8.1 Field preparation

The experimental sites selected for conducting the study were relatively flat to overcome the incidence of soil erosion that at times washes away soil amendments. The sites were not under cultivation so they were manually cleared by use of cutlass to cut short the tall vegetation that can permit easy cultivation of land. Both primary and secondary cultivation was done before planting using a hand hoe to eradicate weeds, improve soil aeration, water infiltration and nutrient uptake for better growth response and yield of sesame. The field was marked using a tape measure, rope and pegs with the area measurement of 12.5 x 10 meters, divided into five blocks where each plot within the block measured 2 x 2 meters and with 0.5 meters between the plots as walk ways

3.8.2 Planting of seeds

The spacing between one rows to another was 30cm and from one plant to another was 15cm to ensure adequate nutrient uptake, absorption of sunlight and moisture by sesame. This was attained by creating small holes in straight lines on fine soils using sticks to a depth of about 2cm. During planting, seeds were dribbled in between fingers and covered slightly using soil to facilitate germination and protect them from being eaten by soil living organisms

3.8.3 Thinning of seedlings

Excess seedlings that germinated were thinned by use of the hands to reduce pest and disease incidences, competition for sunlight, plant nutrients and moisture that may lower growth response and yield of sesame

3.8.4 Weed control

A hoe and hand pulling method was used to weed sesame field on the 3rd and 7^{th} week after planting whereby each weeding operation was completed on the same day since no weeds are allowed to grow in the experimental field because they affect study results due to competition for growth requirements such as sunlight and moisture

3.8.5 Irrigation of sesame

A watering can was used for providing water at the field twice a day at early morning and late in the evening during dry spells to provide moisture required by sesame to enhance growth response and yield

3.8.6 Harvesting of sesame

A knife was used for harvesting mature sesame when not yet dry. The importance of harvesting at an early stage after maturity was to avoid shattering of capsules that cause great loss of yield in sesame at the time of harvest

3.8.7 Drying of sesame

The harvested sesame was exposed under sunshine to ensure that they dry up on the barbed wire so as to avoid odor, rotting and also ensure that capsules open up to release seeds which are not contaminated with soil

3.8.8 Threshing and weighing

A stick was used to thresh dried sesame tilted upside down above a carpet laid on the ground by hitting so as to release seeds whereas an electronic weighing scale was used to take actual measurements of sesame weights which were obtained from each treatment plots after threshing and bagging them into polythene paper bags

3.9 Data Management and Processing

Data collected was quantitative for example plant height (cm), stem girth(cm), number of branches per plant, number of leaves, days to 50% flowering, pests and disease incidence, damage and severity, number of pods, seeds per capsules and seed weight (yield). Data collected was entered and recorded in Microsoft excel from where arrangement was done before transferring data for analysis. Data editing was done for errors and mistakes and to ensure accuracy

3.10 Data Analysis

Data collected on sesame growth and yield was subjected to statistical analysis technique; the analysis of variance (ANOVA) at ($P<0.05$) to ascertain the fishers probability (F.pr), grand mean, estimated standard errors (e.s.e), standard errors of differences (s.e.d), least significant differences (L.S.D) and percentage co-efficient of variations (%CV). Means are compared using least significant difference best (LSD). Gen Stat a statistical package version 3 was used to carry out the analysis

3.11 Ethical Consideration

Ethical consideration was prioritized during the research process to avoid shortcomings during the study for example before setting the experiment and collecting data, the research proposal was first approved by the Academic supervisor. As a researcher, accuracy, valid and timely data collection during data collection process was ensured in order to achieve the goals of the study to avoid false information during data entry and analysis.

3.12 Limitations and delimitations

There was overheating by sunlight during dry spell which affected sesame growth and yield however this was overcome by providing water manually to the field crops by use of a watering can so as to ensure that there is adequate moisture in the soil required by sesame

Heavy rainfall hindered data collection during wet periods which also affected study however this was overcome by use of umbrellas to avoid wetting of data sheets and also starting data collection early to avoid rainfall interferences

There was regular monitoring on the effect of wood ash and chicken manure on growth and yield of sesame with the help of a supervisor who was always available to give guidance for good implementation on the research work.

CHAPTER FOUR: RESULTS AND DISCUSSIONS

4.1 RESULTS

4.1.1 Effect of Chicken Manure and Wood Ash on Sesame Growth Rate

4.1.1.1 Plant Height (cm)

The results in **Table 1, Table 2** and **Figure 2** showed that sesame plant height was significantly ($p<0.001$) different within the treatment plots. Chicken manure treated plots (74.83cm) produced the highest plant height compared to wood ash and chicken manure (70.37cm), wood ash (62.03cm), and control(42.02cm) plots. These findings demonstrated that the application of chicken manure on sesame plants enhanced more plant growth.

No significant ($p>0.05$) difference in plant height was obtained within the seasons of sesame plant growth. Season 1(58.76cm) registered relatively the same plant height as in season 2(74.83cm). Demonstrating that, seasonality factor had no significant bearing on plant height at Equator valley farm.

A significant ($p<0.001$) difference in plant height was attained within the weeks of plant growth. The highest plant growth was registered in week 8 (74.83cm), followed by week 6 (58.66cm), week 4(30.08cm), and week 2(14.23cm). Optimum sesame plant height was thus attained in week 8 characterized as the maturity period.

Between the treatments and the season or season and week, the study does show no significant ($p>0.05$) difference in plant height. This may be explained by the lack of variation in plant height growth within the season affecting the growth patterns in all the treatments and the weeks in both seasons of sesame production.

Between the treatments and the weeks, a significant ($p<0.001$) difference in plant height was registered. Sesame plants under chicken manure treatments in week 8 attained the highest plant height. This was subsequently higher in all the weeks in comparison to, wood ash + Chicken manure and wood ash. An indication of optimal plant height was attained under chicken manure treatments at the maturity period of sesame.

Table 1: Degrees of Freedom and Mean Square value of Plant Height (cm)

***, **, * significant at 0.1%, 1% and 5%, ns=not significant, CV=coefficient of variation, LSD=Least Square Difference and df, Degree of freedom.

Table 2: Plant Height (cm)

Treatment	Seasons	Week 2	Week 4	Week 6	Week 8	Mean(Treatment)
Chicken Manure	season 1	12.35	28.07	54.37	58.76	38.4
	season 2	14.23	30.08	58.66	74.83	
Control	season 1	8.33	24.76	38.65	42.02	28.4
	season 2	10.56	28.46	42.05	54.68	
Wood Ash	season 1	11.2	25.66	48.03	52.32	34.3
	season 2	14.45	28.55	50.05	62.03	
Wood Ash + Chicken Manure	season 1	12.23	27.08	50.4	56.45	36.5
	season 2	16.23	30.56	57.32	70.37	
Mean(Weeks)		13.9	27.9	49.9	58.9	34.4

LSD_T=1.109, LSD_S=0.784, LSD_W=1.109, LSD_{TXS}=1.568, LSD_{TXW}=2.218, LSD_{SXW}=1.568, LSD_{TXSXW}=3.136, cv(%)=26.59 & se=7.93

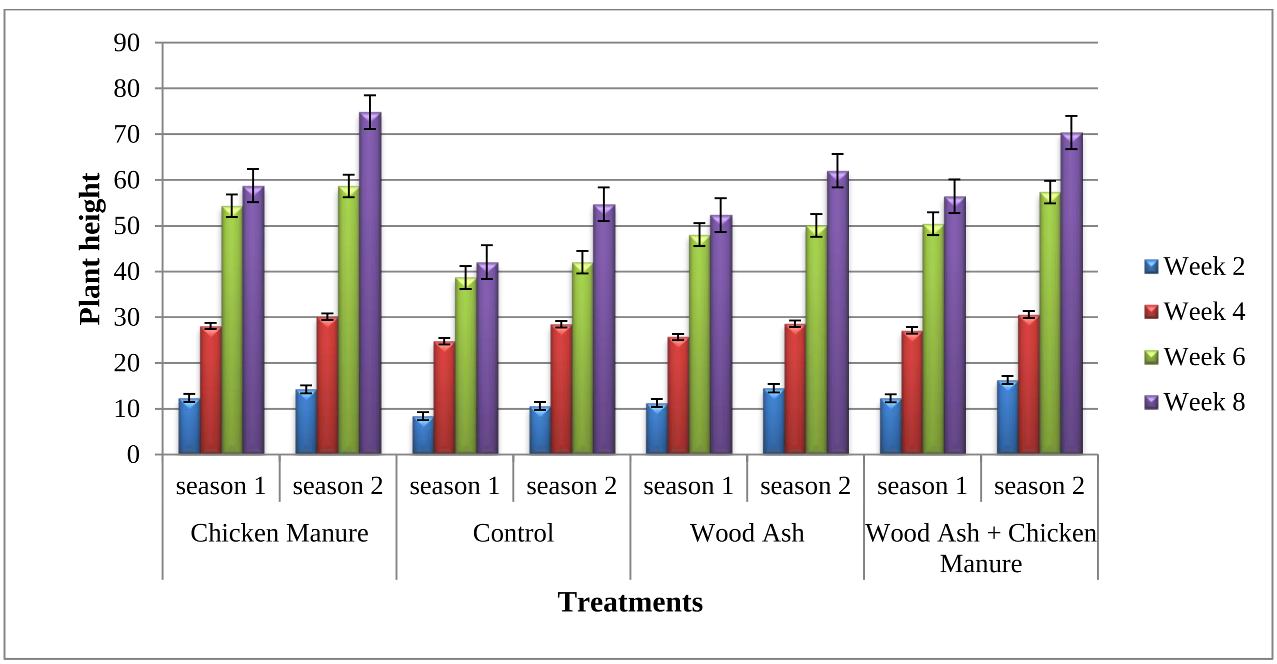

Figure 1: Sesame Plant Height (cm)

4.1.1.2 Number of Leaves per Plant

The results in **table 3**, **table 4** and **figure 2** show that, the number of leaves was significantly ($p<0.001$) different within the treatment plots. The highest number of leaves was attained under chicken manure treated plants (136.42) compared to wood ash + Chicken manure (105.38), wood ash only (105.46) and control (70.12). This was an indication that chicken manure treatment was more effective in influencing optimum growth of leaves per plant in sesame.

No significant ($p>0.05$) difference in the number leaves per plant was attained with the season. Relatively the same number of leaves were obtained in season 1(135.64) and season 2 (136.42) respectively, which otherwise implies that, seasonality variation did not cause a significant change in the growth pattern of leaves leading to similar number of leaves per plant.

A significant ($p<0.001$) difference in the number of leaver per plant was obtained within the weeks of sesame plant growth. The highest of leaves per plant was at its highest in week 6 (136.42) followed by week 4 (123.4), week 8 (50.6) and lastly week 2(10.16). This was a maturity period of the sesame, where podding had begun. An indication that sesame growth was most optimal at maturity.

Between the treatments and the weeks, the study results show, a statistically significant ($p<0.001$) difference in the number of leaves per plant was obtained. The highest number of leaves per plant was highest in week 8 under chicken manure treated plants compared to wood ash + chicken manure, wood ash only, and control treatments.

The study observed no significant ($p>0.05$) difference in the number of leaves per plant between treatments and season and season and weeks. This was attributed to the non-difference in the number of leaves per plant within the season of sesame production.

Table 3: Degrees of Freedom and Mean Square value of Number of Leaves per Plant

Change	d.f.	m.s.

Treatment	3	89939.5***
Season	1	537.1ns
Week	3	868559.9***
Treatment x Season	3	20.4ns
Treatment x Week	9	19620.3***
Season x Week	3	15.5ns
Treatment x Season x Week	9	9.8ns
Residual	1564	463.4

***, **, * significant at 0.1%, 1% and 5%, ns=not significant, CV=coefficient of variation, LSD=Least Square Difference and df, Degree of freedom.

Table 4: Number of Leaves per Plant

Treatment	season	Week 2	Week 4	Week 6	Week 8	Mean Season	Mean Treatment
Chicken Manure	season 1	9.06	120.2	135.64	49.6	81.7	
	season 2	10.16	123.4	136.42	50.6	82.9	134.42
Wood Ash	season 1	7.38	97.9	104.46	38.48	63.2	
	season 2	8.24	99.1	105.38	39.28	64.1	82.3
Wood Ash + Chicken Manure	season 1	8.3	89.5	102.22	43.56	63.6	
	season 2	9.22	96.7	105.04	44.1	65.4	63.6
Control	season 1	7.34	62.2	69.32	36.7	45.2	
	season 2	8.06	60.7	70.12	37.46	45.9	45.6
Mean(Weeks)		8.5	42.5	101.4	103.6	64	64

LSD_T=2.986, LSD_S=2.111, LSD_W=2.986, LSD_{TXS}=4.223, LSD_{TXW}=5.97, LSD_{SXW}=84.22, LSD_{TXSXW}=8.45, cv(%)=33.64 & se=21.53

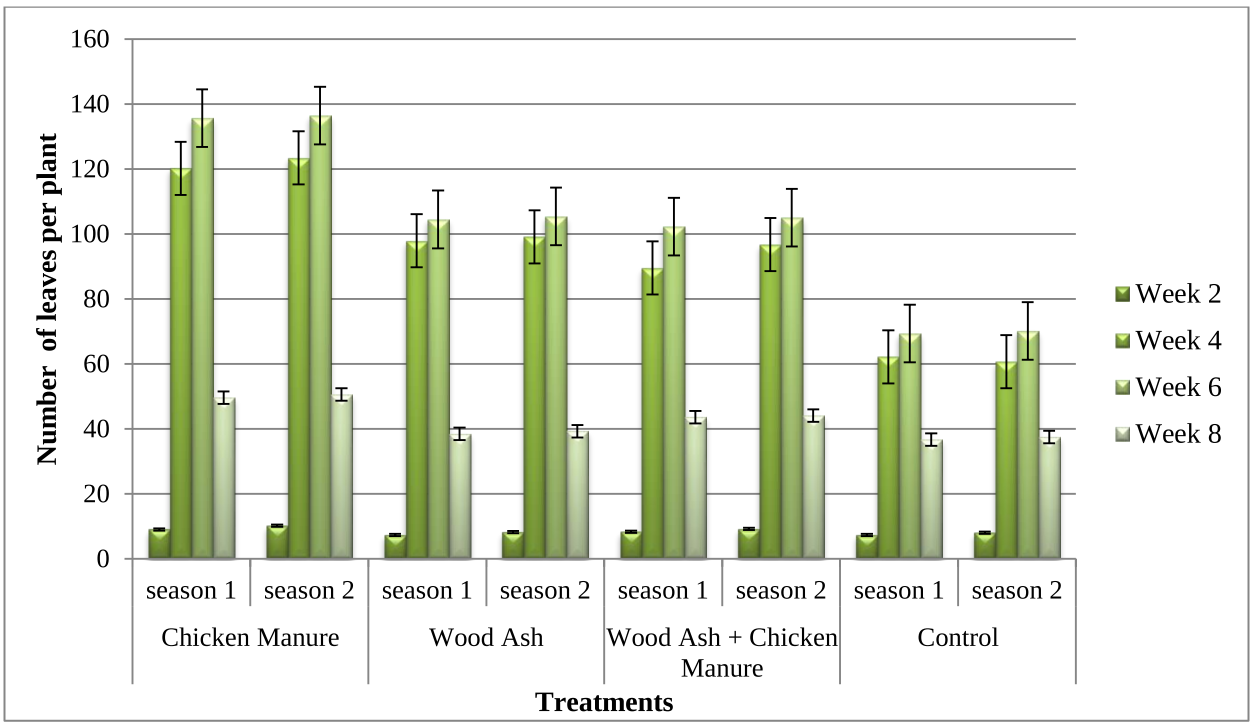

Figure 2: Number of Leaves per Plant

4.1.1.3 Number of Branches

The results in **table 5**, **table 6,** and **figure 3** show that, a significant ($p<0.001$) difference in the number of branches per plant was registered within the treatments. A higher number of sesame branches was attained under chicken manure treated plants (28.9) as compared to wood ash + Chicken manure (24.76), wood ash (22.52), and control (19.44) treated plants. This was an indication that chicken manure treatment enhanced the growth of sesame branches than in other treatments.

