BINDURA UNIVERSITY OF SCIENCE EDUCATION

DEPARTMENT OF CROP SCIENCE

INVESTIGATING THE IMPACTS OF COMPOUND D, COMPOST, COW MANURE, MULCH APPLIED AS BASAL ON SOIL PHYSICAL PROPERTIES IN RELATION TO MAIZE PRODUCTION IN SHAMVA, ZIMBABWE.

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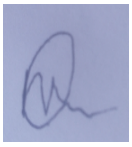
DECLARATION

Student

I, Patrick Jazi, do hereby declare to Senate of Bindura University of Science Education that this research project is a result of my original research work. It is being submitted for the fulfilment of the Bachelor of Agricultural Science Honours Degree in Crop Science and that to the best of my knowledge, the findings have never been submitted nor being concurrently submitted in any other institution.

Signature:  Date: 04/10/2024

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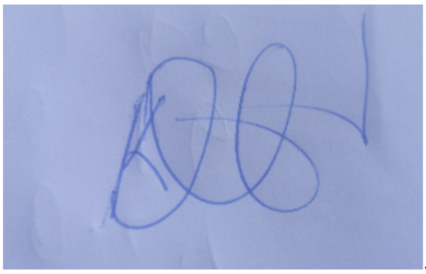
Signature: … Date: 04/10/2024

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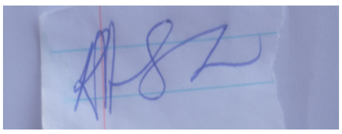
Quality Controller:  Signature: 04/10/2024

DEDICATION

I dedicate this thesis to the Lord Almighty who gave me strength and my family whose emotional and financial support made all of this work to be possible and who made me realize the importance of education at the early age. When the world and circumstances were cheering me down, my family always cheered me up.

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ABSTRACT

This dissertation aims to investigate the impacts of compound D, compost, cow manure, and mulch on soil physical properties and their influence on maize production in Zimbabwe. The study focuses on understanding how these soil amendments affect key soil physical properties, such as bulky density, moisture retention, nutrient availability, and overall soil health Shamva District. A completely randomized design with three replications. The findings from this research can contribute to the development of sustainable agricultural practices in Zimbabwe, promoting enhanced maize production and soil fertility. The research will employ a combination of field experiments, laboratory analysis and data interpretation to evaluate the effects of these amendments on soil physical properties and their subsequent influence on maize growth and yield. Descriptive statistics and multiple regression model were used to analyze the specific objectives of the study. The data was analyzed using analysis of variance (ANOVA). Therefore, the findings from this study will provide valuable insights into the potential benefits of these agriculture practices and contribute to evidence-based recommendations for smallholder farmers in Zimbabwe.

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LIST OF ACRONYMS AND ABBREVIATIONS

DT	Drought Tolerance
GMBs	Grain Marketing Board
WAP	Weeks After Planting
cm	Centimeter
mm	millimeter
ha	hectare
m	meter
kg	kilograms
m^2	square meter
RCBD	Randomized Complete Block Design
g	grams
cm^2	square centimeter
SOC	Soil Organic Content
ANOVA	analysis of variance
BD	Bulk Density

CHAPTER ONE: INTRODUCTION

1.1 Background of study

Maize (Zea mays L.) is the principal staple food and a source of livelihoods for more than one billion people in the sub-Saharan Africa and Latin America (Lunduka, 2019). It is also regarded as a vital crop in the perspective of global nutrition. Zinyengere (2011), says that it is one of the most important cultivated crops amongst cereals with high production potential and wider adaptability across most environments unlike wheat and rice which grows winter and muddy areas respectively. Also, maize can be used in many ways, and this leads to its wide cultivation and management of production of its high importance (Stanning, 1989). It provides raw material source for large number of industry production and it provide food for humans and animals. Worldwide maize production is approximately around 500 million tons, with Africa growing 25 million hectares. According to Mango (2015) global consumption is around 116 million tons. According to (Friedman, Moore, & Purugganan, 2004), 30% of the world total production is consumed in Africa. Sub-Saharan of Africa consumes approximately 21% of the total maize that is consumed in Africa as maize is mostly consumed as a staple crop (Feschotte & Pritham, 2009). Maize production in Africa is mostly rain fed, though unreliable and not well distributed rainfall pattern is the major limiting factor that is causing occasional droughts leading to food shortages (Abate, 2015). Yields in Sub Saharan Africa are continuing to decline averaging below 1.3 ton per hectare (Makadho, 1996). Chivasa (2019), shows that this has been attributed to lack of improved maize seed, poor soil fertility, increased temperature beyond maize threshold and also limited use of fertilizers by farmers.

Maize is a C4 plant that produces 4-carbon sugar as its basic photosynthetic sugar through the process of photosynthesis and (Wang, 2014) this gives a maize plant to become high tolerance to heat stress as compared to other C3 plants (Crafts-Brandner, 2002). C4 plants have a higher optimum temperature for photosynthesis than C3 plants because of the operation of a carbon dioxide concentrating system that inhibits rubisco oxygenase activity in the process of photosynthesis (Landdale, 1988).

In Zimbabwe, (Siziba, 2019), agriculture is the fundamental support of the economy that provides necessities of life for people of around 96% of the population. (Acevedo, 2020), maize falls under food crop and important cash crops. The Grain Marketing Board of Zimbabwe uses 60% for human consumption while 21% for stock feeds and the remaining 19% for other uses factorization. In Zimbabwe maize is eaten as raw, fresh or sadza after dry milling.

In Zimbabwe maize ranks first position amongst most important cereals such as wheat, rice and barley in both production and consumption at all levels (Cairns, 2021). In Zimbabwe maize production is practiced in all Agro-Ecological Regions. (Eicher, 1997), the crop performs good wide ranges of soil but textured and heavy sandy clay loams are most preferred. The pH that ranges from 4.5 to 7.2 but ideal pH ranges between 5.5 and 6.4. Maize is a warm weather crop and prone to frost, its temperature ranges from 20℃ to 30℃ (Lunduka, 2019).

Maize production is of critical importance in Zimbabwe, serving as a staple food crop and a significant source of income for smallholder farmers (Mupangwa, 2014). However, achieving optimal maize yields is challenging due to various factors, including soil degradation, nutrient deficiencies, and limited access to inputs. According to Mashingaidze (2004), these challenges are exacerbated by the changing climate patterns and the need for sustainable agricultural practices.

The average production capacity of maize is around 5.0 tons per hectare. In Zimbabwe production trends is tremendously decreasing. Farmers especially smallholders, produce about 60% of the country's total output of maize, however the yields of communal farmers are now a third of what it used to be a decade ago. Under optimum conditions with good soil fertility and effective management maize can realize yields above 10 tons per hectare (Acevedo, 2020).

According to Crafts-Brandner (2002) soil degradation, resulting from erosion, nutrient depletion, and compaction, has a detrimental impact on soil physical properties, such as soil structure, moisture retention, and nutrient availability is also seriously causing the decline in maize production in Zimbabwe. These properties directly influence the growth and productivity of maize crops. Additionally, nutrient deficiencies in the soil can lead to suboptimal plant growth and reduced yields (Kephe, 2021).

1.2 Problem statement

Maize production in Zimbabwe is crucial for food security and rural livelihoods. However, smallholder farmers face significant challenges in achieving optimal yields. Soil degradation, nutrient deficiencies, and limited access to inputs are among the key factors contributing to suboptimal maize production. While soil amendments, such as Compound D, compost, cow manure, and mulch, have been identified as potential solutions, there is a lack of comprehensive understanding regarding their impacts on soil physical properties and their subsequent influence on maize production in the Zimbabwean context. Most countries regionally have poor soils and are increasingly moving towards shortage of soil fertility due to climate change. The studies are being carried out in eastern and southern Africa to investigate the impacts compound D, humus, cattle manure and mulch on production of maize. There is a decrease in Maize yield in Sub Saharan Africa including Zimbabwe while the population is projected to increase. Africa is currently importing 30% maize from other developed countries. Trials have been conducted to improve soil fertility in maize production. The majority of small holder farmers in the region cannot afford to set up fertilizers to supplement the poor soils.

1.3 Justification

Presently there is no soil amendments that can be used in maize production to increase soil fertility Blanco-Canqui, Lal, Post, Izaurralde, & Shipitalo (2006) pointed out that less effort has been put towards soil amendments in maize production. This research will help to identify the impacts of compound D, humus, cattle kraal manure and mulch applied as basal dressing on soil physical properties on maize production. There are other soil amendments materials but still there is need to increase and improve the soil amendments. This can help in alleviating hunger region by increasing yield in areas with poor soils (Logsdon, 2004). Farmers lacks knowledge of the impacts of soil amendments (compound D, humus, mulch and cattle kraal manure) on the soil physical properties. They don't know how to apply and how quantity to apply per given land.

