BINDURA UNIVERSITY OF SCIENCE EDUCATION

CROP SCIENCE DEPARTMENT

EVALUATION OF MULCHING MATERIAL AND VARIETY ON GROWTH, YIELD AND PEST TUBER DAMAGE OF SWEET POTATO (*IPOMOEA BATATUS*) UNDER RAIN-FED CONDITIONS.

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DEDICATION

I am grateful to my wife and children for their moral support, financial assistance and their motivation to help me pursue with my educational path. This dissertation is evidence of your unwavering support and love which is irreplaceable.

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I, Donald Pfekenye, (B224241B) hereby declare that this research report is the product of my own original work, conducted independently. I have properly cited all references and sources used in this study. Furthermore, I confirm that this report has not previously submitted for any academic test or research project.

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I have supervised the research project for the above-mentioned student and I am convinced that the research can be submitted.

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ABSTRACT

Poor rainfall distribution, high temperatures, pests' outbreak among others are major threat to sweet potato production especially to small holder farmers who rely on rainfed. The study was conducted to evaluate the effects of plastic mulch and organic mulch on two sweet potato varieties under rain-fed conditions. The main objective was to evaluate the effect of plastic mulch and organic mulch on plant growth, tuber yield and tuber pest damage of two sweet potato varieties. The field experiment was laid out in a Randomized Complete Block Design (RCBD) as 2x3 factorial treatment structure with 6 treatments replicated 5 times. There were two factors: variety and mulch. The varieties were, Kakamega (intermediate orange fleshed sweet potato) and German II (white fleshed sweet potato). Mulches used were black polythene plastic and grass as organic mulch. The experiment was carried out in Buhera District. Growth parameters data was collected at 4 weeks after planting (WAP), 8WAP, 12WAP and 16WAP. Yield and pest damage data was collected at harvesting (16 WAP). Analysis of variance (ANOVA) was done using GENSTAT Discovery 3rd Edition. The results showed that plastic mulch have a positive impact on vine branching, number of leaves produced and vine length. On survived plants, it had a negative effect while organic mulch and control performed very well on sustaining plant life. Kakamega variety had a greater number of leaves, more branches and longest vine length than German II. There was no significant difference ($p>0.005$) in tuber yield (t/ha), but there was significant difference ($p=0.011$) in number of tubers produced. There was no interaction effect of mulching material and variety on yield. There was no significant effect of variety on yield parameters. Organic mulch had highest number of tubers produced. Mulching material effect on tuber pest damage was highly significant ($p<0.001$), with organic mulch having highest number of tubers damaged and plastic mulch having the least. There was no interaction effect of mulching material and variety on tuber damage by pests ($p>0.05$). There was also no significant effect of variety on tuber damage ($p>0.05$). Overall results indicate that mulching material has its own advantages and disadvantages, but plastic mulch had more positive impacts as a mulching material. Farmers are recommended to use plastic mulch if they have problems of soil pests and if they want big sized tubers or use organic mulch with pest repellent effect if they want a greater number of tubers but in small sizes. The researcher advises researchers to have further research on the best time to apply plastic mulch soon after planting to minimize desiccation of sweet potato vine at the initial plant growth stages.

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CHAPTER 1: INTRODUCTION

1.1 Study background

Sweet potato *(Ipomoea batatas)* is one of the most important crops that is widely cultivated in several countries worldwide and is ranked as the seventh most cultivated crop (Qin and D'Cunha, 2022). According to Gwari (2020), says that there is an increase in sweet potato production as a commercial crop in Zimbabwe due to its various advantages as compared to other tuber and root crops. The crop yields highly while demanding minimal inputs requirements. Sweet potato is also easy to preserve which can

Sweet potato production as a commercial crop in Zimbabwe has been on the rise over the years due to its various advantages as compared to other tuber and root crops. It requires few inputs while producing high yield. The crop has significant benefits particularly in the face of climate change which Zimbabwe is currently experiencing. The ability of sweet potato to store positions them as a vital famine reserve crop, particularly as the country grapples with intensifying effects of climate change (Gwari, 2020).

Sweet potatoes stand out as the most nutritious crop containing the highest levels of minerals, vitamins and protein. Some of pink or orange fleshed sweet potatoes are sweeter and moister than those white or pale-yellow flesh (Brazier, et al., 2024). Sweet potato is a crop cultivated in most parts the country as food security crop. In the past 15 years, there was a sharp increase in sweet potato production from less than 10 000 tons annually to over 200 000 tons per year (Neurashe, 2019).

The International Potato Center (CIP), in collaboration with its partners, has developed new and improved Orange Fleshed Sweet Potato (OFSP) varieties that have possess desirable traits for smallholder farmers which have high dry matter content with high yield potential, drought tolerance and early maturity (Jogo, et al., 2021). Some of the OFSP varieties are resistant to weevils or avoidance (Clearinghouse, 2020). Additionally, OFSP varieties are enriched with high levels of vitamin A, B, C, E and K, making them nutritious food source. They are also rich in dietary fiber and contain beneficial compounds like phenolic acids and anthocyanins (Brazier, et al., 2024).

Historically, Sweet potato (Ipomoea batatas (L.)Lam) are not native to Africa but were domesticated in tropical America over 5000 years ago. Central America is believed to be the centre of origin for sweet potatoes, from where they were introduced to Africa by Portuguese traders in the 16th century. The crop likely entered Africa through Angola and Mozambique, gradually spreading to the interior regions (Stathers, et al., 2018).

Sweet potatoes can thrive in warm-weather with optimum temperatures above 24°C, ample sunshine, and well-distributed annual rainfall of 750 – 1000mm (Ngeve, et al., 1992). Despite of their importance in addressing poverty in rural communities as well as health and food security in Africa, the crop production faces significant challenges of sweet potato weevil infestation specifically *Cylas sp* (Coleoptera: Apionidae) and *Cylas puncticollis* Boheman as well as *C. brunneus* Fabricius (Andrade, et al., 2009). Moisture levels have a notable impact on sweet potato weevil occurrence (Parr, et al., 2014). Higher weevil incidence is often associated with lower rainfall levels as these pests struggle to invade on wet soils than dry soil (Wijimeersch, 2000). Orange sweet potato varieties are early maturing varieties that can be harvested early during the season before the soil becomes dry and cracked, allowing sweet potato weevils to penetrate the soil to the tubers (Nakibuuka, 2020).

Zimbabwe is experiencing some effects of climate change and economic shocks. Droughts, poor rainfall distribution, and low yields are the major drivers of food insecurity in communal areas (Mushayavanhu, et al., 2022). Adequate soil moisture is very important for optimum plant growth of sweet potato. According to Edem, et al (2024), says that mulching is important to retain moisture for sweet potatoes to achieve faster germination and high growth rate. Mulching plays a pivotal role on regulation of soil temperatures and soil moisture conservation for tuber crops like sweet potato (Sapakhova, et al., 2024). Therefore, the researchers' aim is to evaluate the effect of plastic mulch and organic mulch on plant growth, tuber yield and tuber pest damage of two sweet potato varieties.

1.2 Problem statement

Climate change is expected to continue disrupting global agricultural systems, altering weather patterns, depleting water resources, harming marine ecosystems (Partey, et al., 2018). The convergence of climate change and rapid population growth possess a substantial threat to food and livelihood security, particularly in developing nations (Zougmore, et al., 2018). Key factors affecting food production are rising temperatures, unpredictable rainfall, increased pest and diseases outbreak. Climate change is already exacerbating droughts and floods (Assan, et al., 2018). Rising temperatures results in increasing of evaporation leading to high intensity of precipitation from high water vapour in the air. These changes are directly responsible for the increased frequence of severity weather events and flooding (Wasko and Sharma, 2017).

Based on AGRITEX reports, Buhera district is also facing some challenges of prolonged dry spells and heat waves which may lead to high evapotranspiration resulting in reduced yields. Over the past two years (2022/23 season – 2023/24 season), the district has experienced a shortened rainy season, characterized by rainfall cessation in February and this contributed to poor yields of majority crops including sweet potato. Sweet potatoes were also heavily infested by underground pests especially sweet potato weevils; hence, quality of tubers were compromised. The district is also experiencing some periodic floods which results in washing away of plant nutrients.

Mulching is vital agriculture technique that significantly influences the hydro-thermal regimes of soils weed suppression, soil health conditioning and soil physical environment (Kumar, et al., 2021). Mulching is a widely adopted practice that have a significant influence on soil properties, thereby affecting crop growth. Mulches can promote good soil aeration and regulate microbial diversity, creating a favourable environment for microbial activities, thereby facilitating nutrient cycling (Kumar, et al., 2024). Generally, sweet potato weevils struggle to penetrate wet soils than dry soils (Wijimeersch, 2000). Mulching can also act as a physical barrier to prevent weevils to reach the roots (Nottingham and Kays, 2002).

