EFFECT OF CUTTING POSITION AND VINE PRUNING LEVEL ON GROWTH AND YIELD OF SWEET POTATO (*Ipomoea batatas L.*)

By

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**Certification of dissertation**

The undersigned certifies that they have read and recommended for submission to the department of Horticulture in partial fulfilment of the requirement of the Bachelor of Science Honours Degree in Horticulture, a thesis by Munetsi Moreproof.

Effect of cutting position and vine pruning level on growth and yield of sweet potato *(Ipomoea batatas L.)*

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## ABSTRACT

There is yawning variation in yield of storage roots and vines of sweet potato (*Ipomoea batatas*) among farmers due to the use of different cutting positions and pruning of vines at different levels. Therefore, the aim of this study was to establish the cutting position and the vine pruning level that give the highest yield of both the storage roots and vines. Determination of storage root length, central storage root diameter, storage root weight and vine weight among different cutting positions and vine pruning levels was the objective of the study. The study was conducted in a 3x3 factorial arrangement in randomized complete block design (RCBD) with three replications. Factor 1 was cutting position and it had three levels (apical cutting, middle cutting and basal cutting). Factor 2 was pruning level and it had three levels (0, 25 and 50%). Twenty-seven ridges were aptly constructed using a spade. Length, width and height of each ridge were measured 120, 50 and 40 cm respectively. Vine weight was measured at 50 days after planting (vine pruning day) and 100 days after planting (storage root harvesting day) and added to make total weight. Storage root length, diameter and weight were measured at 100 days after planting. Data was analysed using GenStat version 14 and mean separation was done using the least significance difference (LSD) at 5% significance level. Storage root length indicated significant difference ($p<0.001$) only among cutting positions with highest mean length (16.2 cm/root) obtained from apical cutting and the lowest (11.98 cm/root) from basal cutting. Cutting position and pruning level interacted significantly ($p<0.05$) to affect differences in storage root diameter, storage root weight and vine weight. Highest mean root diameter and root weight were obtained from middle cutting and 25% vine pruning level, with the lowest being 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. Both middle and apical stem cuttings can be recommended for higher storage root and vine yield. Vine pruning at 25% can be recommended for higher storage root yield while pruning at 50% can be suggested for higher vine yield. Therefore, the study came up with the solution for shortage of planting material since both apical and middle cuttings gave higher and not significantly different root diameter, root weight and vine weight that both can be planted rather than planting apical cuttings only.

## DEDICATION

To my parents, Mr and Mrs Munetsi who inspired me to insist on working hard even during the time of cumbersome challenges.

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## CHAPTER ONE

## 1.0 INTRODUCTION

### 1.1 Background of the study and justification

Sweet potato (*Ipomoea batatas L.*) is a herbaceous perennial root crop belonging to *Convolvulaceae* family and it is characterised by creeping vines and adventitious roots (Belehu, 2003; Belehu and Hammes, 2004; Chagonda *et al.*, 2014). The crop came into Africa through trade from South America where it originated (Nedunchezhiyan *et al.*, 2012). Africa's average yield is 6 t/ha while the world production reaches the average yield of 14 t/ha (Mutandwa, 2008). Among root and tuber crops grown in many parts of tropical Sub-Sahara Africa, sweet potato ranks third after Irish potato and cassava in consumption (Belehu, 2003; Teshome-Abdissa and Nigussie-Dechassa, 2012).

Sweet potato performs well even in drier parts of Zimbabwe (Mutasa *et al.*, 2013). Intensive production is mainly referred to agro-ecological regions I, II and III in which Manicaland, Mashonaland, Midlands and some parts of Masvingo are located (Mutandwa, 2008; Chagonda *et al.*, 2014). 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 (Mutandwa and Gadzirai, 2007). Adaptability of sweet potato to marginal environments allows resource-poor farmers to achieve higher yields of up to 15 t/ha with minimum use of fertilizers and herbicides (Mukunyadzi, 2009; Chagonda *et al.*, 2014). However, yield of up to 50 t/ha can be attained with sufficient moisture, proper fertilization and improved varieties (Agronomy Research Institute (ARI), 2002; Chagonda *et al.*, 2014).

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, 2008). Sweet taste and prolonged shelf-life make German 2 popular at Bulawayo and Gweru vegetable markets.

