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FACULTY OF AGRICULTURE AND ENVIRONMENTAL SCIENCE

EFFECTS OF VINE CUTTING POSITION AND LEAF HARVESTING ON YIELD OF SWEET POTATOES (*Ipomoea batatas.* L).

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DEDICATION

Special dedication goes to my loving wife Faith and my kids Anotidaishe, Amia and Alina for their unwavering support and encouragement during stressful moments.

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My heartfelt appreciation goes to my supervisor Ms Kamota for supervising this research project. I benefited immensely from her vast experience, giving me advice and encouragement towards the successful completion of this research project. She selflessly rose to the occasion whenever I sought after her feedback which helped me to navigate through the inevitable challenges. I would also like to thank my sister Loveness Chitonho and the entire BUSE staff especially those in the Department of Crop Science for their immeasurable support towards the success of this study.

ABSTRACT

There is a great variation in yield of storage roots and vines of sweet potato (*Ipomoea batatas*. L) among farmers due to use of different cutting positions and vine pruning levels. This study was carried out to establish cutting position and the vine pruning level that can give smallholder farmers optimum yields of storage roots and vines. The study was conducted in a 3x3 factorial arrangement in Randomized Complete Block Design (RCDB) with three replications. Treatments included cutting positions at three different portions, apical, middle and basal and pruning at three levels, 0%, 25% and 50% respectively. Pruning was done 50 days post-planting and roots were harvested 100 days after planting. The two measurements were summed up to give the total vine weight of sweet potato. Storage root length, diameter and weight were measured at harvesting. Storage root length indicated significant difference ($p<0.05$) among cutting positions with highest mean length obtained from apical and middle cuttings while the lowest was obtained from basal cuttings. Storage root diameter, root weight and vine weight indicated significant interaction ($p<0.05$) of cutting position and vine pruning level. Highest mean root diameter and root weight were obtained from middle cuttings and 25% vine pruning level. The lowest mean root diameter and weight were obtained from basal cutting and 50% vine pruning level. Highest vine weight was recorded from middle cutting and 50% vine pruning level, with the lowest being recorded from basal cutting and 0% vine pruning level. Apical and middle stem cuttings can be recommended for farmers to obtain higher yields.

KEY WORDS: *Ipomoea batatas*, Smallholder farmer, Cutting position, vine pruning level.

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LIST OF ACRONYMS AND ABBREVIATIONS

AGRITEX: Agricultural Technical and Extension Services

ANOVA: Analysis of Variance

FAOSTAT: Food and Agricultural Organization Statistics

g: Grammes

kg: Kilogrammes

t/ha: Tonnes per Hectare

LSD: Least Significance Difference

$P<0.05$: Probability less than 5%

CHAPTER 1

1.0 Introduction

1.1 Background

Sweet potato (*Ipomoea batatas*.L) is a dicotyledonous root crop that belongs to the family Convolvulaceae which includes several varieties of root crops. It is characterized by creeping vines and adventitious roots. Sweet potato is native to Central and South America (Mulungu *et al*., 2006). The crop is grown in over 100 countries and it is extensively cultivated in all tropical and subtropical regions particularly in Asia, Africa and the Pacific (FAOSTAT, 2010). The crop came into Africa through trade from South America. Sweet potato ranks third in consumption after Irish potato and Cassava in the world.

In Zimbabwe, the crop is mainly propagated through stem cuttings and this is through the use of indigenous knowledge systems. Some farmers prefer planting apical stem cuttings only while others use apical, middle and basal cuttings. According to Netsai *et al*., (2019), most farmers prefer cuttings from apical portion to those of the middle and basal portions of the stem. The terminal portion of sweet potato vine is reputed to be superior to the middle and basal portions for plant establishment and root yield (Ahmed and Nigussie, 2012). However, there is shortage of sweet potato planting material in Zimbabwe especially in the smallholder farming sector as nurseries are small and most of them are located at small backyard spaces or near washing areas and irrigated with hard water (Chagonda *et al*., 2014). The shortage of planting material would leave farmers with no option than to use any cuttings available without necessarily considering the yield variations from these different cutting portions. Mukanyadzi (2009), articulated that apical shoot cuttings grow more vigorously and produce larger storage root yields than the middle and basal portions. However, Belehu (2003), argues that cuttings from the apical portion of the stem produce sweet potato roots of low weight as compared to those from the middle and basal portions of the stem.

Belehu and Hammes, (2004), postulated that vine management is done through indigenous knowledge system where some farmers prune vines at different levels depending on the purpose of pruning while others do not practice pruning at all. Vine pruning can be done to remove damaged stems and it also encourages the production of side shoots to give the plant a fuller look (Mulungu *et al*., 2006). According to Hammes, (2002), sweet potato vines should not pruned as pruning affects the energy that the crop puts on the root weight. The author argues that leaves convert solar energy into plant food and without the leaves the crop will starve. However, light pruning can only be done when the tubers have fully formed to slow down maturity.

1.2 Statement of the Problem

Although sweet potato is a crucial root crop with increasing annual consumption per capita in Zimbabwe, its production is limited by shortage of planting material, improper cutting position and improper vine pruning regimes for various purposes (Chagonda *et al*., 2014). Planting of stem cuttings from different positions along the stem and pruning of vines at different levels has resulted in yield variations among farmers. Information about the best cutting position and vine harvesting regimes to optimize yield in smallholder farmers is still very limited.

1.3 Justification

Sweet potato stem cutting positions and leaf harvesting level have an impact on the total yield that can be obtained by communal farmers. It is, therefore, imperative for the communal farmers to know the correct cutting position and leaf harvesting levels that can optimize yields. This research therefore seeks to determine the best cutting position and leaf harvesting levels for communal farmers to meet high and reliable yield of both the storage roots and vines.

1.4 Main Objective

To evaluate the effect of vine cutting position and leaf harvesting on yield of sweet potato.