No significant ($p>0.05$) difference in the number of branches was attained within the season of sesame production. The number of branches attained in season 1 (26.74) and season 2 (28.9) were relatively the sesame. Implying that seasonality variation in Equator valley farm had not affected the plant growth (number of branches).

A significant ($p<0.001$) difference in the number of branches was obtained with the different weeks of sesame growth. The highest number of branches (28.9) was attained in week 8 followed by week 6 (27.86), week 4(8.66) and week (2.76). This was evident that the number of branches significantly increased at every stage of plant growth until maturity where it attained the highest number.

Between treatment and weeks of sesame growth, a significant ($p<0.001$) difference in the number of branches was registered. A higher number of branches was attained in week 8 under chicken manure treated plots. This was indicative of better growth response of sesame under chicken manure treatment at maturity.

Between the treatments and season and season and weeks of plant growth, no significant ($p>0.05$) difference in the number of sesame branches was registered. This was linked to the non-significant variation in the number of branches within the seasons of sesame production.

Table 5: Degrees of Freedom and Mean Square value of Number of Branches

Change	d.f.	m.s.
Treatment	3	1954.33***

Season	1	63.2ns
Week	3	45507.85***
Treatment x Season	3	20.73ns
Treatment x Week	9	327.01***
Season x Week	3	66.63ns
Treatment x Season x Week	9	10.46ns
Residual	1564	38.38

***, **, * significant at 0.1%, 1% and 5%, ns=not significant, CV=coefficient of variation, LSD=Least Square Difference and df, Degree of freedom.

Table 6: Number of Branches

Treatment	Season	Week 2	Week 4	Week 6	Week 8	Mean(Season)	Mean(Treatment)
Chicken Manure	1	1.72	8.38	25.66	26.74	16.715	16.3
	2	2.28	8.66	27.86	28.9	15.835	
Wood Ash	1	0.86	7.42	19.66	20.66	12.15	12.2
	2	1.18	7.5	20.52	22.52	12.18	
Wood Ash + Chicken Manure	1	1.06	8.02	21.92	22.9	14.34	14.0
	2	1.6	8.18	23.52	24.76	13.65	
Control	1	1.04	6.56	18.3	19.1	11.3	
	2	0.62	6.52	18.62	19.44	11.25	11.3
Mean(Weeks)		**1.30**	**7.66**	**21.88**	**22.88**	**13.43**	**13.4**

LSD_T=0.286, LSD_S=0.132, LSD_W=0.186, LSD_{TXS}=0.373, LSD_{TXW}=0.297, LSD_{SXW}=0.235, LSD_{TXSXW}=0.545, CV(%) =47.23 & se=6.979

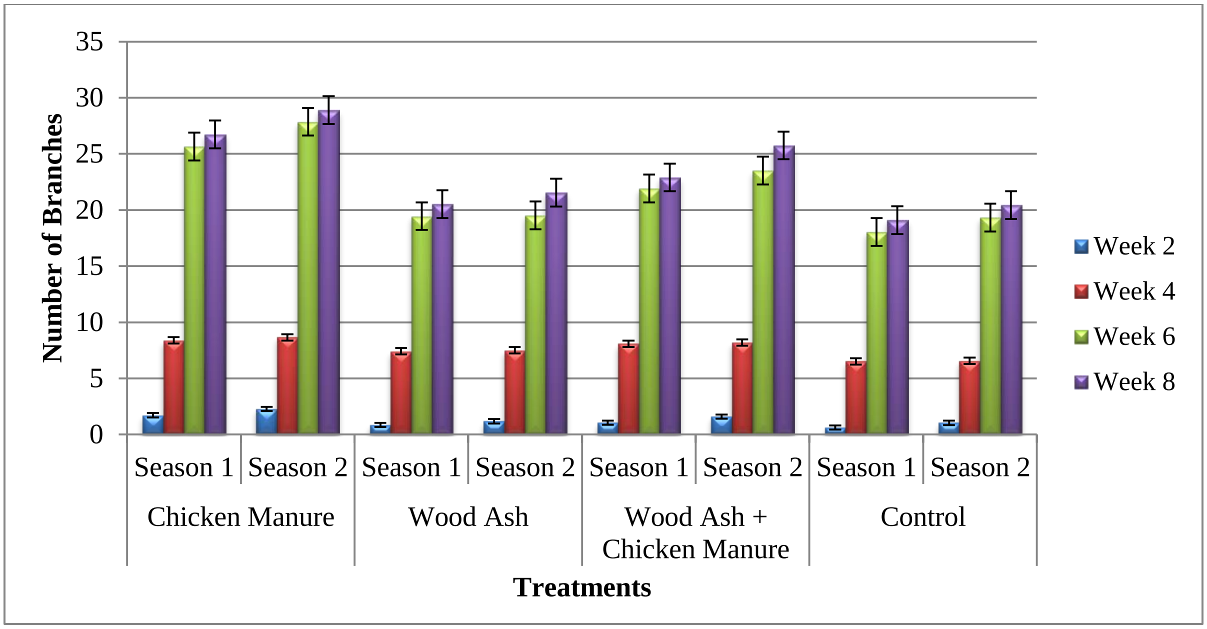

Figure 3: Number of Branches per Plant

4.1.1.4 Stem Girth (cm)

The results in **table 7, table 8** and **figure 4** show that there was a significant ($p<0.01$) difference in the sesame plant stem girth within the treatments. Chicken manure plots (4.91cm) produced the widest sesame plant girth compared to wood ash + chicken manure (4.57cm), wood ash (4.53cm) and control (4.23cm) treated plots. Implying that chicken manure treatment highly enhanced plant growth leading to wider sesame stem girth.

Within the season, a significant ($p<0.05$) difference in stem girth was registered. Season two (4.91cm) registered relatively wider stem girth in sesame plants compared to season one (3.99cm). These findings demonstrate sesame growth (stem girth) was optimal during wet season of sesame production.

Within the weeks of sesame plant growth, significant ($p<0.001$) differences in stem girth were achieved. Widest stem girth was attained in week 8(4.91cm) compared to week 6 (4.50cm), week 4 (4.09cm) and week 2 (2.13cm). These findings demonstrated that, the stem girth increased by the different stages of plant growth. Implying the widest stem girth was achieved when the sesame plants had reach maturity.

No significant (p>0.05) difference in stem girth was attained within the season of sesame production or between the treatments and season, season and weeks. This rather implies that, variation in sesame stem girth was not influenced by seasonality factor, which otherwise indicates that the season/weather conditions at Equator valley farm in Nkozi sub county did not affect sesame growth.

Table 7: Degrees of Freedom and Mean Square value of Stem Girth (cm)

Change	d.f.	m.s.
Treatment	3	16.72***
Season	1	1.3*
Week	3	413.51***
Treatment x Season	3	0.1ns
Treatment x Week	9	0.264ns
Season x Week	3	0.23ns
Treatment x Season x Week	9	0.083ns
Residual	1564	0.22

***, **, * significant at 0.1%, 1% and 5%, ns=not significant, CV=coefficient of variation, LSD=Least Square Difference and df, Degree of freedom.

Table 8: Stem Girth (cm)

Treatment	Season	Week 2	Week 4	Week 6	Week 8	Mean(Season)	Mean(Treatment)
Chicken Manure	Season 1	1.64	3.23	3.79	3.99	3.16	3.5
	Season 2	2.13	4.09	4.50	4.91	3.91	
Wood Ash	Season 1	1.03	2.86	3.12	3.45	2.62	3.1
	Season 2	1.87	3.79	4.20	4.53	3.61	
Wood Ash + Chicken Manure	Season 1	1.64	3.21	3.73	3.93	3.13	3.4
	Season 2	2.01	3.68	4.32	4.57	3.64	
Control	Season 1	1.02	2.24	2.76	2.97	2.25	2.5
	Season 2	1.42	2.78	3.30	3.51	2.75	
Mean(Weeks)		1.72	3.48	3.94	4.23	3.34	3.3

LSD_T=0.159, LSD_S=0.230, LSD_W=0.156, LSD_{TXS}=0.373, LSD_{TXW}=0.347, LSD_{SXW}=0.285, LSD_{TXSXW}=0.662, CV (%) =34.74 & SE=0.9238

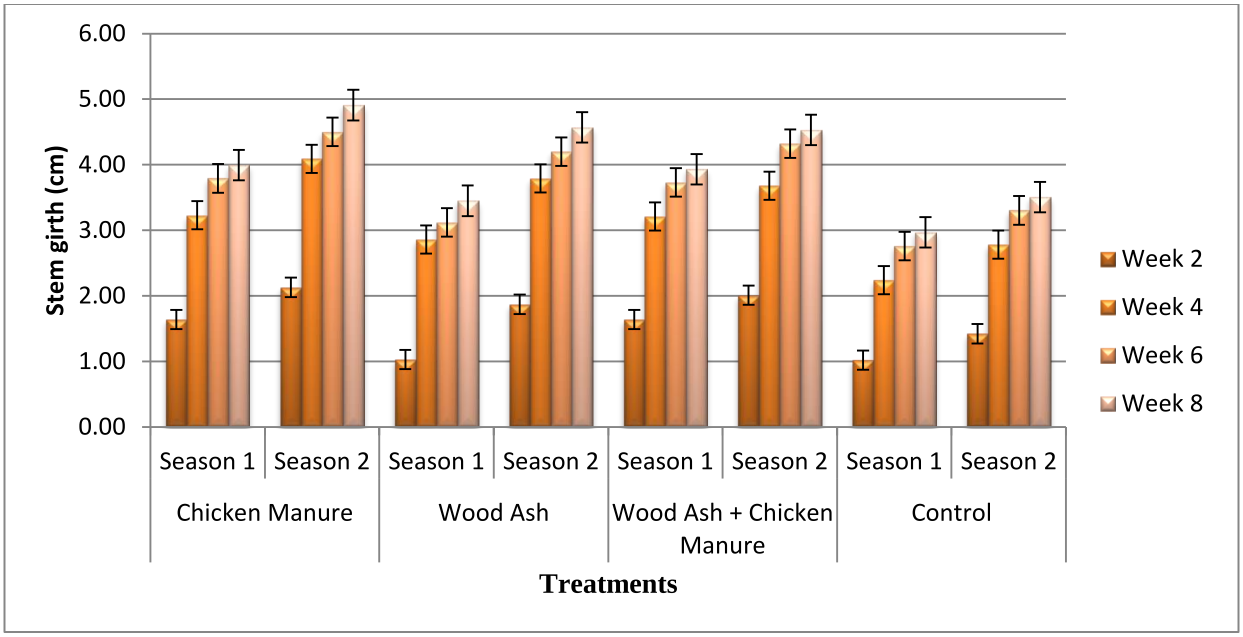

Figure 4: Stem Girth (cm)

4.1.1.5 50% Flowering

The results in **table 9**, **table 10** and **figure 5** show that, a significant difference in 50 flowering of sesame was attained within the seasons of production. Sesame plants flowered within 41.7 days in season 1 compared to 43.9 days in season 2. This implies that, sesame flowering was earliest during dry season of Simsim production.

The study results also, show that a significant ($p<0.001$) difference in 50% flowering was attained within the treatments. Chicken manure treated plots registered the earliest (40.1 days) period compared to 42.1 days under wood ash + chicken manure, 43.6 days wood ash and 45.3 days control treatment plots respectively.

Between the season and treatments, significant difference in 50% flowering was registered. Earliest 50% flowering was attained in 38.8 days in season 1 under chicken manure treated plots while the latest was attained in 46 days under control and 44.4 days under wood ash in season two of sesame production.

Table 9: Degrees of Freedom and Mean Square value of 50% flowering

Source of variation	d.f.	m.s.
Seasons	1	462.25***
Treatment	3	488.917***
Season x Treatment	3	14.917***
Residual	392	1.265

***, **,*, significant at 0.1%, 1% and 5%, ns=not significant, DF=degree of freedom

Table 10: 50% Flowering by Season and Treatments

Treatments	Season 1	Season 2	Mean(Treatment)
Control	44.6	46	**45.3**
Chicken Manure	38.8	41.4	**40.1**
Wood Ash	42.8	44.4	**43.6**
Wood Ash + Chicken Manure	40.6	43.6	**42.1**
Mean(Season)	**41.7**	**43.9**	**42.8**

Sed_S=0.1125, Sed_T=0.1591, Sed_{SXT}=0.2250, LSD_S=0.2212, LSD_T=0.3128, LSD_{SXT}=0.4423 & %CV =20.11 SE= 0.9475

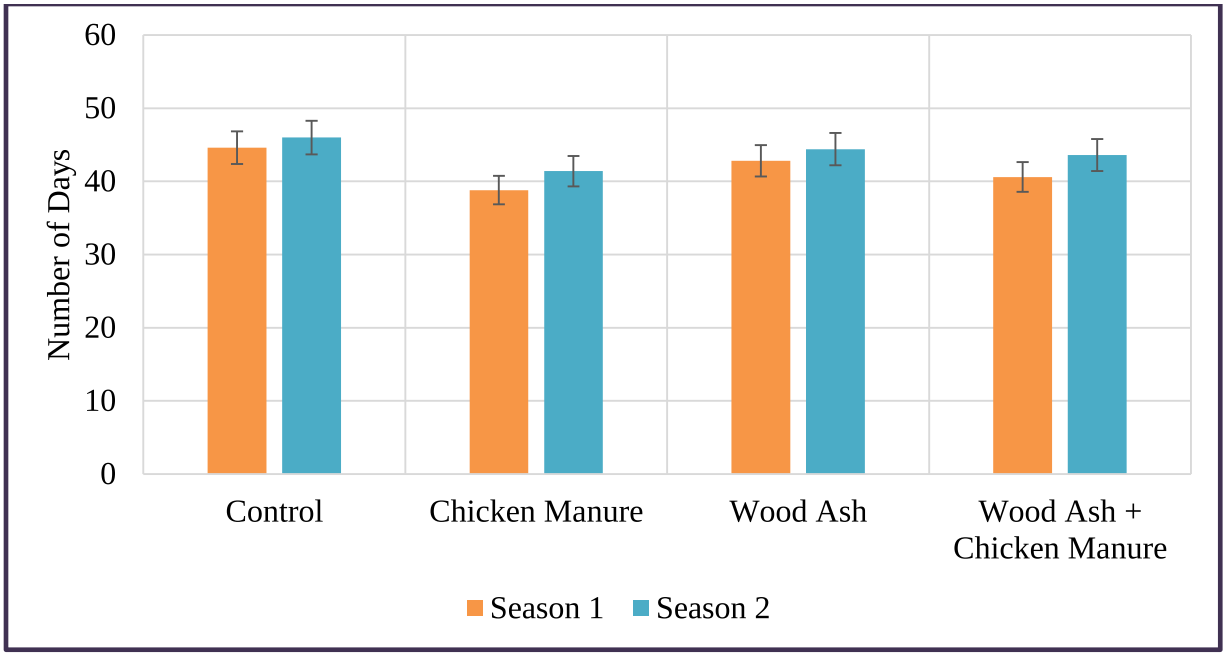

Figure 5: 50% Flowering

4.1.2 Effect of Wood Ash and Chicken Manure on Pests and Disease Prevalence in Sesame

The effectiveness of wood and chicken manure treatments on pests and disease prevalence led to the examination of the incidence, severity and damage on the plant. Specifically, the study examine Alterneria Blight, Phyllody Disease and Sesame Webworm which were present at the time of the experiment.