Annual consumption per capita of sweet potato storage roots is gradually increasing, being estimated at 1-7kg in urban and 3-5kg in rural communities of Zimbabwe (Mutandwa, 2008; Mutasa *et al.*, 2013; Chagonda *et al.*, 2014). However, sweet potato is not only grown for human consumption but the forage is an essential resource for feeding animals (Mulungu *et al.*, 2006; Etela and Kalio, 2011; Nedunchezhiyan *et al.*, 2012).

In Zimbabwe, sweet potato is mainly propagated by stem cuttings using atavistic experience through indigenous knowledge systems. Some farmers plant apical stem cuttings only while others plant apical, middle and basal cuttings. Belehu (2003) stipulated that cuttings from apical portion are preferred to those from the middle and basal portions of the stem. However, Low *et al.* (2009) reported that there is shortage of planting material in Sub-Sahara Africa because nurseries owned by smallholder farmers are small and most of them are located at small backyard spaces or near washing areas where they are irrigated by hard water. Therefore, middle and basal stem cuttings can be used when there is bottleneck in supply of planting material (Belehu, 2003).

Vine management is also done through indigenous knowledge systems. Some farmers prune vines at different levels depending on the purpose of pruning while others do not practise pruning. Use of sweet potato shoots as vegetable, planting material or forage promotes shoot removal and this is expected to decrease the supply of photosynthates to the growing storage roots (Mulungu *et al.*, 2006). However, use of pruned sweet potato vines for feeding animals in developing countries may be beneficial due to gradual increase in prices of commercial feeds (Kebede *et al.*, 2010).

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 and improper vine pruning regimes for feeding animals. Mulungu *et al.* (2006) stipulated that both the storage roots and vines are essential resources for human and animal consumption. However, the information about dual-purpose (contemporary food and fodder producing) attributes of different sweet potato cultivars and vine harvesting regimes to optimize yield of fodder without disturbing root yield is limited (Niyireba *et al.*, 2013). Consequently, planting of stem cuttings from different positions along the stem and pruning of vines at different levels might have resulted in yield variations among farmers. Therefore, this research sought to determine the best cutting position and vine pruning level for farmers to meet high and reliable yield of both the storage roots and vines.

## 1.2 Objectives

**1.2.1 Main Objective:** To evaluate the effect of cutting position and vine pruning level on sweet potato growth and yield.

### 1.2.2 Specific Objectives

To assess the effect of cutting position and vine pruning level on sweet potato growth parameters (storage root length, storage root diameter)

To assess the effect of cutting position and vine pruning level on sweet potato yield parameters (storage root weight, vine weight)

## 1.3 Hypotheses

Different cutting positions and vine pruning levels have an effect on sweet potato growth parameters (storage root length, storage root diameter)

Different cutting positions and vine pruning levels have an effect on sweet potato yield parameters (storage root weight, vine weight)

**CHAPETR TWO**

## 2.0 LITERATURE REVIEW

### 2.1 Climatic and soil conditions required by sweet potato and regions of production in Zimbabwe

Sweet potatoes perform best in areas with an altitude of 0 to 3000 m above sea level and they are grown between $48^0$ North and $40^0$ South of equator (Low *et al.*, 2009; Troung *et al.*, 2011; Ngailo *et al.*, 2013). Warm tropical and equatorial regions with hot summers are favourable for sweet potato production (Mutandwa and Gadzirai, 2007). The crop thrives best under warm climate with a temperature range of 21-26°c and the yield is gradually reduced under shade (Nedunchezhiyan *et al.*, 2012). However, sensitivity to temperature differs among a yawning range of sweet potato cultivars (Belehu and Hammes, 2004). Although sweet potato grows best under full sunlight, 30 to 50% reduction in full solar radiation can be tolerated (Troung *et al.*, 2011; Ngailo *et al.*, 2013).

Annual average rainfall for the crop's best performance is 750-1000 mm with 500 mm falling within the growing season (Belehu, 2003; Dugassa and Feyissa, 2011). Although sweet potato is drought tolerant, it requires well distributed rainfall because prolonged intra-season dry spells result in substantially reduced yield (Low *et al.*, 2009; Ngailo *et al.*, 2013). Well drained soil with pH of 5.5-6.5 is the best for sweet potato production (Nedunchezhiyan *et al.*, 2012; Ngailo *et al.*, 2013). Good drainage and ease of tuber growth make loamy soils ideal for sweet potato production (Mutandwa, 2008). However, sweet potato is tolerant to a wide range of soils giving satisfactory yields even in poor acidic soils but it cannot withstand water logged conditions (Parwada *et al.*, 2011).

