EFFECTS OF WATER CONSERVATION METHODS AND CROPPING SYSTEMS ON GROWTH AND YIELDS OF MAIZE AND BEANS IN WAIRAKA, JINJA, UGANDA.

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A thesis submitted in partial fulfilment to the School of Science and Technology for the degree of Masters of Agricultural and Rural Development of Kenya Methodist University

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Declaration and Recommendation

Declaration

"This thesis is my original work and has not been presented for a degree or any other award in any other University."

Signed………………………………….. Date………………………

KENNEDY KURU (AGR-03-0986-3/2015)

Recommendation

This thesis has been submitted with our approval as University Supervisors.

Signed…………………………………… Date……………………

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Dedication

This thesis work is dedicated to my mother, Angelina, who has been a constant source of support and encouragement.

Acknowledgement

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Abstract

Maize and beans form a significant part of the diet for thousands of households in Uganda and neighbouring countries, but the yields of these crops have been greatly affected by erratic rains and prolonged droughts. Irrigation schemes are often prohibitively expensive for small-scale farmers in Uganda and elsewhere. Low-cost water conservation practices such as double digging, mulching and effective cropping systems can greatly reduce evaporation, surface runoff and increase water retention in the soils and thereby have the potential to enhance the production and yield of maize and beans under variable rainfall conditions without requiring capital input from farmers. This study investigated the impact of double digging, mulching, and also intercropping devices on the development and also yields of beans and maize in Wairaka, Jinja District, Uganda. A randomized complete block layout with 3 replications of the treatments was used, data was collected on the plant growth parameters; plant heights, number of leaves and yield parameters; cob length, number of seeds per cob/pod, weight per bean seed and total maize/bean yields. The results demonstrated that the development of maize and also beans have been discovered to be much higher in double digging, intercropping, and mulching. Double digging increased maize and beans plant heights by 0.91% and 20.78% respectively over single digging. Similarly, the cob length, total maize yields, seeds per pod, and total bean yields by 4.79%, 0.37%, 39.39%, 3.01% was enhanced double digging, respectively. Inter-cropping of maize and beans increased the maize plant height, cob length and total maize yield by 0.54%, 5.52%, and 2.43% respectively over maize monocrop while the bean plant height, seeds per pod and the total were increased by 4.33%, 22.86%, and 3.26% respectively over bean monocrop. Mulch significantly affected the growth and yields of both maize and beans. The mean increase in maize plant height was 1.36% and 0.29%, and bean plant height was 12.76%, and 7.06% in the case of dry banana leaves and dry grass, as compared to the control (no mulch). The mean cob length difference and total maize yields were 4.96%, 2.90% and 1.57% 0.93% while the seeds per pod and total bean yields were 25% and 12.5% and 5.00% and 3.68% in the case of dry banana leaves and dry grass, respectively, over the control (no mulch). The low-cost methods we investigated, mainly double digging, dry banana leaves mulches, and maize-bean intercrop, are promising in ensuring yields against erratic rainfall and drought and can be recommended to farmers.

Table of Contents

List of Tables

List of figures

Abbreviations and Acronyms

CA	Conservation Agriculture
DAP	Days after Planting
DD	Double Digging
DDBs	Double Dug Beds
FAO	Food and Agricultural Organization
ISWCP	Indigenous Soil and Water Conversation Program
LSD	Least Standard Deviation
NUE	Nitrogen Use Efficiency
OECD	Organization for Economic Corporation and Development
SPI	System Productive Index
SSA	Sub Saharan Africa
UNMA	Uganda National Meteorological Association

CHAPTER ONE
INTRODUCTION

1.1 Background to the Study

It's projected that, by 2050, more than two billion people will encounter food insecurity. Thus, agricultural mechanisms to increase productivity are needed (Raseduzzaman & Steen, 2017). Monoculture methods that leave farmers dependent on yields from one or two crops increase food insecurity by leaving them vulnerable to production variability from environmental factors (Sutton, 2015). In SSA countries, the food insecurity situation is worse as most agricultural activities are mainly rainfed (Karuma et al., 2016). This is coupled with the annual conversion of high-quality cropland into nonfarm uses such as housing, roads, and other social needs hence reduction in food production to feed the ever-increasing population thus making them continue depending on traditional farms and ranches to meet their dietary needs (Barioni et al., 2019). Farmers have embarked on the use of soil and water conservation methods together with sustainable cropping systems to make effective use of the available cropland (Turinawe et al., 2015).

Water and soil moisture conservation are vital for crop production as crops effectively utilize rainwater resources through absorption (Rahman et al., 2017). For instance, tillage improves rainwater infiltration and conserving adequate soil moisture for plant growth (Wim et al., 2013). However, land preparation methods lead to a reduction in the soil living organism content, water runoff, soil erosion, and degradation of other forms of physical, chemical, and biological degradation forms of the land (Thierfelder & Wall, 2009). Soil tillage practices (such as grooves, subsoil, and laceration) can retain soil moisture and mitigate dry season periods (Manyatsi et al., 2017). For example, soil preparation conserves about 70-85% of rainwater in sub-Saharan Africa, which would be lost due to water evaporation from the soil, extreme filtration and erosion, supporting crops (Wim et al., 2013).

Most smallholder farmers in most East African countries practice tillage and is mostly manual (such as using an ox plough and the hand hoe. Double digging strengthens the land by breaking up hard soil particles and forming a rich, moist, loose soil base. Well, aerated soil facilitates increased intake of water and preservation, enabling effective use of the available nutrients by plants more effectively and increasing root penetration into the ground (Njoroge, 1994; Owenya et al., 2012). However, evidence indicated that there were higher maize harvests, gross margins, and better returns to work under DDB and composting in low opportunity areas such as Machakos, Kenya, compared to the very prospective areas of the Nyeri district in Kenya. The situation can is attributed to the hard soil particles that are most frequent in Machakos (Hilhorst & Muchena, 2000).

Appropriation and ensuing adjustment are the aftereffect of expanded manure generation, which ought to be included when double unearthing beds are readied. An adoption rate of 22% of the practice could be increased through training, such as low external inputs and sustainable agricultural technologies (Pretty et al., 2011; Viatte, 2001). Digging depth as a type of deep processing in most cases is accompanied by the use of compost and mulch to improve agricultural production in densely populated areas of the world. The goal of deep digging is to loosen the deep layers of the soil for intensive agricultural production. Compost aims to provide nutrients that are essential for plants and enhance the physical qualities of the area through the application of natural matter (Pfirter, 1981). Organic matter has many benefits in soil fertility, as it increases the storage capacity of nutrients (Halvin et al., 2005; Woomer et al., 1995).

Mulching reduces surface evaporation, modulating soil temperature, improving infiltration, reducing runoff flow, preventing wind erosion, and weed control (Prosdocimi, 2016). The material used to cover the soil decomposes (such as; crop residues, natural grass wood chip, peat, cut grass, or other plants) adds manure to the ground improves the air circulation, thus making the soil fit for crop growth (Abubaker, 2013). In East Africa, mulching is a practice where farmers' wetter areas utilize natural vegetative material (Kibwana, 2000; Mruma & Temu, 1999).

Furthermore, mulching makes effective use of rain for cultivation, since they prevent the evaporation of soil moisture and, therefore, limit water losses and soil erosion on the surface (Mehetre, 2014). However, selecting the appropriate mulching materials is vital for the farmer to benefit from mulches (Kader et al., 2017). Mulching compensates for water limits, low temperatures, gravel mulches, and are the essential traditional techniques that farmers have used in many dry areas (Lithourgidis et al., 2011). The application of mulches affects soil conditions, crop growth, and the use of resources to optimize water management and improve maize yield (Lithourgidis et al., 2011). Also, the use of mulches controls weeds, minimizes moisture loss, nutrient loss, controls erosion, insects, and diseases, encouraging the creation of plants and potentially improving crop quality (Mehetre, 2014). However, the adoption rates of these soil and water conservation methods that have been suggested (double digging and mulching) and disseminated to farmers in order to increase soil moisture are still below in expectations in Jinja and the most parts of Eastern Uganda (Turinawe et al., 2015).

The introduction of various systems of cropping over time and space is vital for food production, as farmers manage multiple crops on the same land. Also, the inefficiency of the traditional food production systems, making intercropping imperative the nutrient dissolve into soils most especially when the cereal is intercropped by the legume, thus improving the nitrogen level in the grounds (Raseduzzaman & Steen, 2017). Intercropping promotes in crop production eco-functionality, ecological, and sustainable intensification (Raseduzzaman & Steen, 2017). Intercropping /mixed farming is also a proficient method for accomplishing manageability agriculture as the process increases crop yields from each unit of land harvested by intensive production from a reduced farm size (Undie et al., 2012; Vandermeer, 1992).

In East Africa (Rwanda, Kenya, Uganda, and Tanzania), as a result of a yield-stabilizing effect, enhanced efficient use of land, water, and labour, intercropping is a common practice as it leads to food security (Karuma et al., 2016). The approach frequently leads to risk avoidance in the case of total yield reduction, plant protection, and enhancement of soil fertility and development of adequate human nutritional needs (Lithourgidis et al., 2011; Ondedo et al., 2011). For example, (Karuma et al., 2016) point out that associated cropping can help improve the productivity of low external input agriculture, a feature of small farmers. They rely heavily on rain-fed agriculture and the inherent ability of soil to produce.

Intercrops say between other crops and legume crops improve the natural and man-made factors such as pests and diseases, weeds, and abiotic factors include climatic factors, especially rainfall, temperatures, and moisture (Egal, 1999). The cropping systems contribute to the growth and yields of the two crops. In Uganda, for example, there is intercropping between maize and beans, few studies (Namutebi, 2014; Niringiye et al., 2005) have studied the two crops as intercrops. Intercropping significantly reduces the incidences of Striga in the farmer's field. In contrast, maize desmodium intercrop reduced the impacts of Striga the most at 72% while common bean-maize intercrop reduced the Number of emerged Striga plants by 37% (Namutebi, 2014).

Sebuwufu et al. (2016) have studied the two crops as monocrops and found out that the mean bean yield is less than 30% of the potential return. This is despite some measures being taken to increase production, like, the extension of cultivated land, the use of fertilizers, hence improving the output of a piece of land. However, the low yields have been attributed to low soil fertility, periodic water stress, disease, and pests (Katungi et al., 2015).

The intercropping between the different crops reduces the occurrence of the pests and is recommended agricultural practices for integrated pest management (El-Fakharany et al., 2012). Legume nutrient plants biologically fix atmospheric nitrogen to cereal crops, thus increases the productivity of low external input farming, where smallholder farmers depend primarily on rainfall (Matusso et al., 2014). Also, intercropping increases the efficiency of interception and association of species with different seasonal growth patterns and allowing a better average ground cover (Nandwa et al., 2011). As grain legumes can cope with soil erosion and dense canopy enables light extinction profile. Dense plant canopy intercepts water consumption and energy (Egal, 1999).

Furthermore, the sharing of soil nutrients between individual plants in dense canopies is influenced by their ability to use these resources, their uptake capacity as determined by the size and the spatial distribution of their root system. Thus, the functioning of intercropping systems in terms of efficiency of utilization of soil resources appears to be mainly influenced by the competition for light between the different species. The contribution of one species to the N and other mineral uptake and the water consumption of an intercropping system can be considered in a first approximation is proportional to its contribution to the interception of radiation (Egal, 1999).

In Eastern Uganda, especially Jinja, Maize and beans form a significant part of the diet for thousands of households. Different varieties of seeds have grown that include K13, Kanyebwa, NABE4 NABE6 (Sebuwufu et al., 2016). For instance, the country experiences two seasons (UNMA, 2017). Under these seasons, the yield of most crops, including maize and beans, are affected, and they are appallingly poor with marked incidences of food crises in some parts of the country. This, therefore, calls for an urgent study into the ways of increasing the yields of these two crops (maize and beans) and other crops, especially during this period of unpredictable rains and prolonged drought. Water conservation practices and proper cropping systems that increase growth and yields of maize and beans must be put into practice. This study examined the different water conservation methods (double digging and mulching) and the different cropping systems on the crop growth and yield in Wairaka, Jinja district.

1.2. Statement of the Problem

Wairaka, Jinja is in eastern Uganda, where the farm size has reduced because of the growing population. This is worsened by prolonged drought, erratic rainfall, mining of nutrients, poor nutrient conservation practices that affect food production. Also, Wairaka has low soil fertility, thus causing a decline in maize and beans production and other staple food leading to hunger and poverty. Therefore, adoption of the maize-bean intercropping system and the different water conservation methods would improve crop productivity through integrating legume, hence increasing crop yields and household income. However, small-scale farmers of this region lack information on the optimum cropping system, lack of experimented moisture conversation (i.e., mulching by use of dry grass and banana leaves, and double digging). Besides, lack of mulching, on the other, hand exposes the topsoil to loss of moisture through evapotranspiration hence depriving the crops of humidity. This research, therefore, tried to evaluate the effect of water conservation and cropping system on maize-bean growth and yield in Wairaka, Jinja district.

1.3 Justification of the Study

Intercropping maize and beans are an adequate solution among local farmers to increase revenue and crop production per unit area (Tsubo et al., 2003) and lessen the danger of total loss of yields as a result of ecological restrictions (Prasad & Brook, 2005). Regarding the economic and nutritional importance of beans as leguminous vegetables and corn as an important cereal crop, small farmers in many countries prefer the cultivation of soybeans and corn in the mix to the single-crop system (Karuma et al., 2016). Bean has a tremendous dietary benefit; it contains 20 percent oil, 40 percent top-notch protein, while rice has 7%, wheat 12%, maize 10%, 20 to 25 percent different heartbeats. Its protein is wealthy in the significant amino corrosive lysine (5 percent) in which most oats are inadequate. It additionally contains a decent measure of minerals, salts, and nutrients.

Therefore, findings from the study avail policymakers to guide them on making policies on water and soil conservation through mulching and double digging, cropping system, and intercropping between maize and bean to improve food productivity in Wairaka, Jinja, and Uganda at large. Lastly, the study will provide literature to research in a similar area.

1.4 General Objective

To examine the effects of water conservation methods and cropping systems on the growth and yields of maize and bean in Wairaka, Jinja.

1.5 Specific Objectives

i. To evaluate the effects of double digging on the growth and yield of maize and beans.
ii. To evaluate the effects of cropping systems on the growth as well as yield of beans and corn.
iii. Determine the impacts of various types of mulch on the growth as well as yield of corn and beans

1.6 Research Hypotheses

i. Double digging significantly affects maize and beans growth and yields.
ii. Intercropping significantly increases growth and yield of maize and beans.
iii. The type of mulch significantly influences growth and yield of maize and beans

1.7 Significance of the Study

The double digging and application of mulches are timely in the era of climatic change characterized by recurrent episodes of drought and erratic rainfall. These practices are used to avert the likely effects of drought through appropriate mulching materials to conserve water and maintain moisture. Double digging helps maintain fertility when the nutrients in lower soil layers are brought on top through digging deeper and making organic nutrients available for the crops during drought.

1.8 Definition of Terms

The soil is three-dimensional, dynamic, and natural body located on the surface of the earth and is a means for the growth of plants and whose characteristics are derived from the combined effect of the climate and living matter (Gupta, 2014).

Mulching is the practice of covering the soil surface to reduce surface evaporation, modulating soil temperature, improving infiltration, reducing runoff flow, preventing wind erosion, and weed control (Prosdocimi, 2016).

Double digging is a bed preparation method to promote deep root penetration, healthy crop growth and increased production (Stein, 2008)

Monocropping is growing of single crops yearly on the same piece of land.

Intercropping is the growing of two or more crops simultaneously on the same piece of land (Palaniappan,1996)

CHAPTER TWO
LITERATURE REVIEW

This chapter presents the theoretical review of the literature and the empirical review on double digging, mulching, and intercropping.

2.1 Theoretical Framework

Beans (*Phaseolus vulgaris*) and corn (*Zea mays L.*) are the main food crops for more than 85% of families in East Africa (Rockstrom et al., 2009). Despite the economic value of corn and beans, its production has decreased to 1.8 and 0.5 t ha^{-1} for the corn and bean visa, which exceeds the expected potential (Jagtap & Abamu, 2013). This reduced agricultural output is attributed to regular cycles of drought and soil fertility correlated with improper agricultural practices, such as significant biophysical factors that limit per-capita agricultural output in the zones (Recha et al., 2012).

Farmers consider adopting progressive farming methods, such as CA, with the potential to conserve water and recover resources in order to improve poor soil fertility conditions as part of coping strategies (Nabhan et al., 1999). With the farming mainly for subsistence, typically low yields got for critical crops such as maize, beans, and groundnuts resulting from climate change, and the degraded environment has impacted the ability of the farmers to feed their families and also to get out of absolute poverty. This background forms the adoption of several smart agriculture practices, including double digging, mulching, planting of cover crops, composting of crop residues, mixed cropping, and quality seed selection and treatment, is hoped not only to increase and retain moisture in the soil but also regenerate soil fertility hence increasing crop production (Adimassu et al., 2013; González-Peñaloza et al., 2012).

In areas of dense population, crop production is improved by the utilization of practices such as digging depth, mulching, and the application of manure. As a form of deep tillage, digging depth (double digging) breaks the hardpans and loosens deep layers of fertile soil, thus preparing the ground for cultivation (Miriti et al., 2003). This practice contributes to the improvement of crop production by aerating the soil and improving water absorption and retention. It implies that plants can utilize the readily required nutrients more effectively and increased the vertical root length in the soil (FAO, 2000; Njoroge, 1994). In areas with more frequent hardpans, tests show that double-digging beds (DDB) produce higher maize crops, better gross margins, and return to work (FAO, 2000).

2.2 Empirical Evidence

This section presents empirical literature from similar studies, and they are laid as follows:

2.2.1 Plant growth parameter - Plant height (cm)

Several studies (Abubaker, 2013; Belel, 2012; Mehetre, 2014; Parmar et al., 2013) measured the growth parameters of the plant using the height of the plant in cm. For example, (Mehetre, 2014) in his study found that the highest plant height was recorded under the black silver polythene 45 DAT, 90 DAT and 135, whereas under control the lowest plant height has been recorded.

Abubaker (2013) in his study observed that the overall tomato plant height responded excellently to the different kinds of the soil cover used. The peak of the plant was recorded under the compost (207 cm). However, the height observed under the compost mulch did not differ significantly from the other mulching materials used in the study. Whereas, the treatment with no application of any soil cover (control) produced the shortest plant height (183 cm), with no significant statistical difference to that of the shredded wood's average plant height of 188 cm.

Parmar et al., (2013) in their study, they observed that various cover materials significantly impacted on the growth of watermelon. In general, the T3 treatment (silver on black plastic mulch) produced the highest branches per vein, greater main vein length, and knots/vine number between the various mulch treatments. Meanwhile, the plants under control have experienced minimal growth. (Belel, 2012)found that the maximum number of branches (13.59) was recorded with black polyethene mulch, while plants with white polyethene mulch, mulch, and control recorded 13.57, 13.09 and 10.62 branches per plant respectively.

Number of leaves per plant

Several studies (Ayipio et al., 2018; Fan et al., 2018) measured plant growth using plant height and the number of leaves per plant. For example, (Ayipio et al., 2018) found that a significant difference in maize growth and yield had a significant difference in Roselle's adhesions. The locals have surpassed all other memberships in terms of growth and performance.

In their studies to find out the effect of shading on morphological characteristics, the structure of the leaves and the photosynthetic characteristics of soybeans in an interconnected system of corn and soybeans (Fan et al., 2018), set up three treatments A1(intercrop of a row of maize and a row of beans), A2 (intercrop of 2 rows of maize and a row of soybeans) and CK (pure soybean rows). The results indicated a higher photosynthetically active radiation transmission of the soy canopy in stage V5 in treatment A2 (31.1%) than those in treatment A1 (8.7%) and the percentage of red-red significantly reduced under A1 (0.7) and A2 (1.0) in contrast to CK (1.2) (Fan et al., 2018). Muthaura, (2017) in their study identified the corn growth parameters; Plant height, Number of leaves, and basal diameter collected at two-week intervals at 14, 28, 42, 56, and 70 days after sowing (DAP). The height of the plant and the basal area were used to determine the biovolume of the crops.

2.2.2 Yield measurement

Several studies have measured yields in different ways, for instance; (Raseduzzaman & Steen, 2017) in their study measured yield in terms of the total grain. Muthaura, (2017) in his studies, he used maize grain and stover yield data collected at physiological maturity. While (Matusso,

2014) in his study measured the Number of seeds per soya bean pod to determine the yield of beans.

2.3 Effect of Double Digging on the Growth and Yields of Maize and Bean

Several studies (Karuma et al., 2016; Mitchell et al., 2011) examined the effect of double digging on the growth and yield of corn and beans. Furthermore, they observed that double digging had a significant effect on both the growth and yields of maize and beans as sole crops. However, a study conducted by (Sandoval-Avila et al., 1994) found no any significant influence between tillage methods and the bean yield. However, in other studies, maize and bean yields were less affected by sowing in the coastal plain, with NT yields higher than CT yields in just one year out of three for each crop. The increase in yield for corn and NT soybeans was mainly attributed to better availability of soil moisture as a consequence of the reduction of runoff. Soil tillage had no impact on the grain yield in the previous crop/year. Extreme tillage has substantially reduced the quality of the soil (cone index) (Gill et al., 1996).

Karuma et al. (2016) in their study where they used soil repair (DP), (DPH), (OX), subsoil - tear (SSR), manual plough with tied ropes (HTR) and manual plough (H). These significantly influenced the height of the maize plant, the area of the leaf, wheat, and biomass of maize and beans. The average seasonal yield of wheat with the help of soil tillage indicates that Disc Plow and Harrowing produced significantly higher yields than the rest of the soil tillage methods, the manual hoe is the lowest yield recorded.

Mitchell et al. (2011), in their study entitled "Garden Tillage Research and Demonstrations." They used the following approach Soil was once prepared before spring planting using four tillage remedies that is a front-tine backyard tiller, slit tillage, rear-tine backyard tiller, in-row subsoil. They determined out moisture stress confirmed dramatic, visual, increase responses to the four tillage practices. The level of stress, of course, depended on soil moisture. Total marketable Cullman plot Central Alabama site Auburn plot and yields replicate rainfall distribution as well as tillage practice. Tillage treatments had the most dramatic impact on each corn and bean increase in this region compared to either the Auburn or Cullman sites. Despite the numerous advantages of double digging, it's adoption rates have still remained very low among the small-holders farmers in the Eastern part of Uganda (Turinawe et al., 2015).