1.3 Objectives

1. Assess the effects of Compound D and compost on soil moisture retention, soil structure, and nutrient availability in relation to maize production. This objective aims to understand how the application of Compound D compost as a basal amendment influences key soil physical properties that are critical for maize growth and productivity.

2. Evaluate the impact of cow manure on soil physical properties and its influence on maize growth and yield. This objective seeks to investigate the effects of cow manure as a basal application on soil moisture retention, soil structure, and nutrient availability, and how these changes in soil physical properties translate into improved maize growth and higher yields.

3. Investigate the effects of mulch as a basal application on soil moisture conservation, soil protection, and maize production. This objective aims to explore the impact of mulch on soil moisture retention, erosion control, and weed suppression, and how these factors contribute to enhanced maize production.

4. Determine the interactions between soil amendments (Compound D compost, cow manure, and mulch) and soil physical properties, and their combined effects on maize production. This objective seeks to understand how the simultaneous application of these soil amendments influences soil moisture retention, soil structure, nutrient availability, and ultimately, maize growth and yield.

1.4 Hypothesis

Hypothesis 1: The application of compound D as a basal soil amendment will improve soil structure, moisture retention, and nutrient availability, leading to increased maize production.

Hypothesis 2: The use of compost as a basal soil amendment will enhance soil fertility, promote beneficial microbial activity, and result in higher maize production.

Hypothesis 3: The incorporation of cow manure as a basal soil amendment will improve soil structure, increase nutrient content, and positively impact maize yield.

Hypothesis 4: The application of mulch as a basal soil amendment will conserve soil moisture, regulate soil temperature, suppress weed growth, and contribute to improved maize production.

CHARPTER TWO: LITERATURE RIVIEW

2.1 Origin and distribution of maize

Maize (Zea mays), also known as corn, is native to Central and South America, especially central Mexico, about 9,000 years ago (Zinyengere, 2011). Native peoples of southern Mexico domesticated wild teosinte (a type of grass). Corn is distributed throughout the world and is an important crop in many regions. According to Wang (2020), it was introduced to West Africa by the Portuguese in the 10th century and is highly diverse in many parts of Mexico. This crop is also found in Central and South America and other parts of the world. Hufford (2012), stated that maize cultivation spread to other parts of the world, including Europe and Asia, through exploration and trade today, maize production is widespread globally, with significant production in regions such as North America, South America, Africa, and Asia. In the United States, maize production is concentrated in the Midwest due to the proximity to corn production and the presence of ethanol plants that use corn as a feedstock (Weatherwax, 1918). China is also a major maize producer, contributing 23% to global production and playing a crucial role in stabilizing the market.

Maize is an economically important crop and occupies a significant area of cultivation, ranking third after rice and wheat in terms of area and production worldwide (Nagy, 2006). It is used for various purposes, including livestock feed, fuel ethanol production, and human consumption. The distribution and cultivation of maize have been influenced by factors such as climate suitability, agricultural practices, and market demand. According to Mangelsdorf (1938), different regions have adapted maize varieties to suit their specific environmental conditions and agricultural systems. Additionally, the genetic diversity of maize has led to the development of various races and cultivated varieties.

2.2 Maize production in Zimbabwe

Maize is a very important crop for Zimbabwe, accounting for over 60% of the total cropped area and between 80-90% of the entire land area under cereals (Chivasaa, (2019). It is the staple food crop for most Zimbabweans. The main season is crucial for maize production as it receives the majority of the rainfall. Maize, also known as corn, is one of the staple crops in Zimbabwe and plays a significant role in the country's agricultural sector (Rohrbach, 1989). It has a diverse agricultural industry, with and the off-season lasts from May to July. Corn does not tolerate cold weather, so it should be planted in spring in temperate regions. The root system is usually shallow, so the plant is dependent on soil moisture (Makadho J. M., 1996) . Corn, a C4 carbon fixing plant, is a much more water efficient crop than around the time the mulberries emerge, when the flowers are ready for pollination. Corn used as silage is harvested while the plants are still green and the berries are not ripe. Sweet corn is harvested during the "milk stage" from late summer to early fall, after pollination but before starch has formed. Field corn is left in the field until late fall to completely dry the grain, and sometimes is not harvested until winter or early spring (Chivasaa, (2019). The importance of adequate soil moisture is evident in many regions of Africa. According to Logsdon (2004), periodic droughts there cause regular corn crop failures and subsequent famines.

2.3 The importance of maize in Zimbabwe

Maize is a staple crop in many countries and plays an important role in food security. (Rohrbach, 1989), state that serves as a major source of calories and nutrition for millions of people around the world. Corn and cornmeal (dried corn) are staple foods in many parts of the world. Corn is used to produce corn starch, a food ingredient. Corn starch can be hydrolysed and enzymatically treated to produce high-fructose corn syrup, a sweetener (Ogola, 2002). Bourbon whiskey can be produced by fermenting and distilling corn. Corn oil is extracted from the germ of the grain. Many cultures use coarse corn kernels to make thick porridge. Sweet corn, a genetic variety high in sugar and low in starch, is eaten unripe as corn on the cob. According to Masters (1994), corn production has a significant economic impact, especially in regions where it is a major cash crop. This provides income and employment opportunities for farmers, traders and other stakeholders in the maize value chain. Corn exports also contribute to foreign exchange flows to many countries (Duncan, 1993). Corn is an essential component of livestock feed, providing energy and nutrients to livestock. Widely used in feed production for poultry, pigs and cattle. The availability and availability of corn as feed contributes to the growth and sustainability of livestock production.

Corn is the main source of animal feed. As a grain crop, dried grains are used as feed (Friedman, Moore, & Purugganan, 2004). They are often stored on the cobs of corn bins or shelled for storage in grain bins. If grain is used as feed, the remaining parts of the plant (corn stalks) can later be used as feed, bedding, or soil conditioners. According to Prasanna, et al. (2022), when whole corn (kernels, stems and leaves) is used as feed, it is typically shredded and processed into silage. This is because corn is easier to digest and more palatable to ruminants than the dried form. Traditionally, corn was collected in heaps after harvest and dried further. It can then be stored for several months until fed to livestock. Silage can be produced in silos or silage bags (Schnable, et al., 2009). In tropical countries, corn is harvested all year round and fed to animals as green feed. Compressed corn stalks provide an alternative to hay as animal feed, and corn grown for that purpose is directly grazed. Corn can be used in industry. Corn has a variety of industrial uses, including producing ethanol for biofuel. Using corn for biofuel production can reduce dependence on fossil fuels and promote the development of renewable energy sources. Feed corn is used for heating. Specialized corn stoves (similar to wood stoves) use feed corn or wood pellets to generate heat. Corn cobs can be used as a biomass fuel source. Home heating stoves that use corn kernels as fuel have a large hopper that feeds the corn kernels into the fire. Jugenheimer (1958) stated that maize is used as a raw material for ethanol fuel production. Food prices are indirectly affected by the use of corn for biofuel production. In other words, using corn for biofuel production increases demand, which in turn increases corn prices. The pioneering biomass gasification plant at Stream in Burgenland, Austria, began operation in 2005. Biogas can be used to produce diesel fuel using the Fischer-Tropsch method. Corn starch can also be used to produce plastics, textiles, adhesives, and many other chemical products. Corn extract, a rich and moisture-rich by-product of the wet corn milling process, is used as a growth medium for microbial growth in biochemical industry and research. Corn is often included in crop rotation systems to improve soil health and fertility. According to Lopes, Nóbrega, Pacheco, & Cruz-Silva (2016), deep root systems can break up compacted soil, improve nutrient cycling and reduce the risk of soil erosion. Maize exhibits significant genetic diversity, which allows for the development of improved varieties with desirable traits such as disease resistance, drought tolerance, and higher yields. This genetic diversity contributes to the overall resilience and adaptability of maize production systems.

2.4 Challenges in maize production

Maize production in Zimbabwe is influenced by various factors such as climate, rainfall patterns, government policies, and farming practices. There are many factors affecting production of maize and some of them include drought and climate change.