4.1.2.1 Alternaria Blight Incidence

Alternaria Blight is a common disease caused by fungus *Helminthosporium turcicum* Pass, which affects the plants leaves producing a reddish-purple or tan spots that coalesce to form large lesions. It is aggressive on the seedlings and older plants. During this study experiment, incidence and severity status were measured under the following categories 0=disease free (highly resistant), 1= (0.1-10%) resistant, 2= (10.1-25%) Moderate, 3= (25.1-50%) Tolerant, 4= (50.1-75%) Susceptible, 5=>75% Highly Susceptible. Three-factor analysis of variance was undertaken to determine the effect of the treatments, season and weeks of plant growth on the Alternaria Blight Incidence.

Based on the results presented in **table 9, table 10** and **figure 5** statistically significant ($p<0.001$) difference in Alterneria Blight Incidence within the treatments was attained. Chicken manure plots registered a lower (3.48) incidence level as compared to wood ash plots (3.78), wood ash and chicken manure plots (3.9) and control (4.0) respectively. An indication that, chicken manure was more tolerant to Alterneria blight disease.

Within the seasons, the study results show, statistically significant ($p<0.001$) difference in Alterneria Blight Incidence. Season 1 registered lower (3.4) Alterneria Blight Incidence as compared to season two (4.3). An indication that, Alterneria Blight Incidence was higher during wet season (season 2) than dry season (season 1) of sesame production.

Within the weeks of plant growth, significant ($p<0.001$) difference in Alterneria Blight Incidence was registered. Alterneria Blight Incidence subsequently increased as the sesame plants increased in growth. From seedling (week 2=1.95), vegetative (week 4=3.2), flowering (week 6=5) and maturity stage (week 8=5). Signifying that Alterneria Blight disease was more active when the sesame plant matured.

Between the treatments and weeks of sesame growth, the study shows a significant ($p<0.001$) difference in Alterneria Blight incidence. Alterneria Blight disease was highly prevalent in week 6 and week 8 as compared to week 2 and week 4 in all the treatments. An indication that, Alterneria Blight incidence was highest in all treatments during flowering and maturity stage of sesame growth.

Between seasons of production and weeks of plant growth, the study results indicate a significant difference in Alterneria Blight incidence. Alterneria Blight incidence was highest in season 2 and in all weeks of sesame growth. A clear indication that, Alterneria Blight disease was more prevalent in wet season of sesame production than in dry season.

Table 11: Degrees of Freedom for Alterneria Blight Incidence

Change	d.f.	m.s.
Treatment	3	20.75***
Season	1	361***

Weeks	3	888.25***
Treatment x Season	3	0.1667
Treatment x Weeks	9	8.5278***
Season x Weeks	3	121***
Treatment x Season x Weeks	9	0.8333**
Residual	1568	0.3265

***, **, * significant at 0.1%, 1% and 5%, ns=not significant, CV=coefficient of variation, LSD=Least Square Difference and df, Degree of freedom.

Table 12: Alterneria Blight Incidence under treatments, seasons and weeks of Sesame growth

Treatment	Season	Week 2	Week 4	Week 6	Week 8	Mean (Season)	Mean (Treatment)
Control	Season 1	1.2	2.8	5	5	3.5	4
	Season 2	3.2	4.8	5	5	4.5	
Wood Ash	Season 1	1	2.2	5	5	3.3	3.78
	Season 2	3	4	5	5	4.25	
Chicken Manure	Season 1	0.6	1.4	5	5	3	3.48
	Season 2	2.4	3.4	5	5	3.95	
Wood Ash + Chicken Manure	Season 1	1	2.8	5	5	3.45	3.9
	Season 2	3.2	4.2	5	5	4.35	
	Mean(Weeks)	1.95	3.2	5	5	3.79	3.79

LSD_T=0.1339, LSD_S=0.1957, LSD_W=0.1330, LSD_{TXS}=0.2513, LSD_{TXW}=0.3969, LSD_{SXW}=0.3513, LSD_{TXSXW}=0.6027, %CV =20.11 & SE= 0.9475

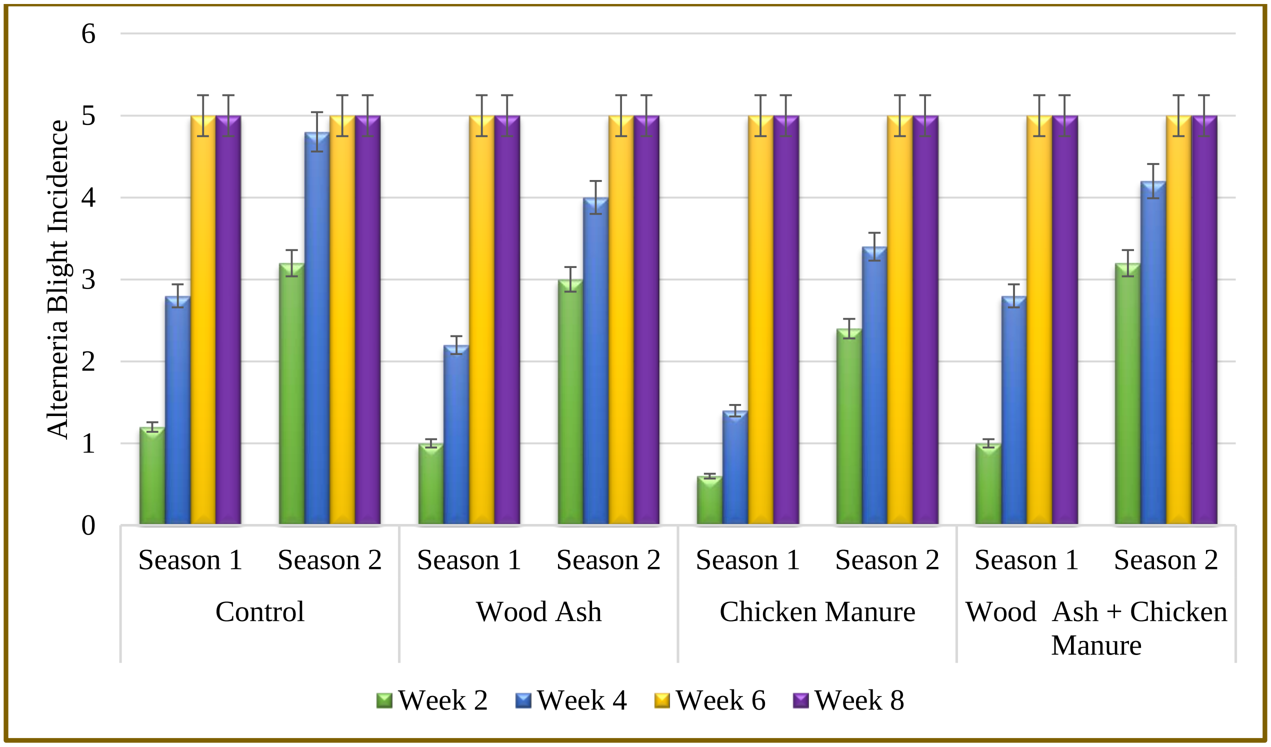

Figure 6: Alterneria Blight Incidence under treatments, seasons and weeks of Sesame growth

4.1.2.2 Alterneria Blight Severity

Alterneria Blight Severity was measured as the extent to which Alterneria Blight disease affects the plants. This was measured through the following grades; 0=disease free (no effect observed on the plant), 2=fairly severe, 3=moderately severe, 4=Very Severe (Susceptible), 5=Very Severe (Highly Susceptible). Three factor analysis of variance was undertaken to examine the extent to which Alterneria Blight Severity affected the treatments, seasons of production and weeks of sesame growth.

As shown in **table 11, table 12** and **figure 6,** significant ($p<0.001$) difference in Alterneria Blight Severity was registered within the treatments. Chicken manure plots (1.23) registered the least level of Alterneria Blight Severity as compared to wood ash (1.43), wood ash and chicken manure (1.53) and control (1.65). An indication that chicken manure contains essential elements that neutralize the effect of Alterneria Blight disease on the sesame plant than wood ash.

Within the seasons of sesame production, significant ($p<0.001$) difference in Alterneria Blight Severity was attained. Season 2 registered higher level of severity as compared to season 1. A clear indication that the Alterneria Blight diseases was highly severe on sesame crop in wet season.

No significant differences were registered between the treatments and seasons, weeks, season and weeks as the Alternaria Blight Severity ranged from 0.1 to 3. Implying that Alternaria Blight Severity was relatively low as it measured from fairly severe to moderately severe on sesame plants.

Table 13: Degrees of freedom and Means square values for Alternaria Blight Severity

Change	d.f.	m.s.
Treatment	3	12.8223***
Season	1	18.2756***
Weeks	3	493.6356***
Treatment x Season	3	0.0373ns
Treatment x Weeks	9	0.644ns
Season x Weeks	3	0.024ns
Treatment x Season x Weeks	9	0.0123ns
Residual	1568	0.5789

***, **, * significant at 0.1%, 1% and 5%, ns=not significant, CV=coefficient of variation, LSD=Least Square Difference and df, Degree of freedom.

Table 14: Alterneria Blight Severity within the Treatments, Seasons of production and Weeks of Sesame growth

Treatments	**Season**	**Week 2**	**Week 4**	**Week 6**	**Week 8**	**Mean (Season)**	**Mean (Treatments)**
Control	Season 1	0.24	0.96	1.96	2.96	1.53	1.65
	Season 2	0.52	1.2	2.2	3.16	1.77	

Treatments	Season	Week 2	Week 4	Week 6	Week 8	Mean (Season)	Mean (Treatments)
Wood Ash	Season 1	0.2	0.72	1.72	2.68	1.33	1.43
	Season 2	0.44	0.88	1.94	2.88	1.535	
Chicken Manure	Season 1	0.14	0.46	1.46	2.46	1.13	1.23
	Season 2	0.34	0.66	1.66	2.64	1.325	
Wood Ash + Chicken Manure	Season 1	0.24	0.82	1.82	2.82	1.425	1.53
	Season 2	0.46	1.04	2.02	3.04	1.64	
	Mean (Weeks	0.32	0.84	1.85	2.83	1.46	1.46

LSD_T=0.2484, LSD_S=0.175, LSD_W=0.2484, LSD_{TXS}=0.3513, LSD_{TXW}=0.4969, LSD_{SXW}=0.3513, LSD_{TXSXW}=0.7027, SE=1.3867 & CV=56.7%

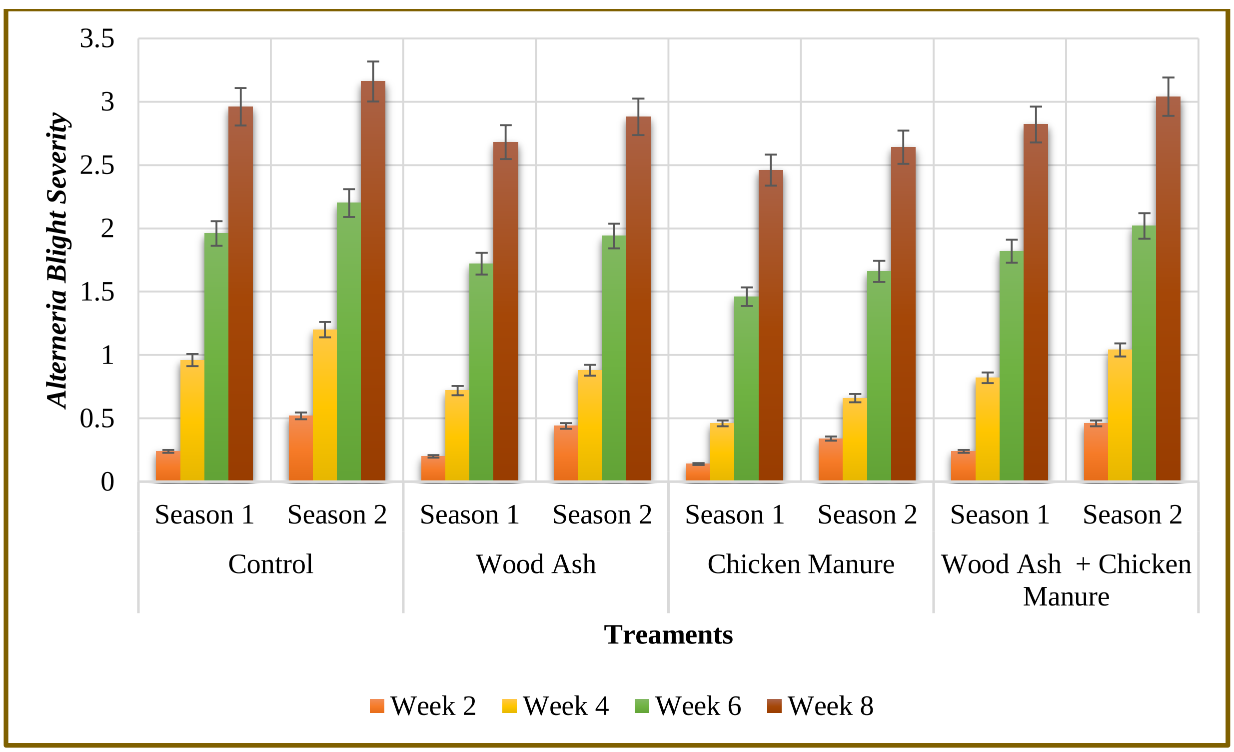

Figure 7: Alterneria Blight Severity within the Treatments, Seasons of production and Weeks of Sesame growth

4.1.2.3 Phyllody Disease Incidence

Phyllody is the abnormal development of floral parts into leafy structures. It is generally caused by phytoplasma or virus infections, though it may also be because of environmental factors that result in an imbalance in plant hormones. Incidence and severity of Phyllody in sesame was measured using the following scale; 0=no infection (Highly Resistant), 1=0.1-10%(Resistant) , 2=10.1-20% (Moderate Resistant), 3=20.1-30% (Tolerant), 4=30.1-40%(Moderately Susceptible), 5=40.1-50% (Susceptible) and 6=More than 50%(High Susceptible).

The results in **table 13, 14** and **figure 7** show that there was a significant ($p<0.001$) difference in Phyllody disease incidence in sesame plants. Wood ash treatments plots (5.5) registered higher Phyllody disease incidence as compared to control (4.95), chicken manure + wood ash plots (4.27) and chicken manure plots (4.14). This implies that wood ash treated plants were susceptible to Phyllody disease while the rest of the treatments were moderately susceptible.

Within the season, a significant ($p<0.001$) difference in Phyllody incidence was registered. Season 1 (5.01) registered high Phyllody disease incidence than in season 2(4.42). Implying that sesame plants were susceptible to Phyllody disease in the first season.