1.3 Justification

Moisture conservation is crucial aspect in crop production especially in semi-arid regions or in areas with limited water resources. Mulching can be used for moisture conservation and there is various mulching material that can be used to conserve moisture. Various mulching materials have their own advantages and disadvantages, meaning that selection of a mulching material depends with the farmers preference and availability but they can serve the same purpose mainly on soil and moisture conservation.

Plastic mulch can be used to suppress some of other microorganisms found in the soil by reducing oxygen content in the soil and increased temperatures. Black polythene plastics can be used to solarize the soil to kill weed seeds, and to suppress pests and diseases. Plastic mulch can also help to reduce washing away of nutrients from the ridges because of its impermeability.

Organic mulch is good for moisture conservation and increased water infiltration by reducing water runoff. Organic mulch can also increase soil fertility due to decomposition as time progresses. Organic mulch can also regulate soil temperatures.

Investigating the effects of different mulching material can assist on selecting the best mulching material for moisture conservation to produce increased yield of high quality. Investing on sweet potato researches to increase crop yields may increase sweet potato production in the country.

1.4 Aim/Main Objective

To evaluate the effect of plastic mulch and organic mulch on plant growth, tuber yield and tuber damage by pests on two sweet potato varieties.

1.4.1 Specific Objectives

- To assess the impact of mulching material and variety on sweet potato plant growth (survived plants, vine branching, vine length, number of primary vine leaves, total number of leaves produced per plant).
- To determine the effect of mulching material and variety on sweet potato yield.
- To compare the effect of mulching material and variety on sweet potato tuber pest damage.

1.5 Hypothesis

- Mulching material and variety have significant effect on sweet potato plant growth.
- Mulching material and variety have significant effect on sweet potato.
- Mulching material and variety have significant effect on sweet potato tuber pest damage.

CHAPTER 2: LITERATURE REVIEW

2.1 Taxonomy

The sweet potato is a perennial plant, belonging to the Convolvulaceae family. It is a crop recognized for generating tuberous roots that are used worldwide for various purposes (Cartabiano-Leite, et al., 2020). The genus of Convolvulaceae is *Ipomoea* and the specie is *Ipomea batatas.* Convolvulaceae family is commonly referred to as the morning glory family of flowering plants. Members of this family are also found in both tropical and in the temperate environments. Many members of the family are identified as erect plants and twining herbs, trees, shrubs or woody vines. *Ipomoea* is the genus with over 500 members and it is one of the largest genera under Convolvulaceae. These plants thrive in warm climates and include herbaceous plants, shrubs and trees characterized by funnel shaped flowers. *Ipomoea batatas* is a native to tropical America widely cultivated food plant. It is a herbaceous perennial vine with heart-shaped lobed leaves producing purplish flowers and large nutritious tuberous roots (Bioweb, 2024).

2.2 Economic importance

Sweet potatoes hold a prominent position globally as food crop, with their production volume ranking seventh worldwide. Cultivated across approximately 9 million hectares, they yield around 140 million tons, averaging about 14 tons per hectare (FAOSTAT, 2001). In regions such as Asia, Africa, and the Americas, sweet potatoes are fundamental staple food, contributing significantly to the diets of many (Cartabiano-Leite, et al., 2020). Sweet potatoes have immense potential as a food crop, ranking high among cultivated crops in the developing countries due to their edible energy produced per unit area per unit time. It is grown for their root tubers and starch used in industry. Sweet potato importance has increased due to its potential for producing ethyl alcohol from starch. The crop is also an excellent source of fibre, vitamin B6, E and C and it is good for the heart health and digestion and good level of starch. It also low glycaemic index which helps in controlling blood sugar (Atal and Narolia, 2021).

2.3 Sweet potato production

Sweet potato is tropical root crop that requires long periods of sunshine, liberal amount of rainfall and warm temperatures throughout the production period. Although sweet potato may be produced under a wide range of temperatures (Dhliwayo, et al., 2004), but it requires moderate temperatures of 21-26°C (Nedunchezhiyan, et al., 2012).

2.3.1 Global sweet potato production

Sweet potatoes are hardy food crop that can thrive in poor soils producing tuberous roots at a lower agriculture production cost. They are highly efficient in converting energy per unit area, per unit time resulting in high yield. In 2018, Asia had the largest sweet potato production accounting for 66% of the total harvest. Africa followed with 28.3%, while America produced approximately 4.6% then Oceania and Europe produced 1% and 0.1% respectively (Cartabiano-Leite, et al., 2020).

2.3.2 Sweet potato production in Zimbabwe

In Zimbabwe, sweet potatoes are of economic importance as a component of their diet for both rural and urban communities particularly due to the rising costs of bread and other starch-based foods (Mutandwa and Gadzirayi, 2007). The sweet potato varieties grown in Zimbabwe are mostly white fleshed, although a few farmers especially large-scale commercial ones, grow OFSP varieties (Jogo, et al., 2021). The main production zones for sweet potatoes in Zimbabwe are in Mashonaland Central, Mashonaland East, Mashonaland West, Manicaland, Masvingo, and Midlands. In terms of natural regions, the crop is grown mainly in Agro-ecological Zones I, II, and III (Mutandwa, 2008).

2.4 Sweet potato varieties

The most cultivated sweet potato varieties in Zimbabwe are; Chingovha, German two, Mozambique White, Brondal, Cordner, Pamhai and Magutse (DR&SS, 2016). Each variety is described in terms of its characteristics, such as leaf shape, flower structure, tuber skin colour growth habit and physiological maturity period.

Germany II – It is a widely grown sweet potato variety in Zimbabwe and that produce red skinned and white fleshed tubers. Its tubers are sweet long and are starchy which stores well. It is an early maturing variety which takes 3 – 4 months yielding up to 30 t/ha. This variety is very popular at the vegetable markets of Gweru and Bulawayo.

Chingovha – is an early maturing variety with cream skin and fresh long starch tubers. It is very popular at Mbare vegetable markets.

The Mozambique White sweet potato variety takes long period to mature which is up to six months yielding tubers with reddish skin and white flesh. Brondal variety has light red skin and cream-coloured flesh, characterized by its cylindrical shape and large tuber size, making it effortless to harvest.

Cordner is an orange fleshed sweet potato with bronze-coloured skin short tubers which are rich in carotene. Magutse is a khaki skin and light cream flesh which takes 4 – 5 months to mature. Pamhai is a pale skin and cream flesh which produces long thick tubers and yields up to 30 t/ha (DR&SS, 2016).

Kakamega is an early maturing (4 months) spreading variety producing vines with more than 100 cm in length. It has 5 lobed thin leaves. Tubers are long and irregular shape with purple red skin colour. It is an intermediate orange fleshed sweet potato variety (Kapinga, et al., 2010).

In Zimbabwe, CIP had introduced biofortified orange fleshed sweet potatoes (OFSP) varieties which are; Alisha, Victoria, Delvia, Sumaia, Namanga and Irene as. Trials conducted under different agroecological environments proved that Alisha was more adaptable to different climatic conditions giving high stable yields as compared to other commercial varieties (Gwaze, 2021). CIP catalogue have 29 sweet potato varieties including orange fleshed sweet potato varieties. According to Stathers, et al (2018) sweet potato varieties may have different names for the same varieties and vice versa.

2.5 General Agronomy

Sweet potato is planted on mounds or raised beds. Mounds or raised beds provides favourable conditions for root development. Tuber development requires loosened friable soil to expand to their potential size and shape (Gwari, 2020). Slips (vine cuttings) should be selected from plants which are healthy, vigorous and free from pests and diseases (Mohansingh, 2012) and they are propagated at an angle of about 45 degrees to even root development. Slightly above half of the slips (3-4 nodes) should be placed and buried at 30cm apart (Gwari, 2020). Planting should be done at the onset of the rainy season for rainfed crop (Dhliwayo, et al., 2004).

Sweet potato crop is very tolerant in a pH range from 5.5 and 6.8. However, the optimum soil pH for high yields of quality sweet potatoes is 5.8 to 6.0. Lime is applied if the soil pH is very low (Brandenberger, et al., 2022). Generally; 300kg/ha of Compound D can be used as a basal fertiliser application in the production of sweet potatoes. Other fertilisers like Compound C or Compound M or any other fertiliser with a high potash or "K_2O" ratio can be applied. A single application of AN (34.5%N) at 120kg/ha and 250kg/ha. Murate of Potash (MOP) (60% K_2O)

is used for top dressing plants as soon as they are established in the field. (Dhliwayo, et al., 2004) Ideally, a soil test is the best guide for determining the types and amounts of fertilisers to be used. Nitrogen and phosphorus are required in moderate amounts with a significant amount of potassium. Low potassium exhibits low yields and increased number of poor and slender roots (Mohansingh, 2012). Organic fertiliser can also be applied in the soil because it can improve the physical, chemical and biological soil (Adiningsih, 1996).