2.4 Effects of Intercropping on Crop Growth and Yields

Several studies (Alemayehu et al., 2017; Karuma et al., 2016) have examined the effects of intercropping on crop growth and yield. (Alemayehu et al., 2017) observed a very significant interaction effect of the variety and time of the interleaved harvest due to common bean varieties that weigh one hundred seeds and wheat yields.

Karuma et al. (2016) in their study used three cultivation systems, which are single corn, single beans, and intercropped corn crops. They found no significant effect on maize cultivation systems; however, they found that higher grain yields were achieved in their own cornfields in the 2012 LR (5.01Mg ha^{1}). (Achieng et al., 2013) reported that one of the main reasons farmers intercrop in most parts of the world is that more yields are harvested from a given area than when the crop is sown individually.

Lithourgidis et al. (2011) pointed out that intercropping/ crop mixtures provide insurance against total crop failure as they complement one another, and also their rooting systems exploit a higher volume of soils and have more access to relatively immobile nutrient. (Lithourgidis et al., 2011) supplemented as they asserted that in maize/beans (legumes) mixtures, legume fixes Nitrogen through roots, which in turn is available to the cereal, thus improving the nutritional quality of the intercropping. (Latati et al., 2016)noted that the beneficial effect of intercropping with legume could either be due to nitrogen excreted by the legumes during growth or nitrogen released during the decomposition of decaying roots and nodules.

Lithourgidis et al. (2011) asserted that intercropping is a standard method of farming in Nigeria as the system is the increase of availability of Nitrogen to the mixed population through fixation by the legumes. (Layek et al., 2018) asserts that the legume/cereal association exhibits complementary effects between species due to the spatial difference in canopy height and rooting patterns. (Raseduzzaman & Steen, 2017) reported that the intercropping system gave higher yields than the respective monoculture over a wide range of agro-climatic conditions. Because of the high yields, the risks were less with intercropping. Improve yield stability is one of the significant reasons why intercropping continues to be a critical practice in many developing countries of the World.

Mucheru-Munaa et al. (2010) noted that maize/beans are sufficient cropping systems in most parts of Africa, and their productivity depends upon the degree of complementarity between them. To increase the productivity of maize and bean intercropping through manipulation of plant arrangement requires improving the interspecies reducing competitive effects.

Raseduzzaman & Steen (2017) argued out that intercropping increases production whereas (Gebru, 2015) asserted that high yields under intercropping were attributed to more efficient use of the environmental factors, mainly where the component crop differ in their resource use and where they complement one another.

2.5 Effect of Mulches on Crop Growth and Yield

Numerous studies (Abubaker, 2013; Belel, 2012; Mehetre, 2014; Parmar et al., 2013) on the effects of different cover materials and double layer tillage on growth using the height of plants (cm) as a growth parameter. For example (Mehetre, 2014) in his study, he found that the highest overall height of the plant was recorded in silver, black polyethene mulch while the height of the lower floor has been recorded under control.

In his studies (Abubaker, 2013) observed that the peak of the tomato plant confirmed a considerable response to the types of mulch. The organic fertilizer produced the highest height of the plant (207 cm). This height was not substantially distinctive of other mulching materials used in the study, which had lower plant height. On the other hand, where no mulch was applied was associated with the shortest plant height (183 cm).

In other studies, (Parmar et al., 2013) found that specific types of mulch substances have greatly influenced the growth parameters of watermelon. They also found that mulch affects the range of branches per vine, the original size of the vine, and the Number of knots per vine on the control. However, there was minimal growth in the control plant. Belel, (2012) found that the maximum number of branches (13.59) was recorded with black polyethene mulch, while plants with white polyethene mulch, grass mulch, control recorded 13.57, 13.09 and 10.62 branches respectively per plant.

In Laikipia district of Kenya, where no mulch is applied, 40-50% of the rain was lost by evaporation, while the 40-50% overlap of the soil was reduced by half (Liniger, 1991). Crop yield has doubled or tripled, and there has been an increase in biomass to feed livestock. Soil cover regulates the diurnal temperature of the soil, controls the loss of soil water as a result of evaporation, and improves infiltrations (FAO, 1988). For arable crops, the most advantageous conservation practices to reduce soil evaporation are those which guarantee a certain level of soil coverage. Soil cover can provide exceptional coverage or through processing practices that retain plant residues on the soil surface. Mulches are any substance placed on the ground floor for reasons of reduced evaporation or control of weeds. The practice of covering soils acts as a barrier to the movement of soil moisture. They can be natural (e.g. straw, wood chips, peat) or artificial (e.g. transparent or opaque plastic sheets). The practice of soil covers can also improve the soil temperature, depending on the type of cover materials used.

In East Africa, farmers practice mulching in places where the rainfalls are considerable high as it provides cover materials. Most of the small owners cover the land only for particular crops, especially vegetables, due to the lack of crop residues. The density of the land cover materials varies between 30 and 70 per cent, depending on available crop residue of the previous season (Kibwana, 2000; Mruma & Temu, 1999). Ground cover reduces soil erosion and leaching. In Laikipia, it has also been discovered that when the soils are covered, crops productivity and animal feed increases (Liniger, 1991). In a trial with innovative farmers in the Mbozi district of Tanzania, (Mati, 2006) tested the use of plant residues to cover coffee in the marginal district of Mbozi. Farmers observed that the coffee yield had increased under the quilted fabrics as a result of increased soil moisture retention.

Mulch is both advantageous or disadvantageous to crops, apart from their impact on weeds, reduction of evaporation, and maintaining soil temperature (Sinkevičienė et al., 2009). Mulches also increase the levels of phosphorus and potassium in crop leaves (Sønsteby, Nes, & Måge, 2004). It was also discovered that the amount of soil available nutrients increased under the padding (Mulumba & Lal, 2008). The padding improves plant growth, yield, and quality(Singh et al., 2007). The yield increases with the padding were even more significant for the harvest at the beginning of the season (Gill et al., 1996). Most of these soil and water conservation technologies, such as mulching, double digging, strips and retention ditches, have been promoted in many areas of Sub-Saharan Africa. However, technology adoption rates have still remained very low (Mugonola et al., 2013).

CHAPTER THREE
RESEARCH METHODOLOGY

This section describes the methods employed in this research work and shows the general approach of the research process, from the theoretical basis to data collection and analysis. The first section of this chapter highlights the experimental design, site description, experimental procedures, treatments, and combinations of treatments, data collection, and analysis methods.

3.1. Experimental Design

The Randomized Complete Block Design (RCBD) with three (3) replications was used in this study. This design was chosen as a result of its ability to control variation in an experiment by accounting for spatial effects in mostly agricultural field.

3.2 Study Site Description

The study was conducted during the dry spell of 2017 (July-October 2017) at Kimanya-Ngeyo Foundation for Science and Education's Agricultural and Training Centre located 10 Km from Jinja town within latitude 0° 29' 0" North, 33° 17' 0" East, and lies at 1,135 meters above sea level.

The area experiences an annual average (high range temperature of 28.1°C to a low temperature of 16.3°C), giving an average temperature of 22.2°C. The area receives an average annual precipitation of 1324mm. The soils are sandy soils, and this poses many challenges since the sand dries quickly and lacks nutrients because the nutrients can be easily washed through the soil with rain or irrigation. They are low in organic matter. Natural soil richness has little capacity to hold dampness and supplements, in return for quickly penetrable cations and buffering. It empties badly, has few air spaces, heats up slowly in spring, heavy to grow (AfSIS, 2014).

3.3 Experimental Procedure

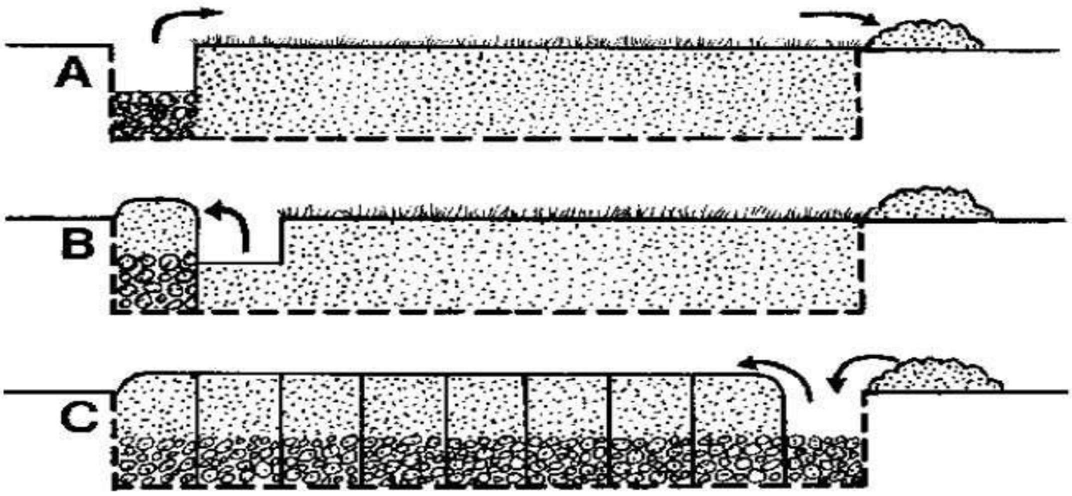
This section describes how the different treatments were administered on the plot. This includes the double digging procedures, intercropping and mulching.

3.3.1 Double Digging

The double-digging treatment was administered by preparing beds two-meter-wide and 3 meters long. The topsoil loosened to remove any weeds, then the soil from the upper part of the first trench was removed (30cm deep) and placed in a wheelbarrow; an additional 30cm of the soil loosened. The upper part of the second trench was dug out and moved forward into the first trench. The lower part of the second trench loosened. Steps were repeated for the remaining trenches, raking after each 3 to 4 trenches to ensure even bed height. The soil from the first trench filled the final trench. The bed was shaped by raking it. The different cropping systems treatments were then applied on the double dug bed.

Figure 3.1

The process of double digging



Adapted from: http://www.frogchorusfarm.com/doubledigging.html

3.3.2 Intercropping

The maize (Longe 5) monocrop design consisted of three rows of maize at a spacing of 75cm between rows and 30cm between plants on a bed of 3m by 2m. The bean (Kanyebwa) monocrop design consisted of five rows planting a space 50cm between rows and 10 cm between plants. The maize/bean intercrop design consisted of three rows of maize planted at a spacing of 75cm between rows and 30cm between plants and the beans planted in two rows between rows of maize at a spacing of 25 cm between rows and 10 cm between rows. A space of 1m was left in between each block to minimize the interaction of other treatments from other blocks.

3.3.3 Mulching

Dry banana leaves and dry grass were used in the mulching treatment. The dry banana leaves were finely chopped. A depth of 5cm of each treatment was put on the beds three weeks after the germination of the crops leaving 10cm margin away from the plant stems to allow plants to transpire and minimize water loss or improve drainage.

3.4 Treatments and Treatment Combinations

3.4.1 Treatments

There were two sets of treatments in this research:

a) Water and Soil Conversation Methods

i. Tillage Methods (Double Digging (DD) and Single Digging (SD)

ii. Mulching materials; Grass (GR), dry banana leaves (BL)

b) Cropping Systems

i. Maize Monoculture (M)

ii. Beans Monoculture (B)

iii. Maize and beans intercropped (MB)

3.4.2 Treatment Combinations

Table 3.1

Treatment combinations

Cropping Systems	**Water Conservation Methods**						
	DDNM	BL	GR		SDNM	BL	GR
M	MDDNM	MDDBL	MDDGR		MSDNM	MSDB	MSDGR
B	BDDNM	BDDBL	BDDGR		BSDNMT	BSDBL	BSDGR
MB	MBDDNMT	MBDDNM	MBDDGR		MBSDNM	MBSDBL	MBSDGR

MDDNM (1), MDDBL (2), MDDGR(3), MSDNM(4), MSDBBL (5), MSDGR (6), BDDNM (7), BDDBL (8), BDDGR (9), BSDNM (10), BSDBBL(11), BSDGR (12), MBDDNM (13), MBDDBL (14), MBDDGR (15), MBSDNM (16), MBSDBBL (17), MBSDGR (18).

KEY

1- Maize and Double Digging, No Mulch
2- Maize and Double Digging and Banana Leaf Mulch
3- Maize and Double Digging and Dry Grass Leaf Mulch
4- Maize and Single Digging, No Mulch
5- Maize and Single Digging and Banana Leaf Mulch
6- Maize and Single Digging and Dry Grass Mulch
7- Beans and Double Digging, No Mulch
8- Beans and Double Digging and Banana Leaf Mulch
9- Beans and Double Digging and Dry Grass Mulch
10- Beans and Single Digging, No Mulch
11- Beans and Single Digging and Banana Leaf Mulch
12-Beans and Single Digging and Dry Grass Mulch
13-Maize-Beans intercrop and Double Digging, No Mulch
14- Maize-Beans intercrop and Double Digging and Banana Leaf Mulch
15- Maize-Beans intercrop and Double Digging and Dry Grass Mulch
16- Maize-Beans intercrop and Single Digging, No Mulch
17- Maize-Beans intercrop and Single Digging and Banana Leaf Mulch
18- Maize-Beans intercrop and Single Digging and Dry Grass Mulch

3.4 Plot Layout

The plot was split into 3 blocks, each comprising eighteen treatment combinations. Each block and the treatment combinations replicated three times to capture any variation within the same set of treatments.

Table 3.2

The plot layout

BLOCK I	T1	T2	T3		T4	T5	T6
	T7	T8	T9		T10	T11	T12
	T13	T14	T15		T16	T17	T18

BLOCK II	T6	T4	T7		T2	T1	T3
	T5	T8	T6		T9	T7	T8
	T18	T16	T17		T15	T13	T14

BLOCK III	T2	T1	T3		T5	T4	T6
	T8	T7	T9		T11	T10	T12
	T14	T13	T15		T17	T16	T18

3.5 Data Collection

The data on the growth and yield parameters was collected from the plants in the central row. Parameters of the growth indicator included the height of a plant, number of leaves per plant. Yield metrics included cob length, number of seeds/pod, and total grain yield. The height of the plant (cm) was measured from the base of the plant to the highest corn/bean leaves once at maturity. The number of functional leaves per plant was a visual count of green leaves (Laekemariam & Gidago, 2013). Common beans were harvested by pulling the plants once the pods were dried, the harvested pods were left in the sun, then threshed using sticks. The threshed grains were cleaned by winnowing and winnowed beans were weighed using a weighing scale per the different treatments.

Maize was harvested by cob sheath was first split by hand, and then the cobs removed. The cobs were dried for a few weeks and later threshed. The threshed cob was cleaned and weighed.

The parameters measured were:

i. Plant height (cm) – measured from the base to the tip of the male flower using tape at harvest. An average of 6 randomly selected plants per plot were selected.

ii. Number of Leaves -The number of leaves per plant was determined by the visual counting of green functional at maturity but just before the harvest period of 6 randomly selected plants.

iii. Cob Length- The cob length average of 6 plants was measured using a ruler at maturity.

iv. Seeds per cob- physical count of the number of seeds per cob of 6 selected was done at harvest.

v. Weight per Bean Seed- The weight of 200 randomly selected bean seeds under the different treatment was taken using a weighing scale.

vi. Total Yield- was measured per treatment using a weighing scale (Kg) after threshing, winnowing and sun drying. The total yields were converted into Kg/ha

3.6 Data Analysis

Data analysis was performed using M.S. Excel and SPPS 25 to examine differences between the treatment configuration in Figure 3.3. Variance analysis (ANOVA) was performed to determine whether there were significant differences between treatments in plant growth and yield parameters. Posthoc and t-tests were used to separate the means at the significance level ($p < 0.05$). The results were presented in tables and graphs with interpretation, discussion, and interference to generate conclusions and recommendations.

CHAPTER FOUR
RESULTS AND DISCUSSION

In this chapter the findings of the study are described and the outcomes discussed per the study objectives. It is consisting twelve (12) sections; 4.1 to 4.12 which are further divided into thirty (30) sub-sections in which the results and discussions of parameters measured in support of objectives one, two and three are highlighted. The parameters measured were plant height, number of leaves per plant, number seeds per cob/pod, cob length, weight per bean seed and total yield.

4.1 Effects of Double Digging on Maize Growth

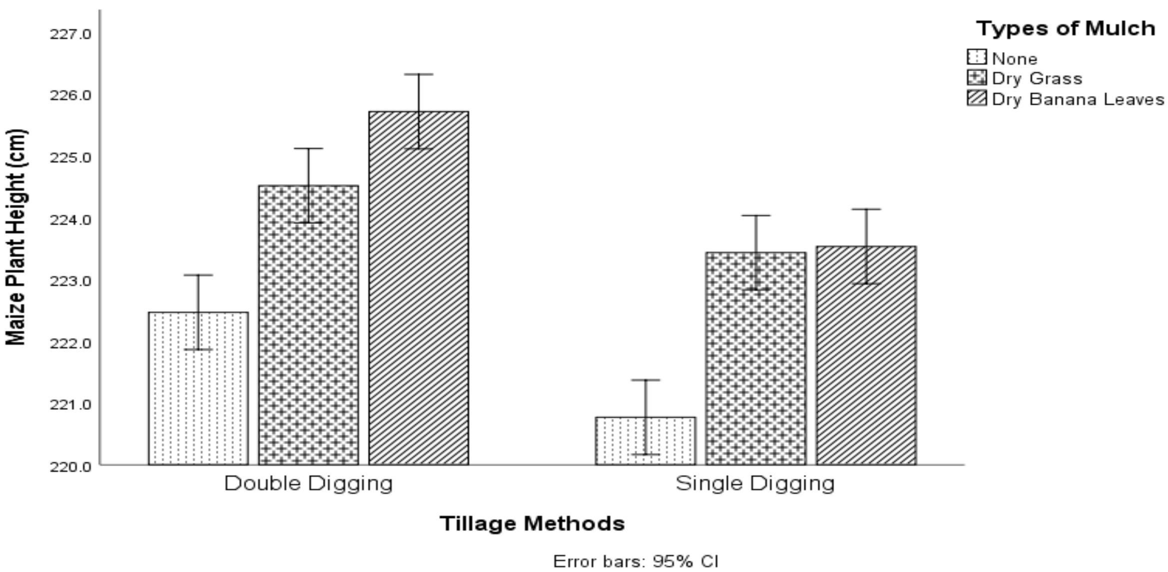
In this section, the effects of double digging on the growth of maize were examined. Data on the growth parameters were collected, recorded, organized (in Excel), and analyzed using SPSS 25. The results were tabulated and figures generated to represent the different findings

4.1.1 Effects of Double Digging on the Maize Plant Height

The results of effects of double digging on the maize plant height are presented in Figure 4.1.

Figure 4.1

Effects of Double Digging on the Maize Plant Height



As seen in Figure 4.1, double digging affected the maize plant height significantly since single digging was associated with lower plant height. Plants under single digging recorded lower heights with the lowest maize plant height (220.8cm) in single digging with no mulch compared to double digging with no mulch (222.8cm). So, the mean increase in plant height was 0.91% for the case of double digging over single digging. This increase over single digging was statistically significant $t(34) = 3.29$, $p = 0.002$ as seen in Table 4.1. This is attributed to the fact that double digging encourages water entry and conservation in the soil. The difference in the height could also be as a result of improved soil structure thereby facilitating deep root growth which is very important to the health of a plant and its ability to withstand drought stress, find nutrients, and keep itself supported. The results of this research conform to the studies done by (Karuma et al., 2016) in which they discovered that the methods of soil tillage significantly influenced the maize height. The results further agrees with (Machinga, 2007) in which they argue double digging encourages deeper water infiltration since the deeply aerated soil acts as a sponge, absorbing water quickly. This in turn allows a better use of rainfall as opposed to single dug bed beds where there is less water absorption capacity of the soil.

Table 4.1

Independent t-test Results for Effects of Double Digging on Maize Plant Height

		F	Sig	t	df	Sig. (2-tailed)
Maize Height (cm)	Equal variances assumed	0.161	.691	3.288	34	.002
	Equal variances not assumed			3.288	33.949	.002

4.1.2 Effects of Double Digging on the Number of Maize Leaves per plant

Results of effects of double digging on the number of maize leaves is shown in the Figure 4.2.

Figure 4.2

Effects of Double Digging on the Number of Leaves per Maize Plant

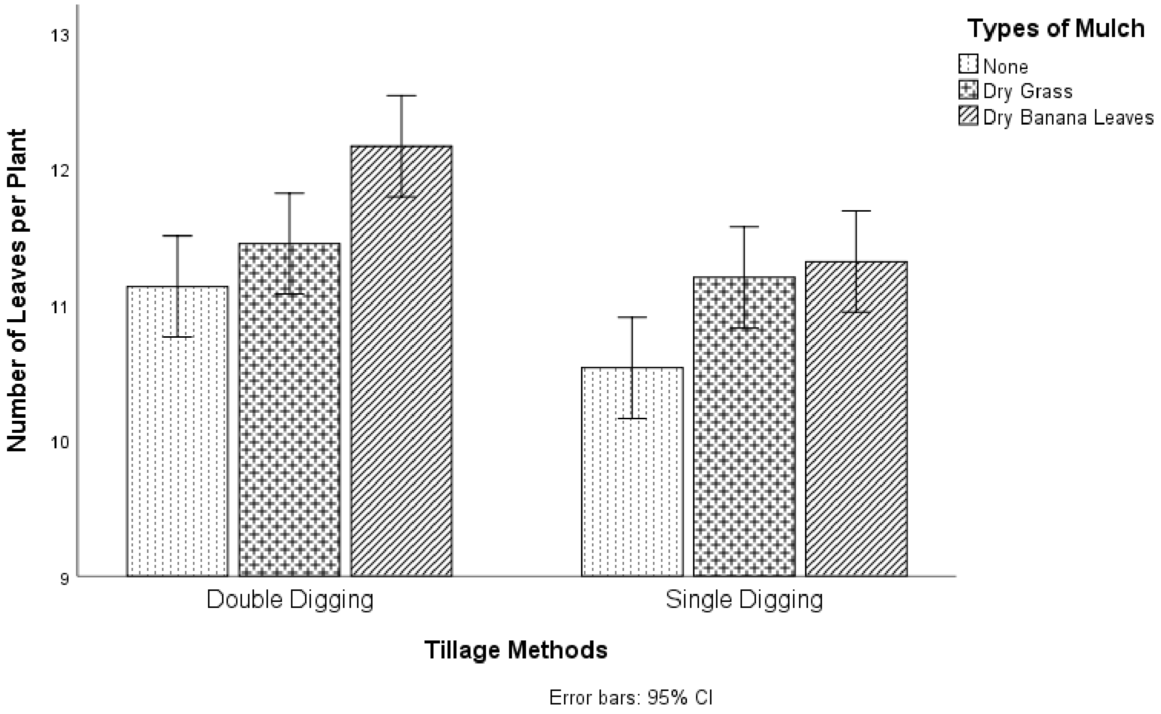


Figure 4.2 indicates that double digging had a statistically significant effect on the number of maize leaves. The highest was registered in double digging with dry banana leaf mulch (12.4) while the lowest was recorded in single digging with no mulch (10.5) while double digging with no mulch recorded 11.5 number of leaves. The increase in the mean number of leaves in double digging over single digging was 9.52%, which revealed a statistically significant difference $t(34) = 2.92$, $p = 0.006$, as indicated in Table 4.2. The results confirm the studies done by (Karuma et al., 2016) in which they discovered that the methods of soil tillage significantly influenced the Number of maize leaves.