2.4.1 Drought

Drought is a huge limiting factor in maize production, mainly in the rain-fed agriculture of sub-Saharan Africa. Foster (2010) said drought has been highlighted as one of the major causes of reduced maize production and food insecurity across the globe and particularly in sub-Saharan Africa (SSA), where agriculture production is largely rain fed estimated that the occurrence of mid-season droughts, particularly at the vegetative and productive phases for maize, reduces yields by 39.3% (Holden, 2015). Although projected changes in precipitation during the maize growing season in SSA vary with location and region, overall temperatures are predicted to increase by 2.1–3.6°C by 2050. The predicted increase in temperature is likely to have huge implications for maize production and, subsequently, the food security and livelihoods of smallholder farming households (Kapuya, 2010). Adaptation to these climate changes is therefore critical to ensuring the country's food security and economic stability. In response to this threat, drought-tolerant (DT) maize varieties have been developed with an aim to ensure maize production under mild drought conditions. (Kassie, 2012) Showed said that one such adaptation strategy has been the development of drought-tolerant (DT) maize varieties. Therefore, since the late 1990s, DT maize varieties have been considered as part of the solution to sustain maize production, mainly by smallholder farmers (Acevedo, 2020).

2.4.2 Climate Change

Africa is recognized as one of the most vulnerable regions in the world to climate change due to widespread poverty and limited survival opportunities. Cairns (2013) said that Zimbabwe is particularly vulnerable due to its heavy dependence on rain-fed agriculture and climate-sensitive resources. Climate data shows that Zimbabwe is already experiencing the impacts of climate change, particularly precipitation variability and extreme events. Precipitation patterns in Zimbabwe are irregular and primarily characterized by sudden and mid-season droughts that destabilize agricultural production (Jones, 2003). Climate change probability estimates show that moderate, severe, and extreme droughts are highly likely to occur in January–March at least twice every 10 years. Smallholder farmers have also reported a change in the weather pattern. Tesfaye (2015) reported that more than 90% of farmers in eastern Zimbabwe have perceived that the climate has changed, with increased rainfall variability characterized mainly by the late onset of rainfall and prolonged mid-season dry spells. They observed that the number of rain days per season has decreased with time, whereas the mean total annual rainfall has not changed, thus indicating an increased number of dry spells within the rainy season. The farmers in southern Africa have experienced one to three droughts in the past decade, with Zimbabwean farmers reporting, on average, the most recent droughts (Oseni, 2011). The impacts of these changes and climate variability primarily affect agricultural production and livelihoods among rural small-scale farmers in Zimbabwe. Abera (2018) predicts that Zimbabwe, like many other SSA countries, will see the largest decline in maize yields by 2050 due to climate change showed that agricultural production in Zimbabwe's smallholder farming system is significantly constrained by climatic factors like high temperature and low rainfall (Mulungu, 2019). According to Tokatlidis (2013), using a Ricardian approach, Mano and Nhemachena show that an increase in temperature of 2.5°C would result in a decrease in net farm revenue of $400 million for all farms in Zimbabwe. Specific to maize production, impacts of climate change have already shown huge negative effects at both the household and national levels. Between 1993 and 2000, average annual maize production stood at 1.64 million tons before dropping to 1.08 million tons between 2001 and 2008 (Erenstein, 2022).

Zimbabwean farmers have faced significant economic constraints due to the increasing shortage of foreign currency for imports such as inorganic fertilizers and rising interest rates that have made credit unaffordable (Araus, 2014). In addition to high temperature and low rainfall, those factors are significantly responsible for the decline in crop production. Zimbabwean smallholder farmer's adaptation to changing climate indicates that farmers are already using some adaptation strategies such as dry and early planting, growing drought resistant crops, changing planting dates, and using irrigation. In Midega (2018) Chiredzi showed that farmers have been planning and implementing some strategies including improvements in water availability, optimizing crop mix during the rainy season, and planting DT crops. The demand for DT crops such as maize and sorghum is increasing in several countries, including Zimbabwe. Tesfaye K. K. (2014) found that the adoption of DT maize varieties by smallholder farmers in sub-Saharan Africa is increasing. The genetic advantage of DT maize varieties was greater than that of non-DT maize in both experimental stations and farmer field trials. Ulfat (2022) reported that the best new hybrids outperformed farmed varieties by more than 35% and 50% under low and high yield conditions, respectively, compared to the most widely grown commercial hybrid varieties in southern Africa.

2.5 Soil Amendments

Soil amendments are substances that are added to soil to improve its physical, chemical, or biological properties (Rechcigl, 1995). They can enhance soil fertility, structure, water-holding capacity, nutrient availability, and overall plant growth. According to Acevedo (2020), soil amendments also known as soil conditioners can be composed of various substances, including organic materials (such as compost, manure, or bio char) and inorganic materials (such as lime, gypsum, or specific chemical compounds)

2.5.1 Compost as soil amendment

Compost is a nutrient-wealthy soil modification this is created through the managed decomposition of natural substances (Garbowski T. B.-M.-P., (2023). The composition of compost can range relying at the substances used, however it usually consists of a mixture of the natural matter. Compost is on the whole made from natural substances consisting of vegetable scraps, backyard waste, leaves, grass clippings, straw, wooden chips, and different plant-primarily based totally substances. According to Goldan (2023), these natural substances offer a supply of carbon, nitrogen, and different crucial nutrients.

Compost is broadly diagnosed as a useful soil modification because of its cap potential to enhance soil properties (Pérez-Piqueres, 2006). Compost affords crucial vitamins which are important for plant increase. It incorporates a number of macro and micronutrients, which include nitrogen, phosphorus, potassium, and hint elements, which may be slowly launched into the soil because the compost breaks down. Compost improves soil shape with the aid of using improving soil physical properties. It facilitates to create a well-tired soil with correct water-preserving ability, permitting for correct root improvement and decreasing the chance of waterlogging. According to Chia (2020), compost will increase the water preserving ability of the soil, that's mainly useful in regions with constrained rainfall or all through dry periods. The natural count number in compost acts like a sponge, assisting to keep moisture and decreasing water loss via evaporation. Compost will increase the whole porosity of the soil, growing greater area for air and water movement. This promotes higher root increase, nutrient uptake, and basic soil health. Compost helps the increase of useful soil microorganisms, which include bacteria, fungi, and earthworms. These organisms make a contribution to nutrient cycling, natural count number decomposition, and basic soil fertility. When carried out as a mulch, compost can assist suppress weed increase with the aid of using acting (Noble, 2011).

Compost improves the water-holding capacity of the soil, increasing its water-holding capacity. The organic matter in compost absorbs and retains water like a sponge, reducing water runoff and improving water availability for plants. Sandy soils with low water holding capacity may benefit from adding compost to improve water retention. According to Ievinsh (2020), compost mulches have been shown to improve soil porosity and water retention, helping to retain soil moisture and reduce water stress in plants. Compost increases the availability of nutrients in the soil. It contains a variety of macro and micronutrients that are released slowly as the compost decomposes, providing a steady supply of nutrients to your plants. The organic matter in compost acts as a nutrient reservoir, retaining nutrients and releasing them gradually, reducing the risk of nutrients leaching. Compost improves the soil's ability to hold nutrients, increasing the availability of essential nutrients for plants to consume (Wright, 2022).

Compost improves soil fertility by adding organic matter and nutrients to the soil. This increases organic matter content, improving nutrient availability and promoting nutrient cycling. Compost mulches have been found to increase the levels of available phosphorus and exchangeable potassium in the soil (Alori, 2023). Animal manure, a type of compost, can increase soil biological activity by promoting nutrient cycling and availability to crops. Well-made compost contains all the nutrients plants need and enriches the soil. Compost improves soil structure by increasing cohesion, resulting in stable soil aggregation. Improves soil porosity, improving water infiltration, root penetration and air movement within the soil. Hattab (2024) discovered that compost can help prevent soil compaction by loosening compacted soil and improving its structure. Organic fertilizers, including compost, can improve soil structure and moisture retention, preventing runoff and runoff of pesticides and nutrients. Compost mulches have been found to improve soil porosity and water retention (Cui, 2013).