Mulches found to be very useful in crop production as they help in soil and moisture conservation, controlling of pests, soil healthy as well as improving microbial activities in the soil (Khawar, 2019). Application of mulch on the soil surface maintaining ground cover soon after planting, help to reduce soil moisture loss and minimize sweet potato weevil infestation through soil cracks (Stathers, et al., 2018).

2.6 Mulching

Mulching has positive impacts to smallholder farmers who relies on rainfed copping production due to various benefits to the rhizosphere (Sangakkara, et al., 2006). It involves applying a protective layer of natural or inorganic on topsoil, which reduces moisture loss from the soil and suppress weeds while improving the soil (Khaskheli, et al., 2022). This is a common practice in small holder farming under rain fed ecosystem aiming to regulate soil temperature and moisture conservation. It also augments the rhizosphere microflora (Kundu, et al., 2006).

Types of mulching material are organic mulches and inorganic mulches. Organic mulches can rapidly decompose adding organic matter and nutrients in the soil. Inorganic mulching material includes, gravel, pebbles, crushed stones and plastic mulch. (Telkar, et al., 2017).

2.6.1 Effects of different mulching material

Natural mulches, including straw, manure, hay, grass, or leaf matter offer several advantages to natural farms. They enhance the overall quality of the soil by increasing overall soil moisture, soil porosity and water retention. Additionally, mulching improves soil vitality and increases nutrient availability (Khaskheli, et al., 2022). Organic mulch plays a vital role in depositing beneficial chemicals into the soil. Organic mulch application increases soil organic matter content (Paustian, et al., 1997).

Organic mulch also reflects solar radiation keeping the soil cooler and preventing moisture loss through evaporation. Covering the soil with organic mulches suppress weeds germination because due to shortage of light for germination and growth. Organic mulch promotes water infiltration during precipitation; hence, the soil erosion is reduced by minimizing water runoff (Telkar, et al., 2017). Decomposition process of organic matter is slow and this increases organic content in the soil and keeping it loose. These organic contents become food for the useful earthworms and other micro-organisms available in the soil (Ranjan, et al., 2017).

Research conducted by Dumbuya et al., (2021) says that using green, black and white plastic mulch proved that higher temperatures significantly increase vine elongation, branching, and leaf appearance. Increased temperatures led to notable increase in leaf chlorophyl content and stomatal conductance. The application of plastic mulch in cooler temperatures appears to enhance the above-ground growth of sweet potatoes substantially (Dumbuya, et al., April 2021). Changes in soil conditions such as increasing soil temperature, reducing evaporation from the soil surface, reducing leaching of nutrients and reducing the growth of weeds are some of the effects of plastic mulch (Gao, et al., 2019). Research conducted by Romic (2003) proved that black plastic mulch can last longer as an impermeable material avoiding nitrate leaching from beds during the rainy season. The advantages of using plastic mulch are increasing water use efficiency, weed control, protecting soil from crusting, increasing soil fertility, preventing temperature fluctuations and moisture stress (Heidari and Aliakbari, 2024). It is also used for soil solarization (with transparent plastic mulch controls disease and pests) (Telkar, et al., 2017).

In Korea in the 1980s quality sweet potatoes were produced through use of polyethylene film mulching method (Jeong, 2000). In Tiwan, weevil infestation was controlled by use of rice straw and black plastic mulches although there was no significant difference in terms of yield obtained from to non-mulched plots (AVRDC, 1987). In study done in United States Virgin Islands, increased yields of sweet potatoes were achieved from plastic and grass mulch (Crossman, et al., 1998).

2.7 Pest and Disease Management

Pests and diseases are organisms which pose a significant threat to the life, quality and yield of crops. These organisms include fungi, bacteria, viruses, nematodes, insects, mites, snails and weeds (Shivanna and Sita, 2012) . Crop yield reduction (yield loss) in form of quantity and/or quality is due to biotic or abiotic factors occurs in the field (pre-harvesting) during harvesting after i.e in the storage (post-harvest) (Oerke, 2006). A survey study undertaken by Sikhu, et al (2019) in Burundi revealed that an estimate of 26% of sweet potatoes were lost due to pests and diseases. Effective pest and diseases management plays a crucial role in stabilizing food production at the household level by minimizing pre and post-harvest food losses.

2.7.1 Sweet potato pests

Common pests that are found at seedling and vegetative stages are; cutworms, grasshoppers, armyworm, sweet potato weevil and sweet potato borer. Pests that are found at reproductive and maturity stages are white grub, wireworm, sweet potato vine borer and sweet potato weevil (Bissdorf and Weber, 2011). Whiteflies, leafminers and other leaf pests are not very common. The most devastating pest is sweet potato weevil *Cylas formicarius* which feeds on roots and tubers (Martini, 2021). Another pest of economic importance is sweet potato vine borer which cause damage on vines causes wilting and poor growth. It can be controlled by avoiding planting of sweet potato for consecutive seasons in the same field (Bissdorf and Weber, 2011) on the same piece of land.

There are various soil pests that cause tuber damage, thereby reducing yield and quality of sweet potato. These pests include sweet potato weevil, white grubs and wireworms. White grubs can be controlled by ensuring proper drainage, as grubs love moist soils. Flooding fields can control wireworms, during sunny weather (Bissdorf and Weber, 2011). Sweet potato weevil poses a significant threat to sweet potato production in tropical and subtropical regions, causing damage to the crop both in the field and during storage (Smith and Beuzelin, n.d.). There are various methods of controlling pests such as cultural control, biological control and chemical control.

Parasitoids and the fungus *Beauvaria bassina* can be used as biological control agents that can be applied to the crops. Fire ants are also good predators to control sweet potato weevil (Martini, 2021). Pheromone traps are also effective to attract, trap and eliminate male weevils. Chemical control guided by the manufacturer's recommendations can also help to control pests (Ram, 2016).

Cultural practices such as turning down the soil two to three months help to reduce weevil problems. Weeds for future use like mulching should be controlled. (Martini, 2021). Irrigate field at least once per week. Cracks in dry soil allow weevils to enter sweet potato roots, lay eggs, and feed Harvest within 2-3 months of crop maturity; leaving the crop for more than 3 months after maturity results in buildup of large numbers of weevils and high levels of damage to the crop. After each harvest, collect and bury/burn all damaged roots and old vines (CARDI-Factsheet, 1995).

2.7.2 Diseases of sweet potato

Sweet potato plants are susceptible to various diseases, including virus (SPVD), fungal, and bacterial diseases. Fungal diseases typically cause lesions on foliage and stem which are circular brown or blackened areas. Other symptoms may include powdery areas, or clusters of hyphae (Stathers, et al., 2018). Disease reduce yield by causing leaf and stem blights, scab and scurf resulting in less vigour, wilting and death of the plants causing root rots in the field and in storage, thus decreasing the amount of consumable and marketable roots (Dhliwayo, et al., 2004). Destroying and burning of crop residues as well as use of clean planting material can help to control sweet potato diseases. Crop rotation and sanitation are also effective as the fungus survives in affected crop debris. For virus diseases, always use propagating material from healthy-looking plants (Stathers, et al., 2018).

2.7.3 Mulching on pest and disease management

Mulches contribute to suppress pests by acting as a physical barrier to limit access of pests to vulnerable crop parts (Hue and Low, 2015). Soil microorganisms respond directly to environmental changes and can grow rapidly under favourable conditions. However, plastic film mulching can increase soil moisture and temperature and can change the biological characteristics of the soil (Xu, et al., 2006). Egg-laying process of sweet potato weevil can be physically hindered by plastic film because the ovipositor fails to penetrate to the surface of the base of the stem. Additionally, plastic mulch UV light can confuse adult weevils, deterring them from laying eggs on plants (Prayogo, et al., 2023). Notably, clear plastic mulch has proven to be more effective in deterring aphids compared to black plastic mulch and traditionally bare-root production methods (Faria-Larios and Orozco-Santos, 1997). Other researches suggests that among coloured plastic film mulches, white and clear plastic film are particularly effective in repelling whiteflies and aphids (Brown, et al., 2019). Dry cypress, eucalyptus, and lucerne are used as effective organic mulch to control weevil population (Martini, 2021). Organic mulches can harbor natural enemies for other pests (Gill, et al., 2011). However, many organic mulches can create breeding spots for insects and pests (Ranjan, et al., 2017).