Within the weeks, significant ($p<0.001$) difference in Phyllody disease incidence was registered. Week 8 (6) registered the highest Phyllody disease incidence as compared to week 6 (4.83) and week 4 (3.3) respectively. Implying that Phyllody disease was prevalent in week 8 of plant growth.

Between the treatments and seasons, significant ($p<0.05$) difference in Phyllody incidence was registered. Highest Phyllody disease incidence was registered in wood ash treatments plots in season one (5.67) while the least was registered in chicken manure plots in the second season (3.8). Implying that sesame plants under wood ash treatments in season one were susceptible while those under chicken manure plots in season one were tolerant.

Between the treatments and weeks, significant (p<0.001) in Phyllody disease incidence was registered. All treatments registered the highest (6) Phyllody disease incidence in week and the least in week 4. However, chicken manure treatment plots registered the lowest Phyllody disease incidence in week 3 (1.8).Implying, chicken manure treated plants were resistant to Phyllody disease in week 3 while highly susceptible in week 8.

Between season and weeks, significant (p<0.001) difference in Phyllody disease incidence was registered. Phyllody disease incidence was highest in week 8 in all seasons and lowest in week 4 in season 2. A clear indication that Phyllody disease was highly susceptible at maturity stage of sesame and lowest at vegetative stage.

Among the treatments, seasons and weeks, the study results indicate a significant difference in Phyllody disease incidence. Phyllody disease incidence was highest in wood ash treatments in season 1, week 4 (week 5.2), week 5(5.8) and week 8(6). Implying that sesame plants under this treatments were susceptible and highly susceptible to Phyllody disease.

Table 15: Degrees of freedom and Means square values for Phyllody Disease Incidence

Change	d.f.	m.s.
Treatment	3	120.7362***
Season	1	100.4577***
Weeks	2	733.4061***
Treatment x Season	3	3.0252*
Treatment x Weeks	6	42.457***
Season x Weeks	2	30.492***
Treatment x Season x Weeks	6	1.9132*
Residual	1175	0.8977

***, **, * significant at 0.1%, 1% and 5%, ns=not significant, CV=coefficient of variation, LSD=Least Square Difference and df, Degree of freedom.

Table 16: Phyllody Disease Incidence within the Treatments, Seasons of production and Weeks of Sesame growth

Treatment	**Season**	**Week 4**	**Week 6**	**Week 8**	**Mean (Seasons)**	**Mean (Treatments)**
Control	Season 1	4.2	5.4	6	5.2	4.95
	Season 2	3	5.061	6	4.69	
Wood Ash	Season 1	5.2	5.8	6	5.67	5.50
	Season 2	4.6	5.4	6	5.33	
Chicken Manure	Season 1	3.2	4.2	6	4.47	4.14
	Season 2	1.8	3.6	6	3.8	
Wood Ash + chicken Manure	Season 1	2.8	5.2	6	4.67	4.27
	Season 2	1.6	4	6	3.87	
Mean(Weeks)		3.30	4.83	6.00	4.71	4.71

LSD_T=0.121, LSD_S=0.100, LSD_W=0.347, LSD_{TXS} =0.325, LSD_{SXW} =0.419, %CV =20.11 & SE= 0.9475

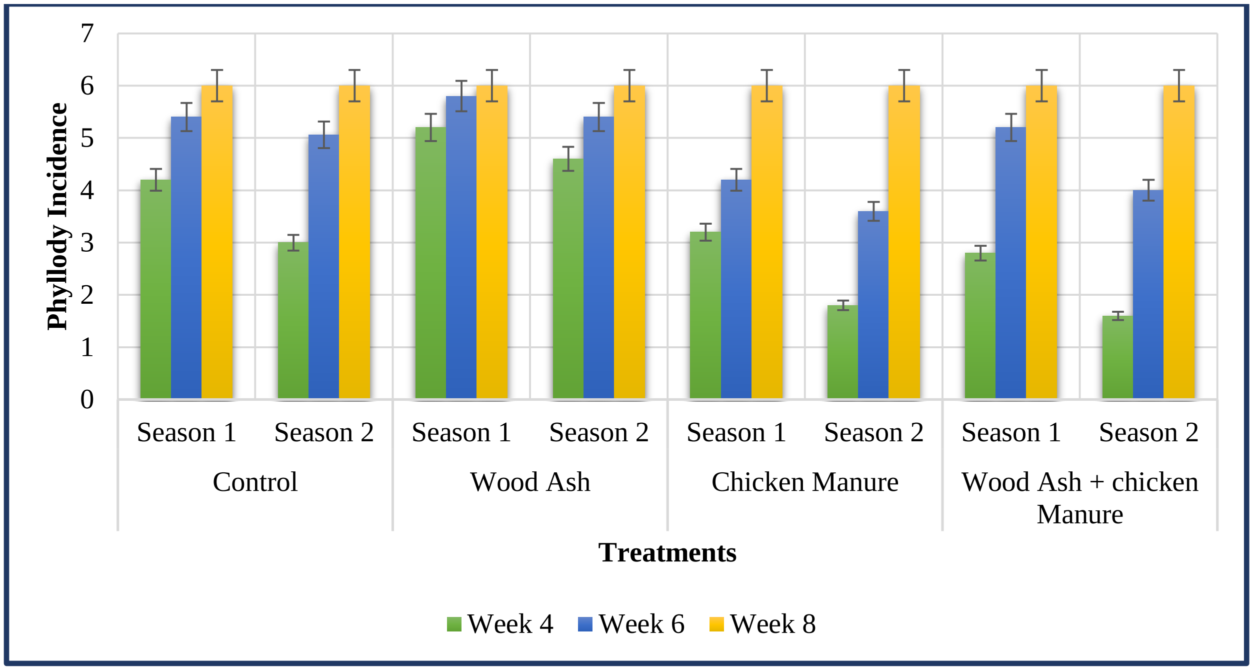

Figure 8: Phyllody Disease Incidence within the Treatments, Seasons of production and Weeks of Sesame growth

4.1.2.4 Phyllody Disease Severity

The results in **table 15, 16** and **figure 8** show that a significant ($p<0.001$) difference in Phyllody disease severity was registered within the treatments. Wood ash (1.6) registered relatively high level of severity as compared to control (1.57), wood ash + chicken manure (1.1) and chicken manure (1.04). Since the level was below 2, then plants within the treatments were all resistant to Phyllody disease, however wood ash plants were almost moderately resistant.

Within the seasons the study results show significant ($p<0.01$) difference was registered. Season 1 registered higher Phyllody disease severity as compared to season 2. Implying that sesame plants were more damaged by Phyllody disease in season 1 when it was prevalent.

Within the weeks, the study registered a significant difference in Phyllody disease severity. Week 8 (2.16) registered the highest disease severity as compared to week 6(1.16) and week 4(0.67). Implying that sesame plants were moderately resistant to Phyllody disease in week 8.

No significant difference in Phyllody disease severity was registered between the treatments and seasons, weeks. This was linked to the low level of Phyllody disease severity throughout the treatments, weeks, and seasons of sesame production.

Table 17: Degrees of freedom and Means square values for Phyllody Severity

Change	**d.f.**	**m.s.**
Treatments	3	26.226***
Seasons	1	14.52**
Weeks	2	230.021***
Treatments x Season	3	0ns
Treatments x Weeks	6	0.456ns
Seasons x Weeks	2	0.003ns
Treatment x Season x Weeks	6	0.009ns
Residual	1176	1.817

***, **, * significant at 0.1%, 1% and 5%, ns=not significant, CV=coefficient of variation, LSD=Least Square Difference and df, Degree of freedom.

Table 18: Phyllody Disease Severity within the Treatments, Seasons of production and Weeks of Sesame growth

Treatment	**Seasons**	**Week 4**	**Week 6**	**Week 8**	**Mean (Season)**	**Mean (Treatments)**
Chicken Manure	Season 1	0.58	0.94	1.94	1.15	1.04
	Season 2	0.36	0.72	1.72	0.93	
Control	Season 1	0.98	1.52	2.54	1.68	1.57
	Season 2	0.74	1.32	2.32	1.46	
Wood Ash	Season 1	0.96	1.58	2.58	1.71	1.6
	Season 2	0.76	1.34	2.36	1.49	
Wood Ash + Chicken Manure	Season 1	0.6	1.04	2	1.21	1.1
	Season 2	0.38	0.8	1.8	0.99	
Mean (Weeks)		**0.67**	**1.1575**	**2.1575**	**1.3275**	**1.33**

LSD_T=0.2484, LSD_S=0.175, LSD_W=0.2484, LSD_{TXS}=0.3513, LSD_{TXW}=0.4969, LSD_{SXW}=0.3513, LSD_{TXSXW}=0.7027, SE=1.348 & CV=56.7%

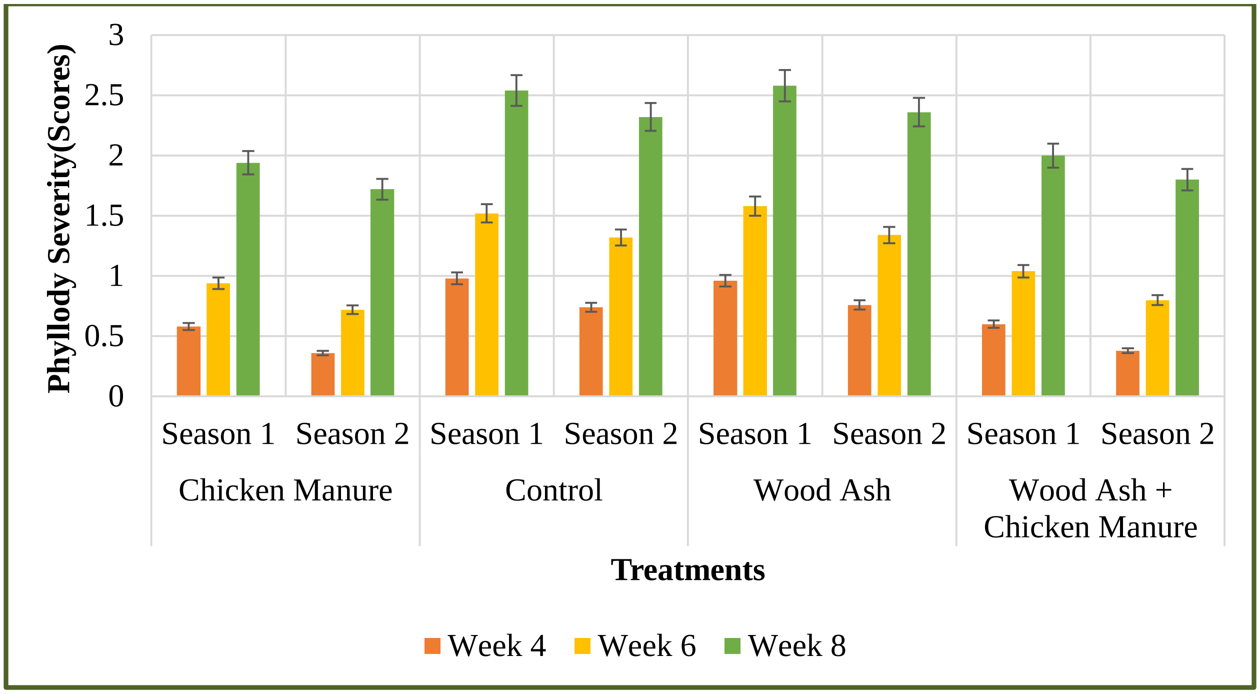

Figure 9: Phyllody Disease Severity within the Treatments, Seasons of production and Weeks of Sesame growth

4.1.2.5 Sesame Webworm Incidence

The results in **table 17**, **table 18** and **figure 9** show that Sesame Webworm Incidence was significantly ($p<0.001$) different within the treatments. Wood ash treated plants registered the highest incidence level (7.1), followed control (6.2), wood ash + chicken manure (5.6) and lastly chicken manure treated plants (4.9). These findings by interpretation of level of Webworm Incidence showed that wood ash treated plants were more susceptible while chicken manure treated plants were moderately resistant.

Within the seasons, a significant ($p<0.001$) difference in sesame webworm incidence was registered. Season 2 registered higher webworm incidence level than in season 1. Implying sesame plants were moderately resistant. An indication that there was high incidence of sesame webworm in wet season than in dry season of sesame production in Equator Valley Farm in Nkozi Sub County.

Within the weeks, a significant (p<0.001) difference in sesame webworm incidence was registered. Incidence was very high in week 8 (9) than in week 6 (7.8), week 4(5.2) and week 2(1.85). Indicating that, sesame plants were highly susceptible to webworm at maturity period, susceptible at flowering stage, moderately resistant at vegetative growth and highly resistant at seedling stage.

Between treatments and seasons of sesame production, sesame webworm incidence was significantly (p<0.001) different. Sesame webworm incidence was higher (7.5) in season two under wood ash treatment plots while lower (4.7) in season one under chicken manure treatment plots. These findings indicate that sesame plants were susceptible to sesame webworm during wet season under wood ash treatment and moderately resistant during dry season under chicken manure treatments.

Between the treatments and weeks, a significant (p<0.01) difference in the incidence of sesame webworm was registered. Sesame webworm incidence (9=40% infestation) was very high in all treatments in week 8 of sesame growth and very low under chicken manure treated plants in week 2. An indication that, sesame plants were highly susceptible to sesame webworm.

Between the seasons and weeks of sesame plant growth, a significant (p<0.001) difference in sesame webworm incidence was registered. Sesame webworm incidence was very high in season two in week 6 and week 8.

Table 19: Degrees of freedom and Means square values for Sesame Webworm Incidence

Change	d.f.	m.s.
Treatments	3	344.563***
Seasons	1	85.562***
Weeks	3	3993.729***
Treatments x Seasons	3	10.729**
Treatments x Weeks	9	75.007***
Seasons x Weeks	3	16.896***
Treatments x Seasons x Weeks	9	4.729ns
Residual	1568	2.52

***, **, * significant at 0.1%, 1% and 5%, ns=not significant, CV=coefficient of variation, LSD=Least Square Difference and df, Degree of freedom.