1.4.1 Specific Objectives

1.4.1.1 To determine the effect of vines cutting position on root yield of sweet potatoes

1.4.1.2 To determine the effect of leaf harvest intensity on sweet potato root and leaf yields.

1.5 Hypotheses

1.5.1 Ho: There is no significant difference on cutting position of sweet potato vines on the yield of sweet potatoes

1.5.2 Ho: There is no significant difference on leaf harvesting intervals on yield of sweet potatoes

CHAPTER TWO

2.0 Literature Review

2.1 Taxonomy and Origin of Sweet Potato

Sweet potato is a dicotyledonous root crop belonging to the morning glory family *Convolvulaceae*. The sweet potato and the wild species closely related to it are classified in the family *Convolvulaceae*, genus *Ipomoea*, section *Eriospermum* (formerly *Batatas*), and series *Batatas* (James, 2004). Heuzé *et al*., (2015) described the cultivated sweet potato as *Convolvulus batatas*. *Ipomoea batatas* is a self-incompatible species. It is generally accepted that the sweet potato is of American origin located between the Yucatán Peninsula of Mexico and the mouth of the Orinoco River, in Venezuela and are one of the oldest vegetables known to man. They have been consumed since prehistoric times as evidenced by sweet potato relics dating back 10 000 years that have been discovered in Peruvian caves. Abundant evidence shows that sweet potato was spread widely through the migration routes of people in the New World tropics before the discovery of America (James, 2004). Christopher Columbus brought sweet potatoes to Europe after his first voyage to the New World in 1492. By the 16th century, they were brought to the Philippines by Spanish explorers and to Africa, India, Indonesia and southern Asia by the Portuguese (James, 2004). The highest diversity of sweet potato was found in Central America using molecular markers (Huang and Sun, 2000).

Sweet potato is now widely cultivated between 40°N and 32°S, from sea level up to 2000 m (and up to 2800 m in equatorial regions) (Heuzé *et al*., 2015). The area under cultivation was 8.5 million ha in 2009 and the worldwide root yield was 36 t ha^{-1} (FAOSTAT, 2010). The main sweet potato producers are China, Indonesia, Vietnam, India, Philippines and Japan in Asia, Brazil and the USA in the Americas and Nigeria, Uganda, Tanzania, Rwanda, Burundi, Madagascar, Angola and Mozambique and Zimbabwe in Africa (FAO, 2010; Low *et al*., 2009).

2.2 Economic Importance and Distribution of Sweet Potato

Sweet potato is an important crop in several countries of the world (FAOSTAT, 2010; Phillips *et al*., 2004). It is an important food crop in many areas of Sub-Saharan Africa, where it is grown on around 2.1 million hectares with an estimated production of 9.9 million tonnes (Kapinga *et al*., 1995). Sweet potato performs well even in drier parts of Zimbabwe (Mukunyadzi, 2009). Intensive production is mainly done in agro-ecological regions I, II and III in which Manicaland, Mashonaland, Midlands and some parts of Masvingo are located (Mukunyadzi, 2019). Among common sweet potato varieties grown in Zimbabwe; Bambas, Brondal, Imby, Chigogo, Cordner and German 2 are red skinned while the white skinned varieties are ChiZambia and Pamhai (Mutandwa and Gadzira, 2007). Sweet taste and prolonged shelf-life make German 2 popular at Bulawayo and Gweru vegetable markets (Chagonda *et al*., 2014). Annual consumption per capita of sweet potato storage roots is gradually increasing, being estimated at 1 to 7kg in urban and 3 to 5kg in rural communities of Zimbabwe (Chagonda *et al*., 2014).

According to FAO statistics, Zimbabwe has 76 percent of its land suitable for sweet potatoes production. Out of the 162 000 km^2 of arable land in Zimbabwe, only 8% of the land is not suitable for Sweet potatoes production in the country, this means that a large part of the land resources in Zimbabwe is suitable for production of sweet potatoes (FAO, 2010). The crop has high biomass yields of both roots and vines (An *et al*., 2003).

Prodigious increase in prices of fertilizers and pesticides caused resource-poor farmers to gravitate from maize, cotton and tobacco production to less input demanding sweet potato (Low *et al*., 2009). Adaptability of sweet potato to marginal environments allows resource-poor farmers to achieve higher yields of up to 15 t ha^{-1} with minimum use of fertilizers and herbicides (Chagond *et al*., 2004. However, yield of up to 50 t/ha can be attained with sufficient moisture, proper fertilization and improved varieties (Low *et al*., 2009). The National fresh root yield at farm level in Zimbabwe is only 5.6 tons per hectare compared to potential yields of 20-40 t ha-1 (FAO, 2010). Such low yields are due to the fact that farmers have little knowledge on the impacts of vine cutting and leaf removal to yield (Kapinga *et al*., 1995 and Mukasa et al., 2003).

2.2.1 Nutritional attributes

Sweet potato roots are believed to be one of the most nutritious foods in the world especially as a source for vitamin A. One medium sweet potato (114 grams) provides 162 calories, 0 grams of fat, 37 grams of carbohydrate including 6 grams of fiber and 12 grams of sugar, and 3.6 grams of protein (Tan, 2007). This will provide well over 100% of daily needs for vitamin A, as well as 37% of vitamin C, 16% of vitamin B-6, 10% of pantothenic acid, 15% of potassium and 28% of manganese. It also, contains small amounts of calcium, iron, magnesium, phosphorus, zinc, vitamin E, thiamin, riboflavin and folate (Ju *et al*., 2011; Antia *et al*., 2006). Although sweet potato is traditionally a root crop; the top however is also valuable forage for ruminants and other livestock species (Hong *et al*., 2003). The leaves can be used fresh, dried or as silage, and can replace fish meal and groundnut cake as a protein source for growing goats (An and Lindberg, 2004).

2.3 Biological Description

Sweet potato is a rooted perennial mainly grown as an annual crop by vegetative propagation using either storage roots or stem cuttings (Kays *et al*., 1992). The roots are adventitious, mostly located within the top 25 cm of the soil. Some of the roots produce elongated starchy root. Root flesh colors can be white, yellow, orange and purple while skin color can be red, purple, brown or white (Chua and Kays, 2013). The stems are creeping slender vines, up to 6 m long. Its growth habit is mainly prostrate with a vine system that expands rapidly horizontally on the ground. The types of growth habit of sweet potatoes are erect, semi erect, spreading or very spreading (Antonio *et al*., 2011). The leaves are green or purplish, cordate, palmately veined, borne on long petioles. Sweet potato flowers are white or pale violet, axillary, sympetalous, solitary or in cymes.