2.5.2 Cattle kraal manure as soil amendment

Cattle kraal manure also known as cow dung is a valuable soil fertilizer that improves soil and provides essential nutrients for plant growth. Cow dung is rich in nutrients such as nitrogen (N), phosphorus (P), and potassium (K), which are essential for plant growth (Okorogbona, 2012). It also contains trace elements necessary for healthy plant development. Sprinkling cow dung on the soil can replenish these nutrients, improving nutrient availability for plants. Mkhabela (2013) stated that cow dung is an excellent source of organic matter that plays an important role in improving soil structure, water holding capacity and nutrient availability. Organic matter increases soil cohesion, reducing soil compaction and improving soil aeration. It also increases the water-holding capacity of the soil, helping plants retain the moisture they need to absorb. Additionally, Kiran (2017) found that organic matter provides a source of nutrients for beneficial soil microorganisms, promoting their activity and improving the overall health of the soil. Using cow dung can improve soil fertility by increasing nutrient availability and improving soil structure. The nutrients present in cow dung are gradually released into the soil, providing sustainable nutrients to plants. This can help improve crop yield and quality (Jauregi, 2021). Additionally, the organic matter in cow dung improves the soil's ability to hold nutrients, reducing the risk of nutrient runoff. Cow dung contains beneficial microorganisms that can increase soil microbial activity. These microorganisms play an important role in nutrient cycling and organic matter decomposition, further improving soil fertility and nutrient availability. Using cow dung as soil fertilizer is consistent with sustainable agricultural practices. This helps reduce dependence on synthetic fertilizers, which can have a negative impact on the environment. By recycling organic waste and using cow dung, farmers can improve soil health, reduce nutrient runoff and promote sustainable nutrient management.More so, Kunene (2019) alluded that cow dung promotes soil fertility by providing essential nutrients for plant growth. It contains organic matter and nutrients such as nitrogen, phosphorus, and potassium. Organic matter in cow dung increases soil fertility by improving soil structure, water holding capacity and nutrient availability. In terms of soil structure, cow manure can improve soil structure by improving soil cohesion and reducing soil compaction (Masarirambi, 2012). The organic matter in cow dung helps bind soil particles together to create stable soil aggregates. This improves soil porosity, aeration and water infiltration, allowing roots to penetrate the soil more easily and promoting healthy plant growth. Cow dung promotes water retention by increasing the water holding capacity of the soil. The organic matter in cow dung acts like a sponge to absorb and retain water. This prevents water runoff, improves drought tolerance and provides a more consistent water supply to plant roots. Cow dung increases nutrient availability in the soil (Motsi, 2022), the organic matter in cow manure undergoes decomposition, releasing nutrients gradually over time. This slow release of nutrients ensures a sustained supply for plant uptake, reducing the risk of nutrient leaching and improving nutrient use efficiency (Mokgolo, 2024).

2.5.3 Compound D as soil amendment

Compound D is a compound used as a soil fertilizer in a variety of agricultural practices. It can be applied to soil to improve soil fertility, structure and nutrient content (Ngadze, 2018). Compound D is used as a soil additive in agricultural practices to improve soil quality and promote plant growth. It can be used alone or in combination with other soil conditioners or fertilizers. According to Coutinho (2014), the specific benefits of using Compound D as a soil amendment may vary depending on soil type, crop, and application method. Compound D can increase the nutrient content of the soil by making essential nutrients more available to plants. This can improve plant growth and productivity. Also, it can improve soil structure by increasing its capacity to hold water and nutrients, reducing compaction, and promoting root development (Bonanomi, 2010). This can improve soil aeration and drainage. Soil amendments can improve soil water retention capacity by reducing water runoff and increasing water availability to plants. This can help plants resist drought. Soil amendments can improve nutrient availability to plants by increasing nutrient retention and reducing nutrient leaching. This allows plants to absorb nutrients more efficiently. By increasing soil fertility and nutrient availability, soil amendments have the potential to minimize the environmental impacts associated with chemical fertilizer use by reducing the need for excess chemical fertilizers and other inputs (Marchal, 2014). Therefore, the specific effects of Compound D on soil physical properties and corn yield may vary depending on factors such as soil type, application rate, timing of application, and specific recommendations from the grower or agricultural expert.

2.5.4 Mulch as a soil amendment

Mulch can serve as both a soil amendment and a protective layer on the soil surface. While mulch primarily functions as a protective covering, many mulches also have the potential to improve soil quality when they break down over time (Luna, 2018). Mulch is a soil conditioner commonly used in horticulture and landscaping. It serves several purposes and can have a variety of effects on soil health and plant growth. The main purposes are to conserve moisture, suppress weed growth, regulate soil temperature and improve overall soil health. According to Mininni (2015), unlike other fertilizers, mulch typically remains on the surface rather than mixing with the soil. One of the main benefits of using mulch is its ability to retain soil moisture (Haynes, 2016). Mulch acts as a protective barrier, reducing evaporation and preventing moisture loss from the soil. This can help maintain sufficient soil moisture for plant growth, especially in dry or arid climates. Mulch helps suppress weed growth by blocking sunlight and preventing weed seeds from germinating. Mulch creates a physical barrier, reducing competition for nutrients and water, allowing plants to thrive without interference from weeds. Mulch acts as an insulating layer and helps regulate soil temperature. Sánchez-Martín (2023), showed that one can keep the soil cooler in hot weather and warmer in cold weather, providing a more stable environment for plant roots. Different types of mulch, such as wood chips, straw or compost, gradually break down over time and add organic matter to the soil. This organic matter improves soil structure, increases nutrient availability, and promotes beneficial microbial activity. As the mulch decomposes, nutrients are released into the soil, promoting the nutrient cycling process. These nutrients are made available to plants to promote healthy growth and development.

Mulch acts as a protective layer on the soil surface, reducing direct exposure to sunlight and wind (Liang, 2021). This shading effect helps minimize evaporation of water from the soil. Mulch helps water stay in the soil longer by covering the soil and creating a barrier that prevents water from evaporating quickly. Mulch also acts as insulation and helps regulate soil temperature. In addition to that, according to Larkin (2020), by keeping the soil cool in hot weather, mulch reduces the rate of evaporation and helps maintain soil moisture levels. This insulation also helps prevent rapid moisture loss during periods of high temperatures. Mulch helps prevent soil cracking, which can expose roots to air and cause moisture loss (Stratton, 2020). Mulch covers the soil surface to maintain a more stable moisture content, reducing the risk of soil cracking and moisture loss. Certain types of mulch, such as organic mulch, can improve water infiltration into the soil. Over time, as the organic mulch breaks down, channels and pores form in the soil, allowing water to penetrate more easily. This improved water infiltration helps replenish soil moisture levels and reduce runoff.

2.6 Soil Physical Properties

Soil physical properties in agriculture are characteristics of the soil that influence its behavior and suitability for various purposes. According to Horn (1994), these properties play a crucial role in determining the availability of water, air, and nutrients for plant growth, as well as the overall health and productivity of the soil. The physical properties of soil, in order of decreasing importance for ecosystem services such as crop production, are texture, structure, bulk density, porosity, consistency, temperature, color and resistivity (Khaleel, 1981). Soil texture is determined by the relative proportion of the three kinds of soil mineral particles, called soil separates: sand, silt, and clay. Soil physical properties as important components of soil health influence water and nutrient movements, aeration, soil temperature, nutrient cycling, and root growth that affect crop yields and environmental quality. As per research by Letey (1985), for example, increased bulk density (BD) due to increased soil compaction results in decreased pore volume that reduces water infiltration, increases aeration stress, lowers soil temperature and nutrient cycling, increases denitrification, losses mycorrhizal fungi, and reduces root growth. In contrast, Greenwood (2001) stated increased soil aggregation enhances water and nutrient movements, reduces soil erosion, promotes C sequestration, favors microbial activity and abundance, and increases root growth and crop yields. Clay concentration is an important indicator of soil health that enhances the retention of soil water and nutrients. While increased soil water retention enhances crop yields, reduced water infiltration capacity of the soil results in anaerobic condition that hampers nutrient cycling and root growth, thereby reducing crop production (Blanco-Canqui H., 2017). Some soil physical properties are related to other soil properties. Numerous researchers reported that BD was negatively correlated to soil organic C (SOC), but soil aggregation, water retention, and water infiltration capacity were positively correlated to SOC. In contrast, Anderson (1990) observed that soil hydraulic conductivity (SHC) was negatively correlated to SOC because soils rich in organic matter have lower water permeability.

2.6.1 Soil bulk density

Bulk density of soil refers to the mass of dry soil per unit volume of soil. Bulky density is calculated as the ratio of the mass of dry soil (g) to its volume (cm^3) (Mulumba, 2008). It is typically measured by collecting the soil sample in an unknown volume, drying it, and then weighing it. It is usually expressed in grams per cubic centimeter (g/cm^3). According to Blake (2000), bulk density varies from about 1.0 g/cm^3 for organic soils to more than 1.8 g/cm^3 for mineral soils. For example, peat soils have a low bulk density of about 1.0 g/cm^3, while compacted clay soils have a high bulk density of 1.8 g/cm^3 (Shaver, 2002). Compacted soils have a high bulk density (1.5-1.8 g/cm^3), have few macrospores, and tend to restrict root growth, water and air flow. Texture and organic matter also affect bulk density. Sandy soils have a higher bulk density than clay soils because they have lower overall porosity. Organic matter is very small in weight and has a large volume, so it has a low bulk density. Bulky density is important because it affects water infiltration and movement, aeration and gas exchange, root penetration, and soil strength and erosion resistance. Also it influenced by soil texture, soil structure, organic matter content and porosity. Hill (2010), reported that some minerals have higher particle densities (mass per particle volume) and can contribute to soil bulk density if they are dominant in the soil. Soils of low bulk density contain more water available to plants than soils of higher bulk density, but tend to deplete quickly, causing drought (Khaleel, 2009). It is a crucial indicator of soil compaction, affecting factors such as infiltration, rooting depth, available water capacity, soil porosity, and aeration. This property reflects the soil's ability to function for structural support, water and solute movement, and soil aeration. Compacted soils exhibit increased bulk density, and several activities can result in soil compaction (Barzegar, 2002).