Although sweet potato is grown by smallholder farmers in many parts of Zimbabwe, production is mainly centred in agro-ecological regions I, II and III which overally receive annual average rainfall ranging from less than 500 mm to above 1050 mm (Mutandwa, 2008; Chagonda *et al.,* 2014). Sweet potato production is increasing in terms of hectrage with much of production being conducted in Zimbabwe's agro-ecological zones I, II and III which have fertile soils and higher rainfall, with farmers attaining high yields of up to 15 t/ha (Parwada *et al.*, 2011; Chagonda *et al.,* 2014). Frequencies of prolonged intra-season dry spells are increasing in Zimbabwe; hence sweet potato can tolerate the country's situation because it is a low input demanding crop which performs well in drier areas (Mutandwa, 2008; Mutasa *et al.*, 2013).

## 2.2 Uses of sweet potato in Zimbabwe

Sweet potato is an essential crop for food security because it thrives under marginal climatic and soil conditions such as drought and less fertile sandy soils, making it a relevant substitute for bread (Chagonda *et al.*, 2014). The starch rich storage roots are consumed as fried chips, nutritious drinks, and flour after value addition (University of Zimbabwe Development Technology Centre (UZ-DTC), 2013). However, value addition to sweet potato in Zimbabwe is so limited that most of storage roots are eaten after boiling or roasting (Mutandwa, 2008). Leaves and shoot tips can be consumed as vegetable and to a greater extend vines are an excellent source of fodder for livestock (Nedunchezhiyan *et al.*, 2012).

## 2.3 Economic importance of sweet potato in Zimbabwe

Increase in prices and bottlenecks in supply of fertilizers and other inputs cause smallholder production patterns to shift from conventional crops such as tobacco, cotton and maize to less input demanding sweet potato (Mutanwa and Gadzirai, 2007). In both the rural and urban communities of Zimbabwe, sweet potato is becoming a paramount component of diet due to increase in prices of Irish potato and bread (Mutandwa and Gadzirai, 2007; Chagonda *et al.*, 2014). As compared to rice, wheat and cassava, the storage root of sweet potato has higher calories since 70% of its dry weight is constituted by starch (Rukundo *et al.*, 2013).

High concentration of beta-carotene (a precursor for vitamin A) in orange fleshed varieties gives sweet potato a great potential to curb vitamin A deficiency in children, thereby reducing cost of additional nutritive foods (Burri, 2011; Williams *et al.*, 2013; Mvuria and Ombori, 2014). Medicinally, sweet potato leaves are an essential mineral rich vegetable containing chlorogenic acid which is a remedy for obesity suppression in humans (Kathabwalika *et al.*, 2013; Williams *et al.*, 2013). Sweet potato vines are rich in minerals and proteins needed in the livestock feeding diets and they are mainly used to feed cattle, goats, pigs and rabbits as a way of reducing feed costs (Moyo *et al.*, 2004; Kebede *et al.*, 2008; Kathabwalika *et al.*, 2013). However, Moyo *et al.* (2004), Kebede *et al.* (2008) and Kathabwalika *et al.* (2013) explored the benefits of feeding animals with sweet potato vines without elucidating the concomitant effect of vine pruning level on total yield of storage roots and vines.

After providing food and feed for home consumption, sweet potato is also a source of income for farmers (Mulungu *et al.*, 2006). Annual sweet potato consumption for urban and rural communities of Zimbabwe is estimated at 1-7kg and 3-5kg per capita respectively (Mutandwa, 2008).

## 2.4 Challenges faced by sweet potato producers in Zimbabwe

Sweet potato production is hindered by several socio-economic, biotic and abiotic constraints (Thottappilly and Loebenstein, 2009; Ngailo *et al.,* 2013). Socio-economic factors such as unstable prices, lack of processed products, long distances to the markets, shortage of planting material and poor preservation methods are some of drawbacks to sweet potato production (Mutandwa, 2008; Andrade *et al.,* 2009; Kassali, 2011). When there is short supply of planting material, middle and basal stem cuttings can be used (Belehu, 2003).

Major biotic constraints are viral diseases, nematodes, rats and insect pests such as millipedes and sweet potato weevils (Fugile, 2007; Ngailo *et al.,* 2013). Sweet potato weevil is a world's serious pest with three species identified in Africa which are *Cylas formicarius, Cylas puncticollis and Cylas brunneus* (Belehu, 2003).