2.3.1 Storage root

Although sweet potato shoot leaves are consumed, the storage root is the main organ used for human consumption. The swollen root is generally called a storage root and by classical botanical definition is an enlarged true root (Kays *et al*., 1992). The initial sign of storage root formation is the accumulation of photosynthates consisting predominantly of starch (Chua and Kays, 2013). Storage root initiation in sweet potato is reported to occur between the period 7 to 91 days after planting (DAP) and varies among cultivars. The yield of sweet potato is highly variable. Differences in yield could be attributed to factors such as cultivar, propagating material, environment, vine cutting levels, leaf harvesting intervals and soil (Villordon *et al*., 2009). The quantity of yield depends on the number of fibrous roots that will be induced to form storage roots or root clusters. This subsequently results in either a high number (four to six uniform and high grade) or low number of roots that may be reduced to one large storage root per plant or no marketable roots at all (Villordon *et al*., 2009). The shape and size of storage root can be between round and long irregular depending on the variety and environmental factors (Woolfe, 1992).

2.4 Climate Requirements for Sweet Potato Production

Sweet potato is a perennial crop but cultivated as an annual in the tropics and subtropics (Purseglove, 1991, Laurie and Niederwieser, 2004). Sweet potatoes are cultivated wherever there is sufficient water to support their growth; optimal annual well-distributed rainfall for growth range between 750-1000 mm (Heerden and Laurie, 2008). Very high rainfall leads to excessive vine development (Workayehu *et al*., 2011; Heerden and Laurie, 2008). When rainfall level is below 500 mm irrigation may be necessary but it should be stopped before harvest in order to prevent the roots from rotting. Sweet potato is a warm-season annual, needs an environment with a mean average temperatures of 18-29°C, a soil temperature of about 30°C and full sunlight for optimal development. It needs a frost-free period of 110-170 days and growth may be hampered below 20°C average day temperatures. The crop grows best where light intensity is relatively high (Etela *et al*., 2008; Heuzé *et al*., 2015)

2.5 Soil Requirements

Soil is an important natural resource, as it constitutes a medium for plant growth. Sweet potato crop grows on marginal soils with limited inputs (Ishaq *et al*., 2001). Sweet potato has the ability to tolerate harsh soil and climatic conditions and yet give satisfactory yield (Kapinga *et al*., 2009). Historically, sweet potatoes have been a poor soil crop that produces a decent harvest in imperfect soil, but will do much better with a loamy and well-drained soil. It grows well in fertile, high organic matter, well-drained, light, and medium textured soils. Optimal soil pH is between 5.0 and 7.0, but ideally the pH is between 5.8 and 6.2 (Wolfe, 1991; Heuzé *et al*., 2015). Heavy and poor textured, poorly drained soils that have frequent water-logging and poor soil aeration impedes the growth of storage roots, reducing their size and yield. Water logging in early growth stages hinders the establishment of roots, and in later growth stages causes decay of the storage roots (Tan, 2008; Gomes *et al*., 2005). To improve drainage, cuttings should be planted on 20 to 35 cm ridges. Ridge height will depend on soil texture. In heavy clay, sweet potato is grown in raised beds amended with compost and sand. Potatoes in clay are sometimes thinner and oddly shaped. Good root development depends on good soil aeration. They are ideal crop for areas with sandy soil. Sandy loam soils that are light and well-drained are the best for growing sweet potato. The crop is very sensitive to aluminium toxicity, which occurs at pH below 4.5 and may lead to death of the crop within six weeks (Gomes *et al*., 2005).

2.5 Propagation and Management

Sweet potato is propagated asexually from vine cuttings (Woolfe, 1992). Propagation of sweet potato is done by vegetative propagation by sprouting of whole storage roots and the sprouts are then used as planting materials or use of stem or vine cuttings from plants used for production or from multiplication plots. In the latter method green vines of approximately 30 cm length with at least four leaf nodes are planted into the soil (Parwada *et al*., 2011). Sweet potato is most commonly grown on mounds or ridges, and occasionally on the flat. Deep cultivation enhances root growth and bulking of the sweet potato roots. Mounds and ridges promote adequate drainage and ease of harvesting (Low *et al*., 2009). Weeding may be necessary particularly in the early stages of growth. To protect the crop from weeds at least two weeding and earthling up has to be given within 45 days after planting along with fertilizer application. Optimal space for planting sweet potatoes is about 30-45 cm apart, and 60 cm between rows. The vines grown under such space will have plenty of room to run. Sweet potato vines produce long vines which soon cover a large area hence need plenty of space to grow. The crop is either planted as pure stand or relay cropped with Maize, banana or cassava.

2.6 Constraints to Sweet Potato Production

The main biotic constraints of sweet potato in the tropics are sweet potato weevil, alternaria blight, sweet potato virus disease (SPVD) and root-knot nematodes mostly found in the temperate zones (Gasura and Mukasa, 2010). According to Low *et al*., (2009) there are five major constraints to improved productivity and incomes from sweet potato among the smallholder sector in Zimbabwe. These includes lack of improved varieties adapted to local environments, insufficient knowledge and use of better agronomic practices, the lack of timely access to virus and pest-free planting material, damage due to the sweet potato weevils particularly in drier production areas and lack of markets.

2.7 Growth Response as Affected by Leaf Harvest

Branching is cultivar dependent (Deblonde and Ledent, 2001; Heerden and Laurie, 2008) and branches vary in number and length. Normally, sweet potato plants produce three types of branches, (primary; secondary and tertiary) at different periods of growth. The total number of branches varies between 3 and 20 among cultivars. Olorunnisomo, (2006), reported that leaf harvest influences the branching intensity in sweet potato crop. Fresh shoot yield is a parameter of economic importance in dry ecological zones where animal feed supply is critical during the dry season (Ahmed and Nigussie, 2012). Olorunnisomo (2007) reported that harvesting leaves of a variety which produces abundant foliage gives high yield in shoot and root and hence is desirable as a source of food and feed.

2.7.1 Effect of Leaf Harvest Intensity on Sweet Potato

An *et al*., (2003:102), reported that Sweet potato vines can be harvested several times throughout the year. Kiozya, (200: 201), reported that higher leaf harvesting frequencies or intensities gave greater yields of total dry matter (DM) and crude protein (CP) than the least leaf harvesting frequencies. The same author also showed that sweet potato plants which were leaf harvested every two months gave a 21.7% higher yield of foliage than leaf harvested every three months which gave 20.8%. FAO, (2010:178) reported that total DM yield of foliage on sweet potato can vary from 4.3 to 6 t ha^{-1}, depending on leaf harvest intensity, variety grown, cultivation practices and nutrient supply.