2.6.2 Water holding capacity

Water holding capacity is the amount of water that can be held in the soil against gravity. Also, it is the ability of soil to store water. It is measured by saturating the soil allowing it to drain and then measuring the amount of water retained (Sujatha, 2016). Water holding capacity ranges from around 20% for sandy to over 60% for clay soils. Water holding capacity is influenced by the soil texture and structure, organic matter content and porosity. Thus, the importance of this storage is that water can be available for plants. According to Bordoloi (2019), environmental conditions such rain, temperature, and isolation join to the soil properties of soil organic matter, texture, and structure and determine the capacity of a soil to retain water, such as silt and clay, have a larger surface area, which contributes to higher water holding capacity. Additionally, Olorunfemi (2016) stated that organic matter plays a significant role in enhancing the water holding capacity of soil. In rain fed agriculture of arid and semiarid environments, the capacity of the soil to store water plays an important role in the success of crops. Infiltration and evaporation are the most important processes that determine the storage of water in the soil (Robinson, 2008). Surface conditions play an important role in determining the rates of water infiltration and evaporation within the soil. Tillage is the most effective way to change soil surface properties by influencing pore space (pore shape, volume and continuity) (Ihedioha, 2017).

2.6.3 Soil porosity

Porosity is the percentage of soil volume that is occupied by pores or voids. It is a key indicator of soil structural quality (Pagliai, 2010). It can be measured using various techniques, including water saturation and gas permeability tests. According to Hardie (2014), porosity range from around 25% for clay soils to over 60% for sandy soils. Soil porosity is influenced by the soil texture, organic matter content and bulky density. Therefore, its characterization is important to evaluate the impact of adding organic matter to soil systems. The decrease in porosity is caused by the loss of large pores and the increase of small pores. Soil porosity and pore size distribution characterize the pore space of the portion of the soil volume that is not occupied by solid materials (Ahuja, 2002). The basic properties of pores are responsible for almost everything that happens in the soil: movement of water, air and other fluids that is transport and reactions of chemicals; and habitat for roots and other biota. Aslam (2014), showed by convention, the definition of pore space excludes pockets of fluid completely surrounded by solid material. Therefore, pore space is considered as a single, continuous space within the soil body. Typically, fluid paths are tortuous, have varying degrees of narrowing, and are generally strongly interconnected. The relationship between water storage capacity and movement in porous soils is obvious and fundamental (Sharma, 2019). However, it is not only the total number of pores that determines the moisture behavior of the soil, but also, in most cases, their shape, size and distribution (Blanco-Canqui, Lal, Post, Izaurralde, & Shipitalo, 2006). From an agronomic perspective, size distribution not only affects the amount of water a soil can hold, but also regulates the energy it holds and its transfer to other areas of the plant, atmosphere, and soil.

2.7 The Relationship between Soil Physical Properties and Maize Production

The relationship between soil physical properties and maize production is an important aspect to consider for optimizing crop growth and yield. Changes in soil physical properties, such as soil compaction, can influence root growth and distribution, which in turn affect crop growth and yield (Maddoni, 2011). Soil compaction can restrict root growth, limit nutrient and water uptake, and reduce overall plant productivity. Therefore, Norkaew (2019) alluded that managing soil compaction through appropriate soil amendments is important for optimizing maize production. Soil organic matter plays a crucial role in soil physical properties and can impact maize production. Increasing soil organic matter content through practices like the addition of compost can improve soil structure, water-holding capacity, nutrient availability, and microbial activity, ultimately benefiting maize growth and yield. Mulching, which helps conserve moisture and protect the soil, can also have a positive impact on maize production. By reducing evaporation and soil erosion, mulching helps retain soil moisture, maintain more stable soil temperatures, and protect the soil surface from the impact of raindrops (Stone, 2010).

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Study Area

This research was carried out in Shamva in Mashonaland Central at Abide farm 26 km from Bindura University of Science Education 2023/24 growing season. The farm was located at a latitude of 17.2980° south and 31.5653° east. This site was chosen according suitability, thus avoiding biased results. The total project 36 square metre marked by four master wood pegs 40cm high.

It lies in region III at the altitude of 1225 metres above the sea level. The average rainfall amount of 600-850mm yearly. Average annual temperature of 24℃ is experienced with a maximum of 26℃ and a minimum of 18.4℃. This zone is known for severe dry spells during the rainy season. Dominating the areas are moderately deep, well drained red to reddish brown soils of high agricultural purpose. The major crops grown around the farm are maize, tobacco, wheat and field beans vegetables which include tomatoes, cabbage, green peas, butternuts, onion, potatoes and livestock production is also done around the farm and it include dairy, poultry and pig production.

3.2 Experimental Design

The research design chosen was simple and randomized experimental design. Treatments were arranged in Randomized Complete Block Design (RCBD), with fifteen treatment combination and 3 replications. The treatments were randomly assigned to the experimental units. With randomization, there is no subjective assignment of treatments to experimental units. The design studied the observable changes that take place in order to establish the impacts of compound D, compost, cow manure, and mulch on soil physical properties and their influence on maize production and it is essentially involved the use of experimental variable and the controlled variable.

3.2.1 Land Preparation and Soil Sampling

Land preparation was done at the onset of the rains which is mostly the case with smallholder farmers in the communal areas of Zimbabwe. It started about two weeks before planting date. The operations included digging, pegging and herbicide application. At the research unit, the first rains were on the 1st of December 2023 and effective on the 3rd of December 2023. Land clearance and burning of previous crop residues was done on 3rd of December 2023. Soil samples was taken and sent them to laboratory. Soil samples was being tested for bulk density, moisture retention and nutrient availability.

3.2.2 Seedbed Preparation and Soil Amendments Application

Digging and levelling was done on the 2nd of December 2023 using a spade and rake respectively when the soil was moist and friable. Soil amendments (humus, compound D, mulch and cattle kraal manure) was incorporated in plots. It was left for a day to aerate. The objective was to produce a seedbed with a fine tilt for good seed-soil contact which promotes successful seed germination, emergence and subsequently take off.

3.2.3 Row Marking and planting

Marking of planting rows was done using a dibber was done on the 4th of December 2023 using a line for digging uniform planting holes in rows of 20 plants each using hole. The planting rows and spacing were spaced at 600mm and 200mm respectively apart at a depth of ±5cm. this was done on the same day after completing row marking. Compound D (400kg/ha), compost (600kg/ha), mulch (500kg/ha) and cow manure (450kg/ha) was applied as basal dressing using the drilling method. The total fertilizer applied on 36m^2 project area was 32kg that is compound D 2kg, cow manure 10kg, mulch10 kg and compost 10kg.

A determinate maize seed SC 403 (Tsoko) was planted in prepared plots on the 6th of December 2023 using hoe. The seed rate used was 100kg/ha. In this view, the project site received ±0.4kg/36m^2 or 1600seeds. On average, each of the five (5) subplots of 6m^2 got 266/7 seeds. The plant spacing was 600mm×200mm. Seed covering with soil was done immediately after dropping the seed onto planting stations.

3.2.4 Water application

The crop was rain fed and irrigation during the dry spells to supplement water for plant growth with the rate 7mm/hour for six hours per day depending on crop water needs. This was done up until maturity.

3.2.5 Labelling of Experimental Plots

The project site was divided into five plots A, B, C, D, and E of 7m2 each with three subplots. Subplots were labelled A1, A2, and A3; for plot A, B1, B2, and B3 for plot B, C1, C2, and C3 for plot C, D1, D2, and D3 for plot D, and E1, E2, and E3 for plot E. Each plot had its own treatment. In order to minimize experimental error, the researcher replicated the beds and this is why each plot had three subplots. As a result, the researcher came up with plot E as control.