Table 20: Sesame Webworm Incidence within the Treatments, Seasons of production and Weeks of Sesame growth

Treatments	**Seasons**	**Week 2**	**Week 4**	**Week 6**	**Week 8**	**Mean (Seasons)**	**Mean(Treatments)**
Control	Season 1	2	4.8	8.2	9	6	6.225
	Season 2	3.2	4.6	9	9	6.45	
Wood Ash	Season 1	2	7.4	8.2	9	6.65	7.075
	Season 2	3.8	8.2	9	9	7.5	
Chicken Manure	Season 1	0	3.4	6.2	9	4.65	4.9
	Season 2	0.4	4.2	7	9	5.15	
Wood Ash + Chicken Manure	Season 1	1.6	4.6	7	9	5.55	5.575
	Season 2	1.8	4.2	7.4	9	5.6	
Mean(Weeks)		1.85	5.175	7.75	9	5.94	5.94

LSD_T=0.5347, LSD_S=0.3781, LSD_W=0.5347, LSD_{TXS}=0.7562, LSD_{TXW}=1.0694, LSD_{SXW}=0.7562, LSD_{TXSXW}=1.5124 , % CV=10.9 & SE=0.6508

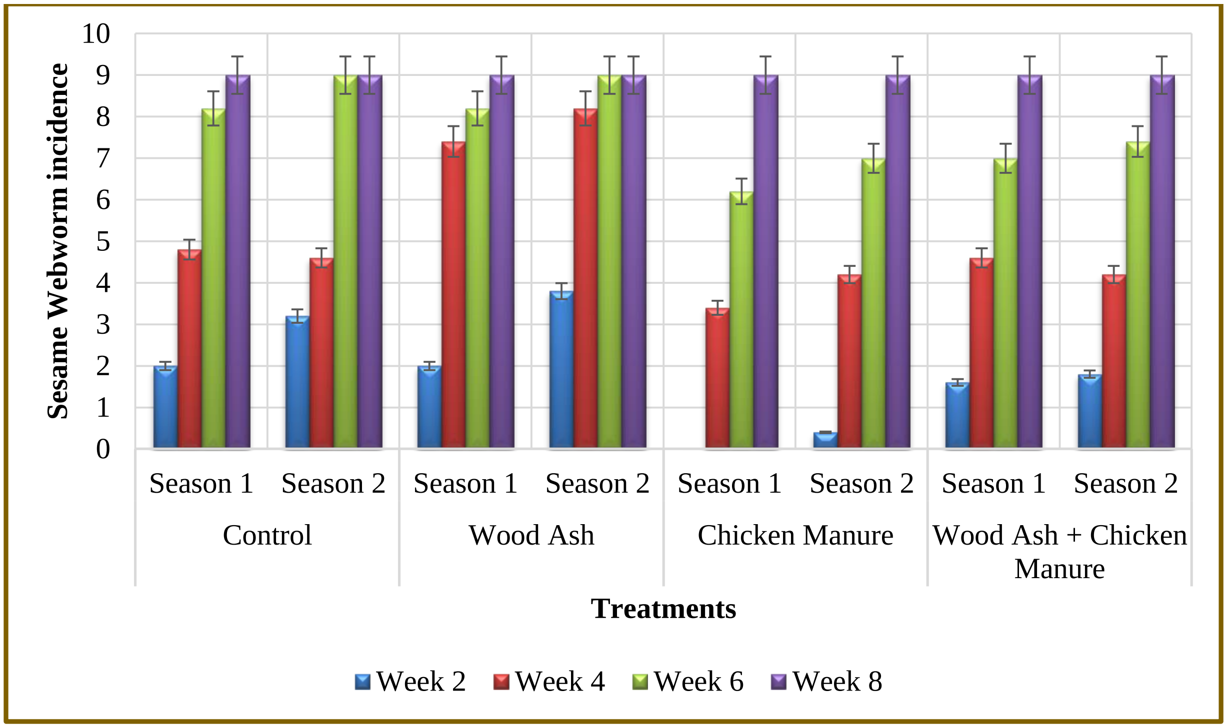

Figure 10: ***Sesame Webworm Incidence within the Treatments, Seasons of production and Weeks of Sesame growth***

4.1.2.6 Sesame Webworm Damage

The results in **table 19, table 20,** and **figure 10** show that there was a significant ($p<0.001$) difference in sesame webworm damage on sesame plants. Wood ash treated plants registered at a higher level (2.52) of damage by sesame webworm while chicken manure treated plants (1.49) registered the least damage level.

Within the season, no significant ($p>0.05$) difference was attained within the seasons. Sesame webworm damage was relatively the same in season one and season two respectively. An average damage level of 1.82 and 1.87 was attained in season 1 and season 2 respectively. Implying that the level of damage was low.

Within the weeks of sesame growth, a significant (p<0.001) difference in sesame webworm damage was attained. Very high damage level was registered in week 8 (4.64) as compared to week 6(2.22), week 4(0.95) and week 2 (0.26). This implies that sesame webworm was more active when sesame plants reached maturity stage.

Between the treatments and seasons, seasons and weeks, no significant (p>0.05) difference in sesame plant damage by sesame webworm was registered. Since significant variation was not attained within the seasons, variation in treatments and weeks as per the seasons was attained. This implies that sesame webworm had relatively the same effect on sesame during dry and wet season at Equator valley farm.

Between treatment and weeks, a significant (p<0.05) difference in webworm damage on sesame was attained. The highest level of sesame plant damage was attained in week 8 (5.28) under wood and ash treatments and the lowest level (0.04) under chicken manure treatments plots in week 2. Implying that wood ash treated plants were highly susceptible to sesame webworm and therefore suffered the most damage.

Table 21: Degrees of freedom and Means square values for Sesame Webworm Damage

Change	d.f.	m.s.
Treatments	3	89.859***
Season	1	7.701
Weeks	3	1484.502***
Treatments x Seasons	3	0.242ns
Treatments x Weeks	9	6.788*
Seasons x Weeks	3	0.386ns
Treatments x Seasons x Weeks	9	0.027ns
Residual	1564	2.896

***, **, * significant at 0.1%, 1% and 5%, ns=not significant, CV=coefficient of variation, LSD=Least Square Difference and df, Degree of freedom.

Table 22: Sesame Webworm Damage within the Treatments, Seasons of production and Weeks of Sesame growth

Treatments	**Seasons**	**Week 2**	**Week 4**	**Week 6**	**Week 8**	**Mean(Seasons)**	**Mean(Treatments)**
Control	Season 1	0.24	1	2.58	4.96	2.2	**2.29**
	Season 2	0.5	1.22	2.84	5	2.39	
Wood Ash	Season 1	0.3	1.4	2.86	5.24	2.45	**2.52**
	Season 2	0.44	1.56	3.04	5.32	2.59	
Chicken Manure	Season 1	0	0.48	1.34	4	1.46	**1.49**
	Season 2	0.08	0.56	1.48	4	1.53	
Wood Ash + Chicken Manure	Season 1	0.18	0.6	1.7	4.24	1.68	**1.75**
	Season 2	0.32	0.76	1.9	4.32	1.83	
	Mean(Weeks)	**0.26**	**0.95**	**2.22**	**4.64**	**2.01**	

LSD_T=0.3115, LSD_S=0.2203, LSD_W=0.3115, LSD_{TXS}=0.4405, LSD_{TXW}=0.623, LSD_{SXW}=0.4405, LSD_{TXSXW}=0.8811, SE=1.702 & CV=84.48%

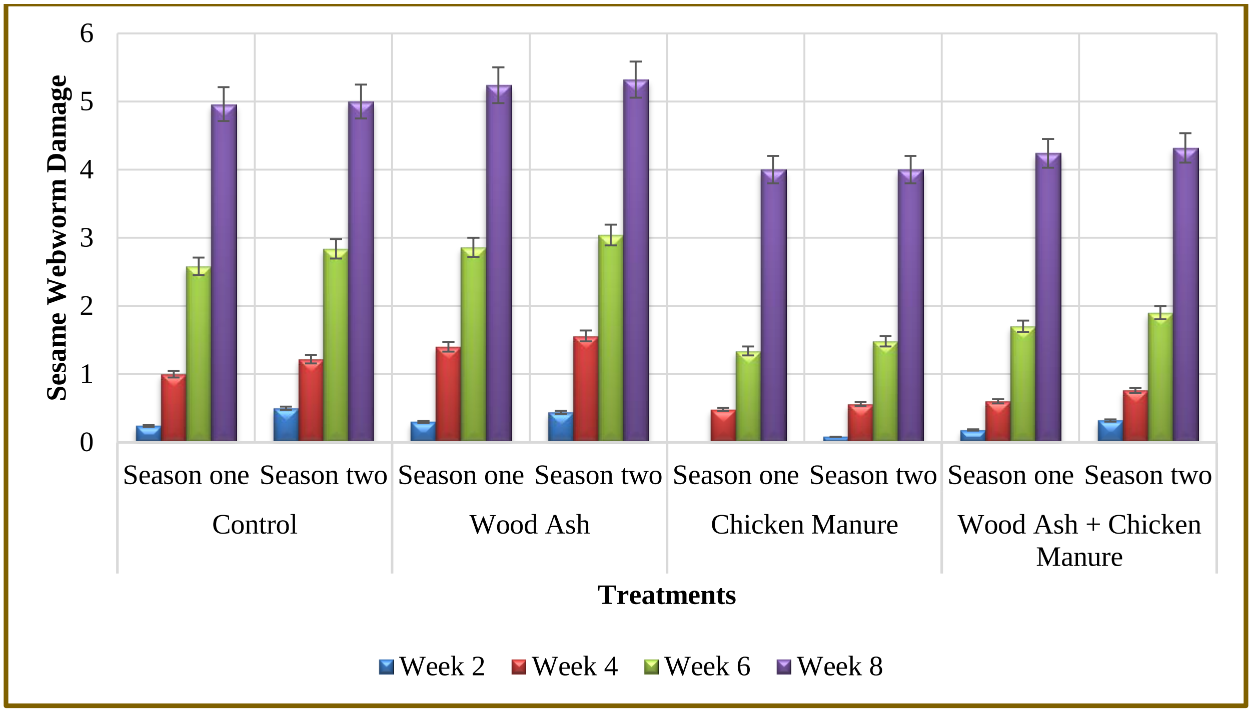

Figure 11: Sesame Webworm Damage within the Treatments, Seasons of production and Weeks of Sesame growth

4.1.3 Effect of Wood ash and Chicken Manure on Yield (g) of Sesame

4.1.3.1 Number of capsules

The results in **Table 21**, **Table 22,** and **Figure 11** show that significant ($p<0.001$) differences in the number of capsules were obtained within the treatments. Chicken manure treated plots (7.05) attained the highest number of sesame capsules compared to Wood ash + Chicken manure (6.6), wood ash (4.7), and control (4.05). This implies that chicken manure treatment highly enhanced the formation of capsules.

Within the season of production, a significantly ($p<0.05$) higher number of capsules was obtained in season 2 compared to season 1. An indication that season 2, characterized as wet or rainy season enhanced the formation of capsules. This was attributed to the availability of moisture to aid the breakdown of nutrients from the soil and organic matter needed for capsule formation.

The study also shows that a significant ($p<0.001$) difference in the number of capsules was registered within the weeks of sesame growth. Week 8(7.6) registered the highest number of capsules compared to week 7(3.6), which Indicates that optimal capsule formation was attained when sesame plants reached maturity.

No significant ($p>0.05$) differences in the number of capsules were attained between the treatments and seasons, treatments and weeks and seasons and weeks of sesame production and growth. This was an indication that the number of capsules between the treatments, seasons, and weeks was relatively the same.

Table 23: Degrees of freedom and Means square values for Number of Capsules

Change	d.f.	m.s.
Block	4	431.05***
Treatment	3	417.1***
Season	1	174.85*
Weeks	1	3120.5***
Treatment x Seasons	3	1.85ns
Treatment x Weeks	3	10.41ns
Season x Weeks	1	0.02ns
Treatment x Season x Weeks	3	0.01ns
Residual	780	40.54

***, **, * significant at 0.1%, 1% and 5%, ns=not significant, CV=coefficient of variation, LSD=Least Square Difference and df, Degree of freedom.

Table 24: Number of Capsules by Treatments, Season and Week

<table>
<tr><th>Treatment</th><th>Season</th><th>Week 7</th><th>Week 8</th><th>Mean(Season)</th><th>Mean(Treatment)</th></tr>
<tr><td rowspan="2">Chicken Manure</td><td>Season 1</td><td>4.2</td><td>8.7</td><td>6.5</td><td rowspan="2">7.05</td></tr>
<tr><td>Season 2</td><td>5.36</td><td>9.86</td><td>7.6</td></tr>
<tr><td rowspan="2">Control</td><td>Season 1</td><td>2.02</td><td>5.38</td><td>3.7</td><td rowspan="2">4.05</td></tr>
<tr><td>Season 2</td><td>2.72</td><td>6.14</td><td>4.4</td></tr>
<tr><td rowspan="2">Wood Ash</td><td>Season 1</td><td>2.32</td><td>6.2</td><td>4.3</td><td rowspan="2">4.7</td></tr>
<tr><td>Season 2</td><td>3.14</td><td>7.04</td><td>5.1</td></tr>
<tr><td>Wood Ash</td><td>Season 1</td><td>4.08</td><td>8.1</td><td>6.1</td><td>6.6</td></tr>
</table>

+ Chicken Manure	Season 2	5.1	9.12	7.1	
Mean(Season)		3.6	7.6	5.6	5.6

LSD_T=0.5759, LSD_S=0.8144, $LSD_{W=}$0. LSD_{TXS}=1.152 SE=1.842 & CV=28.75%

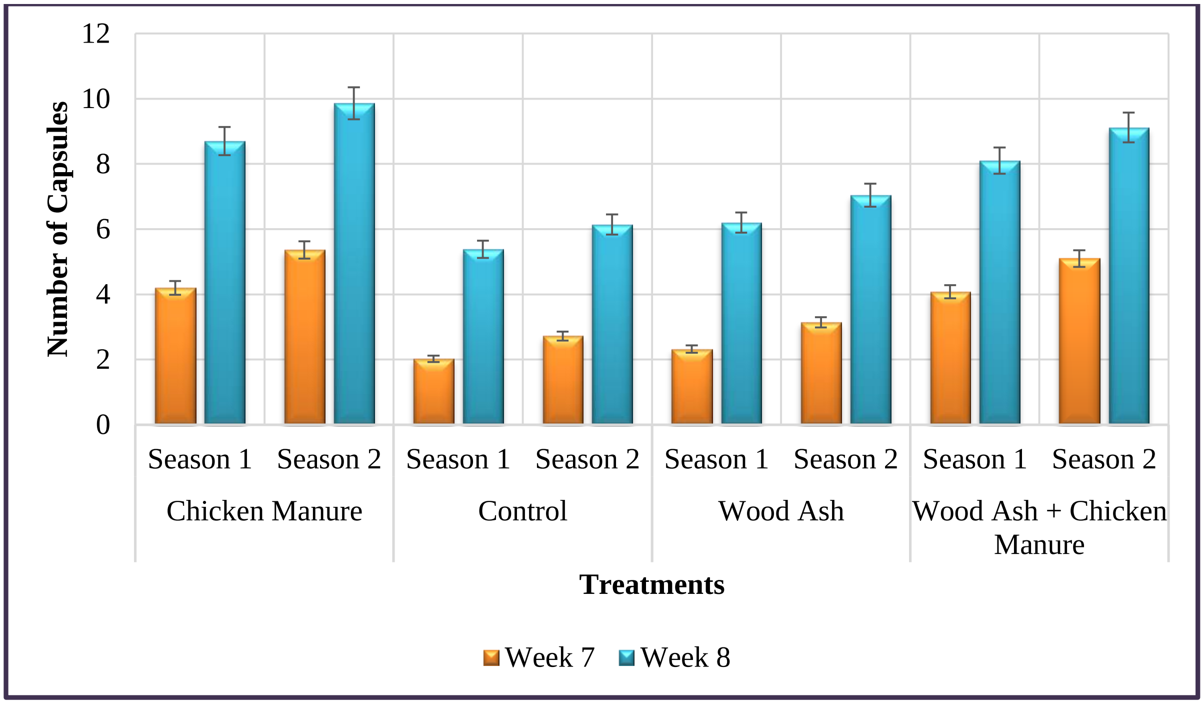

Figure 12: Number of Capsules by Treatments, Season, and Week

4.1.3.2 Number of Seeds per Capsules

The results in **Table 23, Table 24,** and **Figure 12** show that the number of seeds per capsule was significantly ($p<0.001$) higher in season 2 (71.1) than in season 1(66.7). Implying that optimal seed formation was attained during the wet season, which was characterized as moist, a suitable condition for the breakdown of nutrients from the soil and organic matter into absorbable forms, leading to the utilization of the nutrients to boost seed formation.