2.7.2 Effect of Leaf Harvesting Interval of Sweet Potato

Laurie *et al*., (2013:64), found that leaf crude protein (CP) content is highest in the least frequent harvest interval in sweet potato, a 6-week than a 4-week interval. Sweet potato roots and leafy tops are mainly used as food (Heuzé *et al*., 2015). Lebot, (2009: 109), found that leaf can be harvested at intervals of 20 days with a defoliation of 50% of the total stems for optimal root and stem production, since greater defoliation could reduce root production. Vines and leaves can be harvested three or four times per growing season.

2.7.3 Quality of Root as Affected by Leaf Harvest

The productive potential of sweet potato root can reach 24 to 36 t ha^{-1} of roots (Tuyen *et al*., 1993; Workayehu *et al*., 2011). Harvesting the vines during growth reduces root quality (weight, volume, fiber content, crude protein) (An *et al*., (2003).

2.7.4 Dry Matter Yield of sweet potato roots

The dry matter content of sweet potato is low due to the high moisture content. On the average they matter content of sweet potato is 30% but varies widely depending on cultivar, location, climate, soil type, cultivation practice and the incidence of pest and disease (Hoover *et al*., 2005). The dry matter content determined in the University of Cape Coast for five varieties ranged between 34.41 to 37.35 % (Hoover and Ratnayake, 2005; Mbwaga *et al*., 2007). The dry matter content for 18 cultivars grown in Brazil ranged between 22.9 to 48.2 % (Kays *et al*., 1992). All these indicate that dry matter content of the roots in general is dependent on many factors.

Apart from the roots the green parts of sweet potato, mainly the petiole, stem and leaves have a dry matter content of 12 to 14 %. This is higher than some common vegetables like, cucumber, eggplant and carrot. Sweet potato contains considerable amount of carbohydrates, approximately 24 – 27 % of fresh weight (Fonseca *et al*., 2003). This consists of mainly starch, sugar, pectin, hemicelluloses and cellulose. Composition of these compounds that make up the total carbohydrates varies greatly from cultivar to cultivar and time of harvest or maturity. The compounds determine the storage length of the root, the higher the total carbohydrates the better it stores, for carbohydrate content slightly deceases in storage through respiration (Fonseca *et al*., 2003).

CHAPTER THREE

3.0 Materials and Methods

3.1 Study site

The study was conducted in Manicaland province, Rusape district, Zimbabwe, at Nyahawa secondary school. The site is located under Agro-ecological region 2b, with an average annual rainfall of 700mm. The area lies at 18^{o}39’0”S and 31^{o}51’0”E with an average temperature of 18^{o}C. The altitude for the site is 1570 meters above sea level. It is characterized by sandy loam soils.

3.2 Experimental Design

A 3x3 factorial arrangement in a Randomized Complete Block Design (RCBD) with three replications and soil type was used as a blocking factor. The allocation of plots to treatments was done randomly. There were two factors (vine cutting position and leaf harvesting intervals). Apical, middle and basal cuttings were used. Vine pruning was expressed as 0%, 25% and 50% respectively.

3.3 Experimental Procedure

The experimental plot was tilled to a depth of 40 cm using a disc plough. Twenty-seven identical ridges were constructed. The length, width and height of each ridge was 120 cm, 50 cm and 40 cm respectively. The space between ridges was 50 cm while the distance between blocks was 100 cm. Compound S (7: 21:7) was banded at a rate of 0.45t ha^{-1} and covered with soil to a depth of 10 cm. The popular variety in the area, German 2, was used. This is superior in terms of vine production, yield per unit area and keeping quality. It is characterized by purple stems and branched green leaves. Storage roots are red skinned and white fleshed. It is a short-season variety which takes 3-4 months to mature.

Apical, middle and basal stems were cut into 30 cm pieces. Cuttings from each of the position were planted on nine ridges per block. Cuttings were planted at a spacing of 30 cm along the ridge using looped planting orientation. Each ridge accommodated four cuttings leaving 15 cm on both ends. For every cutting, only three nodes were buried and both ends were left uncovered. Vine cutting was done at 50 days after planting (DAP). Pruning was done at 0%, 25% and 50% levels respectively. To allow regrowth, vines were cut at 15 cm above ridge level. Vine cutting percentages was achieved through counting the number of stems per plant and number of leaves per stem. The number of stems cut were determined by the number of leaves per stem.

3.4 Data Collection

Vine weight was measured 50 DAP and at 100 DAP. Storage root weight, length and diameter were measured at harvest. Wet vine and root weights were measured using a digital scale and expressed in tonnes per hectare. Storage root length was measured using a tape measure and a Vernier calliper was also used to measure storage root diameter and expressed in cm/plant.

3.4 Data Analysis

The data was analyzed statistically using Analysis of Variance (ANOVA) technique with GenStat version 14 software. Comparison of treatment means was done using the Least Significance Difference (LSD), at 5% significance level.

CHAPTER FOUR

4.0 RESULTS

4.1 Mean Total Vine Weight

Results collected on total vine weight showed that there was significant ($P<0.05$) differences among the means for the treatments investigated. The highest vine yield (19.13 t ha^{-1}) was recorded from middle cutting and 50% vine pruning level treatment, while the lowest yield (16.32 t ha^{-1}) was recorded from basal cutting and 0% vine pruning treatment as illustrated in fig 4.1 and fig 4.2. Mean total vine weight was 17.63 t ha^{-1}.