3.2.6 Project Layout

Project layout was as shown figure 3.1 below:

A1	
A2	
A3	
B1	
B2	
B3	
C1	
C2	
C3	
D1	
D2	
D3	
E1	
E2	
C3	

KEY

A1; A2; A3: - Humus

B1; B2; B3: - Cattle kraal manure

C1; C2; C3: - compound D

D1; D2 D3: - Mulch

E1; E2; E3: - Control

3.3.7 Thinning

The trial was planted with 2 seeds at a planting station. Thinning was done 3 weeks after crop emergency leaving 1 plant per planting station. Thinning was done so that 2 plants were left on each side of the gap. Thinning was done before of soon after irrigation or rainfall to prevent death of plants that become loose through thinning.

3.3.8 Pest and Weed Management

Weeding was done using Stella Star (700ml/ha) and Dual (1L/ha) as post emergency herbicides and manual weeding using hoes or hand weeding when necessary. For termite control, pyrenex (1.5L/ha) and for maize stalk borer was controlled using Dipterex granules (10%) was used and placed in the maize funnel.

3.4.9 Harvesting

Harvesting was done after 4 months of planting. Each plot was harvested placing the ears in their own bag with a tag showing the site, and plant treatment. The ears were then hand shelled.

3.5 Data Collection and Analysis

Data collection and analysis procedures which involved the systematic assessment of soil physical properties, maize growth parameters, and yield in response to the applied soil organic amendments as basal dressing was collected. The planting dates was recorded first.

3.5.1 Soil Physical Properties

Soil samples was collected in the field in the experimental plots, following established protocols for accurate assessment for bulky density, water holding capacity and soil porosity in the laboratory. It was randomly collected. Appropriate equipment and techniques were used utilized to ensure reliable data collection.

3.5.2 Plant Height

Maize plant height was monitored and recorded. Five plants were randomly selected per plot and tagged for determination of plant height. The plant height was measured from the soil surface to the uppermost leaf using a measuring tape. Recordings was done on a two weekly basics. This was done to determine the growth of maize across all the treatment combinations for valuation of maize growth rate, taking into the influence of soil amendments on plant development and vigor. This was done for all plots and results were recorded as average of the three blocks.

3.5.3 Leaf Number

Plants were selected at random and tagged for the determination of the number of leaves per plant across all replications. All visible leaves were noted and recorded as from the lowest part of the plant to the upper most tip of the plant. Recordings was done on a two weekly basics. Results were collected and recorded as averages of each treatment across all replications.

3.5.4 Leaf Area

On leaf area, plants were selected at randomly and tagged for the determination of the leaf area per plant across all replication. All visible leaves were noted and recorded their leaf area from the lowest part of the plant the upper most tip of the plant. Recordings was done on a two weekly basics.

3.5.5 Yield Assessment

Regular assessment of maize yield and quality attributes such as yield was conducted to determine the impact of the soil organic amendments on maize production in Shamva. Established protocols was employed for accurate yield measurements and quality assessment, considering the insights from previous research on maize productivity and soil fertility management. The weight of the grain from each plot was measured using a Nicolas scale. The moisture of the grain from each plot was also measured using a grain moisture meter. These apparatus were used to obtain the yield per hectare of each plot.

3.5.6 Statistical Analysis

All the results for physical properties (bulky density, water holding capacity and soil porosity), plant height, leaf number, leaf area and final yield were subjected to the analysis of variance (ANOVA) using Gen stat version Seventeenth edition statistical packages. Tables and graphs were used to present results. The outcome was going to be used to determine the impacts of humus, cattle kraal manure, compound D and mulch soil physical properties in relation to maize production.

CHAPTER FOUR: RESULTS

4.1 Effects of water holding capacity, bulky density and soil porosity

At land preparation, there was no significant difference (P>0.005) in terms water holding capacity, soil porosity and bulky density as a soil physical property in all the treatments.

4.2 Effects of compound D, cattle kraal manure, humus and mulch on plant height on maize variety (SC 403)

Treatment	height (cm) 6WAP	height (cm) 8WAP	height (cm) 10WAP	height (cm) 12WAP
1	84.7a	116.233a	145.4a	175.767a
2	84.6a	115.733b	144.767b	175.567a
3	84.433a	115.467b	144.433b	175.467a
4	84.3a	115.6b	144.733b	174.867a
5	84.033a	115.1b	144.133b	175.133a
s.e.d	0.1517	0.1362	0.0989	0.1116
l.s.d	0.3497	0.3141	0.228	0.2272
cv%	0.2	0.1	0.1	0.1
p. value	0.0216	<0.001	<0.001	<0.001

* Means followed by the same letter are not significant different

Table 4.1: Effects of compound D, cattle kraal manure, humus and mulch on plant height on maize variety (SC 403)

There was a significant difference (P<0.05) (Table 4.1) at 6,8,10 and 12WAP on all the treatments in terms of height. There was no significant difference (P>0.05) at 2 and 4 WAP in all treatments in terms of plant height. There was a notable statistical difference (P<0.05) 0n the means of treatment [1] and treatment [2] at 8 and 10WAP. All other remaining means at 10 and 12WAP showed no significant difference (P>0.05). There was no notable statistical difference (P<0.05) on all the means of the treatments at 6 and 12 WAP.

4.3 Effects of compound D, cattle kraal manure, humus and mulch on leaf number on maize variety (SC 403)

Treatment	leaf number 2WAP	leaf number 8WAP	leaf number 12WAP
1	4a	15.0a	17.67a
2	2.67a	14.33a	16.33b
3	3.67a	13.33a	15.67b

4	2.33a	13.33a	16.00b
5	4.30a	13.67a	15.33b
s.e.d	0.596	0.494	0.537
l.s.d	1.375	1.14	1.239
cv%	21.5	4.3	4.1
P value	0.04	0.038	0.019

*Means followed by the same letters are not significant different

Table 4.2: Effects of compound D, cattle kraal manure, humus and mulch on leaf number on maize variety (SC 403)

There was a significant difference (P<0.05) (Table 4.2) at 2, 8 and 12WAP on all the treatments in terms of height. There was no significant difference (P>0.05) at 4, 6 and 10WAP in all treatments in terms of plant height. There was a notable statistical difference (P<0.05) 0n the means of treatment [1] and treatment [2] at 12WAP. All other remaining means at 10 and 12WAP showed no sgignificant difference (P>0.05). There was no notable statistical difference (P<0.05) on all the means of the treatments at 2 and 8 WAP.

4.4 Effects of compound D, cattle kraal manure, humus and mulch on leaf area on maize variety (SC 403)

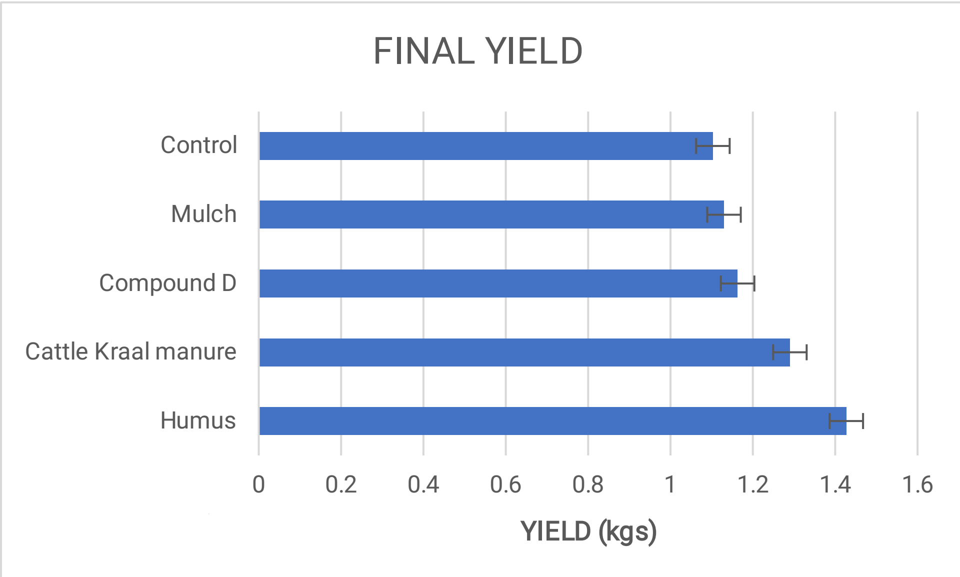
Treatment	Leaf area (cm^2) 6WAP	Leaf area (cm^2) 8WAP	Leaf area (cm^2) 12WAP
1	466.7a	613.3a	706.7a
2	413.3a	573.3b	653.3b
3	493.3a	533.3b	626.76b
4	440.0a	546.7b	640.0b
5	413a	533.3b	613.3b
s.e.d	15.2	16.87	21.5
l.s.d	35.06	38.89	49.58
cv %	4.2	3.7	4.1
p. value	0.003	0.006	o.019

*means followed by the same letters are not significant different

Table 4.4 Effects of compound D, cattle kraal manure, humus and mulch on leaf area on maize variety (SC 403)

There was a significant difference (P<0.05) (Table 4.4) at 6, 8 and 12WAP on all the treatments in terms of height. There was no significant difference (P>0.05) at 2, 4 and 10WAP in all treatments in terms of plant height. There was a notable statistical difference (P<0.05) on the means of treatment [1] and treatment [2] at 8 and 12wWAP. All other remaining means at 8 and 12WAP showed no significant difference (P>0.05). There was no notable statistical difference (P<0.05) on all the means of the treatments at 6WAP.