CHAPTER 3: MATERIALS AND METHODS

3.1 Study site and description

The research study conducted at Mugumbate homestead field, Mavhimira village in Ward 4 under Chief Nerutanga. Buhera District. This area is located at the western side of the district under Natural Region IV of Zimbabwe's agroecological zones. The area is situated at an altitude of 1156 meters above sea level. The GPS Coordinates are as follows; Latitude is -19.3500152, Longitude is 31.3932017. The site has well drained brown sandy loam soils. The site area normally experiences high temperatures as from September to mid-November with a maximum average temperature of 28°C. Cold weather is experienced as from May to mid-August with an average minimum temperature of 15°C.

3.2 Site land preparation

Land preparation was done by end of December and the experimental project started mid-January. Land preparation was done using an ox-drawn plough to loosen the soil before construction of planting ridges. Each block was designed to have 6 beds measuring 2.5 meters. The ridges were 30cm high and 30cm wide with a single row of eight plants. The distance between beds within same block was 40cm apart and blocks were also 90cm apart.

3.3 Experimental design

The experiment was carried out as a 2x3 factorial treatment structure laid in a Randomized Complete Block Design (RCBD) with 6 treatments replicated 5 times. The first factor was mulching material with 3 levels (plastic, organic and control) and the second factor was the variety with 2 levels (Kakamega variety and German II)

The treatment in blocks was set and named in letters representing a treatment as follows;

A – Plastic mulch Kakamega variety

B – Organic mulch Kakamega variety

C – Control variety Kakamega variety

D – Plastic mulch German II variety

E – Organic mulch German II variety

F – Control variety German II variety

The field lay out of the experiment is shown in Table 3.1.

Table 3.1: Experimental field layout

Block 1	**Block 2**	**Block 3**	**Block 4**	**Block 5**	**Block 6**
E	F	A	B	E	F
D	A	C	F	B	D
B	C	F	A	F	B
A	E	B	E	A	E
C	B	D	D	C	C
F	D	E	C	D	A

3.4 Planting

The researcher applied Compound D fertiliser on all beds using a rate of 300kg/ha. The fertiliser was broadcasted and incorporated with soil using a planting hoe. Health vines were selected from an already established sweet potato field and planted in a single row using an in-row spacing of 30cm. Two sweet potato varieties were planted which are, Kakamega variety – an orange fleshed sweet potato variety and German II variety which is very common and adaptive variety to the local environment. No top-dressing fertiliser used due to inadequate moisture to apply the fertiliser as from 6 weeks after planting.

3.5 Mulching

Mulching of the vines were done soon after planting. Grass free from weeds were used as organic mulch and black polythene plastic was also for plastic mulch treatment. A 3m x 0.5m plastic sheet was applied by opening small holes at planting stations along its length.

3.6 Data Collection and Parameters

During plant growth, the researcher collected data using growth parameters which were as follows; Plant count (survived plants), vine branches (primary and secondary branches), Primary Vine length (PVL) measurement, primary vine leaf number (PVLN) and Total Number of Leaves per plant (TNL). For growth parameters, at least three plants were randomly selected from each treatment plot to collect data and find average. Data on number of tubers harvested was collected per each plot and weighed to calculate yield (t/ha) per unit area. Tuber damage was assessed and recorded.

3.6.1 Plant count (Survived plants)

Eight plants were planted per bed, then after every four weeks they were counted and recorded to assess the effects of mulching material on plant health. No replanting was done to replace desiccated or seriously damaged by pests. Plant counting was done at 4 weeks, 8 weeks, 12 weeks after planting and finally at harvesting that is 16 weeks after planting.

3.6.2 Number of branches

Number of branches per plant were counted. Primary and secondary branches were counted and recorded at 4 weeks, 8 weeks and 12 weeks after planting (WAP).

3.6.3 Primary Vine length (PVL)

The vine length measurement was done on the primary vines only and was done using a string and a tape measure. Measurements were recorded in centimeters. Vine length (VL) measurement was done at 4 WAP, 8 WAP and 12 WAP.

3.6.4 Primary Vine Leaf number (PVLN)

Number of leaves of the main (primary) vine branch of three plants were counted, averaged and recorded. This was done at 4 WAP, 8 WAP and at 12 WAP. Three plants per each plot (bed) were measured and averaged.

3.6.5 Total number of leaves per plant

Three plants per plot were randomly selected and counted leaves and calculate average number of leaves per plant at different weeks. First data collection was collected at 4 WAP, then at 8 WAP and finally at 12 WAP.

3.6.6 Number of tubers harvested

Harvesting of sweet potatoes was done at 16 WAP and recorded the counted the number of tubers produced per plot.

3.6.7 Yield calculation (t/ha)

Harvested tubers weighed and recorded. This was done using a digital scale. The following formula was used to calculate fresh tuber yield (tonnes per hectare);

$$\text{Fresh tuber yield (t/ha)} = \frac{\substack{Fresh\ tuber\ weight\ of\ the \\ net\ harvest\ area\ (kg)}}{1000} \times \frac{10000}{Net\ harvest\ area\ (m2)}$$

Where fresh tuber weight of the net harvest area is divided by 1000 to convert kilograms to tonnes; and 10000 is multiplied to convert area from m^2 to hectare (Vandame, et al., 2023).

3.6.8 Number of tubers damaged by pests

During harvesting, tubers were assessed to separate tubers damaged by pests and counted then recorded. This was done to determine the number of tubers damaged when using different mulching material. This data was collected 16 weeks after planting.

3.7 Data analysis

The analysis of variance (ANOVA) of the acquired data were analyzed using GenStat Statistical Package software, 3rd Edition. The mulching by variety treatment differences were determined by using least significant difference procedure (LSD). The differences among treatments were distinguished with Fisher's protected least significant difference test at 5% probability level.

CHAPTER 4: RESULTS

4.1 Effect of mulching material and variety on plant growth

4.1.1 Effect of mulching material and variety on number of plants survived in different weeks (4WAP, 8WAP, 12WAP and 16WAP).

There was a significant interaction effect ($p<0.013$) of mulching material and variety on survived plants throughout the growing period. Kakamega variety under organic mulch treatment and German II variety under control treatment had highest number of plants survived as from 4 weeks after planting (WAP) up to 16 WAP with 8.00 plants. Kakamega variety under plastic mulch had the least number of plants survived with 6.17 plants (Table 4.1).

Table 4.1: Interaction effect of mulching material and variety on plant survival at 4WAP to 16WAP

Treatment	4WAP	8WAP	12WAP	16WAP
Plastic mulch-Kakamega	6.17[a]	6.17[a]	6.17[a]	6.17[a]
Organic mulch-Kakamega	8.00[b]	8.00[b]	8.00[b]	8.00[b]
Control – Kakamega	7.67[b]	7.67[b]	7.67[b]	7.67[b]
Plastic mulch – German II	7.67[b]	7.67[b]	7.67[b]	7.67[b]
Organic mulch – German II	7.67[b]	7.67[b]	7.67[b]	7.67[b]
Control – German II	8.00[b]	8.00[b]	8.00[b]	8.00[b]
Grand mean	7.53	7.53	7.53	7.53
F-prob	0.013	0.013	0.013	0.013
LSD	0.836	0.836	0.836	0.836
CV%	1.7	1.7	1.7	1.7

Mulching material had a significant effect ($p = 0.004$) on plant survival. Treatment under plastic mulch had the least number of plants that were survived as from 4WAP to 16WAP with 6.92 plants and statistically had a significant difference to other treatments. Organic mulch and control had no significant difference, both with 7.83 plants (Table 4.2).

Table 4.2: Effect of mulching material on plant survival at 4WAP to 16WAP.

Treatment	4WAP	8WAP	12WAP	16WAP
Plastic mulch	6.92^a	6.92^a	6.92^a	6.92^a
Organic mulch	7.83^b	7.83^b	7.83^b	7.83^b
Control	7.83^b	7.83^b	7.83^b	7.83^b
Grand mean	7.53	7.53	7.53	7.53
F-prob	0.004	0.004	0.004	0.004
LSD	0.591	0.591	0.591	0.591
CV%	1.7	1.7	1.7	1.7

Variety had a significant effect (p=0.043) on number of plants survived. Kakamega had the least number of plants survived with 7.28 plants while German II with 7.78 plants (Table 4.3).

Table 4.3: Effect of variety on number of plants survived at 4WAP to 16WAP

Treatment	4WAP	8WAP	12WAP	16WAP
Kakamega	7.28^a	7.28^a	7.28^a	7.28^a
German II	7.78^b	7.78^b	7.78^b	7.78^b
Grand mean	7.53	7.53	7.53	7.53
F-prob	0.043	0.043	0.043	0.043
LSD	0.483	0.483	0.483	0.483
CV%	1.7	1.7	1.7	1.7

4.1.2 Effect of mulching material and variety on vine branching at weeks stages

There was no interaction effect (p>0.05) between mulching material and variety on vine branching. Mulching material had a significant effect (p=0.009) on branching of sweet potato vines at 4WAP and had a highly significant effect (p<0.001) at 8WAP, 12WAP and 16WAP. Control treatment had the least number of branches at 4WAP with 2.333 followed by organic mulch (2.667) and lastly plastic mulch with (3.083). Plastic mulch had significant difference with control while organic mulch was intermediate without significant difference with both plastic mulch and control. At 8, 12 and 16 WAP, plastic mulch had the highest number of branches while organic mulch and control had the least number of branches (Table 4.4).