The results also show that significant ($p<0.001$) differences in the number of seeds per capsule were attained within the treatments. chicken manure(72.2) treated plants produced the highest number of seeds per capsule compared to wood ash + Chicken manure (68.8), wood ash (68.1), and control (66.6) treated plants. These findings demonstrate that chicken manure treatment was more effective in providing the needed plant nutrients leading to the formation of more seeds per capsule.

The results finally show that no significant ($p>0.05$) differences in the number of seeds per capsule were obtained between the treatments and seasons. A relative number of seeds was attained in season 1 and season 2 in all treatments, which suggests that there was no particular change in yield since season two (wet season) registered a higher number of seeds than in season 1(dry season).

Table 25: Degrees of freedom and Means square values for Number of Seeds per Capsules

Source of variation	**d.f.**	**m.s.**
Seasons	1	1971.36***
Treatment	3	542.07***
Treatment x Season	3	88.67ns
Residual	392	90.9

***, **, * significant at 0.1%, 1% and 5%, ns=not significant, CV=coefficient of variation, LSD=Least Square Difference and df, Degree of freedom.

Table 26: Number of Seeds per Capsules in Treatments, Season and Week

Treatment	**Season 1**	**Season 2**	**Mean(Treatment)**
Chicken Manure	68.7	75.6	**72.2**
Control	65.4	67.9	**66.6**
Wood Ash	66.3	70.0	**68.1**
Wood Ash + Chicken Manure	66.4	71.2	**68.8**
Mean(Season)	**66.7**	**71.1**	**68.9**

CV(%)=25.06% and SE=9.305, LSD_T=7.586, LSD_S=5.365, LSD_W=5.214

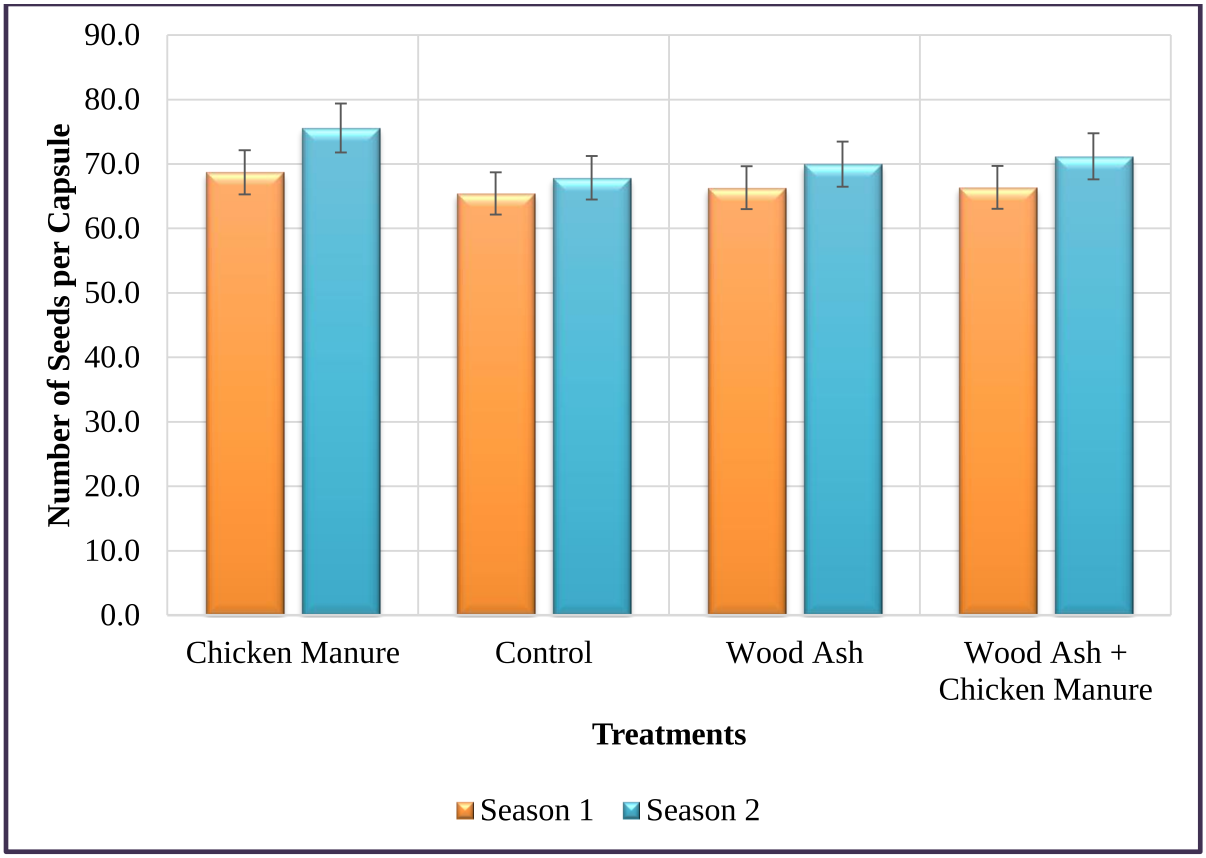

Figure 13: Number of Seeds per Capsules by Treatments, Season, and Week

4.1.3.4 Weight of 1000 seeds

Results in **Table 25, Table 26,** and **Figure 13** show that, a significant ($p<0.001$) difference in the weight of 1000 seeds was attained within the seasons of sesame production. Season 2(3.1g) registered the highest weight of 1000 seeds as compared to season 1(2.7g). These findings imply that higher seed weight was attained during wet season of production than dry season.

The results also show that, a significant ($p<0.001$) difference in weight of 1000 seeds was registered within the treatments. Seeds obtained under Wood ash + chicken manure treated plants registered the highest (3g) weight as compared to chicken manure treated plants (3g), wood ash and control (2.8g) respectively.

Between the season and treatments, a significant ($p<0.001$) difference in weight of 100 seeds was registered. A higher (3.2g) seed weight was attained in season two under wood ash + Chicken manure treated plants and the least under control and wood ash treated plants in season 1 (2.6 g) respectively. These findings suggest that 1000 seed weight was higher under a combination of wood ash and chicken manure treated plants during wet season of sesame production in Equator Valley Farm, Nkozi subcounty.

Table 27: Degrees of freedom and Means square values for Weight of 1000 Seeds

Source of variation	d.f.	m.s.
Season	1	21.16***
Treatments	3	2.468867***
Season x Treatment	3	0.287267***
Residual	392	0.008459

***, **, * significant at 0.1%, 1% and 5%, ns=not significant, CV=coefficient of variation, LSD=Least Square Difference and df, Degree of freedom.

Table 28: Weight of 1000 Seeds by Treatments, Season and Week

Treatment	Season 1	Season 2	Mean(Treatment)
Chicken Manure	2.8	3.2	3.0
Control	2.6	3.0	2.8
Wood Ash	2.6	3.0	2.8
Wood Ash + Chicken	2.8	3.4	3.1
Mean(Season)	2.7	3.1	2.9

LSD_T=0.583, LSD_S=0.413, LSD_{TXS}=0.825, SE=0.568 & CV=49.3%

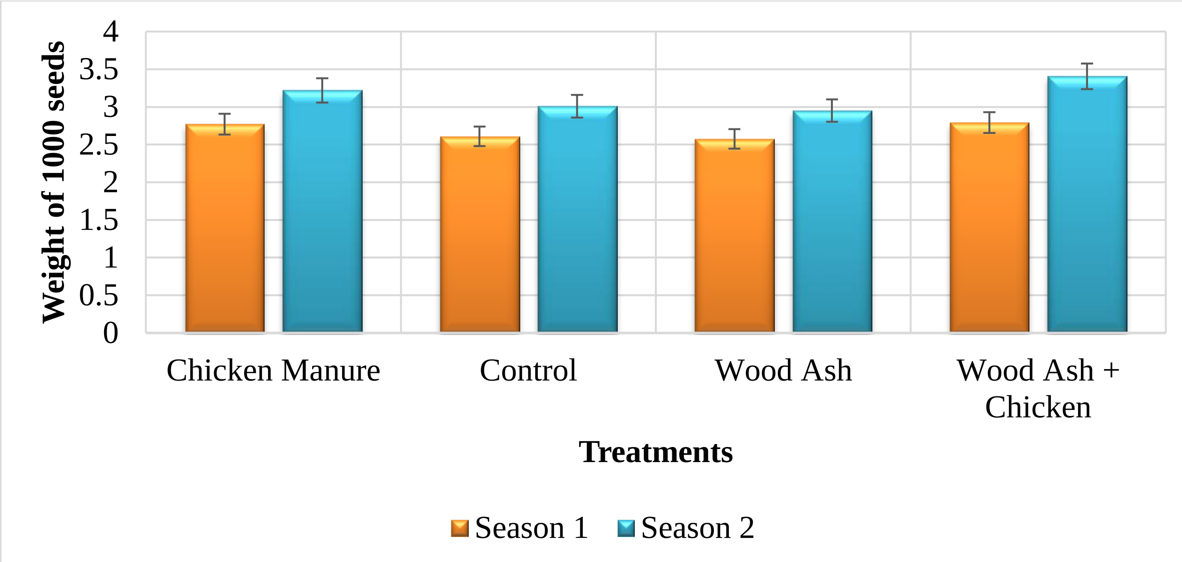

Figure 14: Weight of 1000 Seeds by Treatments, Season and Week

4.1.3.5 Yield per hectare

The results in table 27, table 28 and figure 14 show that there was a statistically significant ($p<0.001$) difference in sesame yield within the seasons of production. A higher yield was attained in season 2 (25.5 tonnes) than in season 1(25.2 tonnes). These findings indicate that yield was higher in second season of sesame production than in dry season.

A significant ($p<0.001$) difference in yield was attained within the treatments. Wood ash + Chicken manure treated plots (27.8 tonnes) attained the highest yield compared to Chicken manure treatments (26.3 tonnes), control (23.8 tonnes) and wood ash (23.5 tonnes). These findings reveal that a combination of wood ash and chicken manure lead to higher yield.

No significant ($p>0.05$) difference in yield per hectare was determined between season and treatments. Relatively yield per hectare was obtained a cross the season and treatments during sesame production at Equator valley farm in Nkozi subcounty.

Table 29: Degrees of freedom and Means square values for Yield per Hectare (t)

Source of variation	d.f.	m.s.
Season	1	8.263**
Treatment	3	421.076***
Season x Treatment	3	1.722ns
Residual	392	1.01

***, **, * significant at 0.1%, 1% and 5%, ns=not significant, CV=coefficient of variation, LSD=Least Square Difference and df, Degree of freedom.

Table 30: Yield per hectare by Treatments, Season and Week

Treatment	Season 1	Season 2	Mean(Treatments)
Chicken Manure	26.0	26.5	**26.3**
Control	23.6	24.0	**23.8**
Wood Ash	23.5	23.4	**23.5**
Wood Ash + Chicken Manure	27.6	27.9	**27.8**
Mean(Season)	**25.2**	**25.5**	**25.3**

LSD_T=13.8.02, LSD_S=15.19, LSD_{TXS}=23.03, SE=20.32 & CV=56.3%

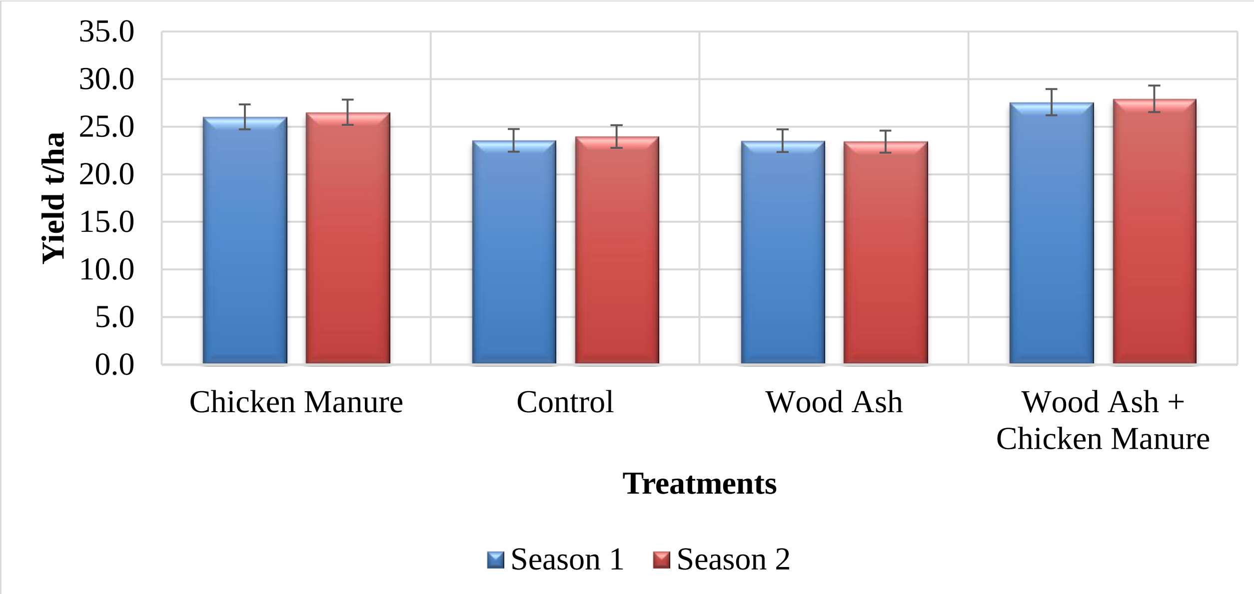

Figure 15: Yield per hectare by Treatments, Season and Week

4.2 Discussions

4.2.1 Effect of Wood Ash and Chicken Manure on the Growth Response of Sesame

Plant Height

The study determined that chicken manure treatments produced higher plant height compared to wood ash + chicken manure and wood ash. This was highly attained when the plants had reached (week 8). This was attributed to the availability of the vital plant nutrients nitrogen, phosphorous, and potassium, and particularly nitrogen in chicken manure, which is considered a building block for plant growth hence optimum growth. The highest plant height was attained when sesame plants reached maturity. This was linked to the availability of plant nutrients such as phosphorous that enhanced optimum growth. This was also facilitated by the established root system during maturity that supported the absorption of nutrients, especially during utilization the plant nutrients were easily broken from the soil and organic matter. These findings corroborated Fan et al (2018) that determined that unlike other manure such as wood ash, cow dung, chicken manure is highly rich in nitrogen that has a significant effect on the growth of plants. Plants need nitrogen to enhance the plants growth. Anyaegbu et al (2019) also found that chicken manure treatments had demonstrated a positive effect on maize growth . The sufficiency of the nutrients ; nitrogen in chicken manure and aided by the micro-bacterial that breaks down the nutrients in chicken manure easily enhanced the absorption of nitrogen, phosphorous and potassium leading better plant growth hence highest plant height. These findings also confirmed Edema(2018) study that acknowledged that wood ash compared to chicken has very limited traces of nitrogen, as a result the plants under its treatment register lower growth.

Number of Leaver per Plant

The study findings showed that chicken manure produced the highest number of sesame leaves compared to wood ash + chicken manure and sole wood ash. This was highly demonstrated at maturity week 6. This was highly attributed to the adequacy of vital plants nutrients ;nitrogen essential for plant leaf development. These findings were in agreement wit Jean et al (2015) who argue that chicken manure as an organic fertilizer has comprehensive and long lasting nutrients needed for different growth in plants. Viegas et al (2012) further confirms that chicken manure contains a decomposing agent that equally contains a medium and trace elements, beneficial biological activities and various enzymes required by plants. These agents inform of microbes in the soil fix nitrogen in the air and loosen the soil to allow the absorption of water to enhance plants utilization of the nutrients to attain vegetative growth (Hoog, et al., 2010).