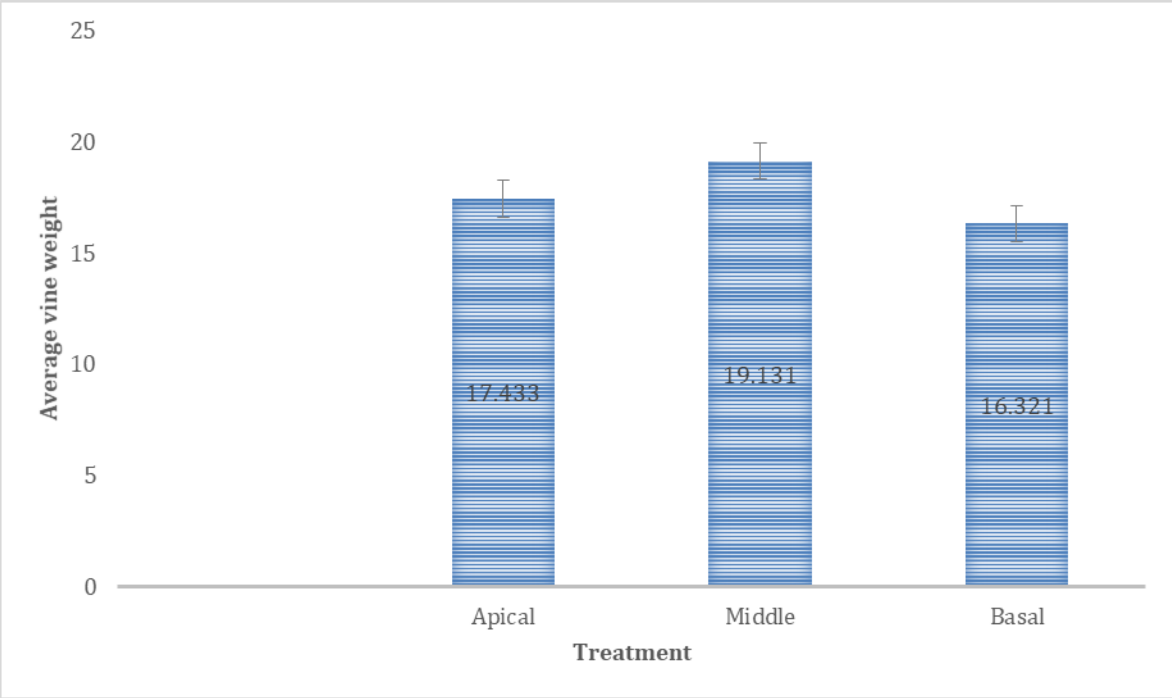

Fig 4.1: Effects of cutting position on vine weight
Error bars denote significant differences where they do not overlap and significant differences where they overlap

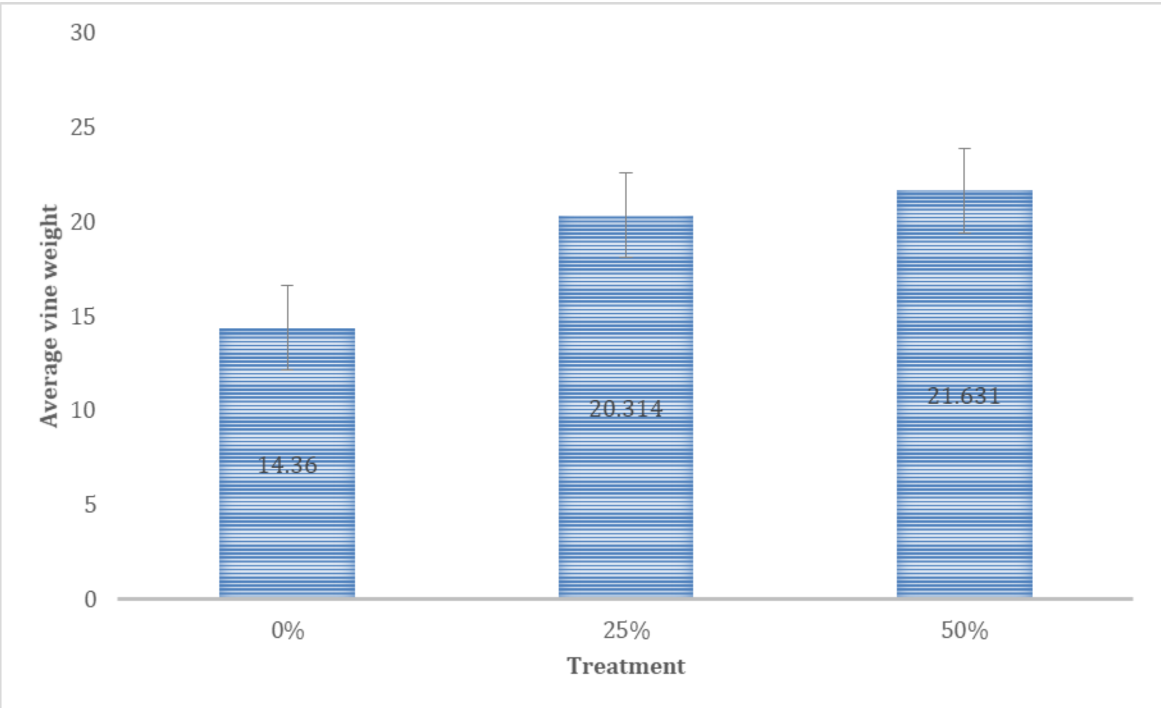

Fig 4.2: Effects of pruning level on average vine weight
Error bars denote significant differences where they do not overlap and significant differences where they overlap.

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4.2 Mean Length of Storage Roots

Data regarding cutting position and vine pruning level showed no significant interaction (P>0.05) to influence mean root length. Results collected after harvesting on length of storage root showed significant differences (P<0.05) for the vine cutting position (Figure 4.3). The mean shortest roots length (10.2 cm) was observed from vines cut from the basal portion. The storage root length recorded from middle and apical cuttings treatments, 14.9 and 15.2 cm respectively, were however not significantly different (P>0.05) from each other. There was no significant (P>0.05) influence of the vine pruning on the mean root length obtained at all pruning level treatments (0%, 25% and 50%). Mean storage root length was 13.43 cm.