The higher number of leaves per maize plant in double digging was due to improved aeration. A loose, healthy soil assist in diffusing air and moisture into the soil and exchanging nutrients. Double digging improves the aeration of the soil unlike single digging (Machinga, 2007) thereby promoting root growth and increasing the photosynthetic rate and chlorophyll content, thus promoting plant growth and reducing the plant death rate (Li et al., 2019).

Table 4.2

Independent t-test Results for Effects of Double Digging on Maize Plant Leaves

		f	sig	t	df	sig. (2-tailed)
Leaves Number (Maize)	Equal variances (assumed)	.170	.682	2.924	34	.006
	Equal variances not assumed			2.924	33.221	.006

4.2 Double Digging Effects on the Growth of Beans

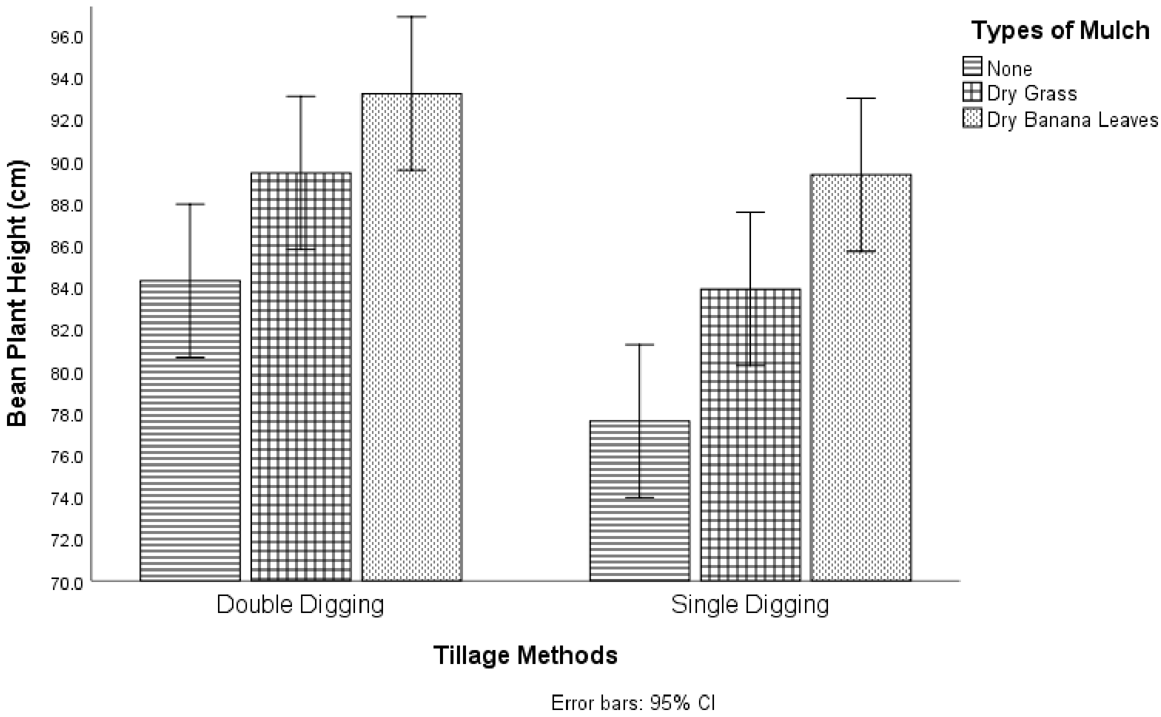
In this section, the effects of double digging on bean growth were examined. The data of the growth parameters were collected, recorded, organized (in Excel), and SPSS 25 used to analyze. A set of tables and graphs were used to present the results.

4.2.1 Effects of Double Digging on Bean Plant Height

Bean plant height data were obtained from 6 randomly selected plants and the results are shown in Figure 4.3.

Figure 4.3

Effects of Double Digging on the Beans Plant Height



As can be observed in Figure 4.3, the bean plant height was significantly affected by double digging. Double digging was associated with higher bean plants (84cm) while single digging without mulch, registered the least height of bean plant (77cm). The highest height of the plant was observed in double digging with dry banana leaves mulch (93cm). The increase in the mean bean plant height was 9.09% in the case of double digging over single digging. This increase in the plant height was consistent with a statistical effect $t(34) = 2.673$, $p = 0.011$, as seen in Table 4.3. This result confirms studies conducted (Tan & Tu, 1995) in which they found that tillage methods affected the growth of beans. This was attributed to an increase in the amount of space in the soil for air and water, enhanced water, and nutrient retention, which in turn improved plant growth and yields.

Table 4.3

Independent t-test Results for Effects of Double Digging on Bean Plant Height

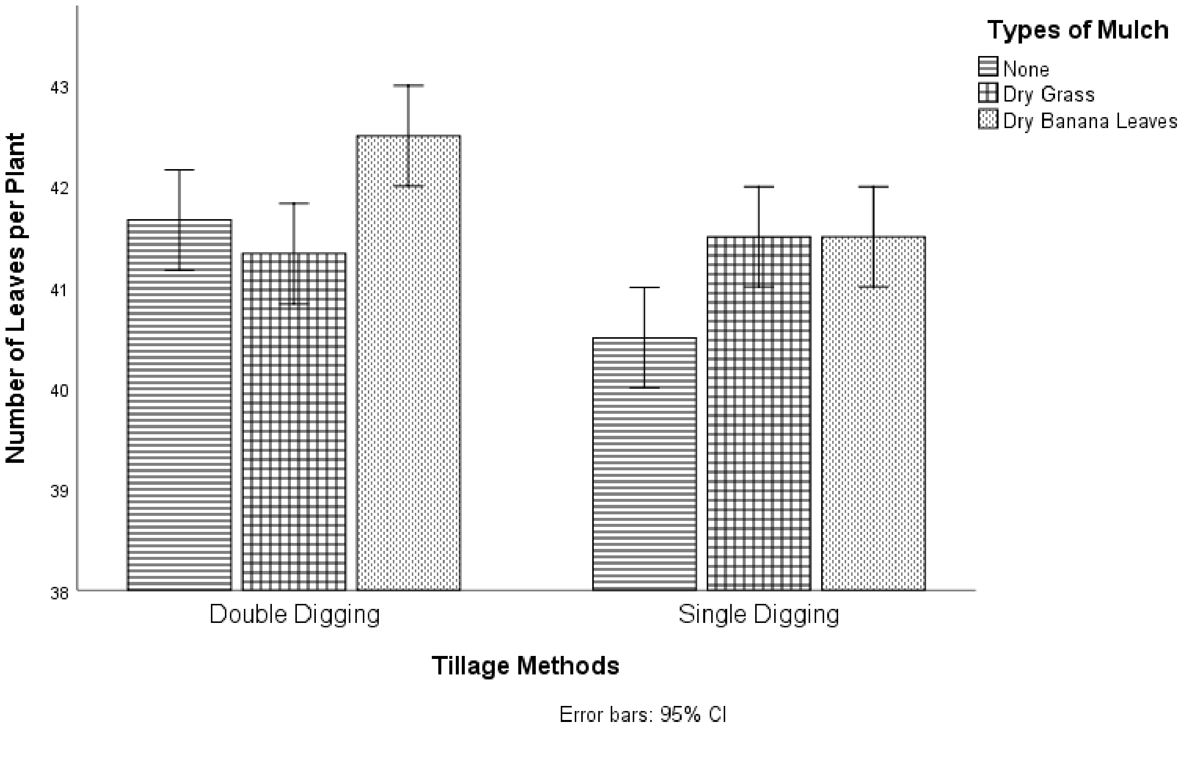
		F	Sig	t	df	Sig. (2-tailed)
Bean Height (cm)	Equal variances assumed	1.171	0.287	2.673	34	.011
	Equal variances not assumed			2.673	31.590	.012

4.2.2 Effects of Double Digging on the Number of Leaves per Bean Plant

The results of effects of double digging on the bean plant leaves are presented in Figure 4.4.

Figure 4.4

Effects of Tillage Methods on the Bean Plant Leaves



By comparison, the mean plant leaves per bean plant seem to be slightly more under double digging (42) than single digging (40), as seen in Figure 4.4. The mean increase in the number of leaves in double digging over single digging is 5%, which is associated with significantly different bean leaves per plant in the two tillage methods $t(34) = 2.675$, p =0.11 as seen in

Table 4.4. And hence there were more leaves per plant in double digging as compared to single digging. These findings confirm with the study by (Sebuwufu et al., 2016) in their study found out that double digging impacts the Number of beans of leaves per plant. This result is attributed to improved soil structure thereby facilitating deep root growth which is very important to the health of a plant and its ability to withstand drought stress, find nutrients, and keep itself supported.

Table 4.4

Independent t-test Results for Effects of Double Digging on Number of Bean Leaves

		F	Sig	t	df	Sig. (2-tailed)
Leaves Numbers (Beans)	Equal variances assumed	.014	0.907	2.675	34	.011
	Equal variances not assumed			2.675	33.627	.011

4.3 The Effects of Double Digging on Maize Yield

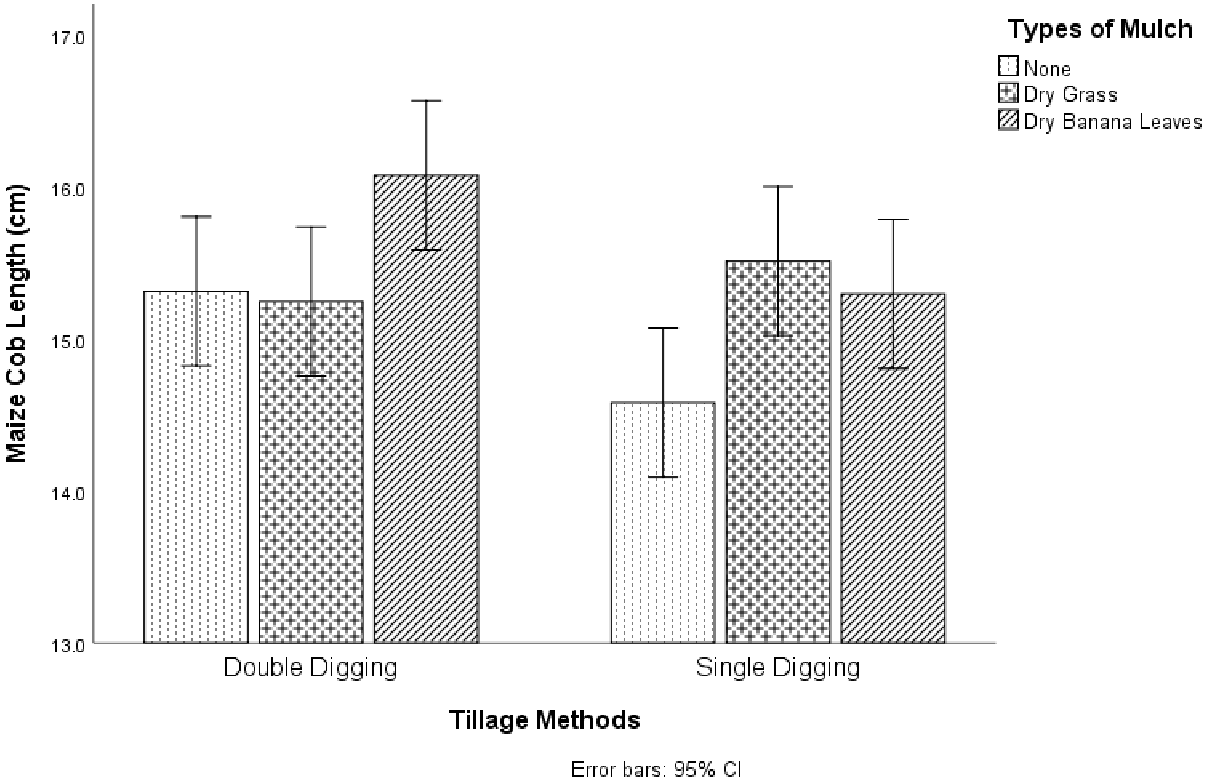
Data on the identified maize yield parameters (cob length, seeds/maize cob, and total grain yields) were collected, organized, and analyzed using SPSS 25. The results presented then under different sub-headings.

4.3.1 Effects of Maize Cob Length

The maize cob length was measured using a ruler and the results presented in Figure 4.5.

Figure 4.5

Effects of Double Digging on the Maize Cob Length



It can be seen from Figure 4.5, the longest maize cob registered under double digging with dry banana leaves mulch (16.1). In contrast, the lowest cob length was registered under single digging without mulch (14.6) while double digging with no mulch registered (15.4). The increase in the mean cob length in double digging over single digging is 5.48%. This increase was associated with a no statistically significant difference in mean maize cob length, as can be seen in Table 4.5, $t(34)= 1.83$, $p= 0.76$. Hence, double digging did not influence the maize cob length. This result is contrary to the study by (Egal, 1999) who found out that double digging had a significant effect on the maize Cob Length. This difference could be attributed to the variety of maize planted and as well the spacing adopted in the two studies.

Table 4.5

Independent t-test Results for Effects of Double Digging on Cob Length

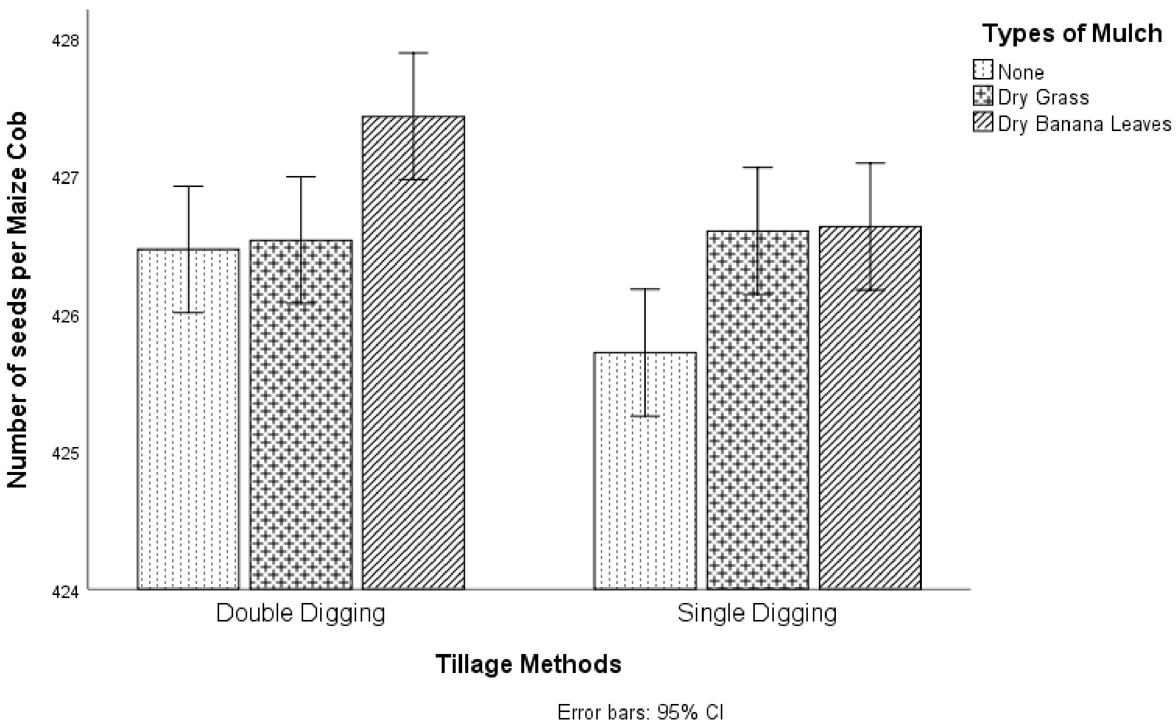
		F	Sig	t	df	Sig. (2-tailed)
Cob Length (Maize)	Equal variances assumed	.049	.827	1.830	34	.076
	Equal variances not assumed			1.830	34.000	.076

4.3.2 Effects of Double Digging on the Number of seeds per maize cob

The results of effects of the Number of seeds per maize cob is presented in Figure 4.6.

Figure 4.6

Effects of Double Digging on the Number of Seeds per Cob



As seen in Figure 4.6, double digging had a positive influence on the number of seeds per cob. Double digging with no mulch registered 426.5 seeds per cob compared to single digging with no mulch (425.8). There seemed to no difference in the number of seeds per cob under double digging with no mulch, double digging with dry grass mulch, single digging with dry grass, and single digging with banana leaves mulch. The mean increase in the number of seeds per cob in double digging is 0.16%, which was associated with a statistically significant difference $t(34) = 2.17$, $p = 0.037$, as seen in Table 4.6. Therefore, the number of seeds per maize cob in double digging is slightly higher than those in single digging. This result confirms with the studies conducted by (Aikins et al., 2012; Memon et al., 2011; Rashidi & Keshavarzpour, 2007) in which they found out that double digging had a significant effect on the number of seeds per maize cob. However, the results were contrary to the studies contacted by(Adams et al., 1997), in which they found that double digging and number of seeds per maize cob were not significantly associated.

Table 4.6

Independent t-test Results for Effects of Double Digging on Number of Seeds per Maize Cob

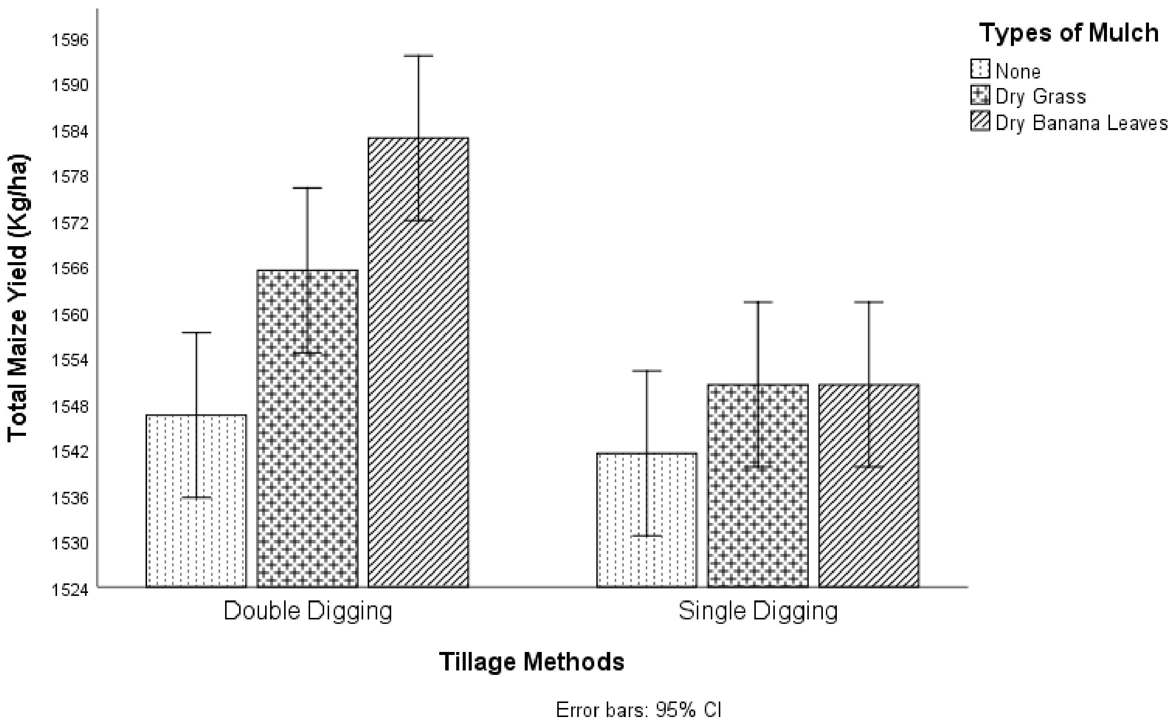
		F	Sig	t	df	Sig. (2-tailed)
Number of seeds per Cob (Maize)	Equal variances assumed	.308	.583	2.170	34	.037
	Equal variances not assumed			2.170	33.805	.037

4.3.3 Effects of Double Digging on the Total Maize Yields (Kg/ha)

Results on the effects of double digging on the Total Maize Yield is presented in Figure 4.7.

Figure 4.7

Effects of the Double Digging on the Total Maize Yields



From Figure 4.7, by comparison, single digging was associated with a numerically lower total maize yield (1541.9 Kg/ha) and double digging with a higher total maize yield (1546.8 Kg/ha). The mean increase in the total maize yield was 0.37% in for double digging over single digging. This difference showed a statistically significant positive effect of double digging on the total mean yields $t(34)= 4.52$, $p= 0.000$, as can be seen in Table 4.7. Thus, double digging was associated with significantly higher total yields than single digging.