Number of Branches

By the number of branches, chicken manure plots produced the highest number of branches per plant compared to wood ash + chicken manure and wood ash. This was highly attained at maturity week 8. This was attributed to the high nutrient composition in chicken manure (Nitrogen, phosphorous and potassium) highly needed to enhance plant growth. More so, the number of branches were high at maturity because by week 8, the plants had established root system that easily enhanced the absorption of plants needed to enhance plant growth, hence plants that received high amounts of nutrients attained highest growth rate. The number of branches was also significantly higher in week 8 under chicken manure treated plants. Highlighting the importance of chicken manure as a vital source of organic nitrogen needed to boost the development of branches to aid the maturation and yielding process. These findings were in agreement with Anyaegbu *et al* (2019) who found that sesame plants treated with chicken manure attained the highest number of branches at maturity due to the ease of nutrients absorption. Chicken manure contained several beneficial nutrients such as nitrogen, phosphorus , potassium, calcium, manganese , magnesium which both increased plants growth but also inhibited pests and disease infestation enabling the plants to attain optimum growth. Miranda *et al* (2012) also agrees with the study's outcome and note that nitrogen in chicken manure is highly needed by plants for complete development of roots, stems, branches and flowering .

Stem Girth

The study also showed that, chicken manure plots and wood ash + chicken manure treated plots produced the widest stem respectively compared to wood ash treated plots. This was an indication that both chicken manure and wood ash + Chicken manure treatments were essential sources of phosphorous and nitrogen responsible for the development of stems . With adequacy of nitrogen and phosphorus, sesame plant stem girth was considerably able to increase in size. This was highly attained at maturity week 8. This was a maturity period when the sesame plant had demonstrated ability to maximally utilize the available nutrients aided by an established root system. These findings corroborated Fernandez *et al* (2015) that demonstrated that a number of macronutrients and micro-nutrients are abundant in wood ash that include potassium , phosphporus, iron, calcium while chicken manure is a vital source of nitrogen, sodium highly needed for the development of both the stem and the root system, hence a combination of these treatments enhances plant growth leading to wider stem girth. Dayo-Olagbende, et al., (2018) also affirms to the findings and note that wood ash + chicken manure contain large amounts of potassium, nitrogen, phosphorous, calcium, sodium , iron nutrients required to enhance the development of stems in plants.

50% flowering

The study also shows that chicken manure (40.1 days) treated plots produced the earlier 50% flowering in sesame plants compared to wood ash + chicken manure (42.1 days) and wood ash(43.6 days). This was attained less more under chicken manure treated plots in the dry season of sesame production (38.8 days). A clear manifestation that earliest 50% flowering was attained most under chicken manure during the dry season of production. At this period the sesame plants had to register earlier flowering as limited nutrients were available to enhance prolonged plant growth as in wet season hence plants matured earlier . This can also be explained by the adequacy of phosphorous and nitrogen in chicken manure treatments that are responsible for assisting the growth of flowers. These findings were in agreement with Fernandez *et al* (2015) who found the adequacy of phosphorous , potassium and nitrogen essential for earlier flowering influenced by the dry season of production.

4.2.2 Effect of Wood Ash and Chicken Manure on Pests and Disease Prevalence in Sesame

***Alterneria Blight* Incidence and Severity**

The study found *Alterneria blight* incidence to be significantly lower in chicken manure treated plots compared to wood ash plots wood ash and chicken manure plots and control. This was particularly higher in dry season compared to the wet season and very high at flowering and maturity of sesame production. Low incidence under chicken manure treated plots can be explained by the strong presence of phosphorous and potassium that are aid in the suppression of pests and diseases. The high *Alterneria blight* incidence during dry season can also be attributed the strong wind currents during dry season and accumulation of fungus due to plant debris. Subsequently incidence was high at flowering and maturity, when the plants had large surface area for the fungus to cause effect. These findings corroborate Chastain, *et al.*, (2018) study that demonstrated that besides enhancing plant growth due to the presence of nitrogen , phosphorous and potassium, chicken manure applications supply micronutrients such as calcium (Ca), magnesium (Mg), sulfur (S), manganese (Mn), zinc and (Zn) into soil along with foliar spray that have a potential to inhibit *Alternaria* leaf blight infection in leafs up to 82.3% compared to control. Lal, (2015) was also in agreement that the integration of the different management practices including soil treatment with sulphur-zinc-magnesium-molybdenum-boron most of which are contained in wood ash help reduce on the incidence level of *Alternaria blight* in oilseed Brassica. Boureima *et al* (2016) were in agreement that *Alternaria blight* tends to be high when there is strong wind currents and heavy rains. These were mediums in which *Alternaria blight* was transmitted.

Alterneria Blight Severity

The study also determined that *Alterneria Blight* Severity was significantly ($p<0.001$) lower in chicken manure treated plots and high in wood ash, wood ash + chicken manure treatments. It was higher in wet season and during maturity period (week 8). The lower severity in chicken manure plots can be attributed to the presence of an inhibiting nutrient potassium and phosphorus which aids in the control of pests and disease infestation while the higher severity in wet season can be attributed the high incidence in dry season and by wet season when the foliage had grown, the effect was realized. *Alterneria Blight* Severity was also high during maturity due to the higher foliage. These findings were in agreement with Bedigian (2013) who argues that potassium in chicken manure provides disease resistance mainly through mobilization of plant defense system and increase in cuticle thickness which inhibits the pathogen infection. Rawashdeh *et al.* (2016) further conforms to the study findings that *Alterneria Blight* Severity can be high in wet season due to high rate of fungus development. The moisture aids fungi growth increasing the rate of plant infection whereas Ungsethaphand *et al* (2009) concurs that severity of *Alterneria Blight* on plants can be high at maturity due to high number of leaves that aids the transmission from one plant to the other.

Phyllody Disease Incidence

Phyllody disease incidence was found to be significantly lower under chicken manure treated plots compared to wood ash + chicken manure, wood ash and control. An attribute explained by the presence of potassium and phosphorous nutrients that control pests and disease incidence in plants. However, Incidence was high during dry season (season 1) and at maturity. This was linked to the high temperatures that normally causes imbalance in plant hormones during the dry season and enabling condition for vector reproduction (leaf hoppers), subsequently affecting sesame plants during flowering and maturity. These findings were confirmed by Haggag & Saber (2017) who found chicken manure to be a very vital source of phosphorous and potassium that aid in reduction of disease incidence in plants. Bedigian (2013) also attributed the higher

Phyllody Disease during dry season, flowering and maturity, to the enabling high temperatures that aid high reproduction of leaf hoppers, a vector that transmits *Phytoplasma virus*.

Phyllody Disease Severity

The study found *Phyllody* Disease Severity to be very low under chicken manure and wood ash + chicken manure (1.1) treated plots. This was evident that the two treatments were more teloarence to *Phyllody* Disease. This can be attributed to the presence of the vital macro-nutrient phosphorous that enhances plant tolerance to diseases in both treatments. *Phyllody* Disease Severity was also high during dry season than wet., associated with an imbalance in plant hormones during flowering. By weeks of plants growth, Phyllody Disease Severity was high in week 8. This was a maturity period of the sesame which was highly associated with flowering and podding. Consequently, Phyllody Disease highly affects the flowers and the pods. These findings were in agreement with Rawashdeh *et al* (2016) who explained that chicken manure and wood ash + chicken manure treatments contain large amounts of potassium and phosphorous, calcium, boron that are vital sources of plant resistance to pests and disease infestation leading to low effect or damage on the plant. However the high severity in dry season and during maturity was confirmed by Markou *et al* (2016) to be as a result of high temperatures suitable for disease causing vector; (leaf hoppers reproduction) that carry the virus infecting highly foliated plants or plants that have reached flowering and maturity.

Sesame Webworm Incidence

The study findings indicate that sesame webworm was least prevalent in Chicken manure treated plots than wood ash + chicken manure and wood ash treated plots. This was an indication that chicken manure treatment was more tolerant to sesame webworm, and this can be attributed to the availability of phosphorous and potassium nutrients that aid tolerance of the sesame plants to pests. Within the season, Incidence of sesame webworm was low in season 1 than in season 2. This was attributed to the favorable conditions that encourage breeding and infestation in wet season . Incidence was also very high in week 8, at a maturity stage when the plants have developed pods and still flowering. These findings were in agreement with Wazire & Patel (2015) who agreed that chicken manure treatment has demonstrated tolerance to pests such as sesame webworm due to the presence of macro and micro nutrients that aid growth but also inhibit pests and disease effects on plants. Dayo-Olagbende *et al.* (2018) also agree and note that chicken manure has potassium, phosphorus, calcium, boron, manganese which all play important role of enhancing plant growth but also develop plant defensive mechanism against pests and diseases. Furthermore, Materechera & Salagae (2011) also confirms the study findings by noting that Sesame Webworm Incidence is high during wet seasons/rainy seasons because its best suitable for reproduction and generally affects matured plants.

Sesame Webworm Damage

The study findings showed that chicken manure treated plots registered least damage, which can be explained by the high tolerance exhibited by the treatment. Chicken manure is known to contain phosphorous essential for tolerance in plants to pests. Sesame Webworm Damage was very high in week 8. Week 8 was a maturity period where sesame plants completed flowering and developed pods that were heavily affected by sesame webworm. By treatments and weeks, sesame webworm damage was least registered under chicken manure treated plots in season under week two. Suggesting that, chicken manure treatment which contains a vital nutrients, phosphorous that inhibits pests attack on the plant had the least damage. These findings were in agreement with Ghafariyan *et al* (2013) who found out that the potassium and phosphorous in both chicken manure and wood ash highly induce the plants resistance to pests by development of thick plant tissue rendering the penetration of the pests less effective. Jia, *et al.,* (2016) however argue that sesame webworm damage can be high in wet conditions when its reproduction is high, affecting matured plants that it burrows in.

4.2.2 Effect of Wood ash and Chicken Manure on Yield (g) of Sesame

Number of capsules

Sesame plants under Chicken manure treatments produced the highest number of capsules than wood ash + chicken manure and wood ash treated plots. This can be attributed to the presence of macro and micro-nutrients such as Nitrogen, Potassium, Phosphorusm calcium, boron, magnesium, manganese which are very essential toewards the growth and yield. The number of capsules were higher in wet season (season two) than in dry season (season one). Characterised as wet, providing the needed moisture to break down the macro and micro-nutrients needed by the plant for growth and yield hence the formation of more capsules. The number of capsules was high in week 8. Week 8 was known as maturity period of the sesame where there was high formation of capsules, compared to the flowering, vegetative and seedling stages. This was attributed to the higher utilisation of plants nutrients supported by the established root system. These findings were in agreement with Mohamed Amanullah *et al.* (2010) who found application of chicken manure and wood ash to produce the highest number of capusles due to the presence of supportive plant nutrients such as calcium, boron, phosphopous needed for development of capsules. Akande, *et al.,* (2015) agrees that plants attained highest number of capsusles during wet season and at maturity due to the ease with which the nutrients were broken down and established root system absorping these nutrients.

Number of Seeds per Capsules

The study demonstrated that a higher number of seeds were produced in chicken manure treated plots compared to wood ash + chicken manure, wood ash treated plants and control. This was attributed to the ability of Chicken manure treatment to fix the needed nutrients such as nitrogen, potassium and phosphorus needed to enhance growth and yield particularly seed formation. The number of seeds per capsules was also high in season 2 than season 1 of sesame production. Season 2 was noted as essential for plant growth and yield since it enabled the breakdown of nutrients needed for plant growth and yield. These findings corroborated Singer *et al* (2014) study that found out that that poultry manure and wood ash were efficient in terms of total nitrogen as fertilizer and had appreciable residual effect on seed formation. This was subsequently high when plants were able to attain the nutrients during wet season and when the plants attaine maturity (Fan, et al., 2018).

Weight of 1000 seeds

The study revealed that Wood ash + chicken manure treated plants produced the highest (3g) weight as compared to chicken manure treated plants (3g), wood ash and control (2.8g) respectively. This was attributed to the availability of important nutrients in wood ash and a combination of those responsible for seed development and weight in chicken manure. These findings were in agreement with Kairu *et al* (2013) who note that a combination of wood ash and chicken manure was a powerful source of plant nutrients that boost both growth and yield. The composition of various nutrients such as nitrogen, potassium, phosphorous , calcium, boron, magnesium enhances plant growth and yield. Seed weight in this case can be attributed to boron which is needed to aid seed balance.

The weight of 1000 seeds was also very high in season 2 (3.1g) than in season 1(2.7g). Attributed to the adequacy within which the nutrients were broken down easily to enhance plant growth and yield in wet season than in dry season. These findings corroborate Sarvari & Pepo, (2014) who reported that plants gain higher weight and yield when there is sufficient uptake of plant nutrients, hence better performance in wet season.

Yield per hectare

The findings have revealed that Wood ash + Chicken manure treated plots (27.8 tonnes) attained the highest yield compared to Chicken manure treatments (26.3 tonnes), control (23.8 tonnes) and wood ash (23.5 tonnes). This can be linked to the adequacy of the vital nutrients that enhance yielding in sesame in both the combination of wood ash and chicken manure that were not exhaustively used during vegetative growth and flowering. These findings were in agreement with Koelsch (2019), who noted that substituting chicken manure and wood ash for inorganic fertilizer led to 14% increase in yield suggesting that improved soil biological and physical characteristics in fields using chicken litter mixed with wood ash explained why the yield increases.

The yield per hectare was particularly high in wet season (25.5 tonnes) than in dry season (25.2 tonnes). This was equally aligned with the principle that when there is easy break down of the nutrients from the soil, plants gain the needed nutrients for growth and yield hence higher yield in season 2 of sesame production at Equator Valley Farm-Nkozi sub county. These findings confirm Basa, *et* al., (2016) study that revealed that plants attain better growth and yield when nutrients uptake is adequate, this can be attained highly during wet season when the plant nutrients such as nitrogen ,potassium, phosphorous, calcium, magnesium, boron can be broken down easily and absorbed by the plants.

CHAPTER FIVE: SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.0 Introduction

This chapter presents the summary of findings, conclusions and recommendations in line with the study objectives.

5.1 Summary of Findings

The study has shown that in terms of growth, chicken manure treated plots registered higher plant height, highest number of leaves per plant, highest number of branches, largest stem girth and earliest 50% flowering than wood ash + Chicken manure, wood ash and control. It has also shown that plant growth was enhanced more in second season, considered wet season than in dry season and particularly enhanced at in week 8 than in week 6, week 4, and week 2. All these performance in growth was attributed to a number of factors, such as the presence of macro and micro nutrients in chicken manure treatments that include nitrogen, phosphorus, potassium and a number of micro nutrients that include calcium, magnesium that aid plant growth, enhancement of plant growth by access to water during wet season that aided the break down and absorption of the plant nutrients to aid growth, and the optimal utilization of plant nutrients at maturity period.

The study has also indicated that chicken manure treated plant registered the least *Alterneria blight* incidence and severity, Phyllody disease incidence and severity and sesame webworm incidence and damage. This was attributed to the presence of vital plant nutrients such as potassium, phosphorous that enhances plants resistance or tolerance to pests and diseases. This was particularly common in wet season for the *Alterneria* and sesame webworm. However, the incidence, severity and damage were most prominent at maturity, which otherwise suggests that the pests and disease infestation was high when the sesame plants were mature.