4.5 Effects of compound D, cattle kraal manure, humus and mulch on final yield on maize variety (SC 403).



*means followed by the same letters are not significant different

Table 4.6: Effects of compound D, cattle kraal manure, humus and mulch on final yield on maize variety (SC 403)

There was no significant different (P>0.05) (Table 4.6) at 12 WAP on all treatments in terms of final yield. There was no notable statistical difference (P>0.05) on all the means at 12 WAP.

CHAPTER FIVE: DISCUSSION OF RESULTS

5.1 Soil Physical Properties

The absence significant difference among soil physical properties that is soil porosity, bulky density and water holding capacity in all treatments was recorded this study indicates that the soil had good performances. The soil is likely a well-structured, fertile soil with good physical properties, such as bulky density approximately around 1.3-1.5 g/cm3, water holding capacity is high that is around 50 -60% and soil porosity is moderately to high that is around 40-50%. The soil can be described as clay loam soil (Greenwood, 2001).

It is great importance to understand the soil properties before planting. It will help in determining the amount of lime to apply. Also, Horn (1994) states that it helps in determining the amount of fertilizer to apply. Understanding soil properties will determine the type of crops to grow and activities to do. It will help the amount water to apply.

5.2 Plant height

There was no significant difference in plant height at 6 and 12 weeks after planting on maize variety (SC403). Maybe it was environmental factors (Wang, 2020) which include weather conditions like temperature could have been affected the plant height, which would not be significant different at maturity stage. Week 12 may be too late to detect significant differences in plant height, as maize plants typically reach their maximum height around the silking stage (around 60-70 days after sowing). The experimental design, including factors such as plot size, replication, and randomization, might not have been sufficient to detect significant differences in plant height.

However, there was significant difference in plant height at on maize variety (SC 403) at week 8 and 10. Plant height of maize variety varied due to weather conditions, soil quality water availability affected plant height potentially causing significance differences in maize variety in all treatments. The experimental design, including factors such as plot size, replication, and randomization, maybe could have been sufficient to detect significant differences in plant height (Hufford, 2012).

Highest plant height is attained at day 115 which it is more or less constant and this is supported by who also conducted the similar experiment and observed that plant height is affected by plant variety, environmental conditions that is temperature, light, water and nutrient availability.

5.3 Leaf number

There was no significant difference on maize variety (SC 403) at week 2 and 8 in terms leaf numbers in all treatments. Maybe it was due to photoperiod during growth rate stages especially on V7 to V11 (Weatherwax, 1918). Photoperiod could have affected the total leaf number and below the primary ear. The plants did not receive enough sunlight which was caused by cloud the whole week. The sunlight is used during photosynthesis to take place by plants. The environment could have cause no difference in leaf number of plants because if the temperature becomes too high the leaf number of a plant will not increase, also if the plant did not receive enough rainfall the amount of plant leaves will not increase. Also wet dry spells could have caused no significant difference in leaf numbers of a plant because if the dry spells caused maize plant leaves not to increase in leaf number.

However, there was significant difference at week 12 on maize variety (SC 403) and maybe the cause was due environmental conditions. (Mangelsdorf, 1938), reported that environmental factors such as temperature, water, and solar radiation affect maize leaf number. If plant have enough water it will produce many leaves and these leaves will help in the production of food for plant through photosynthesis. Plants requires optimum temperature the plant to grow well and the plant will increase the number of leaves. Nutrients available is another cause that could have cause significant difference in leaf number stated that nutrient availability, particularly nitrogen, affects maize leaf number with higher nutrient levels resulting in increased leaf number.

5.4 Leaf area

There was no significant difference on maize variety (SC 403) at 6 weeks in terms of leaf area. It was due to environmental influences that is environmental factors like light, temperature, and water may affect leaf area development differently among varieties during the maturity stage. The plant did not receive enough rainfall supply at week 6 which led to no significant difference in terms of leaf area in all treatments.

Also, Friedman, Moore, & Purugganan (2004) state that light and temperature maybe it caused the leaf area not to change as the light and temperature if they increase the plant leaf area shrinks thereby reducing the area. At the end there was no significant difference on maize variety in terms of leaf area. Nutrient availability maybe can caused no differences in nutrient uptake and utilization among varieties may impact leaf area development during the maturity stage. The absorption and the availability of the nutrients are important for the maize plant to increase its leaf area. Nutrients availability maybe it was poor (Nagy, 2006).

However, there was a significant difference at week 8 and 12 on maize variety in all treatments. Maybe it was due to hormones responses like auxins and cytokinins play a crucial role in leaf growth and development; variations in hormonal regulation among varieties maybe led to differences in leaf area during maturity (Erenstein, 2022). There was enough good response from hormones in plant growth which led to an increase in leaf area. If the leaf area increases which means the plant physiology like photosynthesis and transpiration increases leading the significant difference in maize variety. Also maybe it was due to environmental factors like enough water, temperature and light intensity which led to the significant difference on leaf area of a maize variety (Araus, 2014).

Therefore, the leaf area in maize crop may varies according to the maize variety, growing season, growing season, environment and nutrient available. This will determine the significant difference on maize variety in terms of leaf area.

5.5 Final yield

The results showed that there was no significant difference in final yield on the maize variety (SC 403) in all treatments. (Crafts-Brandner, 2002), did a similar experiment and observed that yield of maize was affected by a number of factors such as location, environment, planting spacing and the plant variety.

Genetics difference in maize variety (SC403) maybe caused the final yield to have no significant difference. Varieties may have similar genetic makeup for early growth, but differ in genes controlling later growth stages and these affected the yield later causing it to have no significant difference. Also, environmental factors like light, temperature, and water may affect leaf area development differently among varieties during the maturity stage resulted in the no difference on yield (Araus, 2014). Hormones play a crucial role in maize growth and development. Variations in hormonal regulation among varieties may lead to differences in leaf area during maturity. The hormones responses contributed to no significant different yield of the maize variety in all treatments. Differences in nutrient uptake and utilization on maize variety in all treatments maybe impacted yield as it affected the development of leaf number and area during the maturity stage (Friedman, Moore, & Purugganan, 2004). The yield showed the same trend of yield in all the treatments.

CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

Maize has a potential for increasing diversification of Zimbabwe agriculture. This is because the crop has many major advantages; firstly, maize is a primary food source for many people in Zimbabwe. It is used as staple food. Maize provides energy and essential nutrients for the human body. Also, maize is used in various food products like cornmeal and cornflakes. Maize is stored in national reserves, ensuring food availability during times of scarcity for example maize is reserved in silos in GMBs.

Maize is used as feed for poultry, pigs, and cattle, supporting the livestock industry. Maize is used in animal breeding and rearing, supporting the dairy and meat industries. Maize is used as a cash crop here in Zimbabwe. Maize is exported to other countries there by generating revenue for the country.

There is employment opportunities. Maize production and processing create jobs for farmers, laborers, and industry workers. It has raised standard of living for many people. Through maize production in Zimbabwe, there is rural development. Maize production supports rural livelihoods, contributing to local economic growth after selling their products to GMBs and exporting outside the country. It will allow them to buy their basics their by improving the standard of living. Since maize might serve a multiple purpose in Zimbabwe that is food security, livestock feeds, export earnings, rural development and national food reserves. It is recommended that the crop's expansion be based on the results.

6.2 Recommendations

The maize variety (SC 403) grown on different treatments (humus, compound D, mulch and cattle kraal manure) performed the same because they have shown no significant difference on final yield. Maize is an ideal crop to integrate into the crop production system of the local farmers in Shamva. A wide range of treatments in maize variety will the farmers the opportunity to choose the best treatment suited to their needs.