This result conforms with the studies done by (Njoroge, 1994; Owenya et al., 2012), who found out that double digging produced high maize yields. The higher yields can be attributed to double digging encouraging deep root penetration and conservation of moisture as soil moisture content influences forms, solubility, and accessibility of plant nutrients necessary for crop growth and increasing yields. A similar result was obtained by (Gill et al., 1996) in which they discovered double digging had significant effect on the total yields and attributed to increase in yield to better availability of soil moisture as a consequence of the reduction of runoff. However, the results are contrary to the studies conducted by (Karuma et al., 2016) in which they found out that no significant effect on the maize yields and they attributed the lower yields to the uneven rainfall distribution and the maize genotype.

Table 4.7

Independent t-test Results for Effects of Double Digging on Total Maize Yield

		F	Sig	t	df	Sig. (2-tailed)
Total Maize yield (Kg/ha)	Equal variances assumed	3.139	.085	4.522	34	.000
	Equal variances not assumed			4.522	30.833	.000

4.4 The Effects of Double Digging on the Yield of Beans

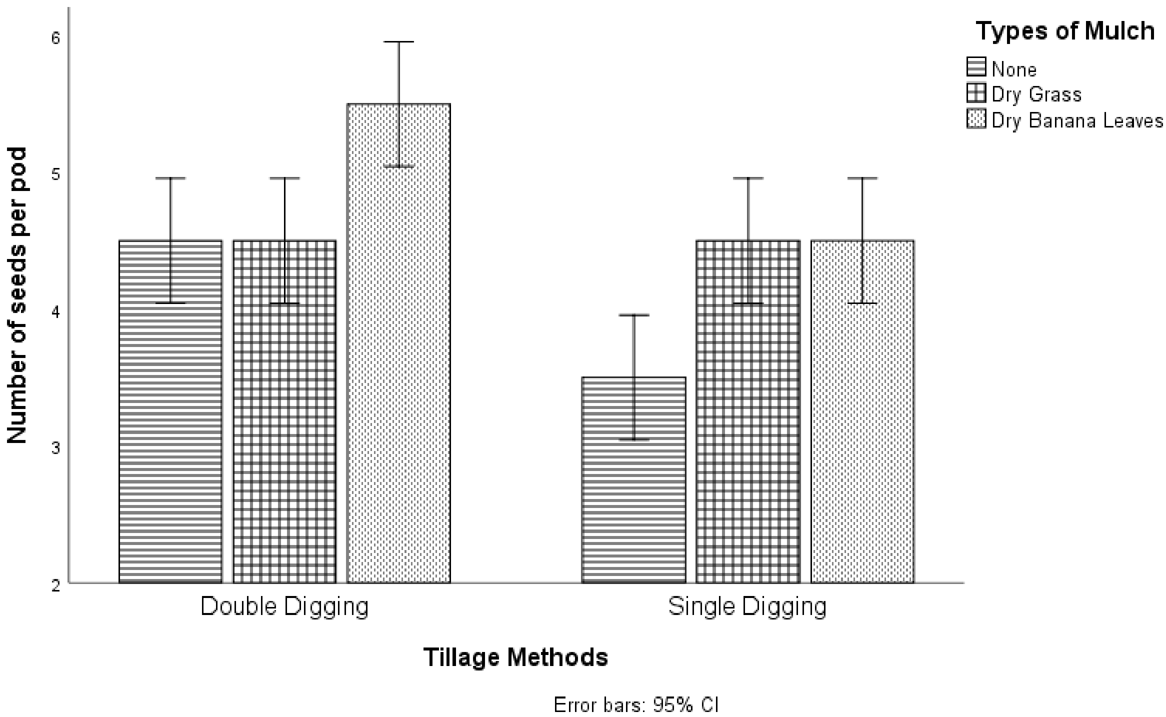
This section presents the effects of double digging on the yield of beans and the results as follows:

4.4.1 Effects of Double Digging on the Number of seeds per bean pod

The seeds per pod from the bean plants were counted, and the results presented in Figure 4.8.

Figure 4.8

Effects of Double Digging on the Number of Seeds Per Pod



From Figure 4.8, the highest number recorded in double digging with mulch of dry banana leaves (5.3) and the lowest recorded in a single digging without mulch (3.4) while double digging with no mulch registered (4.5). No differences were observed in double digging without mulching, double digging, and single digging with dry grass mulch and single digging with dried banana leaves. The mean increase in the number of seeds per pod is 32.35% in double digging over single digging. The t-test for independent samples was associated with a statistically significant effect $t(34) = 2.828$, $p = 0.008$, as can be seen in Table 4.8. Thus, double digging was statistically associated with a significantly more significant number of seeds per bean pod than single digging. This result confirms the studies conducted by (Tan & Tu, 1995).

Table 4.8

Effects of Double Digging on Seeds per Bean Pod

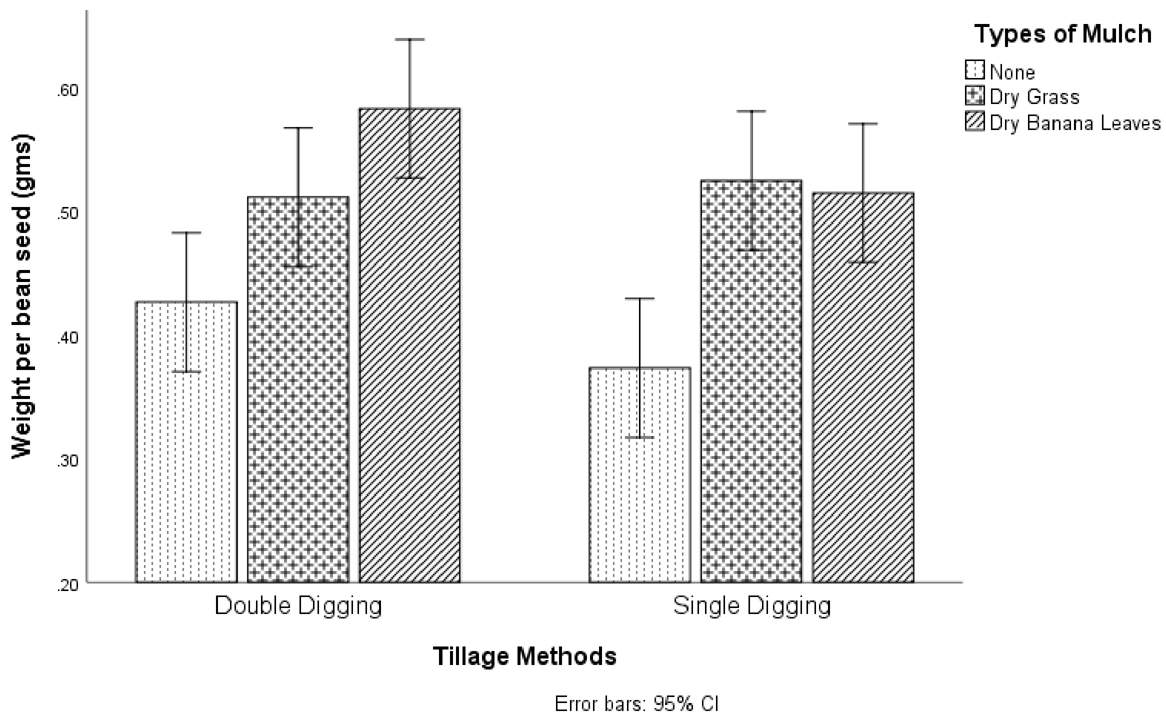
		F	Sig	t	df	Sig. (2-tailed)
Seeds per pod (Beans)	Equal variances assumed	.000	1.000	2.828	34	.008
	Equal variances not assumed			2.828	34.00	.008

4.4.2 Effects of Double Digging on Weight per bean seed (grams)

The weight of selected bean seeds under the different treatment was taken using a weighing scale, and the results are shown in Figure 4.9.

Figure 4.9

Effects of Double Digging on the Weight per Bean Seed



The highest bean seed weight was recorded when double digging was used with dry banana mulch (0.58), and the lowest was observed when single digging was used without any mulch (0.37) while the double digging with no mulch registered 0.42 as seen in Figure 4.9. The mean increase in the weight per bean seed in double digging over single is 13.51%. These results showed no statistically significant effect of double digging on the weight per bean seed t(34) = -1.160, p = 0.254, as can be seen in Table 4.9. These results are contrary to the study conducted by (Warner et al., 1985), who found that there was a significant relationship with the double digging and weight of the beans in grams.

Table 4.9

Independent t-test Results for Effects of Double Digging on Weight per Bean Seed

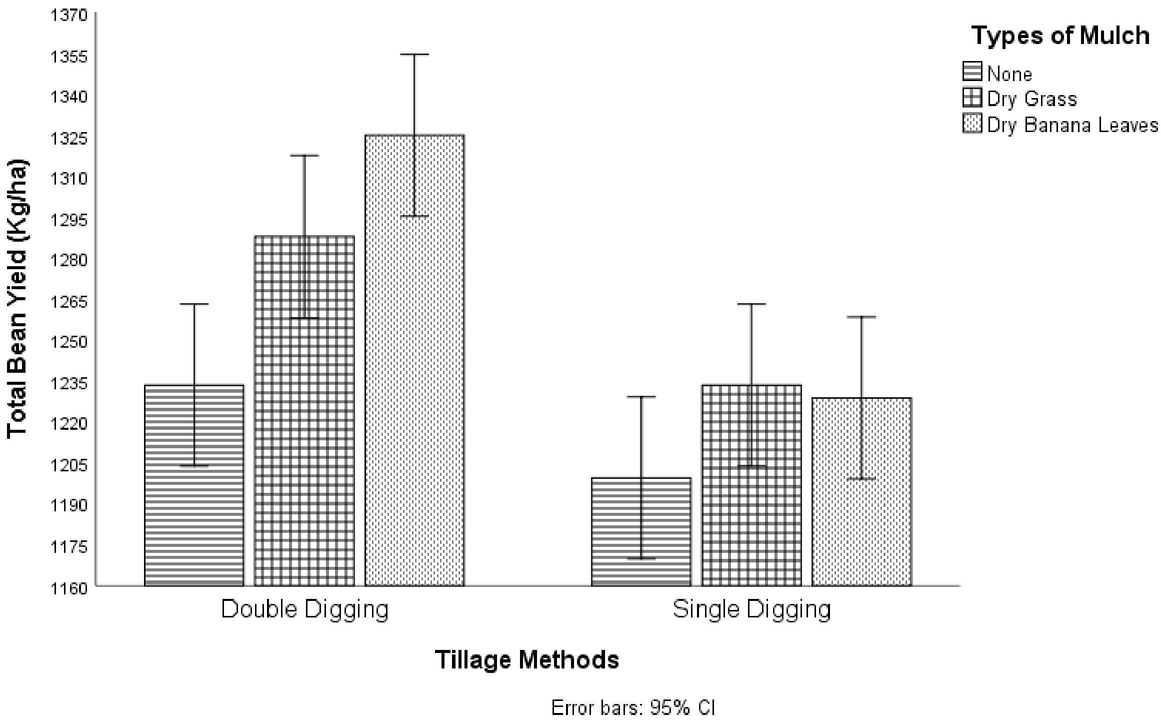
		F	Sig	t	df	Sig. (2-tailed)
Weight per bean seed (gms)	Equal variances assumed	.224	0.639	-1.160	34	.254
	Equal variances not assumed			-1.160	33.821	.254

4.4.3 The Effect of Double Digging on Total Bean Yield

Total Bean Yield was measured using a weighing scale (Kg) for the different treatments. The total yields were converted into Kg/ha and the results presented in Figure 4.10.

Figure 4.10

Effects of Double Digging on the Total Bean Yield (Kg/ha)



The data on the total bean yield showed a lower yield (1200.3 Kg/ha) in single digging compared to 1236.4 Kg/ha in double digging as shown in Figure 4.10. The mean difference in the total bean yield in double digging over single digging was 3.01%, which revealed a statistically strong results $t(34)= 4.356$, $p= 0.000$, as can be seen in Table 4.10. Thus, double digging higher total bean yield than the single digging. These results conform with the studies done by (Kariaga, 2004) in which they discovered out that there was a strong positive relationship between the beans total yield (kg) per ha and double digging. This was attributed to an additional space in the soil for air and water, enhanced water, and nutrient retention, which in turn improved yields. However, contrary to studies done by (Holt & Smith, 1998) in which they discovered double digging led to reduced total bean yields. Equally (Dawkins et al., 1984) discovered that double digging did not increase yield above the single digging recording a 25% yield reduction to this treatment. They attributed the lower yields to the modification of causal agent; soil and plant water relations resulting into altered crop physiology.

Table 4.10

Results for Effects of Double Digging on Total Bean Yield

		F	Sig	t	df	Sig. (2-tailed)
Bean Total Yields (Kg/ha)	Assumed equal variances	1.880	.179	4.356	34	.000
	Equal variances not assumed			4.356	31.425	.000

4.5 The Effects of Intercropping on the Growth of Maize

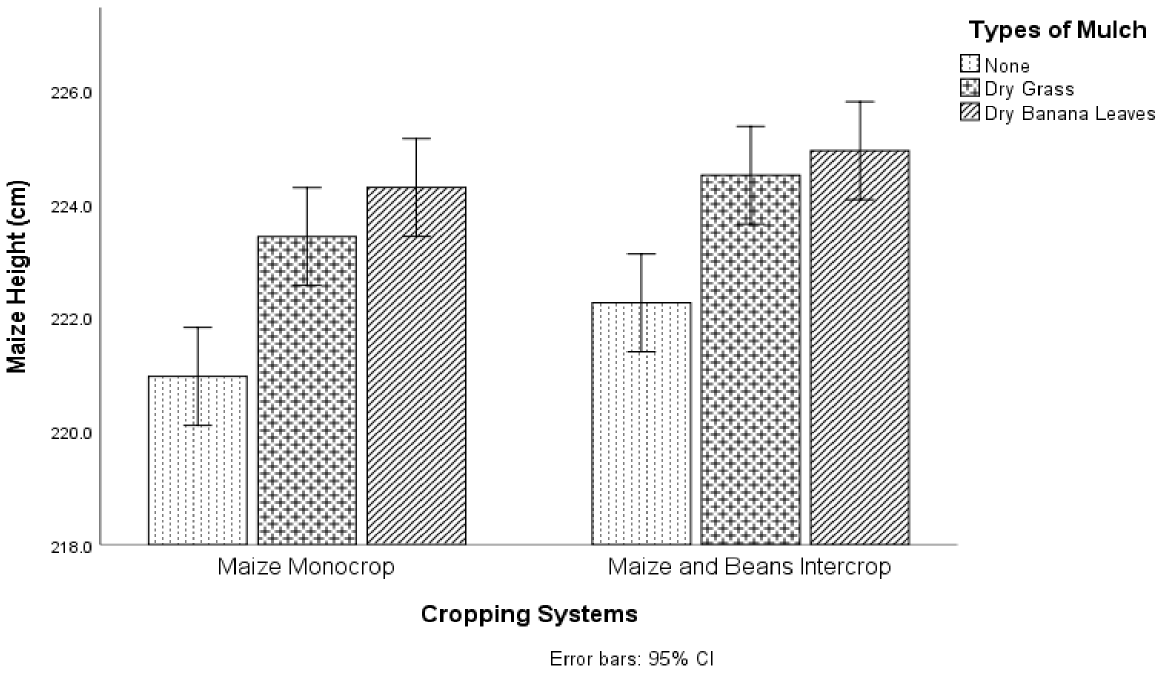
In this section, effects of intercropping on the growth of maize were examined. Data on the growth parameters; (height of the plant and the leaf number/plant) were collected, recorded, organized (in Excel), and analyzed using SPSS 25.

4.5.1 The Effects of Intercropping on the Maize Plant Height

From figure 4.11, the highest maize plant height was registered in maize-bean intercrop mulched with dry banana leaves (224.9 cm) followed by maize-bean intercrop mulched with dry grass (224.4 cm) while the lowest maize plant height was recorded under maize monocrop without mulch (221.0 cm). The maize plant height in maize-bean intercrop with no mulch was 222.2 cm. The mean difference in the maize height was 0.54% for maize-bean intercrop over maize monocrop, which showed a statistically non-significant effect $t(34)= -1.83$, $p=0.75$, as shown in Table 4.11.

Figure 4.11

Effects of Intercropping on the Maize Height



Thus, the maize plant height in maize monocrop and maize-bean intercrop were the same. This result could be explained by the contest for nutrients among the crops and hence reduced growth rate, thus shorter plant heights in maize plants. This result was in agreement with (Getahun & Abady, 2016) where the highest plant height was recorded from sole cropped maize but the lower plant height was recorded from intercropped common bean with maize. Similarly, a study conducted by (Karuma et al., 2016; Silwana & Lucas, 2002) discovered intercropping of maize and beans adversely affected the plant heights and circumferences of the component crops and attributed the results to the competition for space, nutrient and air. However, studies by (Geren et al., 2008) discovered that maize-bean intercrop had a significant effect on the maize height and attributed it to the extra nitrogen fixation to companion plants.

Table 4.11

Results for the Effects of Intercropping on the Maize Height

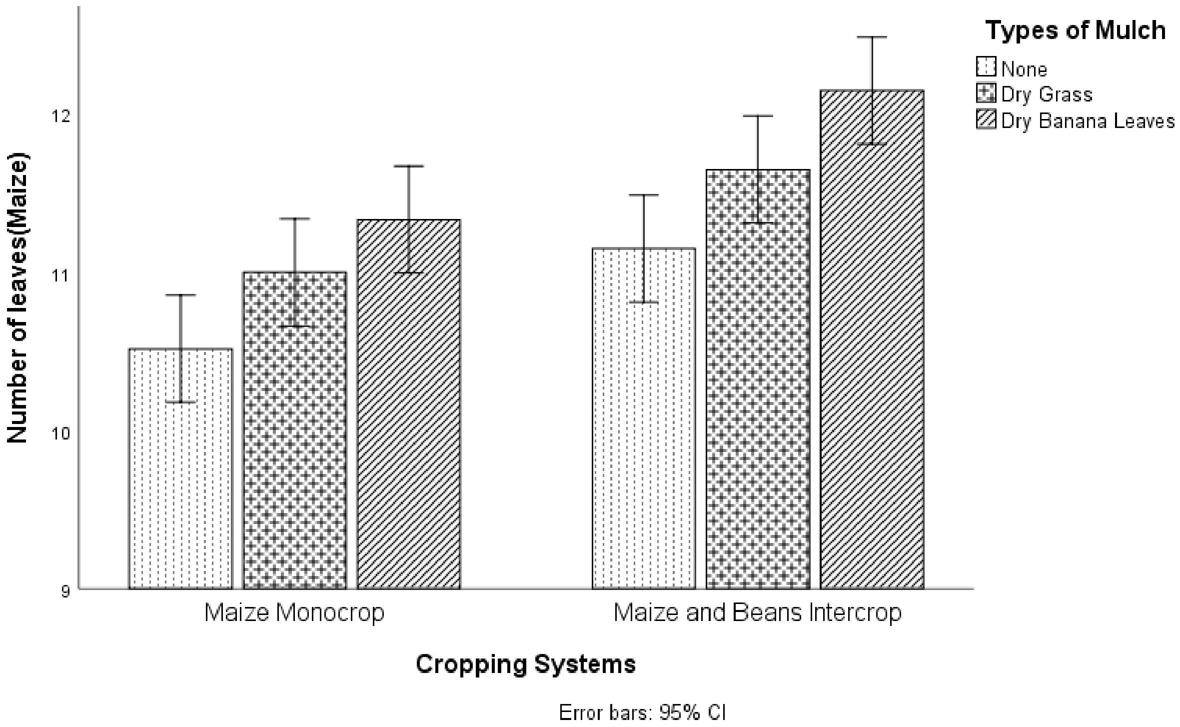
		F	Sig	t	df	Sig. (2-tailed)
Maize Height (cm)	Equal variances assumed	.053	.819	-1.834	34	.075
	Equal variances not assumed			-1.834	33.854	.076

4.5.2 Effects of Intercropping on the Number of leaves per Maize Plant

Figure 4.12 presents the results on the effects of intercropping on the number of leaves per maize plant

Figure 4.12

Effects of Intercropping on the Number of Leaves per Maize Plant



The lowest number of leaves (11) was observed under maize monocrop cropping system with no mulch while the highest number of leaves was registered under maize and bean intercrop with dry banana leaves mulches (12.5) as seen in Figure 4.12. Maize-bean intercrop without mulch recorded an average of 12 leaves per plant. The mean increase in the number of leaves in maize-bean intercrop over maize monocrop is 9.09% and was associated with a significant effect $t(34)=-3.88, p=0.000$, as seen in Table 4.12. Therefore, maize plants under the intercropping system had statistically significant more leaves than those under maize monocrop, this could be explained by the lack of competition for soil nutrients between the maize and beans. The maize and legume probably extracted nutrients from different zones in the soil profile since they have different rooting depths so competition for nutrient could be minimal (Allen et al., 1998). The crops in the intercropping systems could benefit from the nitrogen fixed by the legume crops. Giller (2001), mentioned this benefit could be due to sparing of soil N rather than direct transfer from the legume. This study confirms the findings by (Geren et al., 2008) in which they found that maize-bean intercrop had a positive effect on the average number of maize leaves.