Table 4.4: Effect of mulching material on vine branching

Treatment	4WAP	8WAP	12WAP	16WAP
Plastic mulch	3.083^{b}	8.25^{b}	9.83^{b}	11.50^{b}
Organic mulch	2.667^{ab}	5.00^{a}	6.67^{a}	8.08^{a}
Control	2.333^{a}	5.42^{a}	6.58^{a}	7.92^{a}
Grand mean	2.694	6.22	7.69	9.17
F-prob	0.009	<0.001	<0.001	<0.001
LSD	0.4562	1.357	1.479	1.750
CV%	6.1	6.5	8.2	13.3

Variety had a significant effect (p=0.002) on vine branching. German II had the least with 2.333 and Kakamega with 3.000.

Table 4.5: Effect of variety on vine branching

Treatment	4WAP
Kakamega	3.000^{b}
German II	2.333^{a}
Grand mean	2.694
F-prob	0.002
LSD	0.3725
CV%	6.1

4.1.3 Effect of mulching material and variety on vine length

There was no significant interaction effect (p>0.05) between mulching material and variety on vine length as from 4WAP to 16WAP. There was no significant effect of mulching material on vine length at 4WAP (P>0.05). However, mulching material had significant effect (p<0.05) at 8WAP, 12WAP and 16WAP. Significant differences were noted at 8WAP with plastic mulch having the longest vine length of 128.3cm while organic and control had no significant difference. At 12 and 16WAP the plastic mulch and control had no significant differences but plastic with the longest vine length of 174.8 at 12WAP and 194.6 at 16WAP. Organic mulch and control had no significant difference but organic mulch with the shortest vine, i.e at 152.6 at 12WAP and 171.9 at 16WAP (Figure 4.1).

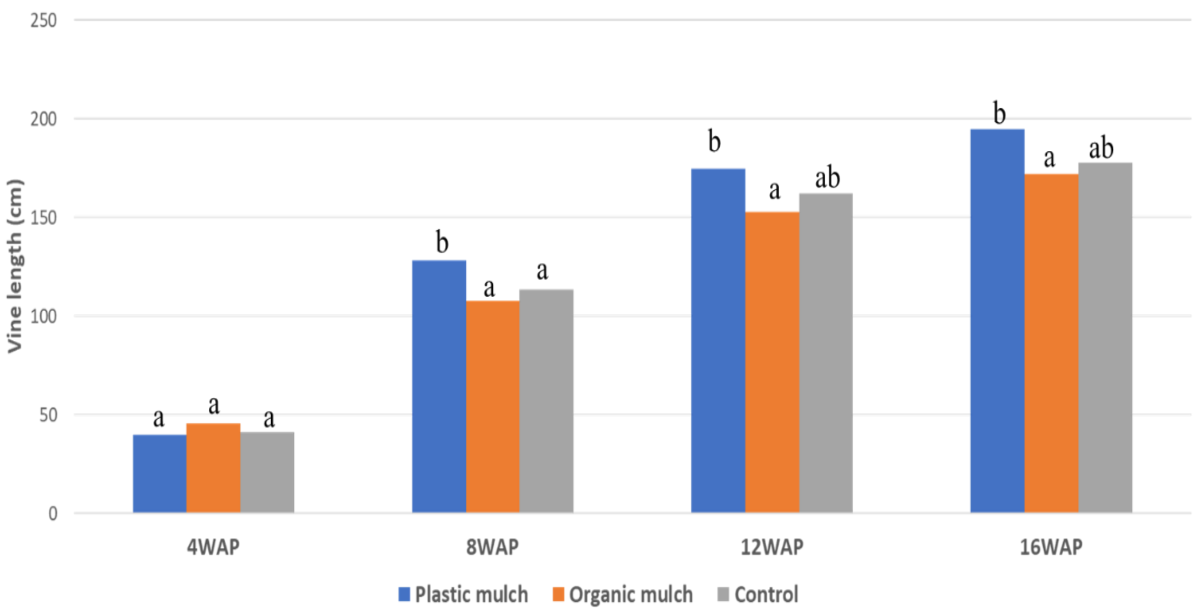

Figure 4.1: Effect of mulching material on vine length

There was highly significant effect of variety on vine length (p<0.001). Kakamega had the longest vine length as from 4WAP with 50.3cm while German II had 34.5cm. Significant difference was highly significant from 4WAP up to harvest (16WAP) with 208.6cm for Kakamega and 154.4cm for German I (Figure 4.2).

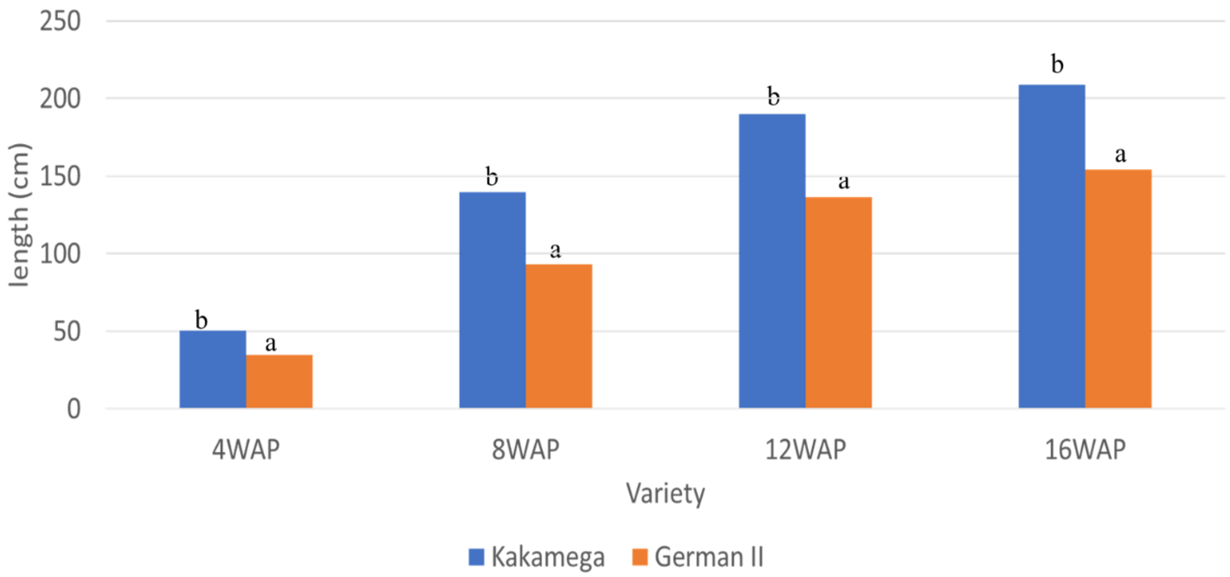

Figure 4.2: Effect of variety on vine length

4.1.4 Effect of mulching material and variety on primary vine number of leaves

There was no significant interaction effect ($p>0.05$) between mulching material and variety on primary vine number of leaves. There was no significant effect of mulching material on primary vine number of leaves ($p>0.05$). However, there was highly significant effect ($p<0.001$) of variety on primary vine number of leaves from 4WAP to 12WAP. Kakamega produces significantly more leaves than German II at 4WAP, 8WAP and 16WAP as illustrated on the Table 4.6.

Table 4.6: Effect of variety on primary vine number of leaves

Treatment	4WAP	8WAP	12WAP
Kakamega	15.67^{b}	31.00^{b}	49.7^{b}
German II	12.72^{a}	24.50^{a}	36.5^{a}
Grand mean	14.19	27.75	43.1
F-prob – Variety	<0.001	<0.001	<0.001
LSD	1.642	4.024	5.25
CV%	4.2	6.9	17.6

4.1.5 Effect of mulching material and variety on total number of leaves produced per plant

There was no significant interaction (>0.05) between mulching material and variety on total number of leaves per plant. There was no significant effect ($p>0.05$) of mulching material on total number of leaves per plant at 4WAP. However, mulching material had significant effect ($p=0.001$) and highly significant effect ($p<0.001$) on total leaf number at 8WAPand 12WAP respectively. Plastic mulch had highest number of leaves followed by control and lastly the organic mulch. Plastic much had 157.8 and 220.8 leaves at 8WAP and 12WAP respectively followed by the control with 116.6 and 166.4 leaves at 8WAP and 12WAP respectively. Organic mulch had 112.9 and 158.4 leaves (Figure 4.3).