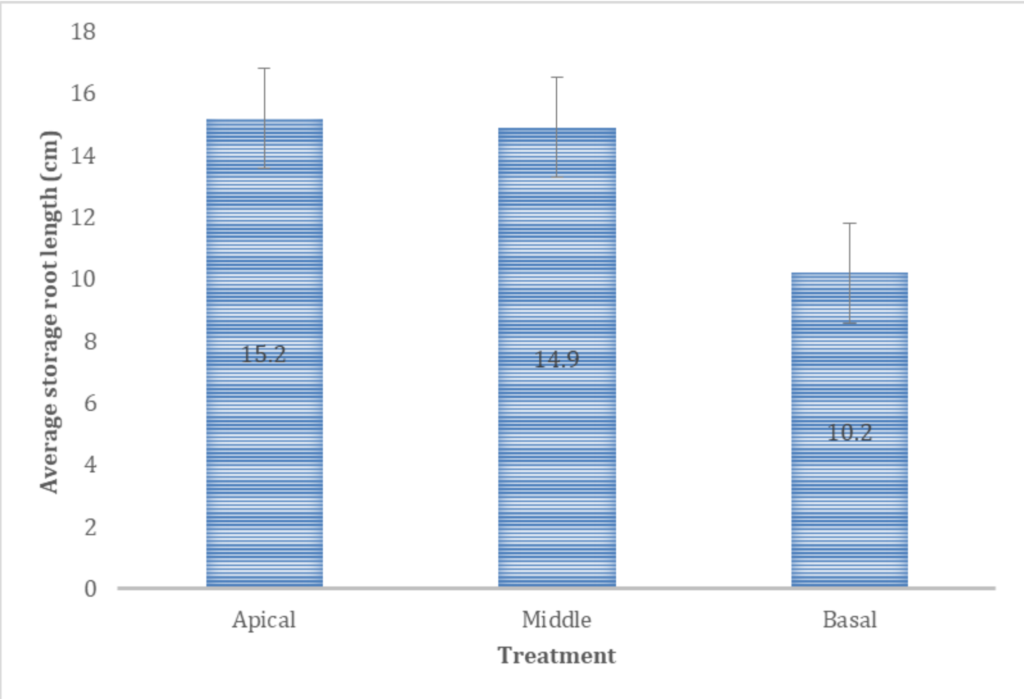

Fig 4.3: Effects of cutting position on root length
Error bars denote significant differences where they do not overlap and significant differences where they overlap.

4.3 Mean Storage Root Diameter

As indicated in Table 4.1, there were significant differences (p<0.05) for cutting potion and vine pruning level treatment with regard to storage root diameter. Storage roots with the largest diameter (32.29 cm) were recorded from middle cuttings and 25% pruning level treatment while the smallest tuber diameter was recorded from a treatment of basal cuttings and 50% pruning level. Mean storage root diameter was 29.18 cm. Fig 4.4 and Fig 4.5 show the effects of cutting position on root diameter and effects of pruning level on root diameter respectively.

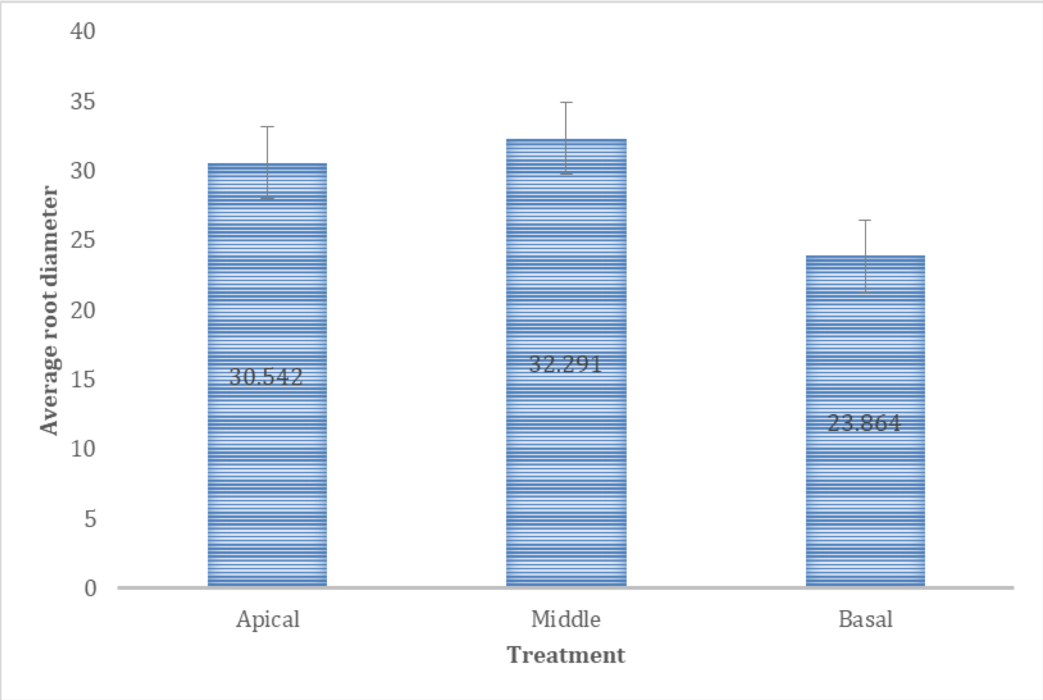

Fig 4.4: Effects of cutting position on root diameter
#Error bars denote significant differences where they do not overlap and no significant differences where they overlap

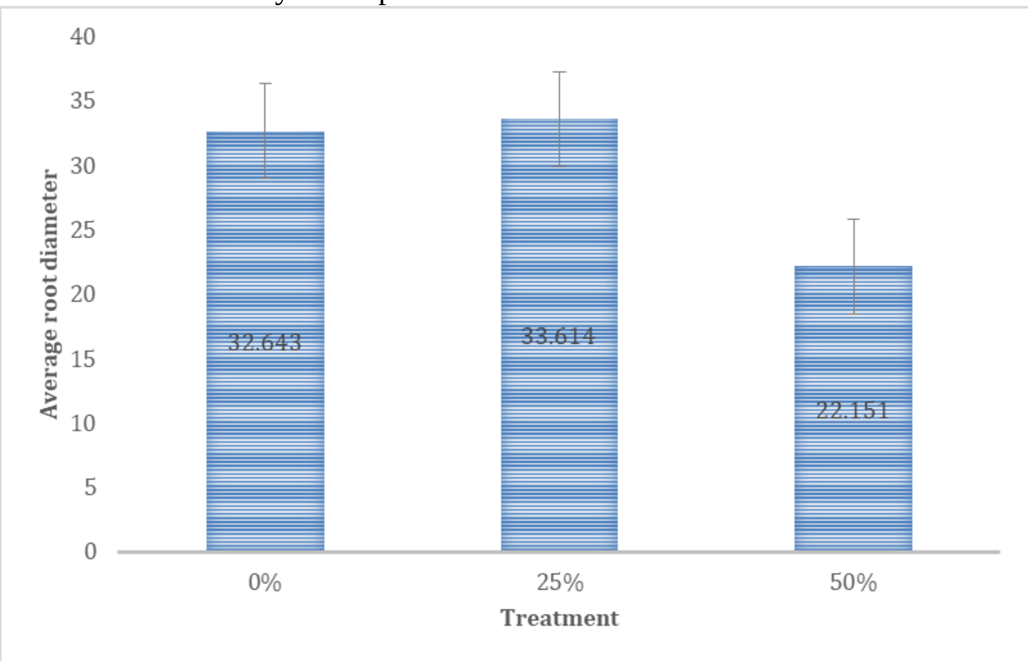

Fig 4.5: Effects of pruning level on root diameter
#Error bars denote significant differences where they do not overlap and significant differences where they overlap.