The study finally showed that sesame yield was highly attained under wood ash and chicken manure treated plants than in chicken manure or wood ash treated plots. This was attained by the number of seeds per capsule, the weight per 1000seeds and yield per hectare. In contrast, chicken manure treatments had registered higher number of capsules.

5.2 Conclusions

This study demonstrates that chicken manure treatments unlike wood ash sesame was more effective in attaining plant growth due to the adequacy of nutrients such as nitrogen, phosphorus and potassium that enhance plants growth. This was most effective during wet season when plants could easily access the nutrients through the ease with which they break down from the soil and organic matter. Consequently, the plants were maximally able to utilize these nutrients till maturity.

The study also demonstrated that chicken manure treatment of had enhanced disease; *Alterneria* Blight, *Phyllody* Disease and pests; Sesame Webworm Damage tolerance. This was attributed to the presence of phosphorus that aids the inhibition of the pests and disease infestation on the plants.

The study however, demonstrated that the despite chicken manure treatments registering effectiveness in enhancing plant growth, a combination of wood ash + Chicken treatments was more effective in influencing the yield. This was highly attributed to the adequacy of the nutrients provided wood ash and chicken manure that enhanced yielding in the sesame.

5.3 Recommendations

Although chicken manure treatments showed significant improvement in sesame growth, a combination of chicken manure and wood ash was found to influence yield. It is therefore recommended for farmers to apply both wood ash and chicken manure in their sesame gardens. This would provide both the essential nutrients present in wood ash and chicken manure that have potential to influence growth and yield.

Farmers are also recommended to use wood ash and chicken manure treatment to minimize *Alterneria* blight incidence and severity, *Phyllody* disease incidence and severity and sesame webworm incidence and damage. Phosphorous a vital nutrient for plant growth and yield was also found to enhance plants tolerance to diseases and pests.

Farmers are also encouraged to undertake sesame production in wet season. This period registered higher growth and yield than in dry season. This was because the wet season enhance the breakdown of macro and micro-nutrients observed by the sesame plants to enhance optimum growth and yield. So, farmer in Nkozi Sub County, could undertake its production in wet season to attain higher growth and yield.

There is need for farmers to be trained on the application of wood ash and chicken manure treatments towards the production of sesame. These skills are essential in aiding the understanding of the necessary agronomic practices

Lastly, farmers need to train on proper management of pests and diseases such as *Alterneria* blight, *Phyllody* disease and sesame webworm which have been found to be common in Nkozi sub county. This can be further through the application of botanical extracts to control the incidence, severity and damage on sesame.

5.4 Areas of Further Research

For further studies, the study recommends for the following topical areas to be further researched on;

Effect of Botanical Extracts (Neem, Garlic and Ginger) on the control of as *Alterneria blight*, *Phyllody* disease and sesame webworm in sesame.

Effect of Botanical Extracts (Aloe Vera, Tithonia and Neem) on the control of selected pests and Diseases in Sesame.

Effect of Application rates of Wood ash and Chicken manure on the growth and yield of Sesame.

Cost-Benefit Analysis of Sesame Production among small-holder farmers in Lira sub county, Lira District.

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APPENDICES

APPENDIX A: SAMPLE OF THE DATA COLLECTED USING EXPERIMENTAL DATA COLLECTION TOOL

season	Week	PlotNo	Block	Treat	Trt Name	Plant	Plant height	Leaves per plant	Branches	Stem girth
seasonone	weektwo	1101	1	1	W	1	7	4	0	1.5
seasonone	weektwo	1102	1	1	W	2	5	6	0	1.5
seasonone	weektwo	1103	1	1	W	3	5.5	6	0	1.5
seasonone	weektwo	1104	1	1	W	4	5.5	4	0	1.7
seasonone	weektwo	1105	1	1	W	5	3.5	3	0	1.1
seasonone	weektwo	1106	1	1	W	6	6	4	0	1.3
seasonone	weektwo	1107	1	1	W	7	7	4	0	1.3
seasonone	weektwo	1108	1	1	W	8	3.7	4	0	1.1
seasonone	weektwo	1109	1	1	W	9	3	4	0	1.2
seasonone	weektwo	1110	1	1	W	10	5.5	4	0	1.2
seasonone	weektwo	1201	1	4	None	1	3.7	2	0	1
seasonone	weektwo	1202	1	4	None	2	7	4	0	1.1
seasonone	weektwo	1203	1	4	None	3	6	4	0	1.6
seasonone	weektwo	1204	1	4	None	4	5.1	6	0	1.2
seasonone	weektwo	1205	1	4	None	5	7	6	0	1.2
seasonone	weektwo	1206	1	4	None	6	6.3	5	0	1.2
seasonone	weektwo	1207	1	4	None	7	5.5	6	0	1.8
seasonone	weektwo	1208	1	4	None	8	5.6	6	0	1.1
seasonone	weektwo	1209	1	4	None	9	3.2	4	0	1.5
seasonone	weektwo	1210	1	4	None	10	4.9	6	0	1.1
seasonone	weektwo	1301	1	3	W+C	1	7	4	0	1.5
seasonone	weektwo	1302	1	3	W+C	2	5	6	0	1.6
seasonone	weektwo	1303	1	3	W+C	3	8.2	6	0	1.3
seasonone	weektwo	1304	1	3	W+C	4	8	5	0	1.5
seasonone	weektwo	1305	1	3	W+C	5	5	6	0	1.2
seasonone	weektwo	1306	1	3	W+C	6	6	6	0	1.8
seasonone	weektwo	1307	1	3	W+C	7	7	6	0	1.3
seasonone	weektwo	1308	1	3	W+C	8	5.4	4	0	1.5

seasonone	weektwo	1309	1	3	W+C	9	8.8	6	0	1.4
seasonone	weektwo	1310	1	3	W+C	10	5.7	6	0	1.8
seasonone	weektwo	1401	1	2	C	1	5	5	0	1.5
seasonone	weektwo	1402	1	2	C	2	7	7	0	2
seasonone	weektwo	1403	1	2	C	3	6	6	0	1.7
seasonone	weektwo	1404	1	2	C	4	6.9	10	2	1.5
seasonone	weektwo	1405	1	2	C	5	7.5	7	1	1.9
seasonone	weektwo	1406	1	2	C	6	6	11	2	1.7
seasonone	weektwo	1407	1	2	C	7	7	6	0	1.7
seasonone	weektwo	1408	1	2	C	8	7	6	0	1.4
seasonone	weektwo	1409	1	2	C	9	7	6	0	1.6
seasonone	weektwo	1410	1	2	C	10	6	6	0	1.6
seasonone	weektwo	2101	2	1	W	1	6	6	0	1.4
seasonone	weektwo	2102	2	1	W	2	7	8	0	1.2
seasonone	weektwo	2103	2	1	W	3	6	6	0	1.5
seasonone	weektwo	2104	2	1	W	4	7.4	6	0	1
seasonone	weektwo	2105	2	1	W	5	9	7	0	1.5
seasonone	weektwo	2106	2	1	W	6	10	8	0	1.2
seasonone	weektwo	2107	2	1	W	7	7.8	6	4	1.5
seasonone	weektwo	2108	2	1	W	8	7	7	0	1.5
seasonone	weektwo	2109	2	1	W	9	8	9	0	1.6
seasonone	weektwo	2110	2	1	W	10	7.7	8	0	1.3
seasonone	weektwo	2201	2	2	C	1	9	9	2	1.5
seasonone	weektwo	2202	2	2	C	2	6.8	8	3	1.6
seasonone	weektwo	2203	2	2	C	3	5	7	3	1.7
seasonone	weektwo	2204	2	2	C	4	5	6	0	1.2
seasonone	weektwo	2205	2	2	C	5	8	11	2	1.9
seasonone	weektwo	2206	2	2	C	6	7	10	1	1.5
seasonone	weektwo	2207	2	2	C	7	7	6	4	1.6
seasonone	weektwo	2208	2	2	C	8	8	13	4	1.7
seasonone	weektwo	2209	2	2	C	9	6.5	10	4	1.4
seasonone	weektwo	2210	2	2	C	10	5.7	8	2	1.2
seasonone	weektwo	2301	2	3	W+C	1	9	10	2	1.8
seasonone	weektwo	2302	2	3	W+C	2	8.3	14	4	1.7
seasonone	weektwo	2303	2	3	W+C	3	6.8	7	0	1.6

PlotNo	Block	Treat	Trt Name	Plant		days to 50% flowering	no of capsules week 7	no of capsules week 8	seeds per capsule
1101	1	1	W	1	36	44	0	1	88
1102	1	1	W	2			0	3	72
1103	1	1	W	3			8	18	48
1104	1	1	W	4			3	9	64
1105	1	1	W	5			0	0	76
1106	1	1	W	6			0	0	60
1107	1	1	W	7			0	2	52
1108	1	1	W	8			0	0	64
1109	1	1	W	9			0	0	56
1110	1	1	W	10			0	0	60
1201	1	4	None	1	36	47	0	0	60
1202	1	4	None	2			0	0	64
1203	1	4	None	3			0	4	68
1204	1	4	None	4			0	6	60
1205	1	4	None	5			0	20	64
1206	1	4	None	6			0	0	68
1207	1	4	None	7			0	0	52
1208	1	4	None	8			5	17	60
1209	1	4	None	9			6	2	48
1210	1	4	None	10			0	3	56
1301	1	3	W+C	1	38	42	4	15	76
1302	1	3	W+C	2			7	9	60
1303	1	3	W+C	3			3	3	76
1304	1	3	W+C	4			1	3	76
1305	1	3	W+C	5			6	13	64
1306	1	3	W+C	6			10	15	72
1307	1	3	W+C	7			0	0	60
1308	1	3	W+C	8			0	0	52
1309	1	3	W+C	9			0	0	80
1310	1	3	W+C	10			0	7	64
1401	1	2	C	1	40	42	7	22	72
1402	1	2	C	2			12	11	80

1403	1	2	C	3			4	10	76
1404	1	2	C	4			0	0	64

APPENDIX B: EXPERIMENTAL SITE PHOTOS

Figure 16: Field Set up

Figure 17: Examining the effect of Webworm, Phyllody Disease and Alterenia Blight

Figure 18:Phyllody disease signs

Figure 19: Alterneria blight signs

Figure 20: Sesame webworm signs

Figure 21: Measuring Soil Treatments (Chicken Manure and Wood Ash)

APPENDIX C: RESEARCH TIME FRAME

Table 31: Research Time Frame

No	Item	2018	2019	2020
1	Development of a Research Topic/Concept			
2	Chapter one: Introduction			
3	Chapter two: Literature Review			
4	Chapter three: Materials and Methods			

5	Development of Data Collection Tools			
4	Set of the Experiment			
5	Data Collection			
6	Data Entry & Editing			
7	Data Analysis			
8	Presentation of Results and Findings			
9	Development of the Research Report			
10	Submission of the 1st draft of the Dissertation			
11	Review of the Superviusors Comments			
12	Submission of the Final Copy of the Dissertation			

APPENDIX D: RESEARCH BUDGET

Table 32:Research Budget

No	Item	Quantity	Cost Per Item	Amount(UGX)
1	Seeds	2	4000	8000
2	Soil treatments	3	12000	36000

3	Tape measure	1	10000	10000
4	Rope	1	3000	3000
5	Pens	2	500	1000
6	Data sheets	8	1400	11200
7	Ruler	1	1700	1700
8	Airtime	1	20,000	20000
9	Printing	3	35000	105000
10	Total			195,900

APPENDIX E: MAP OF MPIGI DISTRICT SHOWING EQUATOR VALLEY FARM IN NKOZI SUBCOUNTY

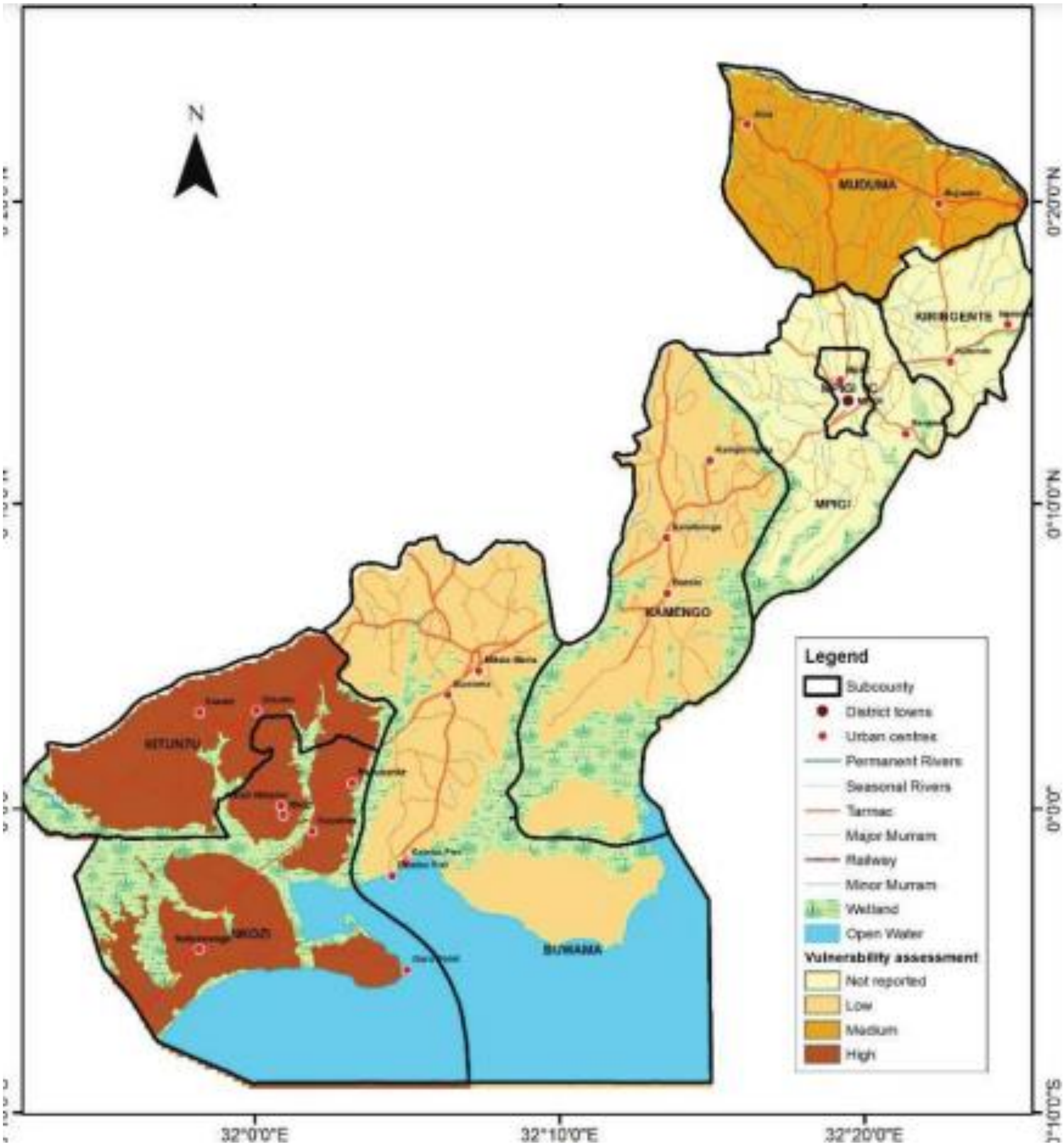

Figure 22: Map of Mpigi District Showing Nkozi Sub County