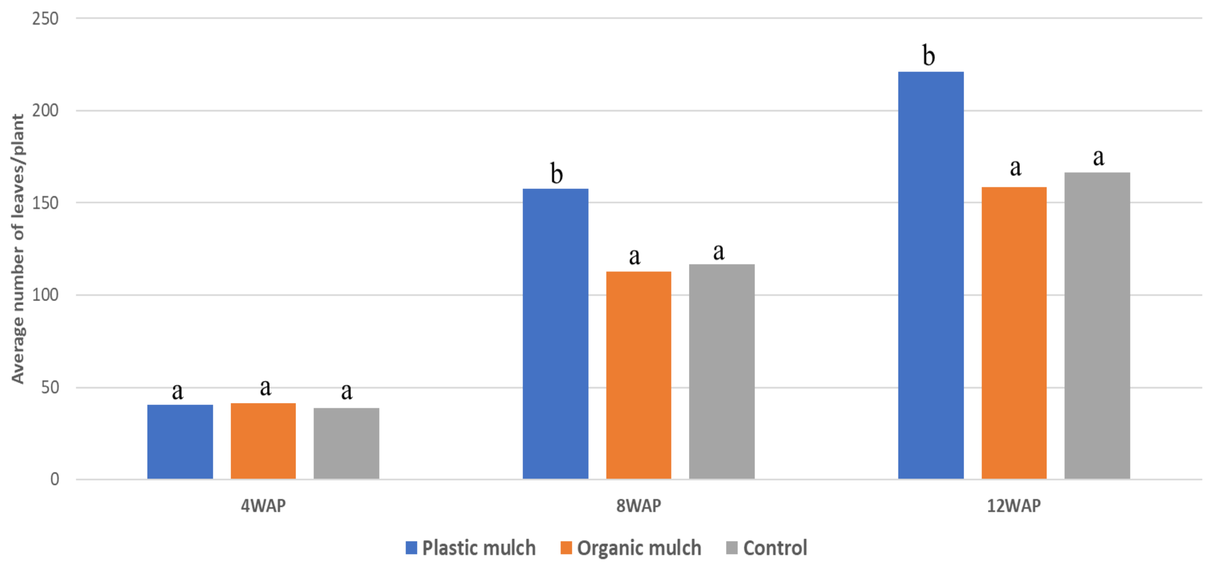

Figure 4.3: Effect of mulching material on number of leaves produced.

Variety had a significant effect on total number of leaves produced per plant, with Kakamega producing higher number of leaves than German II from 4WAP to 8WAP (Figure 4.4).

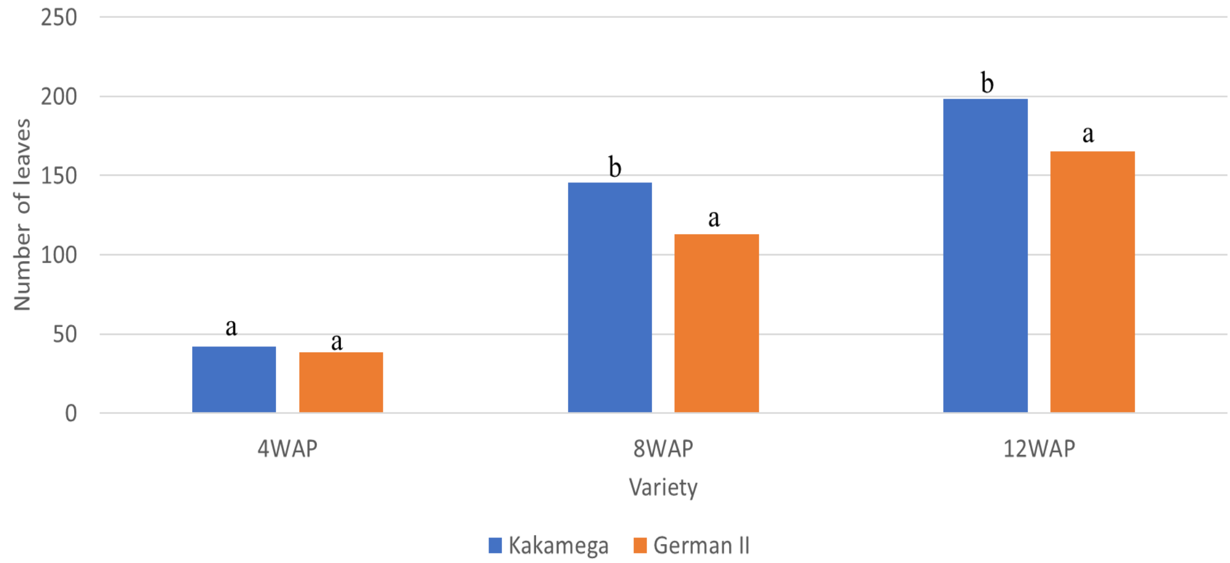

Figure 4.4: Effect of variety on total number of leaves produced per plant.

4.2 Effect of mulching material and variety on yield

4.2.1 Effect of mulching material and variety on number of tubers harvested

There was no interaction ($p>0.05$) between mulching material and variety on number of tubers harvested. There was also no significant effect ($p>0.05$) of variety on number of tubers harvested. However, there was a significant effect ($p=0.011$) of mulching material on number of tubers harvested. Plastic mulch had lowest number of tubers with 23.8 followed by the control treatment (30.1), while organic mulch had the highest number of tubers (35.6 tubers) (Table 4.7).

Table 4.7: Effect of mulching material on number of tubers harvested

Treatment	16WAP
Plastic mulch	23.8^{a}
Organic mulch	35.6^{b}
Control	30.1^{ab}
Grand mean	29.8
Fprob	0.011
LSD	7.42
CV%	7.1

4.2.2 Effect of mulching material and variety on yield (t/ha)

There was no interaction ($p>0.05$) between mulching material and variety on tuber yield(t/ha). There was also no significant effect ($p>0.05$) of mulching material on yield. However, plastic mulch had the highest yield (19.89t/ha), followed by organic mulching (18.69t/ha) and control was the least with 18.48t/ha. There was no significant effect ($p>0.05$) of variety on yield, with German II having slightly more yield (19.30t/ha) than Kakamega variety (18.73t/ha)than .

4.3 Effect of mulching material and variety on sweet potato tuber pest damage

There was no significant interaction ($p>0.05$) between mulching material and variety on number of tubers damaged by pests. There was also no significant effect ($p>0.05$) of variety on number of tubers damaged. However, there was highly significant effect ($p<0.001$) of mulching material on number of tubers damaged by pests, with organic mulch having the highest number of tubers damaged followed by control treatment, and plastic mulch having the least. However, plastic mulch and control treatment had no significant difference. Organic mulch had the highest number of tubers damaged (18.5 tubers), followed by the control with 10.6 tubers, while plastic mulch had the least number of tubers damaged (6.7 tubers) (Figure 4.5).

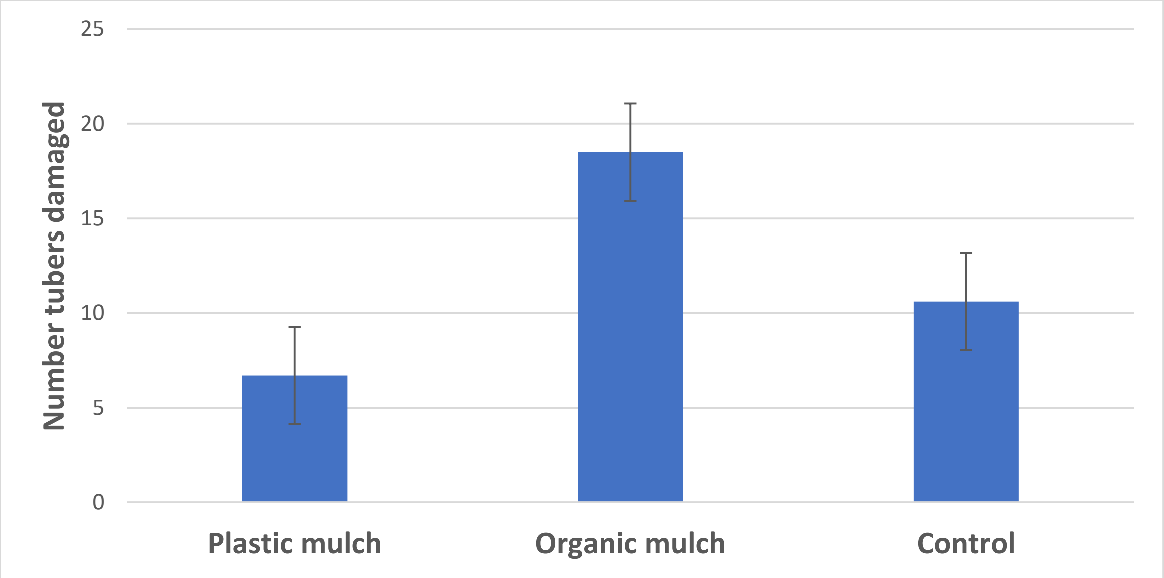

Figure 4.5: Effect of mulching material on tuber damaged by pests

CHAPTER 5: DISCUSSION

5.1 Effect of mulching material and variety on plant growth

5.1.1 Survived plants

Kakamega variety had highest number of survived organic mulch and without mulch with the least under plastic mulch maybe due to high temperatures raised by plastic mulch. German II proved that it is adaptive to the local environment because there was no significant effect observed from using different mulching material or not.