4.4 Mean Storage Root Weight

The comparison of the treatment means regarding storage root weight was significant ($P<0.05$) for vine cutting position and pruning level (Table 4.1). The highest tuber yield (28.98 t ha^{-1}) was recorded from middle cuttings and 25% vine pruning level treatment as shown on fig 4.6. The treatments, basal cuttings and 50% pruning level, recorded the lowest tuber yield of 23.391t ha^{-1}as shown on fig 4.7. Mean total tuber weight was 28.37 t ha^{-1}.

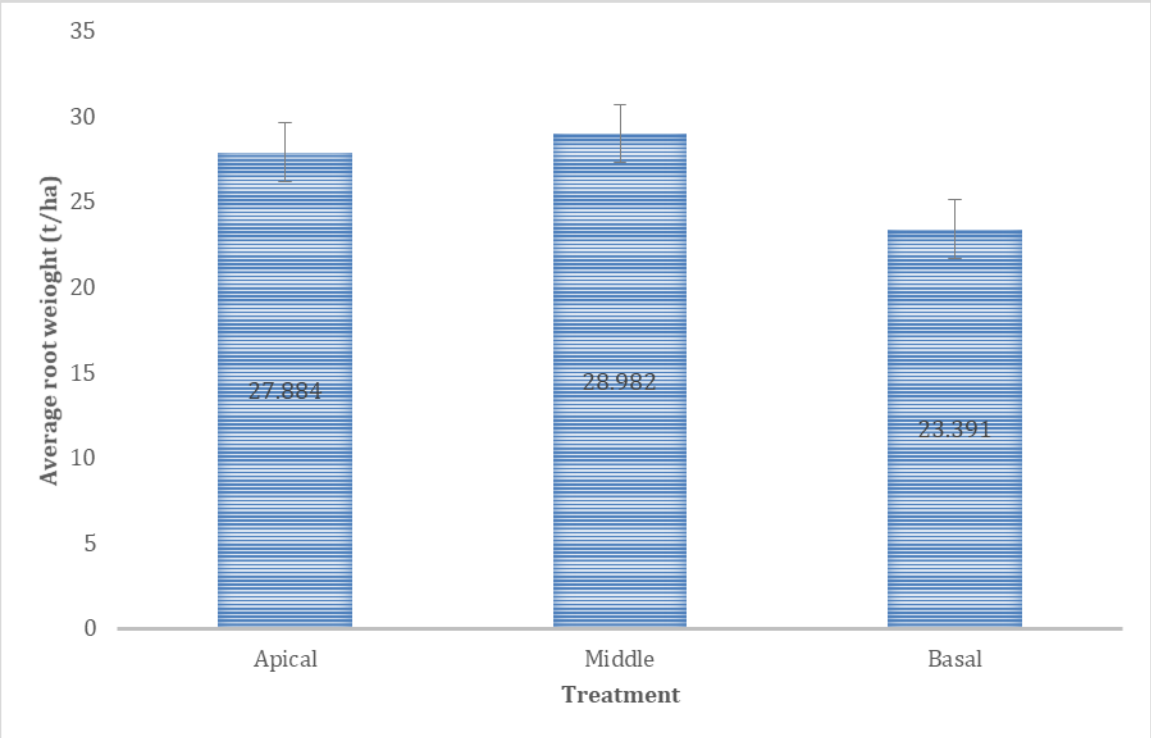

Fig 4.7: Effects of cutting position on root weight

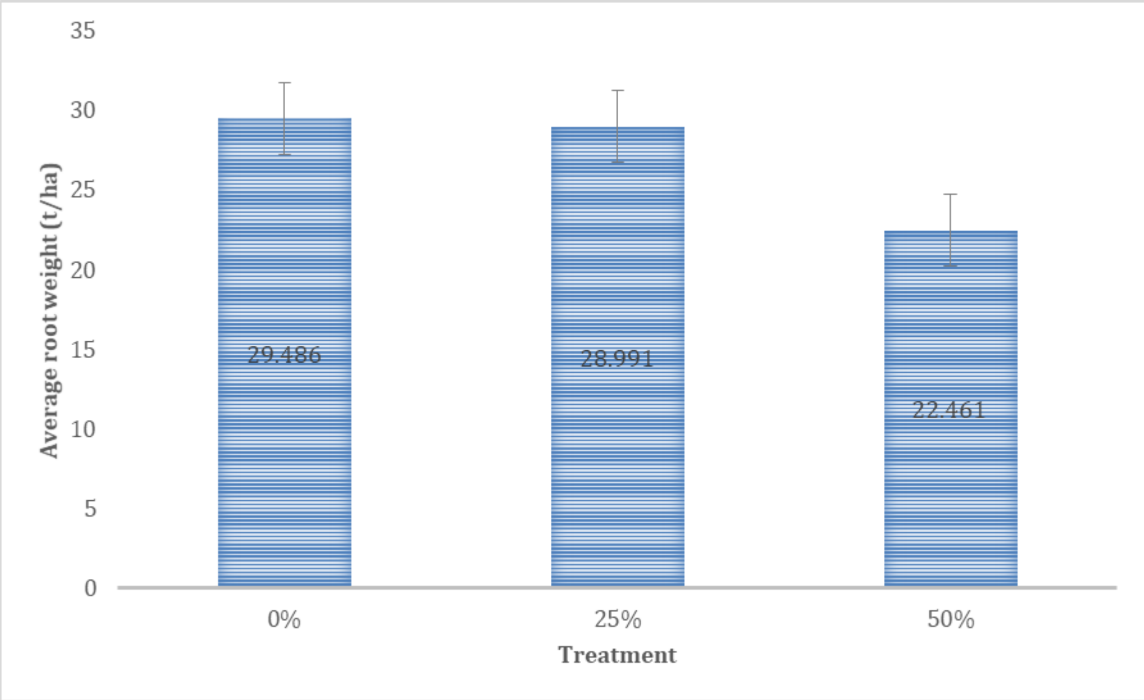

Fig 4.8: Effects of pruning level on root weight

CHAPTER FIVE

5.0 DISCUSSION

5.1 Total Vine Weight

There was no significant interaction between cutting positions and vine pruning levels on total vine weight. The highest vine yield was recorded from middle cuttings as a result of development of more secondary stems due to partial suppression of apical dominance during cutting preparation as well as higher level of starch stored in the cutting. Chagonda *et al*., 2012 also reported that middle cutting can grow better than the apical cutting particularly in cultivars which develop long stems. Basal cuttings had the lowest vine yield due to cells which are highly lignified and this probably resulted in poor root system development to facilitate water and nutrient uptake to support vine growth. More so, apical cuttings produce higher vine weights than basal cuttings and this is because the young apical cuttings are vigorous and growing rapidly. The basal cuttings are old and therefore put most of their energy into tuber production and their vine tips are weak and grow slowly (Nedunchezhiyan *et al*., 2012). Among all cutting positions, vine pruning at 50% resulted in highest vine yield as a result of the suppression of apical dominance to promote the development of more secondary stems as compared to 25% and 0% pruning levels. Un-pruned plots had lowest vine yield due to apical dominance and shedding of lower leaves owing to senescence (Ahmed and Nigussie, 2012).