The researcher recommends the use of soil amendments (humus, cattle kraal manure, mulch and compound D) in maize production in order to increase yields. Also, the recommend the farmers to do soil analysis before planting as it will help them to know type of soil, the amount of fertilizer to apply and the amount of fertilizer to apply. The researcher recommends early planting, use of resistant variety and use best varieties which suit to the local area.

This will assist the local farmers the identification of the best treatment with the best good soil fertility good nutrients, good water holding capacity, good soil bulky density, and good variety with high yield potential. Humus is the best soil amendment in maize variety as it show that highest plant height, leaf area and leaf number and growth and yield. Also mulch as treatment used showed the lowest in plant height and leaf number on maize variety. Concerning yield, all the treatments performed the same because they have shown o significant difference in final yield. Therefore farmers are able to used improved treatment for any soil type.

APPENDIX

Analysis of variance

Variety: soil porosity

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	2	1.600	0.800	0.38	
block.*Units* stratum					
treatment	4	5.333	1.333	0.62	0.658
Residual	8	17.067	2.133		
Total	14	24.000			

Least significant differences of means (5% level)

Table	treatment
rep.	3
d.f.	8
l.s.d.	2.750

Analysis of variance

Variety: water holding capacity

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	2	4.1333	2.0667	2.82	
block.*Units* stratum					
treatment	4	5.7333	1.4333	1.95	0.195
Residual	8	5.8667	0.7333		
Total	14	15.7333			

Least significant differences of means (5% level)

Table	treatment
rep.	3
d.f.	8
l.s.d.	1.612

Analysis of variance

Variety: bulky density

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	2	0.05200	0.02600	2.56	
block.*Units* stratum					
treatment	4	0.03067	0.00767	0.75	0.583
Residual	8	0.08133	0.01017		
Total	14	0.16400			

Least significant differences of means (5% level)

Table	treatment
rep.	3
d.f.	8
l.s.d.	0.1898

Analysis of variance

Variate: leaf_number_10

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	2	1.6000	0.8000	1.00	
block.*Units* stratum					
treatment	4	3.6000	0.9000	1.12	0.409
Residual	8	6.4000	0.8000		
Total	14	11.6000			

Least significant differences of means (5% level)

Table	treatment
rep.	3
d.f.	8
l.s.d.	1.684

Analysis of variance

Variety: Leaf_number4

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	2	1.7333	0.8667	1.00	
block.*Units* stratum					
treatment	4	0.6667	0.1667	0.19	0.936

Residual	8	6.9333	0.8667		
Total	14	9.3333			

Least significant differences of means (5% level)

Table	treatment
rep.	3
d.f.	8
l.s.d.	1.753

Analysis of variance

Variety: height 2

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	2	0.05200	0.02600	0.39	
block.*Units* stratum					
treatment	4	0.21600	0.05400	0.82	0.548
Residual	8	0.52800	0.06600		
Total	14	0.79600			

Least significant differences of means (5% level)

Table	treatment
rep.	3
d.f.	8
l.s.d.	0.4837

Analysis of variance

Variety: hieght4

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	2	0.5053	0.2527	2.03	
block.*Units* stratum					
treatment	4	1.0333	0.2583	2.08	0.176
Residual	8	0.9947	0.1243		
Total	14	2.5333			

Least significant differences of means (5% level)

Table	treatment
rep.	3

d.f.	8
l.s.d.	0.6639

Analysis of variance

Variety: height 8

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	2	0.01733	0.00867	0.31	
block.*Units* stratum					
treatment	4	2.04933	0.51233	18.41	<.001
Residual	8	0.22267	0.02783		
Total	14	2.28933			

Least significant differences of means (5% level)

Table	treatment
rep.	3
d.f.	8
l.s.d.	0.3141

Analysis of variance

Variety: height 10

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	2	0.16933	0.08467	5.77	
block.*Units* stratum					
treatment	4	2.66267	0.66567	45.39	<.001
Residual	8	0.11733	0.01467		
Total	14	2.94933			

Least significant differences of means (5% level)

Table	treatment
rep.	3
d.f.	8
l.s.d.	0.2280

Analysis of variance

Variety: height 12

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	2	0.08400	0.04200	2.25	
block.*Units* stratum					
treatment	4	1.54267	0.38567	20.66	<.001
Residual	8	0.14933	0.01867		
Total	14	1.77600			

Least significant differences of means (5% level)

Table	treatment
rep.	3
d.f.	8
l.s.d.	0.2572

Analysis of variance

Variety: height 6

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	2	0.03733	0.01867	0.54	
block.*Units* stratum					
treatment	4	0.82400	0.20600	5.97	0.016
Residual	8	0.27600	0.03450		
Total	14	1.13733			

Least significant differences of means (5% level)

Table	treatment
rep.	3
d.f.	8
l.s.d.	0.3497

Analysis of variance

Variety: leaf area 2

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	2	640.	320.	0.16	
block.*Units* stratum					
treatment	4	4693.	1173.	0.57	0.691
Residual	8	16427.	2053.		

Total	14	21760.			

Least significant differences of means (5% level)

Table	treatment
rep.	3
d.f.	8
l.s.d.	85.3

Analysis of variance

Variety: leaf area 4

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	2	2413.	1207.	0.99	
block.*Units* stratum					
treatment	4	840.	210.	0.17	0.946
Residual	8	9720.	1215.		
Total	14	12973.			

Least significant differences of means (5% level)

Table	treatment
rep.	3
d.f.	8
l.s.d.	65.63

Analysis of variance

Variety: leaf_area6

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	2	1493.3	746.7	2.15	
block.*Units* stratum					
treatment	4	14506.7	3626.7	10.46	0.003
Residual	8	2773.3	346.7		
Total	14	18773.3			

Least significant differences of means (5% level)

Table	treatment
rep.	3

d.f.	8
l.s.d.	35.06

Analysis of variance

Variety: leaf area 12

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	2	1920.0	960.0	1.38	
block.*Units* stratum					
treatment	4	15573.3	3893.3	5.62	0.019
Residual	8	5546.7	693.3		
Total	14	23040.0			

Least significant differences of means (5% level)

Table	treatment
rep.	3
d.f.	8
l.s.d.	49.58

Analysis of variance

Variety: leaf area 8

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	2	1920.0	960.0	2.25	
block.*Units* stratum					
treatment	4	13866.7	3466.7	8.13	0.006
Residual	8	3413.3	426.7		
Total	14	19200.0			

Least significant differences of means (5% level)

Table	treatment
rep.	3
d.f.	8
l.s.d.	38.89

Analysis of variance

Variate: leaf area 10

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	2	2560.	1280.	1.00	
block.*Units* stratum					
treatment	4	5760.	1440.	1.12	0.409
Residual	8	10240.	1280.		
Total	14	18560.			

Least significant differences of means (5% level)

Table	treatment
rep.	3
d.f.	8
l.s.d.	67.36

Analysis of variance

Variety: leaf_number2

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	2	0.4000	0.2000	0.38	
block.*Units* stratum					
treatment	4	8.9333	2.2333	4.19	0.040
Residual	8	4.2667	0.5333		
Total	14	13.6000			

Least significant differences of means (5% level)

Table	treatment
rep.	3
d.f.	8
l.s.d.	1.375

Analysis of variance

Variety: leaf number 6

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	2	0.9333	0.4667	0.58	
block.*Units* stratum					
treatment	4	4.4000	1.1000	1.37	0.324

Residual	8	6.4000	0.8000		
Total	14	11.7333			

Least significant differences of means (5% level)

Table	treatment
rep.	3
d.f.	8
l.s.d.	1.684

Analysis of variance

Variety: leaf number 12

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	2	1.2000	0.6000	1.38	
block.*Units* stratum					
treatment	4	9.7333	2.4333	5.62	0.019
Residual	8	3.4667	0.4333		
Total	14	14.4000			

Least significant differences of means (5% level)

Table	treatment
Rep	3
d.f.	8
l.s.d.	1.239

Analysis of variance

Variety: leaf number 8

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	2	1.7333	0.8667	2.36	
block.*Units* stratum					
treatment	4	6.2667	1.5667	4.27	0.038
Residual	8	2.9333	0.3667		
Total	14	10.9333			

Least significant differences of means (5% level)

Table	treatment

rep.	3
d.f.	8
l.s.d.	1.140

Analysis of variance

Variety: final yield 12

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	2	0.007693	0.003847	1.55	
block.*Units* stratum					
treatment	4	0.217493	0.054373	21.85	<.001
Residual	8	0.019907	0.002488		
Total	14	0.245093			

Least significant differences of means (5% level)

Table	treatment
rep.	3
d.f.	8
l.s.d.	0.0939

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