Generally, there was a low number of plants (6.92) that survived or established under plastic mulch while organic mulch and control had highest number of plants survived (7.83). This could be due to high temperatures raised by plastic mulch soon after planting which led to increased water loss and stress on planted vines. The available moisture at planting was favourable for the plants to establish under organic mulch and without any mulching material. According to Ngouajio (2011), the surface of plastic mulch can absorb temperature, which can rise to over 54°C on a clear sunny day which potentially resulting in the desiccation of young plants especially those in direct contact with the plastic mulch.

Kakamega variety had least number of plants survived than German II. Statically it Kakamega had 7.28 plants while German II with 7.78 plants. The differences could be due to genotype response to the local environment described as genotype by environment interactions (Napier, et al., 2022)

5.1.2 Vine branches

The results proved that plastic mulch has a positive effect on branch development sweet potato vines. The control treatment had the least number of branches (2.333), followed by organic mulch (2.667), and plastic mulch had the highest number of branches (3.083) at 4 weeks after planting. At 8, 12, 16 WAP plastic mulch consistently show superior performance due to soil temperature regulation and moisture conservation favourable for the crop. These results concurred with Dumbuya, et al, (2021) who indicated that plastic mulch can promote branching and increase vine elongation. This could be attributed to the fact that there was weed suppression under plastic mulch meaning that there was minimum competition for water and nutrients. Kakamega variety had highest number of branches as compared to German II and this is due to genotypic and phenotypic differences.

5.1.3 Vine length

Vine length differences were noted at 8 WAP, plastic mulch with the longest vine length as compared to the other two treatments (organic mulch and control) and this is in agreement with the research done by Sapakhova, et al. (2024). Plastic mulch remained with the longest vine length for the entire growth although it had no significant difference with control treatment at 12WAP and 16WAP. This proves that plastic mulch promotes vine growth, particularly vine length than organic mulch and control. Kakamega variety had the longest vine length than German II. This is one of the characteristics of Kakamega variety described by Kapinga et al (2010). Vine length which were more than 100cm. Plastic promotes vine lengthening.

5.1.4 Number of leaves of the primary vine

Mulching material had no contribution on number of leaves produced by the primary vine because the results showed that there were no significant differences between different mulching treatment. The differences were noted on varieties. Kakamega had the highest number of leaves on the primary vine than German II and the differences could be attributed to genotypic traits and characteristics of the variety.

5.1.5 Total number of leaves produced per plant

Plastic mulch had a positive effect on promoting foliage accumulation, which is responsible for photosynthesis. Plastic mulch retains heat and moisture better than organic mulch, hence creating more favourable conditions for optimum plant growth. Organic mulch and control showed no significant differences in promoting leaf production, but both had lowest number of leaves produced. Based on similar research results produced by Permanasari, et al (2024) plastic mulch produced higher number of leaves per plant than control and rice straw. Plastic mulch creates microclimate for the plants by raising temperatures and moisture conservation. This enhances metabolic processes such as photosynthesis resulting in high plant growth rate including foliage accumulation (Mahadeen, 2014). Table 5 shows that there were more branches produced under plastic mulch treatment than other treatments, which also have the relation to the total number of leaves produced per plant. Varieties also showed differences in terms of total number of leaves produced. Kakamega remained with the highest number of leaves produced during the entire period of growth than German II which is one of the phonotypic traits that differentiate the two varieties.

5.2 Yield

5.2.1 Number of tubers harvested

The results also indicate that organic mulch had the highest number of tubers harvested (35.6), followed by the control treatment (30.1), and then plastic mulch (23.8). the significant difference between plastic mulch and organic mulch suggests that organic mulch is more effective in promoting tuber number. Organic mulch could have a contribution on soil fertility with time due to degradation of the mulch material. This can add more nutrients to the soil which could have an effect on production of tubers of more tubers per plant.

5.2.2 Yield (t/ha)

The yield produced by two varieties had no significant difference although Kakamega had the least (18.73t/ha) while German II had the highest (19.30t/ha). The slight difference depends on the variety yield potential under its optimum conditions. Plastic mulch treatment had highest yield (19.89t/ha), followed by organic mulch (18.69t/ha) and control had the least with 18.48t/ha. Tuber number and size have a contribution to the final yield because many tubers in small sizes compromises yield. The differences were noted between the three treatments which had significant differences in number of tubers while the final yield had no significant difference. Results from the study conducted by Nair, et al, (2014), statistically shows that mulch material had no significant effect on yield. However, organic mulched sweet potatoes had highest number of tubers but they were small tubers while plastic mulch treatment had large tubers but they were outnumbered by organic mulch treatment. The differences can be attributed to variations in soil temperatures, soil moisture and nutrient availability. Plastic mulch treatment had also fewer plants survived than other treatments from 4WAP to harvesting period (Table 4.2) which could have affected the final yield.

Sweet potato does not need too much nitrogen or very fertile soils because this may result in small tubers and lot of leaves (Becky, 2024). This might be the reason why organic mulch produced large number of tubers but with less weight than of plastic mulch. Plastic mulch had very large tubers but they were fewer than that of organic mulch and control but they obtained highest yield although statistically all treatments had no significant difference. Sweet potatoes require adequate potassium and phosphorus which could be released from the soil mineral due to high temperatures (Zhang, et al., 2022) raised by plastic mulch resulting in big tuber development.

5.3 Tuber pest damage

Plastic mulch had the least number of tubers infested by pests (6.7) followed by control (10.6) and organic with the highest number of tubers damaged by pests (18.5). Organic mulch exhibits highest number of tubers damaged, this is in agreement with Gill, et al. (2011) and Ranjan, et al. (2017) who reported that organic mulch can harbor pests and can create breeding spots for insects and pests. Similarly, Martini (2021) especially if they do not have repellent effect such as dry cypress, eucalyptus, and lucerne which can control soil pests including sweet potato weevil. The organic mulch used was grass mulch from around the experiment site. Plastic mulch had less tuber damage because the plastic mulch acted as a physical barrier to pests which concurs with Nottingham and Kays (2002). Plastic mulch produces high temperatures which could be unfavourable for the soil pests.

CHAPTER 6

6.0 CONCLUSION AND RECOMMENDATION

6.1 Conclusion

Mulching is important in sweet potato production as it regulates soil temperatures and conserves moisture. Plastic mulch proved that it has more advantages in sweet potato production as compared to organic mulch or sweet potato without mulch. Plastic mulch promotes vigorous plant growth followed compared to organic mulch. However, plastic mulch has a negative effect on plant establishment because results showed that plants may desiccate soon after planting due to increased water loss and stress on planted vines.

Mulching type had no significant effect on yield obtained but can affect tuber number. Organic mulch promotes development of more tubers than plastic mulch. Tubers obtained under organic mulch were small to average sizes while tubers obtained from plastic mulch were few but they were bigger which then resulted in no significant difference on yield in t/ha.

Organic mulch has a negative effect on sweet potato in terms of pest infestation as more tuber damage was observed from the treatment. Plastic mulch has a positive effect on sweet potato in terms of pest infestation as a smaller number of tubers damaged by pests were observed from the treatment.

6.2 Recommendations

- Farmers should provide all the required inputs to sweet potatoes for optimum plant growth.
- Farmers should monitor their plants soon after planting if they use plastic mulch so that they can replace desiccated plants.
- Farmers are also recommended to use plastic mulch if they want bigger tubers and to use organic mulch if they want small sized tubers.
- If farmers have decided to use organic mulch, they are recommended to use insect repellent mulching material or pesticides to reduce tuber damage.
- Further research on the best time to apply plastic mulch soon after planting to minimize desiccation of sweet potato vine at the initial plant growth stages is also recommended.