5.2 Mean Storage Root Length

There was a significant difference ($P<0.05$) on average root length among cutting positions as shown is fig 4.3. This could be as a result of fast root establishment on apical and middle cuttings compared to basal cuttings. Apical and middle cuttings have new and active cells which support the development of lateral roots through the supply of auxins from growing apical point (Mukunyadzi, 2009). Apical cuttings supply the establishing roots with starch stored in the stem cells since they have higher starch level than lignin. The growing tip of the apical and middle cutting also grow nippily and support growth of new shoots that in turn photosynthesize to supply roots with photosynthates (Nedunchezhiyan *et al*., 2012). More so, young nodes near the vine apex result in fast growing lateral roots that bulk to form storage roots. Mutandwa, (2008), argues that basal portion of the vine usually provide thick and woody cuttings which are characterised by poor root establishment and growth. Apical cuttings probably developed longer lateral roots before root bulking. The length of lateral roots attained before root bulking is a determinant of storage root length since storage root bulking initiates with the accumulation of starch at the distal end of lateral root, proceeding upwards to the proximal end (Nedunchezhiyan *et al*., 2012). Increase in the root length at distal end after first deposition of starch is only for water and nutrient uptake and not for bulking into storage root. Belehu, (2003), attributes this to the bulking of sweet potato storage root that begins with deposition of carbohydrates near the root apex and the deposition continues upward to the lower end of storage root shoulder.

5.3 Mean Storage Root Diameter

There was no significant interaction between the treatments. Thickest roots were obtained from middle cuttings because of development of more stems as compared to apical and basal cuttings resulting in more leaves for photosynthesis and more apical shoots for auxin production. According to Mutasa *et al*., 2013 higher level of auxin promotes elevated cell division, elongation and maintenance of meristematic state in cambial cells of growing roots after transport of auxin from apex of stem shoot. Unlike apical cuttings, middle cuttings have no growing tip resulting in complete suppression of apical dominance during cutting preparation and this enhances development of many shoots. Belehu and Hammes, (2004), reported that middle cuttings can perform slightly better than the apical cutting especially in cultivars with fast growing vines resulting from apical dominance.

Basal cuttings had the thinnest roots because of limited photosynthesis (Niyireba *et al*., 2013). Basal cuttings developed fewer and shorter vines as compared to middle and apical cuttings. Failure of the basal cutting to develop many and long vines might be a result of senescence and lignification of cells of the cutting (An *et al*., 2003). Basal cutting also developed fewer and shorter roots as compared to apical and middle cuttings. This might contributed to the reduction in storage root diameter due to limited water and nutrient uptake (Mutasa *et al*., 2013). Belehu in 2003 also stipulated that basal cutting has a poor root establishment.

However, for all cutting positions, vine pruning at 25% had highest root diameter, followed by 0% and the lowest diameter was recorded from 50%. This could be attributed to development of new and more stems due to partial suppression of apical dominance (Niyireba *et al*., 2013). International Potato Centre reported that vine pruning is normally done at 40-60 days after planting and it is a multiplicative tool for generating more and new shoots to enhance photosynthesis (Mutasa *et al*., 2013). Belahu and Hammes in 2004 concluded that the photosynthetic ability of sweet potato leaves is affected by age, with higher rate of photosynthesis being found in young leaves.

The thinnest roots from vine pruning at 50% could be an indication that over-pruning negatively affects root growth. Storage root growth might have been suppressed either through extremely reduction in photosynthesis just after pruning, development of excess vines after re-growth or overproduction of auxin by new shoots (An *et al*., 2003). Development of excess vines causes imbalances in distribution of photosynthates between storage roots and the tops. Overproduction of auxin also causes imbalances in the auxin to cytokinin ratio in the storage roots after transport of auxin from vine tips and this disturbs cell division and elongation (Chagonda *et al*., 2014)

5.4 Mean storage root weight

The highest root yield was obtained from the middle cuttings because of development of more stems on the middle cutting (fig 4.7) as compared to apical cutting which is affected by apical dominance (An *et al*., 2003). Apical dominance is excluded from middle cutting during cutting preparation by removal of apical tip hence more stem shoots develop enhancing photosynthesis and auxin production. Although the apical tip was removed during the preparation of basal cutting, it had the lowest root yield because of the failure to develop many stems as a result of senescence and lignification. Belehu, (2003), also noted that basal stem cuttings are not preferred by farmers since they result in very low root yield.

For all cutting positions, pruning vines at 25% resulted in the highest storage root yield due to partial suppression of apical dominance for the development of many new shoots which are favourable for photosynthesis and auxin synthesis (An *et al*., 2003). Pruning vines at 50% has resulted in the lowest root yield due to extremely reduced photosynthesis just after pruning, imbalance in auxin to cytokinin ratio due to over-production of auxin after regrowth or imbalances in distribution of photosynthates between roots and the aboveground parts after re-growth. Increase in storage root size is a result of increase in the number of cells in which photosynthates are deposited to increase the root weight (Chagonda *et al*., 2014).

CHAPTER SIX

CONCLUSION

Apical and middle stem cutting had the longest storage roots as compared basal cuttings. Middle stem cuttings had highest storage root diameter, storage root weight and vine weight than apical and basal cuttings. Pruning vines at 25% resulted in highest storage root diameter and storage root weight as compared to 0% and 50%. Vine pruning at 50% resulted in highest vine weight as compared to 25% and 0%.

RECOMENTATIONS

Based on the results, farmers should plant both apical and middle stem cuttings since they are both high yielding in terms of storage roots and vines. Farmers should also prune 25% of vines to improve the contemporary storage root and vine production attributes especially for cultivars which develop long vines

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