Table 4.12

Independent t-test Results for the Effects of Intercropping on the Number of Leaves per Maize Plant

		F	Sig	t	df	Sig. (2-tailed)
Number of leaves (Maize)	Equal variances assumed	.009	.926	-3.878	34	.000
	Equal variances not assumed			-3.878	31.772	.000

4.6 The Effects of Intercropping on the Growth of Beans

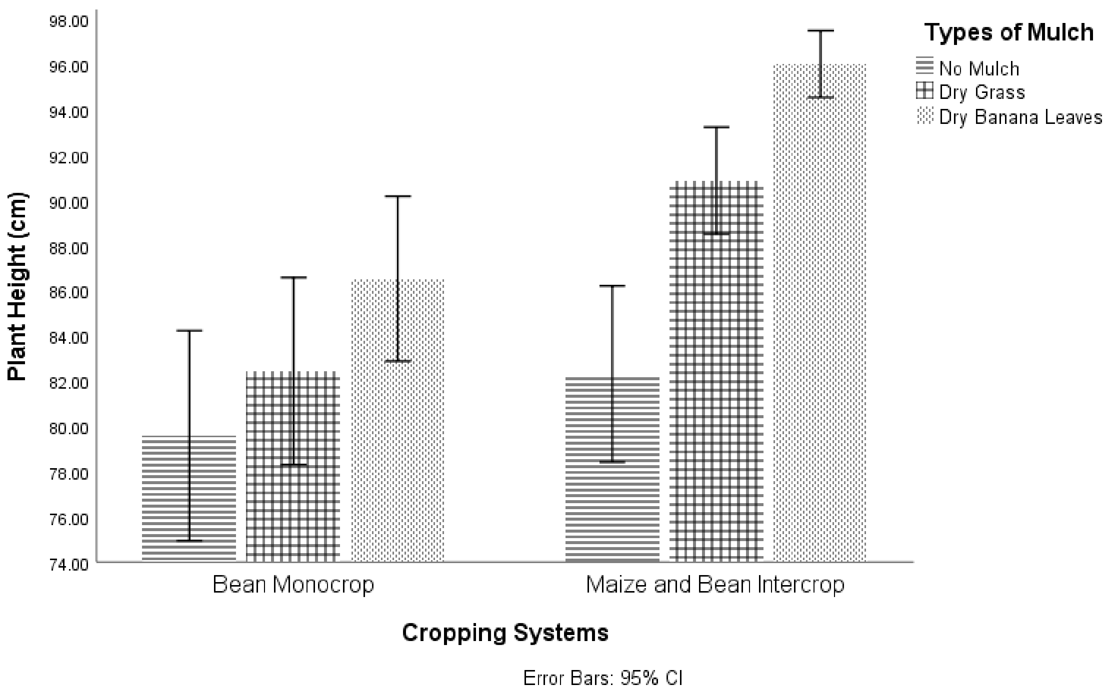
In this section, data on the growth parameters (the plant height and the number of leaves) were considered. The plant heights were measured using a tape measure, recorded, and analyzed, and so were the number of leaves per plant counted, recorded, and analyzed. The results were presented in the form of tables and graphs under the different subsections outlined below.

4.6.1 The Effects of Intercropping on Bean Plant Height

The results of the effects of Intercropping on the bean plant height are presented in Figure 4. 13.

Figure 4.13

Effects of Intercropping on the Bean Plant Height



From Figure 4.13, the highest bean height was recorded when beans were intercropped with maize (82.0cm) while the lowest height was recorded in bean monocrop (78.6). The mean difference was 4.33% in the case of the maize-bean intercrop over bean monocrop. This difference was statistically significant $t(34)= 3.698$, $p= 0.00$ as per the independent sample t-test conducted to find out the hypothesis that intercropping and monocropping were associated with statistically significant different mean bean plant heights, in Table 4.13. Thus, intercropping was associated with a statistically significant larger Mean Bean Height than Beans Monocrop. This result could be attributed to the beans competing for light. A similar result was obtained by (Thapa, 2019) in which they discovered that bean plant heights were relatively higher in mono crop compared to intercrop. However, the result was contrary to the studies by (Tembakazi Silwana & Lucas, 2002), in which they discovered that maize-beans intercrop had no positive effect on the average height of beans.

Table 4.13

Independent t-test Results for the Effects of Intercropping on the Bean Plant Height

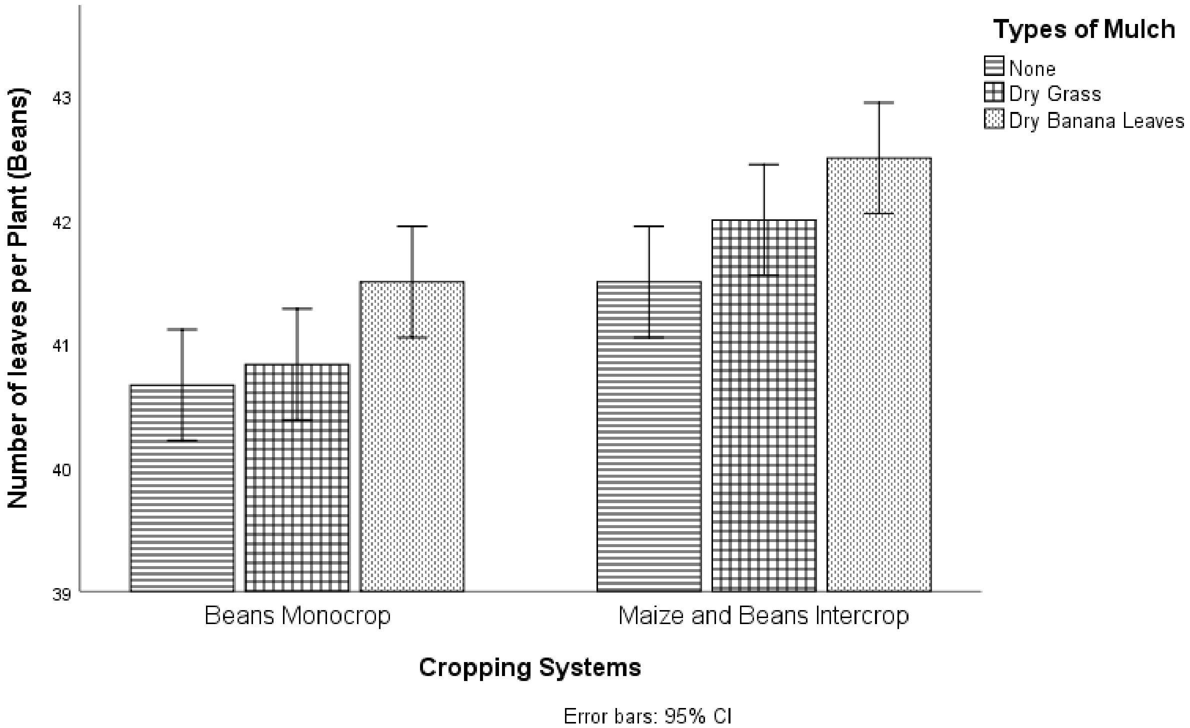
		F	Sig	t	df	Sig. (2-tailed)
Bean Height (cm)	Maize and Beans Intercrop	2.681	.111	3.698	0.001	
	Beans Monocrop			3.698	0.001	

4.6.2 The Effects of Intercropping on the Number of Leaves per bean plant

The results of the effects of intercropping on the number of leaves per bean plant are presented in the Figure 4.14.

Figure 4.14

Effects of Intercropping on the Number of Leaves per Bean Plant



As can be observed in Figure 4.14, bean monocrop without mulch recorded the lowest mean number of bean leaves (40.6) compared to the number of leaves in maize-beans intercrop without mulch (41.4). The mean difference in the number of bean plant leaves in maize-bean intercrop was 1.97% over bean monocrop. The difference was associated with a statistically significant effect $t(34) = -5.050$, $p = 0.000$. Therefore, bean plants in maize-bean intercrop had a statistically significantly higher number of leaves than those under the monocrop. This was a result of increased water storage in the root zone, reduced inter-row evaporation, and controlled excessive transpiration. Maize and beans intercrop also created a unique microclimate advantage to plant growth and development.

This study confirms studies done by (O'Callaghan et al., 1994) in which they found maize and beans intercrop had a significant effect on the number of bean leaves. Similarly studies done by (Midega et al., 2013; Oswald et al., 2002) in which they argue that the higher number of leaves is as a result of suppressing weeds that reduce the competition between cultivated plants and weeds for water and nutrition and succeed the growth of cultivated plants.

Table 4.14

Independent t-test Results for the Effects of Intercropping on the Number of Leaves per Bean Plant

		F	Sig	t	df	Sig. (2-tailed)
Number of leaves (Beans)	Equal variances assumed	.000	1.000	-5.050	34	.000
	Equal variances not assumed			-5.050	34.000	.000

4.7 The Effects of Intercropping on Maize Yield

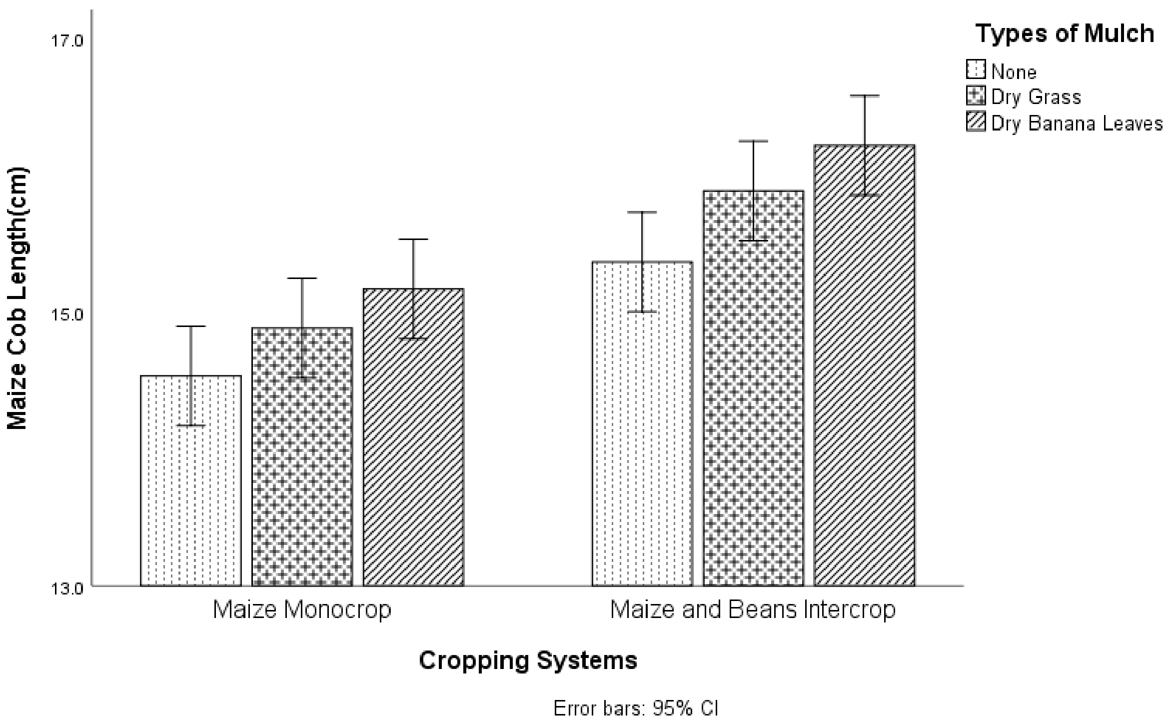
Data on the maize cob length, seeds per cob, and the total maize were collected, organized, and analyzed. The results were presented in tables and figures in the subsections below.

4.7.1 The Effects of Intercropping on Maize Cob Length

The cob length of the randomly selected maize cobs were measured using a ruler and the results presented in Figure 4.15.

Figure 4.15

Effects of Intercropping on Maize Cob Length



As observed from Figure 4.15, the highest maize cob registered in maize-beans intercrop (15.3cm) while the lowest cob length was registered in maize monocrop (14.5cm). So the mean increase in the cob length was 5.52% for the case of intercropping over monocropping and was statistically significant $t(34)=-5.57$, $p=0.000$, as in Table 4.15. Thus, intercropping was associated with a statistically more significant mean maize cob length than mono-cropping. This could be attributed to increased water storage in the root zone, reduced inter-row evaporation, and controlled excessive transpiration. Maize and beans intercrop also created a unique microclimate advantage to plant growth and yields.

This study is similar to studies conducted by (O'Callaghan et al., 1994) in which they discovered out that maize-beans intercrop resulted in a longer cob length. However, this result is contrary to the study of (Thwala & Ossom, 2004) in which no significant difference was found in yield components (cob length and grain number per cob) when maize was intercropped with beans.

Table 4.15

Independent Samples Results for the effects of Intercropping on Maize Cob Length

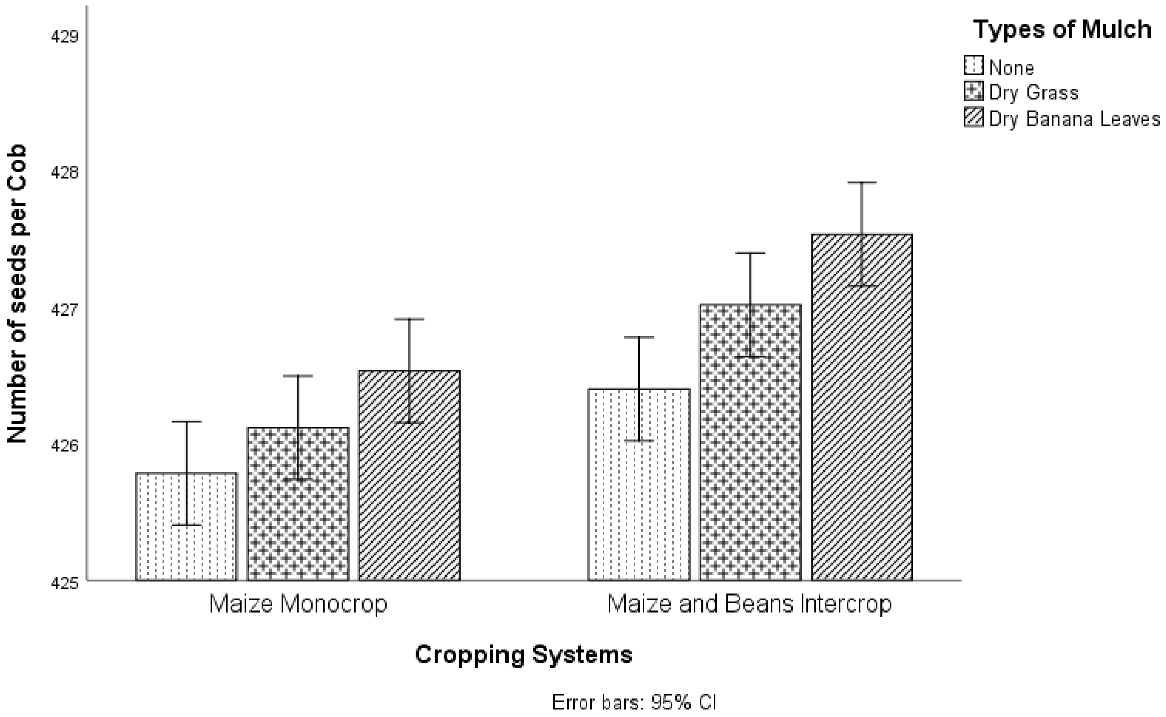
		F	Sig	t	df	Sig. (2-tailed)
Cob Length (Maize)	Equal variances assumed	.091	.764	-5.569	34	.000
	Equal variances not assumed			-5.569	33.505	.000

4.7.2 The Effects of Intercropping on Number of seeds per cob

Seeds per cob of the selected maize plant cobs were counted, and the number of seeds of each cob was recorded, and the results presented in Figure 4.16.

Figure 4.16

Effects of Intercropping on Number of seeds per cob



As seen in Figure 4.16, maize-beans intercrop (no mulch) associated with a higher mean seed per cob (427) compared to maize monocrop with no mulch (426). The mean difference in the seeds per cob in maize-bean intercrop over maize monocrop is 0.23%. A t-test was conducted to investigate the assumption that double digging and single digging were correlated with a statistically significant different mean number of seeds per maize cob showed a significant effect $t(34)=-4.28$, $p=0.000$, as shown in Table 4.16. Thus, the number of seeds per maize cob under Maize intercrop is statistically significantly more than the Number of seeds per maize cob under Maize monocrop. This result shows a positive correlation between the length of the cob and number of seeds per cob. The result is attributed to the fact that in intercrops maize usually has a competitive advantage over beans for light and water since they are tall and with larger root system and hence experience limited competition as reported also reported in a study conducted by (Mburu et al., 2011) .This results conforms with the studies done by (O'Callaghan et al., 1994) in which they found that maize and beans intercrop resulted in an increased number of seeds per maize cob.

Table 4.16

Independent t-test Results for Effects of Intercropping on Number of seeds per cob

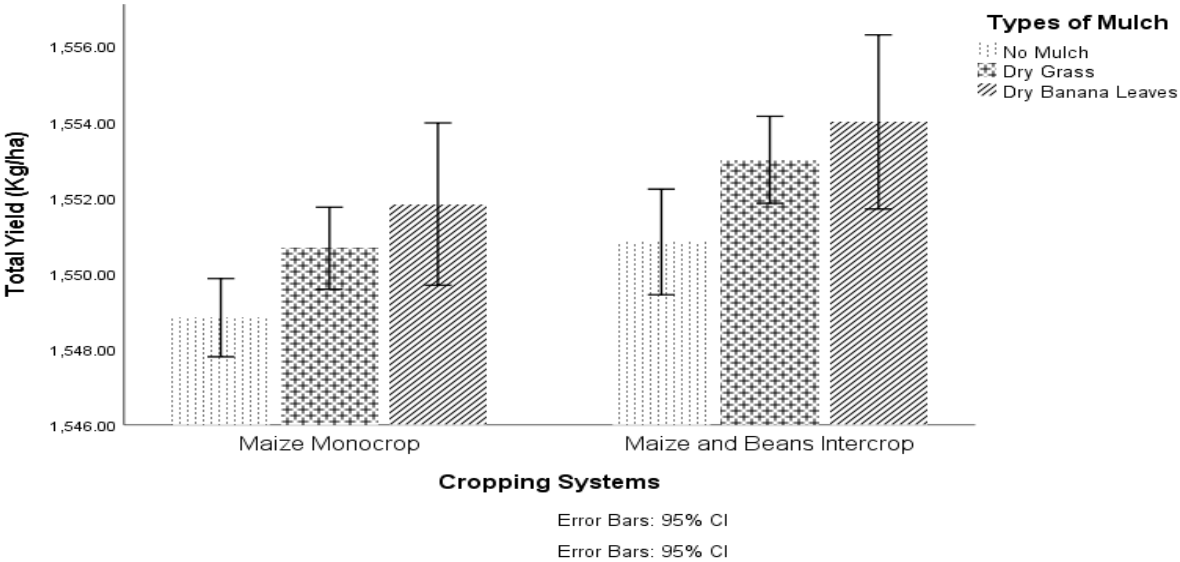
		F	Sig	t	df	Sig. (2-tailed)
Number of seeds per	Equal variances assumed	.033	.857	-4.281	34	.000
Cob (Maize)	Equal variances not assumed			-3.925	34.000	.000

4.7.3 The Effects of Intercropping on the Total Maize Yields

The results of the effects of cropping systems on the total maize yield are presented in Figure 4.17.

Figure 4.17

Effects of Intercropping on the Total Maize Yields



It can be seen in Figure 4.17 that intercropping of maize and beans positively affected the total maize yield. The data collected indicated that maize-bean intercrop was associated with higher total maize yields (1542.8 Kg/ha) than maize monocrop (1541.8 Kg/ha). The mean increase in the total maize yields was 0.288% for maize-beans intercrop over maize monocrop. This result was associated with a strong positive effect $t(34)$ -2.925, p = 006 in Table 4.17. Thus, intercropping had a higher Total Maize Yield than monocrop.

This result is attributed to increased water storage in the root zone, reduced inter-row evaporation, and controlled excessive transpiration. Maize and beans intercrop also created a unique microclimate advantage to plant growth and development. This could have been as a result of the fact that in intercrops maize usually has a competitive advantage over beans for light and water since they are tall and with larger root system and hence experience limited competition as reported also reported in a study conducted by (Mburu et al., 2011). These results are contrary to studies done by (Karuma et al., 2016), in which they obtained higher maize grain yields in maize monocrop plots. Furthermore, they attributed it to the competition for moisture, nutrients, and solar radiation associated with intercropping mixtures. However, confirms studies done by (Kibwana, 2000) who found out that intercropping affects the yields of crops.

Table 4.17

Independent t-test Results for Effects of Intercropping on Total Maize Yield

		F	Sig	t	df	Sig. (2-tailed)
Total Maize Yield (Kg/ha)	Equal variances assumed	0.000	1.000	-2.925	34	.006
	Equal variances not assumed			-2.925	34.000	.006

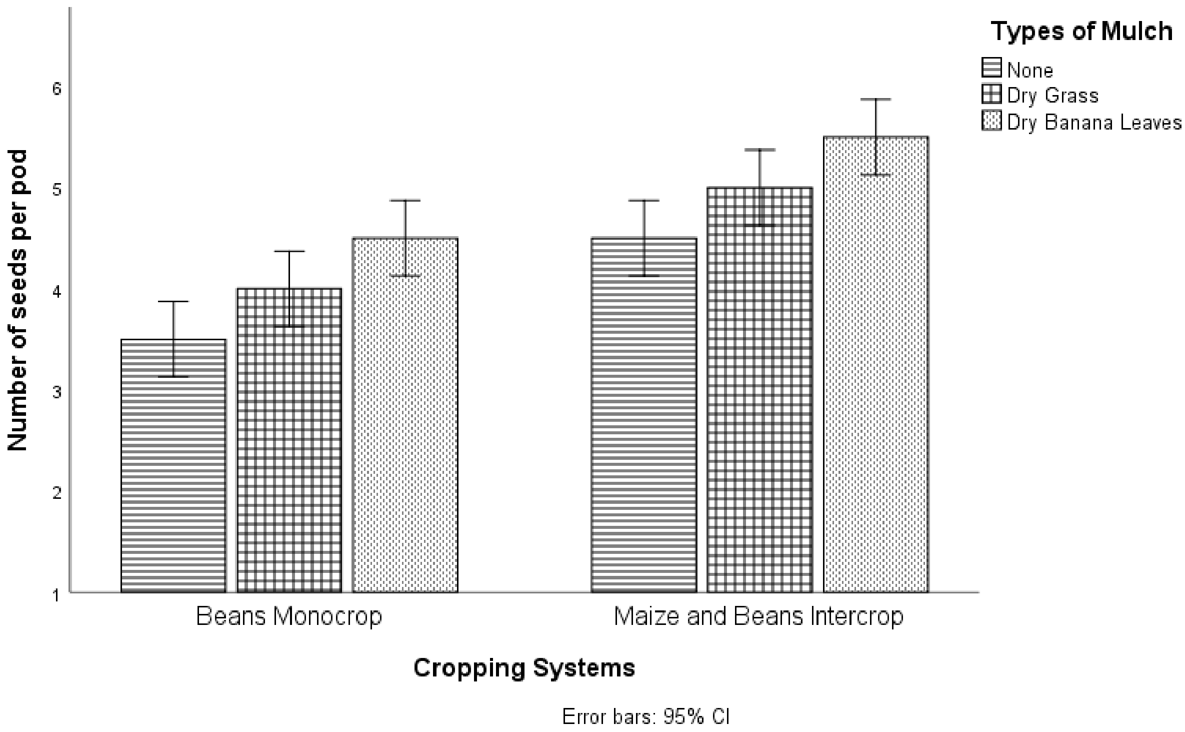
4.8 The Effects of Intercropping on Bean Yields

4.8.1 The Effects of Intercropping on the Number of Bean Seeds per pod

Seeds per pod of the randomly selected bean plants was counted, and the results presented in Figure 4.18.