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APPENDICIES

Appendix 1.1.1 Number of survived plants at 4WAP

Source of variation	d.f.	s.s.	m.s.	F. value	F pr.
Block	5	0.4722	0.0944	0.19	
Mulch	2	6.7222	3.3611	6.8	0.004
Variety	1	2.25	2.25	4.55	0.043
Mulch × Variety	2	5.1667	2.5833	5.22	0.013
Residual	25	12.3611	0.4944		
Total	35	26.9722			

Appendix 1.1.2 Number of survived plants at 8WAP

Source of variation	d.f.	s.s.	m.s.	F. value	F pr.
Block	5	0.4722	0.0944	0.19	
Mulch	2	6.7222	3.3611	6.8	0.004
Variety	1	2.25	2.25	4.55	0.043
Mulch × Variety	2	5.1667	2.5833	5.22	0.013
Residual	25	12.3611	0.4944		
Total	35	26.9722			

Appendix 1.1.3 Number of survived plants at 12WAP

Source of variation	d.f.	s.s.	m.s.	F. value	F pr.
Block	5	0.4722	0.0944	0.19	
Mulch	2	6.7222	3.3611	6.8	0.004
Variety	1	2.25	2.25	4.55	0.043
Mulch × Variety	2	5.1667	2.5833	5.22	0.013
Residual	25	12.3611	0.4944		
Total	35	26.9722			

Appendix 1.1.4 Number of survived plants at 16 WAP

Source of variation	**d.f.**	**s.s.**	**m.s.**	**F. value**	**F pr.**
Block	5	0.4722	0.0944	0.19	
Mulch	2	6.7222	3.3611	6.8	0.004
Variety	1	2.25	2.25	4.55	0.043
Mulch × Variety	2	5.1667	2.5833	5.22	0.013
Residual	25	12.3611	0.4944		
Total	35	26.9722			

Appendix 1.2.1 Number of Branches at 4WAP

Source of variation	**d.f.**	**s.s.**	**m.s.**	**F. value**	**F pr.**
Block	5	0.8056	0.1611	0.55	
Mulch	2	3.3889	1.6944	5.75	0.009
Variety	1	3.3611	3.3611	11.42	0.002
Mulch × Variety	2	0.7222	0.3611	1.23	0.31
Residual	25	7.3611	0.2944		
Total	35	15.6389			

Appendix 1.2.2 Number of Branches at 8WAP

Source of variation	**d.f.**	**s.s.**	**m.s.**	**F. value**	**F pr.**
Block	5	4.889	0.978	0.38	
Mulch	2	75.056	37.528	14.41	<.001
Variety	1	1	1	0.38	0.541
Mulch × Variety	2	10.167	5.083	1.95	0.163
Residual	25	65.111	2.604		
Total	35	156.222			

Appendix 1.2.3 Number of Branches at 12WAP

Source of variation	d.f.	s.s.	m.s.	F. value	F pr.
Block	5	11.806	2.361	0.76	
Mulch	2	82.389	41.194	13.31	<.001
Variety	1	3.361	3.361	1.09	0.307
Mulch × Variety	2	8.722	4.361	1.41	0.263
Residual	25	77.361	3.094		
Total	35	183.639			

Appendix 1.2.4 Number of Branches at 16WAP

Source of variation	d.f.	s.s.	m.s.	F. value	F pr.
Block	5	44.333	8.867	2.05	
Mulch	2	98.167	49.083	11.33	<.001
Variety	1	4	4	0.92	0.346
Mulch × Variety	2	8.167	4.083	0.94	0.403
Residual	25	108.333	4.333		
Total	35	263			

Appendix 1.3.1 Primary vine length at 4WAP

Source of variation	d.f.	s.s.	m.s.	F. value	F pr.
Block	5	282.2	56.4	0.46	
Mulch	2	236.1	118	0.97	0.393
Variety	1	2240.4	2240.4	18.41	<.001
Mulch × Variety	2	127.4	63.7	0.52	0.599
Residual	25	3042.4	121.7		
Total	35	5928.6			

Appendix 1.3.2 Primary vine length at 8WAP

Source of variation	d.f.	s.s.	m.s.	F. value	F pr.
Block	5	4767.8	953.6	4.57	
Mulch	2	2718.7	1359.4	6.52	0.005
Variety	1	19553.4	19553.4	93.75	<.001
Mulch × Variety	2	1067.1	533.5	2.56	0.098
Residual	25	5214	208.6		
Total	35	33321			

Appendix 1.3.3 Primary vine length at 12WAP

Source of variation	d.f.	s.s.	m.s.	F. value	F pr.
Block	5	6778.3	1355.7	3.24	
Mulch	2	2985.5	1492.7	3.56	0.043
Variety	1	25546.7	25546.7	61	<.001
Mulch × Variety	2	1360.1	680	1.62	0.217
Residual	25	10470.3	418.8		
Total	35	47140.8			

Appendix 1.3.4 Primary vine length at 16WAP

Source of variation	d.f.	s.s.	m.s.	F. value	F pr.
Block	5	5437.9	1087.6	2.28	
Mulch	2	3324.7	1662.3	3.49	0.046
Variety	1	26623.4	26623.4	55.9	<.001
Mulch × Variety	2	2220.2	1110.1	2.33	0.118
Residual	25	11906.6	476.3		
Total	35	49512.8			

Appendix 1.4.1 Primary vine leaf number at 4WAP

Source of variation	d.f.	s.s.	m.s.	F. value	F pr.
Block	5	10.472	2.094	0.55	
Mulch	2	9.556	4.778	1.25	0.303
Variety	1	78.028	78.028	20.46	<.001
Mulch × Variety	2	6.222	3.111	0.82	0.454
Residual	25	95.361	3.814		
Total	35	199.639			

Appendix 1.4.2 Primary vine leaf number at 8WAP

Source of variation	d.f.	s.s.	m.s.	F. value	F pr.
Block	5	111.58	22.32	0.97	
Mulch	2	32.17	16.08	0.7	0.505
Variety	1	380.25	380.25	16.6	<.001
Mulch × Variety	2	2.17	1.08	0.05	0.954
Residual	25	572.58	22.9		
Total	35	1098.75			

Appendix 1.4.3 Primary vine leaf number at 12WAP

Source of variation	d.f.	s.s.	m.s.	F. value	F pr.
Block	5	1724.56	344.91	8.85	
Mulch	2	1.72	0.86	0.02	0.978
Variety	1	1573.44	1573.44	40.4	<.001
Mulch × Variety	2	52.06	26.03	0.67	0.522
Residual	25	973.78	38.95		
Total	35	4325.56			

Appendix 1.5.1 Total number of leaves per plant at 4WAP

Source of variation	**d.f.**	**s.s.**	**m.s.**	**F. value**	**F pr.**
Block	5	166.81	33.36	1.31	
Mulch	2	32.72	16.36	0.64	0.534
Variety	1	117.36	117.36	4.62	0.042
Mulch × Variety	2	27.06	13.53	0.53	0.594
Residual	25	635.69	25.43		
Total	35	979.64			

Appendix 1.5.2 Total number of leaves per plant at 8WAP

Source of variation	**d.f.**	**s.s.**	**m.s.**	**F. value**	**F pr.**
Block	5	24738.2	4947.6	5.97	
Mulch	2	14930.1	7465	9.01	0.001
Variety	1	9473.8	9473.8	11.44	0.002
Mulch × Variety	2	284.4	142.2	0.17	0.843
Residual	25	20709.1	828.4		
Total	35	70135.6			

Appendix 1.5.3 Total number of leaves per plant at 12WAP

Source of variation	**d.f.**	**s.s.**	**m.s.**	**F. value**	**F pr.**
Block	5	32955	6591	6.29	
Mulch	2	27606	13803	13.18	<.001
Variety	1	9768	9768	9.33	0.005
Mulch × Variety	2	207	103	0.1	0.906
Residual	25	26182	1047		
Total	35	96718			

Appendix 1.6 Number of tubers harvested

Source of variation	**d.f.**	**s.s.**	**m.s.**	**F. value**	**F pr.**
Block	5	132.81	26.56	0.34	
Mulch	2	841.56	420.78	5.4	0.011
Variety	1	6.25	6.25	0.08	0.779
Mulch × Variety	2	302	151	1.94	0.165
Residual	25	1949.03	77.96		
Total	35	3231.64			

Appendix 1.7 Yield (t/ha)

Source of variation	**d.f.**	**s.s.**	**m.s.**	**F. value**	**F pr.**
Block	5	560.37	112.07	8.48	
Mulch	2	14.02	7.01	0.53	0.595
Variety	1	2.91	2.91	0.22	0.643
Mulch × Variety	2	11.75	5.88	0.44	0.646
Residual	25	330.36	13.21		
Total	35	919.41			

Appendix 1.8 Number of tubers damaged

Source of variation	**d.f.**	**s.s.**	**m.s.**	**F. value**	**F pr.**
Block	5	220.89	44.18	1.11	
Mulch	2	861.72	430.86	10.86	<.001
Variety	1	81	81	2.04	0.165
Mulch × Variety	2	78.5	39.25	0.99	0.386
Residual	25	991.78	39.67		
Total	35	2233.89			

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