Figure 4.18

Effects of Intercropping on the Number of Bean Seeds per pod



From Figure 4.18, the highest number of seeds per pod recorded in the maize-bean intercrops mulched with dried banana leaves (5.3), while the lowest was recorded in bean monocrop without mulch (3.5) and 4.4 in maize-bean intercrop with no mulch. The mean difference in the number of seeds per pod in the maize-bean intercrop was 25.17% over the bean monocrop. An independent samples t-test conducted to validate the assumption that bean monocrop and maize-beans intercrop were associated with a statistically significant different mean number of seeds per bean pod, registered significant effect $t(34) = -5.050$, $p = 0.000$, as seen in Table 4.18. Therefore, bean plants under maize-bean intercrop had statistically substantial more seeds per pod than those under bean monocrop. This could be attributed to climbing nature of the variety of the beans planted in this research resulting in less shading in intercropping, hence showing a better competitive ability with maize for light interception. This could as well be attributed to the reduced weed density by crop interference as one of the main causes of yield advantages in intercropping as reported by (Poggio, 2005). These findings confirm with the study by (Undie et al., 2012), who found out that intercropping influences the average number of seeds per bean pod.

Table 4.18

Results for the Effects of Intercropping on the Number of Bean Seeds per pod

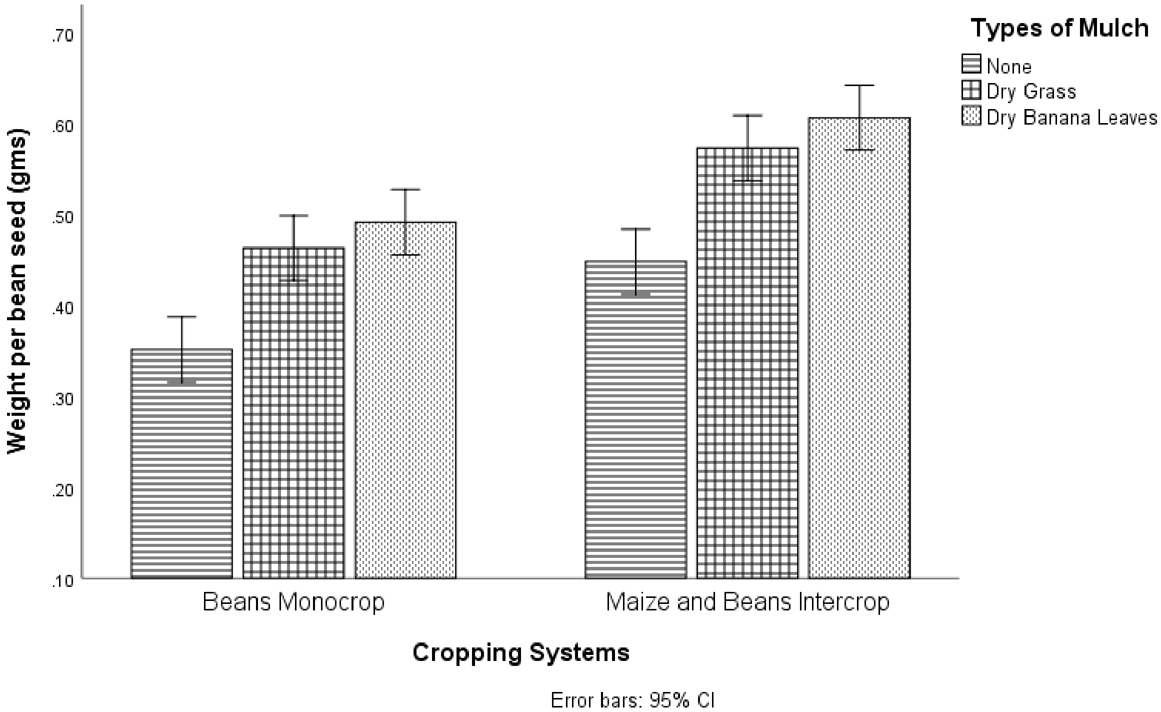
		F	Sig	t	df	Sig. (2-tailed)
Number of seeds per pod (Beans)	Equal variances assumed	.000	1.000	-5.050	34	.000
	Equal variances not assumed			-5.050	34.000	.000

4.8.2 The Effects of Intercropping on Weight per Bean seed (grams)

The weight of selected bean seeds under the different treatment was taken using a weighing scale, and the results are presented in Figure 4.19.

Figure 4.19

Effects of Intercropping on Weight per Bean seed (grams)



It can be noted from figure 4.19 that the highest bean seed weight was recorded in maize-beans intercrop with dry banana mulch (0.60), and the lowest was observed in maize monocrop without any mulch (0.35) while maize-bean intercrop recorded 0.42. The mean difference in the weight per bean seed in maize-bean intercop over the bean monocrop was 20%. A t-test was performed to deduce if the difference in mean weight per bean seed between bean monocrop and maize-bean intercrop was different.

The result came with statistically positive effect $t(34) = -3.646$, $p = 0.001$, as seen in Table 4.19. Therefore, the maize-bean intercrop is associated with a statistically significant, more substantial mean weight per bean seed than the bean monocrop. This study confirms to the studies carried out by (O'Callaghan et al., 1994) in which they concluded that the maize- beans intercrop had aa significant effect on the weight per bean weight.

Table 4.19

Results for the Effects of Intercropping on Weight per Bean seed (grams)

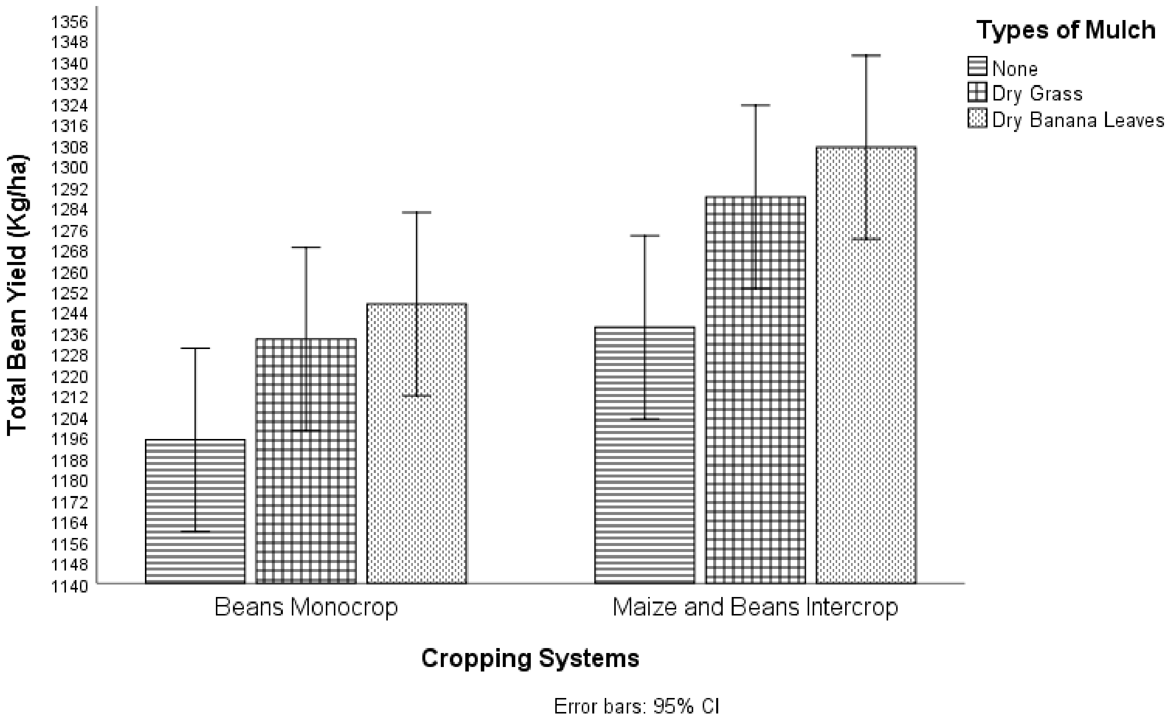
		F	Sig	t	df	Sig. (2-tailed)
Weight per bean seed	Equal variances assumed	.001	.981	-3.646	34	.001
(gms)	Equal variances not assumed			-3.646	33.891	.001

4.8.3 The Effects of Intercropping on Total Bean Yield (Kg/ha)

The total yields were converted into Kg/ha and the results presented in Figure 4.20.

Figure 4.20

Effects of Intercropping on Total Bean Yield (Kg/ha)



As observed in Figure 4.20, by comparison, bean monocrop was associated with a numerically lower total beans yield (1295 Kg/ha). Maize-beans intercrop was associated with a higher total bean yield (1239.3 Kg/ha), while the highest total yield was recorded in maize-bean intercop with dry banana leaf mulch. So mean the increase in the total bean yield was 3.26% in case of the maize-bean intercrop over bean monocrop. The Independent Samples t-test was performed to confirm the assumption that maize monocrop and maize-beans intercrop were correlated with statistically significant mean total yields, and the results indicated significant effect $t(34) = -3.267$, $p = 0.002$ as presented in Table 4.20.

This was a result of increased water storage in the root zone, reduced inter-row evaporation, and controlled excessive transpiration. Maize and beans intercrop also created a unique microclimate advantage to plant growth and development. These findings is similar to studies conducted by (Thapa, 2019) in which they reported a significant increase in the total bean yields and attributed it to lack of competition for soil nutrients between the maize and beans arguing maize and beans probably extracted nutrients from different zones in the soil profile since they have different rooting depths so competition for nutrient could be minimal. These findings confirm with the studies done by (Namutebi, 2014), who found that bean grain yield was affected by intercropping. However, in the experiment carried out in China by (Mao et al., 2012) where intercropping of maize with beans was evaluated, the yields of both crops in intercropping system were smaller than in solo crops, they attributed it to the competition for nutrients.

Table 4.20

Results for the Effects of Intercropping on Total Bean Yield (Kg/ha)

		F	Sig	t	df	Sig. (2-tailed)
Total Bean Yield (Kg/ha)	Equal variances assumed	.063	.804	-3.267	34	.002
	Equal variances not assumed			-3.267	33.946	.002

4.9 The Effects of Mulch on Maize Growth

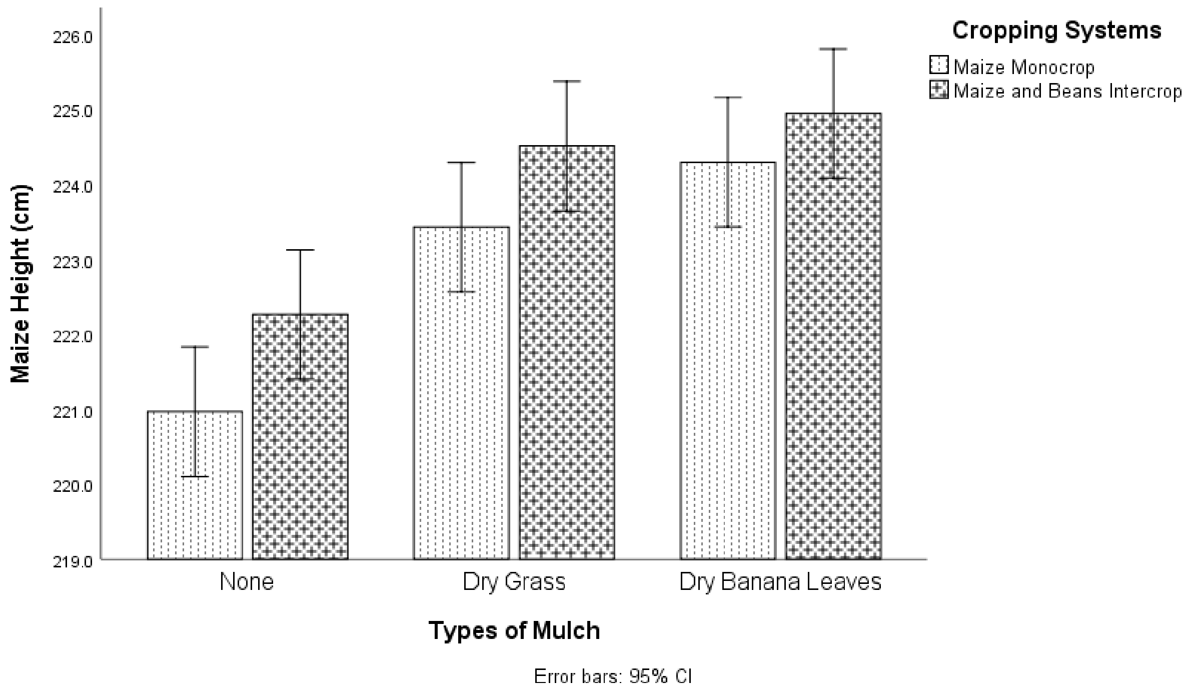
Data were collected ion the identified growth variable (plant height and number of leaves) were collected, organized, coded, and analyzed using SPSS 25. The results presented in the forms of tables and graphs in the section below.

4.9.1 The Effects of Mulch on Maize Plant Height

The maize plant height was measured from the base to the tip of the male flower, and the results are presented in Figures 4.21.

Figure 4.21

Effects of Mulch on Maize Plant Height



From figure 4.21, the lowest maize plant height was recorded when in maize monocrop with no mulch (221.0 cm), followed by maize-bean intercrop with dry grass mulch (222.1 cm) while the highest maize plant height was recorded in maize-bean intercrop with dry banana leaf mulch. An ANOVA was performed to examine the effect of mulching on Maize Plant Height and the results presented in Table 4.21.

Table 4.21

ANOVA for the Effects of Mulch on Maize Plant Height

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Block	.202	2	.101	.075	.928
Mulch	60.137	2	30.069	22.236	.000
Error	41.919	31	1.352		
Total	102.259	35			

a. R Squared = 1.000 (Adjusted R Squared = 1.000)

As seen in Table 4.21, simple major effects analysis showed that a statistically compelling difference between maize plant height and mulch (p=0.000) at the 0.05 level. LSD post-hoc conducted found out that the maize plant height difference in dry grass mulch, and dry banana leaf mulch was over the control (no mulch) was 2.358 cm (1.06%) and 3.008 cm (1.36%) respectively. While the difference in the maize plant height between dry grass mulch and dry banana leaves is 0.65 (0.29%), as shown in Table 4.22.

The results indicated a statistically significant difference in maize plant height between dry grass, dry banana leaves, and the control. However, there was no significant difference in the plant heights between the dry banana leaf mulch and dry grass mulch. This results could be attributed to the fact that mulching is effective in reducing evaporation, conserving soil moisture, increasing the infiltration rate of rain water, modifying the hydrothermal regime of soil as reported by (Bhagat & Acharya, 1988) and also improved soil physical conditions by enhancing biological activity of soil fauna and thus increased soil fertility and hence increase in the plant height (Lal, 1989). These findings confirm with the study by (Abubaker, 2013; Parmar et al., 2013), who found out the plant height was affected by mulching.

Table 4.22

Posthoc Results for The Effects of Mulch on Maize Plant Height

	None	Dry Grass	Dry Banana Leaves
None		-2.358*	-3.008*
Dry Grass			-.650
Dry Banana Leaves			

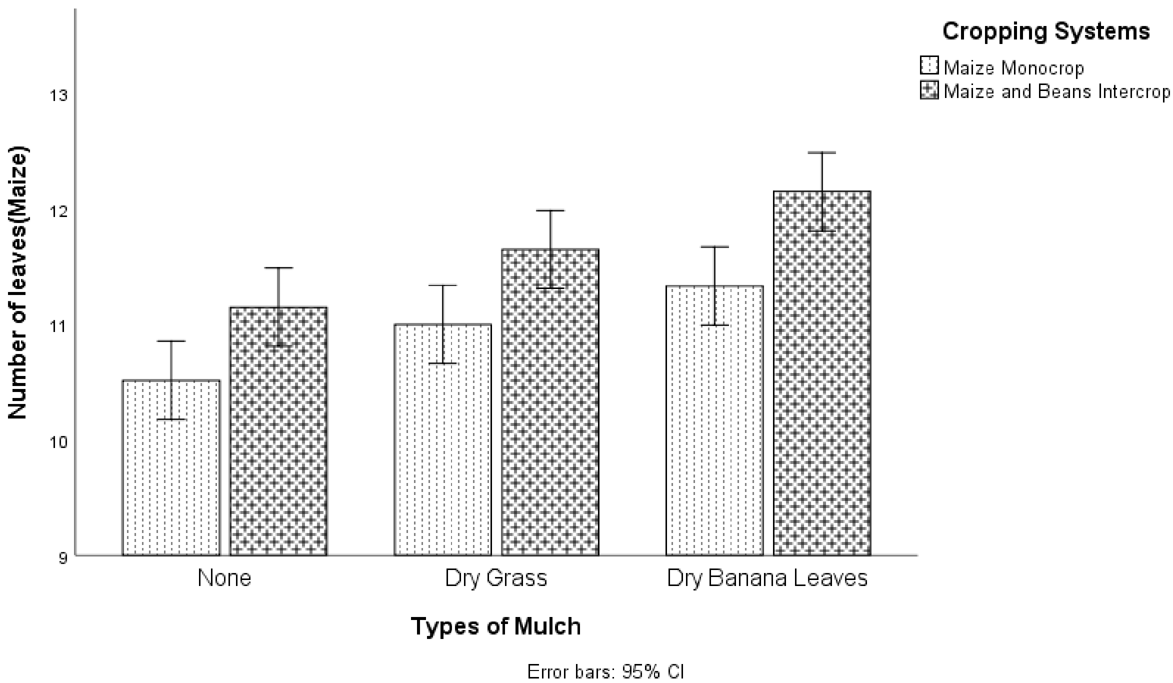
*. The mean difference is significant at the 0.05 level.

4.9.2 The Effects mulches on Maize Leaves per Plant

The number of functional leaves per plant at maturity but shortly before the harvesting period was counted, and the results presented in Figure 4.22.

Figure 4.22

Effects of Mulching on the Number of Maize Leaves per Plant



The highest number was recorded in maize-bean intercrop with dry banana leaf mulch (12.4) while the lowest number of leaves was registered in maize monocrop with no mulch (10.4). An

ANOVA was performed to determine the response of mulch on the number of leaves per plant and the results presented in Table 4.23.

Table 4.23

ANOVA Results of the Effects mulches on Maize Leaves per Plant

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Block	.132	2	.066	.220	.804
Mulch	4.962	2	2.481	8.281	.001
Error	9.287	31	.300		
Total	14.380	35			

a. R Squared = 1.000 (Adjusted R Squared = 1.000)

The results show that there was a statistically significant difference in the number of leaves between the different mulch types F(2.31) = 8.281, p = .001), as seen in Table 4.23. A post hoc LSD test was performed to determine where the differences are, and the results are presented in Table 4.24.

Table 4.24

Posthoc of the Effects mulches on Maize Leaves per Plant

	None	Dry Grass	Dry Banana Leaves
None		-.49*	-.91*
Dry Grass			.42
Dry Banana Leaves			

*. The mean difference is significant at the 0.05 level.

From Table 4.24, the variation in the mean number of leaves per maize plant between dry grass mulch and dry banana leaf mulch was 0.42 (3.82%). The result demonstrates none compelling response in the number of leaves per maize plant between dry grass mulch and dry banana leaf mulch. The mean the number of leaves per plant variations between dry banana leaves and dry grass mulch over the control (no mulch) was 0.91 (8.75%) and 0.49 (4.71%) respectively. These results showed a statistically significant effect in the number of maize leaves per plant between the control and the two mulch materials (dry banana leaf mulch and dry grass mulch). This was because mulching helped to maintain the stable surface and soil temperatures for the plants; thus, the plants to be less stressed. The mulch materials, especially the dry banana leaves, used greatly improved water retention and reduced evaporation on the plot. These findings confirm with the study done by (Abubaker 2013; Parmar et al., 2013), who found out that mulching affected the number of leaves per plant.

4.10 The Effects of Mulch on the Growth of Beans

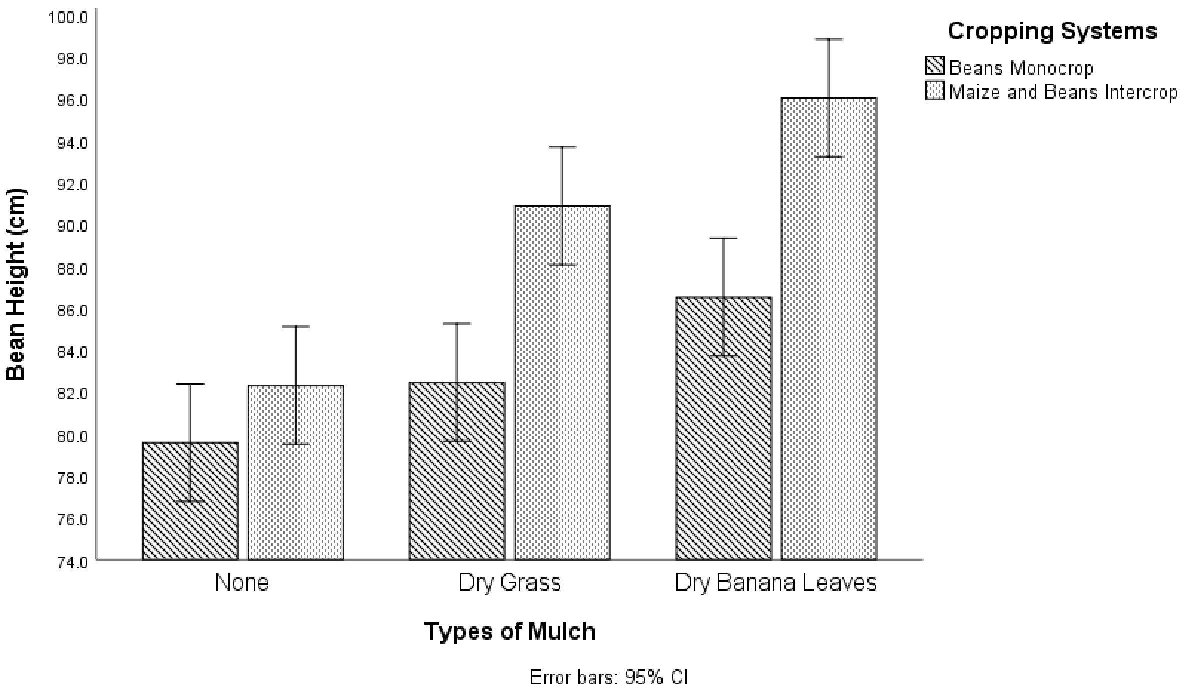
Data on beans growth parameters were collected, organized, analyzed, discussed, and presented in forms of figures and tables in this section.

4.10.1 The Effects of Mulch on the Bean height

The heights of each selected bean plants were measured using a tape measure, and the results presented in Figure 4.23.

Figure 4.23

Effects of Mulching on Bean Plant Height



The maximum bean height was recorded when dry banana leaves were used as mulch (91.278 cm) followed by dry grass (86.664 cm), while the lowest height (80.948 cm) was recorded while beans were planted without any mulch, as seen in figure 4.23. An ANOVA was performed to test if the application of mulches were associated with statistically significant different mean bean plant heights, and the results indicated a significant main effect for Mulch, $F(2, 27) = 10.437$, $p= .000$ as presented in Table 4.25.

Table 4.25

ANOVA Summary for the Effects of Mulch on the Bean height

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Block	.042	2	.021	.001	.999
Mulch	642.788	2	321.394	11.776	.000
Error	846.092	31	27.293		
Total	1488.922	35			

a. R Squared = 1.000 (Adjusted R Squared = 1.000)

Post–hoc comparisons using the LSD test was performed to see where the differences in the mean plant height lay, and the results are presented in Table 4.26. The mean increase in the bean plant height was 10.33 cm (12.76%), and 5.717cm (7.06%) in dry banana leaves mulch and dry grass mulch respectively as correlated to where no mulch was applied. From the results, dry banana leaves and dry grass were statistically significant with respect to the control (no mulch). And they were statistically significant with each other. The result could be attributed to the fact that dry banana leaves conserving more moisture than the dry grass mulch as dry banana leaf mulch was associated with significantly higher plant height. This result is conformity with studies conducted by (Kwambe et al., 2015), in which they concluded that mulch had a statistically significant effect on the bean height.

Table 4.26

Posthoc Results for the Effects of Mulch on the Bean height

	None	Dry Grass	Dry Banana Leaves
None		-5.717^{*}	-10.331^{*}
Dry Grass			-4.614^{*}
Dry Banana Leaves			

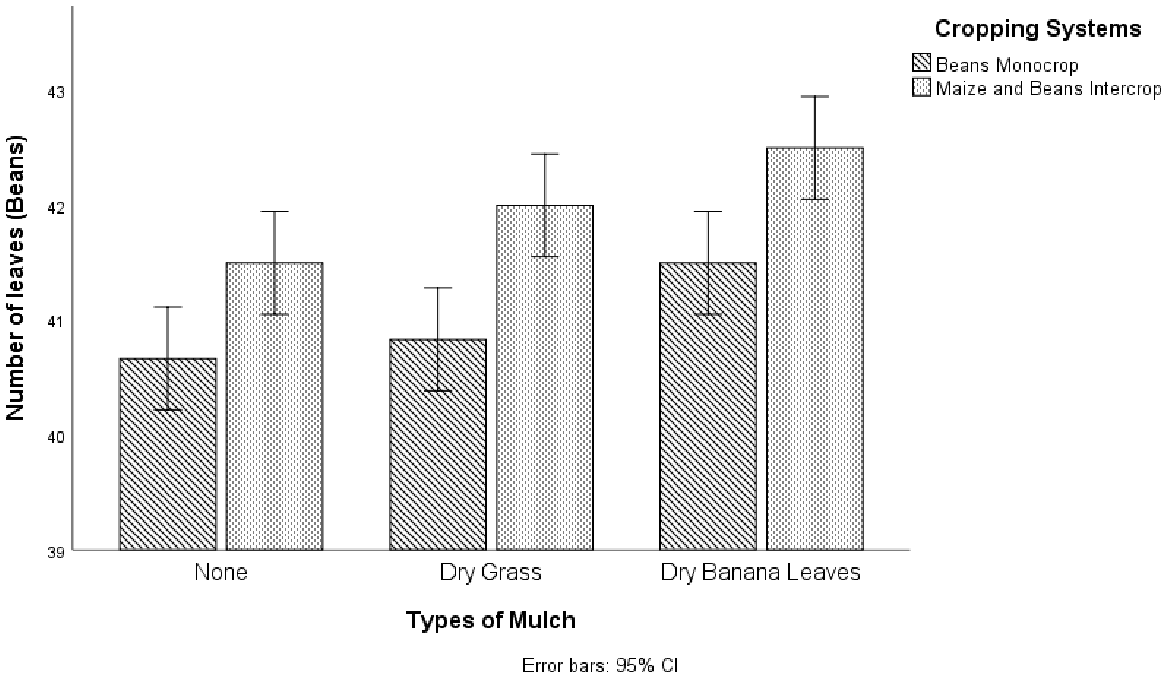
*. The mean difference is significant at the 0.05 level.

4.10.2 The Effects of Mulch on Number of Bean Leaves per plant

The data on the number of leaves of the selected plants was collected, recorded, and the results were presented in figure 4.24.

Figure 4.24

Effects of Mulching on the Number of Leaves per Bean Plant



As can be seen in Figure 4.24, the average number of bean leaves was positively influenced by mulching. Fewer leaves were observed on beds where no mulch was applied, while a higher number of leaves were registered on beds where mulches were applied. Furthermore, the highest number of leaves was observed when dry banana leaves were used as mulch. An

ANOVA was performed to evaluate the effect of mulching on the number of leaves per bean plant, and the results showed a statistically compelling variations in the number of leaves per bean plant between the types of mulches [F(2,31) = 4.491, p = .019] as seen in Table 4.27.

Table 4.27

ANOVA Summary Results for the Effects of Mulch on the Bean height

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Block	.000	2	.000	.000	1.000
Mulch	5.167	2	2.583	4.491	.019
Error	17.833	31	.575		
Total	23.000	35			

a. R Squared = 1.000 (Adjusted R Squared = 1.000)

An LSD post hoc test was conducted to determine where the differences lie, and the results are presented in Table 4.28. The variations in the mean number of leaves per plant was 0.92 (2.27%) and 0.33 (0.81%) in the case of dry banana leaf mulch and dry grass mulch respectively over the control (no mulch). The variation in the sum of leaves between the dry banana leaf and dry grass mulch was 0.58 (1.42%) over the dry grass mulch.

This result shows no compelling variations in the total of leaves between the dry grass and dry banana leaf mulches. There was equally no considerable change in the mean sum of leaves between the control (no mulch) and the dry grass mulch. However, dry banana leaf mulch and the control were associated with a significant difference in the mean number of leaves per plant. These findings confirm with the study by (Abubaker, 2013; Parmar et al., 2013), who found that mulching affected average plant leaves.

Table 4.28

Posthoc Results for The Effects of Mulch on Number of Bean Leaves per plant

	None	Dry Grass	Dry Banana Leaves
None		-.33	-.92*
Dry Grass			-.58
Dry Banana Leaves			

*. The mean difference is significant at the 0.05 level.

4.11 The Effects of Mulch on Maize Yield

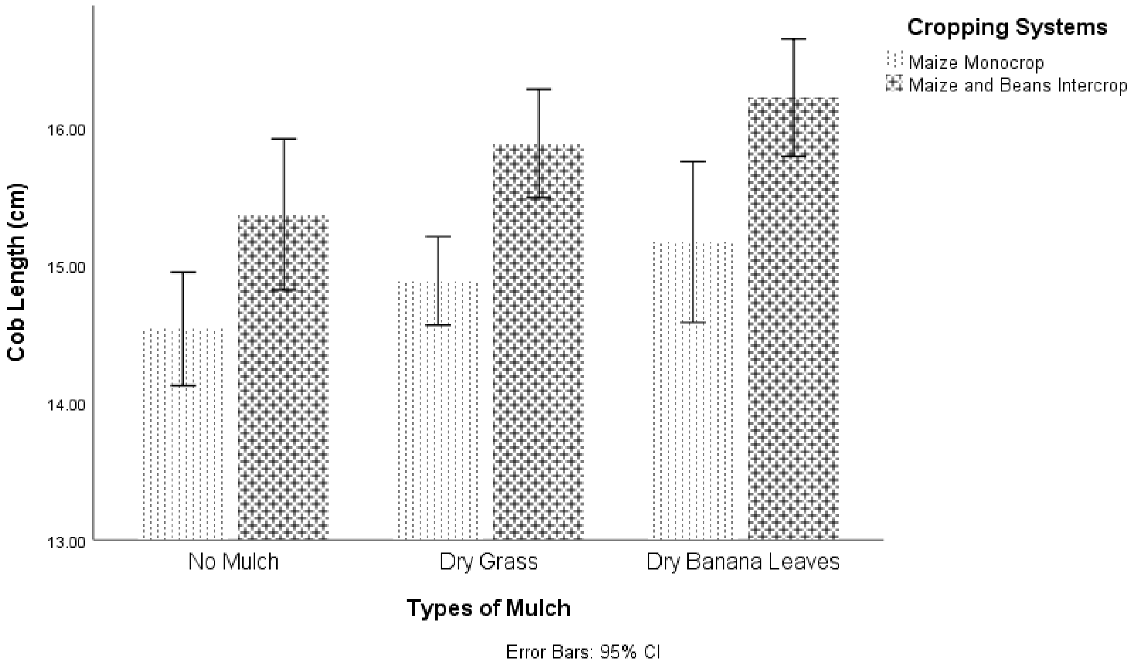
Data on the maize yield variables were collected, analyzed and the results were presented in forms of tables, charts, and graphs, as discussed below.

4.11.1 The Effects of Mulch on Maize Cob Length

The results of the effects of mulch on maize cob length are presented in Figure 4.25 and show that mulching affected the cob length positively. The highest maize cob length was registered in maize- bean intercrop and dry banana leaf mulch (16.2 cm). In comparison, the lowest cob length was registered in maize monocrop with no mulch (14.5 cm). The cob length in maize monocrop with dry grass and dry banana leaves mulch recorded 14.8 cm and 15.2 cm, respectively.

Figure 4.25

Effects of Mulches on the Maize Cob Length



An ANOVA was performed to validate the assumption that the various mulch types were correlated with a compelling variation in the mean maize cob length. The results were associated with a statistically significant effect [$F(2, 31) = 3.680$, $p = 0.037$] at the $p<.05$ level, as presented in Table 4.29.

Table 4.29

ANOVA Summary for the Effects of Mulch on Maize Cob Length

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Block	.062	2	.031	.068	.934
Mulch	3.332	2	1.666	3.680	.037
Error	14.034	31	.453		
Total	17.428	35			

a. R Squared = 1.000 (Adjusted R Squared = 1.000)

Post–hoc comparisons using the LSD test was performed, and the results presented in Table 4.30. The mean difference in the cob length between dry banana leaf mulch and dry grass mulch was 0.742 cm (5.12%) and 0.433 cm (2.99%) over the control (no mulch) respectively. Furthermore, the difference in the mean cob length between dry grass and dry banana mulch was 0.308 cm (2.08%) in case of dry banana leaf mulch over the dry grass mulch. There was no significant difference in the cob length among dry grass mulch and the control; dry grass and dry banana leaf mulch. However, the difference in the cob length between dry banana leaf mulch and the control was statistically significant. This study conformed with studies conducted by (Khurshid et al., 2006), in which they found that mulching significantly affected the maize cob length.

Table 4.30

Posthoc Results for the Effects of Mulch on Maize Cob Length

	None	Dry Grass	Dry Banana Leaves
None		-.433	-.742*
Dry Grass			-.308
Dry Banana Leaves			

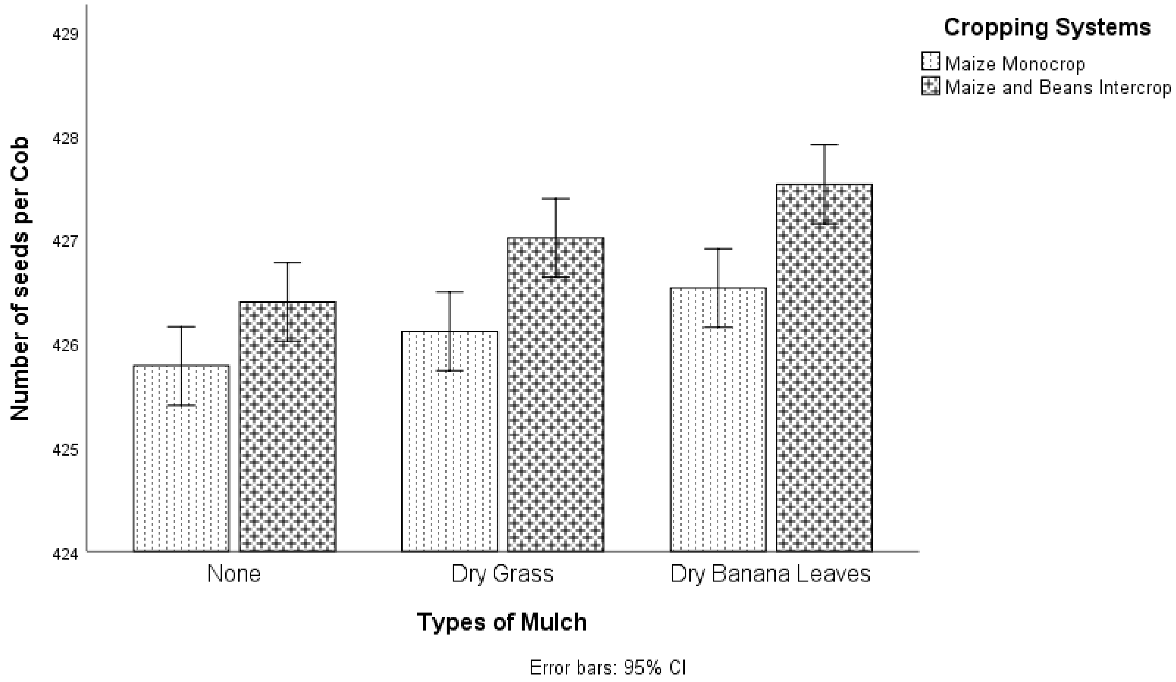
*. The mean difference is significant at the 0.05 level.

4.11.2 The Effects of Mulch on the Average Number of seeds per Maize cob

The results of the effects of mulch on the seeds per maize cob are presented in Figure 4.26.

Figure 4.26

Effects of Mulch on the Number of Seeds per Maize Cob



Mulching had a positive effect on the number of seeds per maize cob, as seen in Figure 4.26. The highest number of seeds per cob was registered in maize-bean intercrop with dry banana leaves mulch (427.4) while the lowest number of seeds per cob was observed in maize monocrop with no mulch (425.8). The number of seeds per cob in maize monocrop mulched with dry grass and dry banana leave was 426 cm and 426. 4 cm respectively. An ANOVA was performed to evaluate the effects of mulch on the average number of seeds per maize cob. The finding reported a statistically significant main effect of mulch on the number of seeds per maize cob ($F(2,31) = 6.614$, $p= 0.004$) at the $p<.05$ level as seen in Table 4.31.

Table 4.31

ANOVA Summary for The Effects of Mulch on the Number of seeds per Maize cob

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Block	.294	2	.147	.365	.697
Mulch	5.321	2	2.660	6.614	.004
Error	12.469	31	.402		
Total	18.083	35			

a. R Squared = 1.000 (Adjusted R Squared = 1.000)

An LSD was performed to establish where the differences lay, and the outcomes are presented in Table 4.32. The difference in the mean number of seeds per maize cob in case of dry banana leaf and dry grass mulches over the control (no mulch) are 0.94 (0.22%) and 0.48 (0.11%) respectively. And the difference in the mean number of seeds between dry banana leaves over dry grass mulch was 0.47 (0.11%).

This result demonstrates none statistically significant effect in the mean number of seeds per cob in between the dry grass mulch and the control. Equally, there was no significant difference in the number of seeds per cob between dry grass and dry banana leaf mulches. However, there was significant effect in difference in the mean of seeds per cob between the control and the dry banana leaf mulch. These findings confirm with studies done by (Khurshid et al., 2006; Kibwana, 2000) who found out that mulching affects the yield of crops.

Table 4.32

Posthoc Results for the Effects of Mulch on the Average Number of seeds per Maize cob

	None	Dry Grass	Dry Banana Leaves
None		-.48	-.94*
Dry Grass			-.47
Dry Banana Leaves			

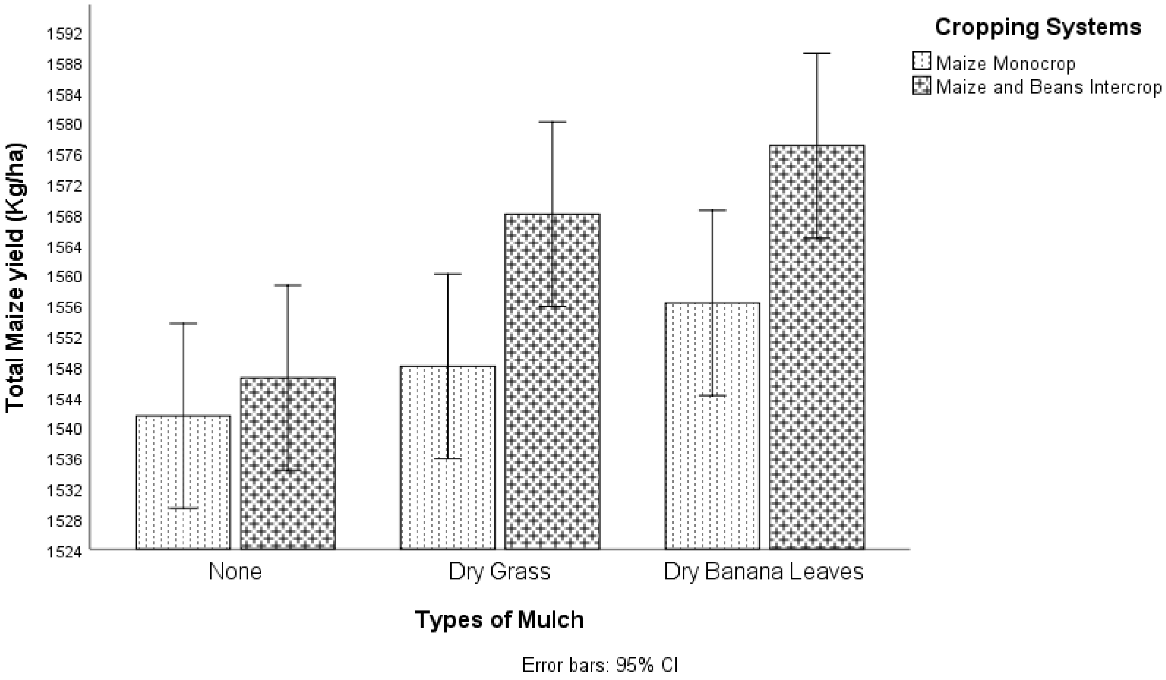
*. The mean difference is significant at the 0.05 level.

4.11.3 The Effects of mulch on Total Maize Yield

Presented in Figure 4.27 is the data on the effects of Mulch on Total Maize Yield.

Figure 4.27

Effects of Mulch on the Total Maize Yields



It can be observed in Figure 4.27, that mulching positively influenced the total maize yields. The highest total yield was recorded in dry banana leaves (1577.08 Kg/ha), followed by the dry grass (1568 Kg/ha), while the control (no mulch) was associated with a numerically lower total maize yield (1541.8 Kg/ha). ANOVA was performed to evaluate the effectiveness of the three types of mulches on total maize yields, and the results showed a statistically significant difference in overall maize yields [$F(2,31)= 8.564$, $p= 0.001$] between the mulches as presented in Table 4.33.

Table 4.33

ANOVA Summary for the Effects of mulch on Total Maize Yield

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Block	.584	2	.292	.077	.926
Mulch	64.954	2	32.477	8.564	.001
Error	117.558	31	3.792		
Total	183.096	35			

a. R Squared = 1.000 (Adjusted R Squared = 1.000)

Post-hoc correlations were made using the LSD test, and results are presented in Table 4.34. The data on the effects of mulching on the total maize yields showed a statistically significant difference in overall maize yields [F (2,31) = 8.564, p= 0.001] between the mulches. The mean total maize yield increase was 22.67 Kg/ha (1.57%) and 14.00 Kg/ha (0.93%) for the case of dry banana leaves and dry grass mulches over the control (no mulch). There was a significant difference in total maize yields when dry banana leaves and dry grass mulch were applied as compared with the control (no mulch). However, there was no significant difference in the total yields between the two mulch materials (dry banana and grass). These results confirm the studies done by (Khurshid et al., 2006), in which they found that mulching had a significant effect on maize yield. Furthermore, attributed it to mulching, helping in conserving soil moisture, and suppressing weeds hence reducing competition for nutrients and thus increased yields.

Table 4.34

Posthoc Results for the Effects of mulch on Total Maize Yield

	None	Dry Grass	Dry Banana Leaves
None		-14.00*	-22.67*
Dry Grass			-8.67
Dry Banana Leaves			

*. The mean difference is significant at the 0.05 level.

4.12 The Effects of Mulch on Bean Yield

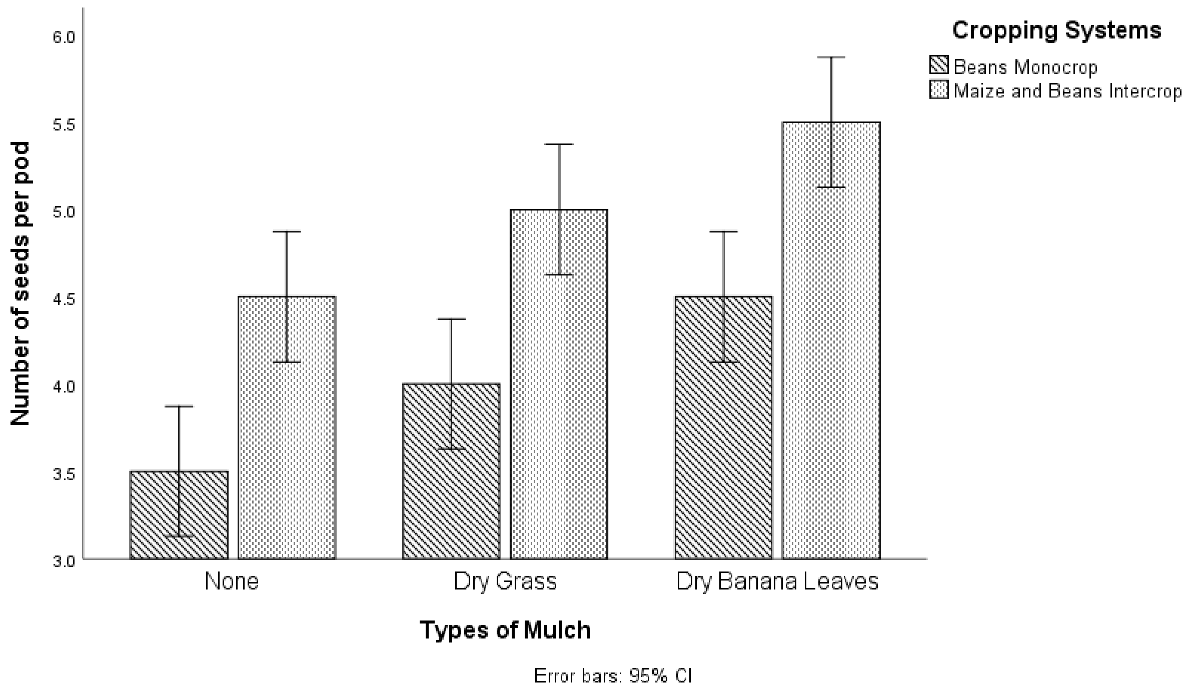
Data on bean yield parameters were collected, organized, analyzed, discussed, and presented in forms of figures and tables in this section.

4.12.1 The Effects of Mulch on the Number of seeds per Bean Pod

The data on the number of seeds per pod of the randomly selected bean plants was counted, and the results presented in Figure 4.28.

Figure 4.28

Effects of Mulch on the Number of Seeds per Bean Pod



From figure 4.28, the highest number of seeds per pod was registered in dry banana leaves mulch (5.00) followed by the dry grass mulch (4.50), while the least was registered in control (4.00). However, ANOVA was performed to find out any difference in the number of seeds per bean pod as a result of mulch, and the results showed a strong correlation between mulch types and the number of seeds per bean pod $F(2.27) = 5.400$, $p = 0.011$ at the $p < .05$ level as presented in Table 4.35.

Table 4.35

ANOVA Summary for the Effects of Mulch on the Number of seeds per Bean Pod

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Block	.000	2	.000	.000	1.000
Mulch	6.000	2	3.000	5.400	.011
Error	15.000	31	.556		
Total	21.000	35			

a. R Squared = 1.000 (Adjusted R Squared = 1.000)

An LSD was performed to determine which mulch material was the best and the results presented in Table 4.36. The mean differences in the number of seeds per pod were 25% (1.00) and 12.5% (0.50) in the case of dry banana leaves and dry grass, respectively, over the control. And the mean difference between the dry banana leaf mulch and dry grass mulch was 11.11% (0.50) over the dry grass mulch. These results show a compelling variation in the mean among the dry banana leaves and the control. However, there was none in the mean number of seeds per pod between the dry grass and the control and dry banana leaves. These findings confirm with the study by Sebuwufu et al. (2016), in their study, which found out that mulches impact the average number of seeds per bean pod.

Table 4.36

Posthoc Results on the Effects of Mulch on the Number of seeds per Bean Pod

	None	Dry Grass	Dry Banana Leaves
None		-.50	-1.00*
Dry Grass			-.50
Dry Banana Leaves			

*. The mean difference is significant at the 0.05 level.

4.12.2 The Effects of Mulch on the Weight of Bean Seeds (grams)

The results of the effects of mulch on the weight of bean seeds are presented in Figures 4.29.

Figure 4.29

Effects of Mulch on the Weight per Bean Seed (gm)

From Figures 4.29, the application of mulch affected the weight of bean seeds positively. With the highest weight registered with dry banana leaves mulch application (0.62 gm) while the lowest was recorded in bean monocrop with no mulch (0.34 gm). The weight per bean seed in bean monocrop with dry grass and dry banana leaf mulched was 0.47 gm and 0.49 gm respectively. In order to assess the effect of mulch on weight per bean seed (gms), an ANOVA was performed, and the outcomes indicated was a compelling effect of Mulch on mean weight per bean seed [$F(2, 27) = 3.373$, $p = 0.000$] at the $p<.05$ level, as presented in Table 4.37.

Table 4.37

Summary for the Effects of Mulch on the Weight of Bean Seeds (grams)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Block	.008	2	.004	.804	.457
Mulch	.149	2	.074	15.235	.000
Error	.151	31	.005		
Total	.308	35			

a. R Squared = 1.000 (Adjusted R Squared = 1.000)

Thereafter, comparisons using the LSD test was conducted, and the results indicated that the difference in mean weight per bean seed in the case of dry banana leaf and dry grass mulches over the control were 0.1492 (43.88%) and 0.1183 (34.79%) respectively as seen in Table 4.38. Furthermore, the difference in mean weight per bean seed in dry banana leaf mulch over dry grass mulch was 0.0308 (6.55%).

The results, showed no significant difference in the weight per the bean seed between dry grass mulch and dry banana leaf mulch. However, there was compelling variations in the mean weight per bean seeds between the control (no mulch) and the two mulch materials (dry grass and dry banana leaf mulches). However, overall dry banana leaves showed better results. These outcomes are in agreement with the studies carried conducted by (Kwambe et al., 2015) in which they found that mulches had a positive effect on the weight per bean seed.

Table 4.38

Posthoc Results for the Effects of Mulch on the Weight of Bean Seeds (grams)

	None	Dry Grass	Dry Banana Leaves
None		-.1183*	-.1492*
Dry Grass			-.0308
Dry Banana Leaves			

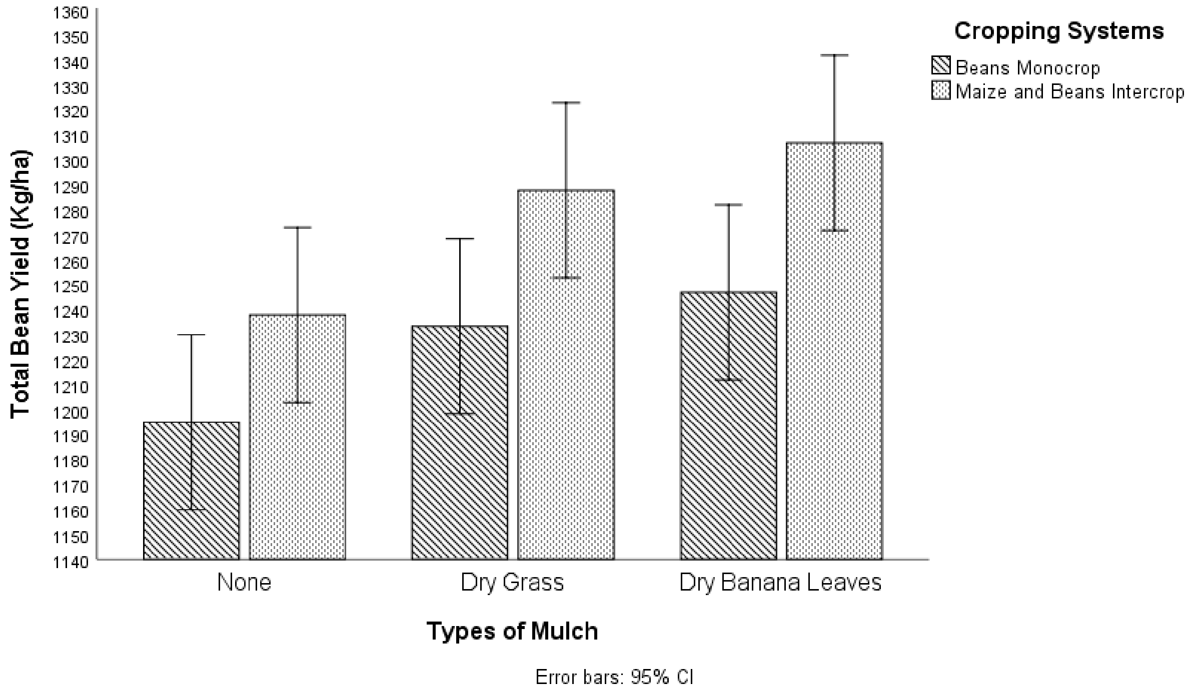
*. The mean difference is significant at the 0.05 level.

4.12.3 The Effects of Mulch on Total Bean Yield

The results of the effects of mulch on total bean yield are presented in the figure below.

Figure 4.30

Effects of Mulch on Total Bean Yields



Mulching influenced the total bean yields positively, as seen in figure 4.30. The highest yield was observed when dry banana leaves mulch was applied (1277.33 Kg/ha), followed by dry grass mulch (1260.75 Kg/ha), while the control registered the lowest yields (1216.50 Kg/ha). An ANOVA was conducted to compare the effectiveness of the three types of mulches on total bean yields, and the results indicated a statistically significant difference in total yields [$F(2,27) = 6.081$, $p = 0.003$] between the types of mulches, as shown in Table 4.39. This result is attributed to the fact that mulching protected the roots of the plants from heat thereby creating congenial condition including temperature moderation, reduce salinity and weed control for the growth thus exerting decisive effects on earliness, yield and quality of the crop

Table 4.39

Summary for the Effects of Mulch on the Total Bean Yield (Kg/ha)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Block	1.844	2	.922	.214	.809
Mulch	59.901	2	29.950	6.946	.003
Error	133.674	31	4.312		
Total	195.419	35			

a. R Squared = 1.000 (Adjusted R Squared = 1.000)

An LSD posthoc analysis was conducted, and the results presented in Table 4.40. The mean difference in the total bean yield was 5.00% (60.76 Kg/ha) and 3.68% (44.25 Kg/ha) for the case of the dry banana leaves and dry grass mulches over the control. The mean difference in the total yields in the case of dry banana leaf mulch over dry grass mulch was 16.58 Kg/ha (1.32%). The results indicated a compelling variations in the total bean yield among the two mulch materials (dry grass and dry banana mulch) and no mulch. However, the results showed no significant difference in the total bean yields between the dry banana leaves and the dry grass. These results conform with the study by (Kwambe et al., 2015; Sebuwufu et al., 2016), who found out that Mulches impacts the total bean yield per hectare.

Table 4.40

Posthoc Results for the Effects of Mulch on the Total Bean Yield (Kg/ha)

	None	Dry Grass	Dry Banana Leaves
None		-44.25*	-60.76*
Dry Grass			-16.58
Dry Banana Leaves			

*. The mean difference is significant at the 0.05 level.

CHAPTER FIVE

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This chapter presents an overview, conclusions, and recommendations from the analysis. The findings of Chapter Four made up the conclusion and were linked to the objectives of the study and hypotheses. The recommendations generated were presented according to the objectives of this study, as laid out in Chapter One.

5.1 Summary

Water and soil moisture conservation are vital for crop production, as crops effectively utilize rainwater resources through absorption. Besides soil and water conservation methods, the cropping system also performs a main part in crop development and yield. This analysis researched the effects of water conservation procedures and cropping systems over the growth and yield of beans and maize in Wairaka, Jinja. Water conservation methods were identified as Tillage Methods (double digging and single digging) and Mulch (Dry grass and dry banana leaves). In contrast, cropping systems was identified as (Monocrop and Intercrop of maize and beans). The study addressed three specific objects, i.e., investigated the impact of tillage methods on the growth and yields of beans and maize, analyzed the impact of mulches (dry banana leaves and dry grass) on the growth and yields of beans and maize and evaluated the effects of cropping systems on the growth and yields of maize and legumes.

Information on growth variables (height of the plant and the amount of leaves per plant), maize yield parameters (cob length, seeds per maize cob and complete maize yield) and beans return parameters (number of seeds per gallon, typical bean seed weight and the complete bean return) were collected. The obtained data were tested using the ANOVA test with the Post Hoc to test for the difference in the means of maize height (cm) and the number of leaves as the growth parameter and maize yields in kgs.

The data collected were analyzed SPSS 25. The study reviewed the literature regarding the theoretical and empirical literature on double digging, mulching and intercropping as well as literature from the previous studies on the effects of double digging, mulching and intercropping on the growth and yield of maize and beans.

5.2 Conclusions

From the analysis, it was concluded that double digging had a positive effect on the growth of both maize and beans. Plant heights and the number of leaves per plant of both maize and beans were positively affected by double digging. Double digging was found to be associated with a significantly higher number of seeds per maize cob, seeds per bean seed, total bean yields, and total maize yield than single digging. However, there was an insignificant difference in the weight per bean seed and maize cob length between double digging and single digging. Overall, double digging influenced the yields of both maize and beans positively.

This study further confirmed that intercropping affected the growth of both maize and beans as it was associated with statistically significant plant heights and the number of leaves of the two crops at $p<0.05$ level. The maize yield was influenced by intercropping as there was a significant difference in the cob-length, the number of seeds per cob, and the total maize yields at $p<0.05$ level. Also, this study found out intercropping was associated with an increased mean number of seeds per bean pod, weight per bean seed, and total bean yields. Hence it was concluded that the yields of both maize and beans were positively affected by intercropping.

In the study, it was established that mulching had a significant effect on the growth of maize and beans. Mulching was associated with a statistically significant difference in the number of seeds per maize cob, seeds per bean pod, weight per bean seed, total bean yield, and total maize yield (Kg/ha). However, the p-value was found to be insignificant for all the mulch materials in their measure of maize cob length. The study further established that dry banana leaves mulch had a much more significant effect on the growth and yields of maize and beans more than dry grass mulch.

5.3 Recommendations

The water conservation methods we investigated, mainly double digging, dry banana leaves mulches, and maize-bean intercrop, are promising in ensuring yields against erratic rainfall and drought and can be recommended to farmers since they are low cost and readily available to small-scale farmers but could help them from crop failures due to inconsistent rainfall.

There is a need to provide extension service to the farmers on the importance of water and soil conservation methods and practices that are cheap and can easily be adapted.

5.4 Areas for further study

The findings of this research must not be generalized to all regions of the country. The soil types and other physical factors/conditions vary from one region of Uganda to another. This research was done in Wairaka, Jinja district, one district in the Eastern Region of Uganda. Further research can be conducted in different regions of the country to see if the results will be similar. Other areas that may be studied like the measurement of N balances under intercropped lands should also be considered for further research in the different regions of the country. Future research should look into soil moisture content under the use of different soil and water conservation methods. Effects of double digging should be evaluated in the subsequent seasons, since its advantages in enriching soil structure and consequently water retention increases over time.

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APPENDICES

APPENDIX I: Map of Wairaka, Jinja Uganda

Adapted from https://nona.net/features/map/placedetail.2412034/Wairaka/

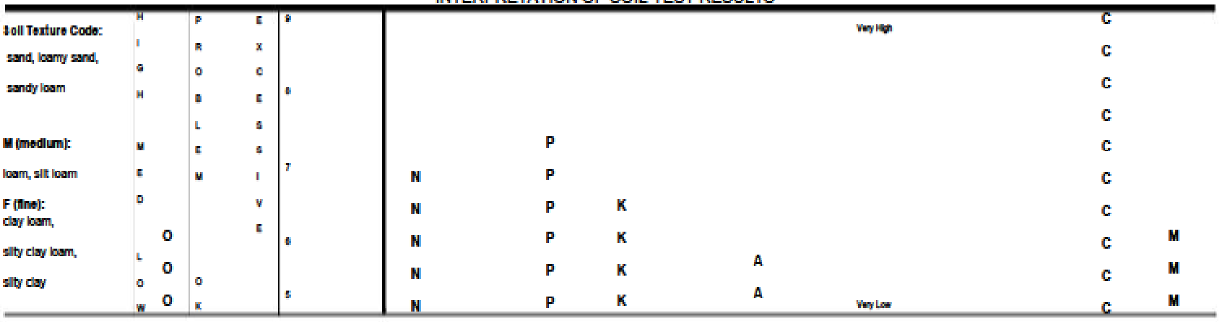
APPENDIX II: Soil Analysis Report

SOIL TEST REPORT

Location: **Nalubale Centre, Wairaka**
Address: **P.O. Box 1600, Jinja**

Date Sampled: **14/06/2017**
Date Reported: **16/06/2017**

INTERPRETATION OF SOIL TEST RESULTS



SOIL TEST RESULTS

Sample/ Field Number	Estimated Soil Texture	Organic Matter %	Soluble Salts mmhos/cm	pH	Buffer Index	Nitrate NO3-N ppm	Olsen Phosphorus ppm P	Bray 1 Phosphorus ppm P	Potassium ppm K	Sulfur SO4-S ppm	Aluminum ppm	Iron ppm	Manganese ppm	Copper ppm	Boron ppm	Calcium ppm	Magnesium ppm
	Medium	**3.0**		**5.65**	**6.5**	**11.5**		**26**	**110**		**13.5**					**1500**	**5**

REMARKS

The soil has low organic matter and is moderately acid.

The nitrogen level is adequate for the growth of most of the arable crops. Phosphorus, calcium,potassium levels are adequate for most crops. However, the soils has low levels of magnesium and aluminum.

For additional information, contact the soil extension specialist: **+256393280454**

APPENDIX III: Raw Data

BLOCK	WATER_CONSERVATION_METHODS	CROPPING_SYSTEM	MAIZE_HEIGHT	BEAN_HEIGHT	Number_of_Leaves_maize	Number_of_Leaves_beans	Cob_Length	Number_of_seeds_Per_Cob	Total_Grain_Yield_Maize	Number_of_Seeds_per_Pod	Weight_per_Bean_Seed	Total_Grain_Yield_Beans
1	1	1	222.20		11		15	426	1519			
1	2	1	223.90		11		14.7	426	1543			
1	3	1	225.20		12		15.6	427	1553			
1	4	1	220.30		10		14.1	427	1548			
1	5	1	223.10		11		15.3	426	1543			
1	6	1	223.30		11		14.5	426	1543			
1	1	2		82.80		41				4	0.40	1000.29
1	2	2		84.5		41				4	0.45	1002.4
1	3	2		85.8		42				5	0.56	1004.68
1	4	2		80.9		40				3	0.34	999.45
1	5	2		78.5		41				4	0.45	1000
1	6	2		84.2		41				4	0.46	1000.75
1	1	3	223.3	85.9	12	42	15.6	427	1558	5	0.45	1001.45
1	2	3	225.2	92.9	12	42	16.4	427	1578	5	0.56	1001.5
1	3	3	225.2	97.3	13	43	16.7	428	1596	6	0.65	1006.75
1	4	3	222.5	79.3	11	41	15.4	426	1543	4	0.37	999
1	5	3	223.5	89.5	12	42	15.6	427	1558	5	0.56	1000.7
1	6	3	223.7	94.6	12	42	15.6	427	1558	5	0.55	1002.6
2	1	1	222		11		14.9	426	1543			
2	2	1	223.5		11		14.6	426	1558			
2	3	1	225.4		12		15.6	427	1578			
2	4	1	220.2		10		14.1	425	1548			
2	5	1	222.6		11		14.9	426	1543			
2	6	1	223.2		11		14.5	426	1543			
2	1	2		83		41				4	0.35	1000.45
2	2	2		86.8		41				4	0.48	1001.98
2	3	2		90		42				5	0.55	1006.7
2	4	2		73.9		40				3	0.32	998.95
2	5	2		79.5		41				4	0.47	999.55
2	6	2		83.6		41				4	0.49	1000.65
2	1	3	222.5	85.7	12	42	16	427	1558	5	0.52	1002.17
2	2	3	225.4	93.3	12	42	15.5	427	1578	5	0.55	1002.5
2	3	3	226.9	97.7	13	43	16.5	428	1596	6	0.66	1008.2
2	4	3	220.8	78.7	11	41	14.6	426	1543	4	0.44	945
2	5	3	223.6	88.5	12	42	16.3	427	1558	5	0.62	999.88
2	6	3	223.5	94.5	12	42	15.9	427	1558	5	0.56	1001.78
3	1	1	221.6		11		14.7	426	1543			
3	2	1	224.1		11		14.6	426	1558			
3	3	1	225.3		12		15.7	427	1578			
3	4	1	219.5		10		14.4	425	1548			
3	5	1	223.4		11		15.2	426	1543			
3	6	1	223.4		11		15.1	426	1543			
3	1	2		82.9		41				4	0.36	1000
3	2	2		86.6		41				4	0.51	1000.5
3	3	2		91.7		42				5	0.56	1005.9
3	4	2		74		40				3	0.34	999.43
3	5	2		78.8		41				4	0.46	999.68
3	6	2		83.9		41				4	0.47	999.78
3	1	3	223.2	85.5	12	42	15.7	427	1519	5	0.48	1003.41
3	2	3	225	92.5	12	42	15.7	427	1543	5	0.56	1001.78
3	3	3	226.3	96.8	13	43	16.4	428	1553	6	0.66	1008.45
3	4	3	221.3	78.8	11	41	14.9	426	1548	4	0.43	885
3	5	3	224.4	88.6	12	42	15.8	427	1543	5	0.59	998.75
3	6	3	224.1	95.3	12	42	16.2	427	1543	5	0.56	1002.8