## 2.5 Varieties of sweet potato grown in Zimbabwe

Most of the varieties grown are landraces which are selected for taste and climatic adaptation. Among common sweet potato varieties grown in Zimbabwe, Bambas, Brondal, Imby, Chigogo, Cordner and German 2 are red skinned while the white skinned varieties include ChiZambia and Pamhai (Mutandwa, 2008). However, Mutandwa (2008) did not give an account of dual-purpose (contemporary storage root and vine producing) attributes of these cultivars.

## 2.6 Land preparation for sweet potato production

Root growth is promoted by deep cultivation, and the vine cuttings are planted on ridges, mounds, flat beds and raised beds in Sub-Sahara Africa (Low *et al.,* 2009). Although sweet potato can be planted on ridges or flat beds, root quality improvement on heavy textured soils and easy of harvesting are some of benefits obtained from planting the crop on ridges (Coolong *et al.,* 2012).

## 2.7 Sweet potato propagation

Stem cuttings and sprouts from storage roots are the planting material commonly used in sweet potato production. Sweet potato develops long stems with a range of 1-6m, from which cuttings are obtained (Belehu, 2003). Smallholder farmers rarely obtain planting material from extension personnel but they mainly cut vines from their own sweet potato fields or buy cuttings from their neighbours (Low *et al.,* 2009).

Apical cutting is preferred since basal portions of the vines are usually thick and woody with poor establishment, and they have closer vicinity to the crown portion where sweet potato weevil multiplies (Belehu, 2003; Nedunchezhiyan *et al.,* 2012). However, both Belehu (2003) and Nedunchezhiyan *et al.* (2012) were putting much emphases on the woodiness of basal portions of the vine without considering the vine growth rate of cultivars which they used as sources of stem cuttings.

Young nodes near the vine apex develop typically healthy performing root premordia and this might be the reason for apical cuttings to be more productive as compared to basal cuttings (Belehu, 2003). As mentioned earlier, Belehu (2003) did not give a detailed report about the exact yield effect of using middle and basal stem cuttings as planting material.

Although apical stem cuttings are expected to be disease and weevil free, middle and basal cuttings are planted mainly at the beginning of the rain season due to shortage of planting material (Low *et al.*, 2009). Vine nurseries owned by smallholder farmers in Sub-Sahara Africa provide insufficient planting material since most of them are located at small backyard spaces or near washing areas where they are irrigated by hard water (Low *et al.*, 2009). Unfortunately, Low *et al.* (2009) did not describe the vine harvesting regimes conducted in nurseries and their respective effect on the future performance of these nurseries.

Middle and basal stem cuttings can be planted when there is shortage in supply of planting material causing a slight decrease in expected yield (Belehu, 2003). However, some researchers found both the apical and middle stem cuttings giving higher storage root yield (Nedunchezhiyan *et al.*, 2012).

**2.8 Planting sweet potato stem cuttings**

Planting vine cuttings by burying the middle with both ends left exposed is recommended (Nedunchezhiyan *et al.*, 2012). The best way of planting sweet potato vine cutting is to insert it in the soil with half or two thirds of its length lying under the soil surface (Belehu, 2003). Therefore, horizontal, vertical and loop planting orientations can be used in sweet potato production (Parwada *et al.*, 2011; Chagonda *et al.*, 2014). When growing sweet potato for storage roots, the recommended spacing is 30cm between plants and 70-100cm between rows (Low *et al.*, 2009). Although closer spacing is recommended, farmers use a yawning plant population range of 25 000 to 125 000 plants per hectare (Nedunchezhiyan *et al.*, 2012).

## 2.9 Vine growth and yield

Storage roots of sweet potato develop from long thin stems that trail along the soil surface. Stem length, number of branches per plant and number of leaves per plant vary with cultivars, being estimated at ranges of 1-6m, 3-20 and 60-300 respectively (Belehu, 2003). Farmers and researchers attained fresh vine yields of 11 to 40t/ha with non-pruned sweet potato having lower vine yield because of leaf shedding resulting from leaf senescence (Belehu, 2003; Niyireba *et al*, 2013). Vine yield can be increased through vine pruning which promotes growth of new and more vines through suppression of apical dominance (International Potato Centre, 2009).

## 2.10 Vine pruning

Increase in prices of imported livestock feeds results in increased demand for additional feed sources which in turn intensifies demand for using sweet potato as animal feed in developing countries (Kebede *et al.*, 2010). Sweet potato vines and storage roots can be used to feed small ruminants, pigs, cattle and chickens, and the vines are possible supplementary feed for goats and calves during the dry season (Kebede *et al.*, 2010; Khalid et al., 2013). During the periods of scarce grazing, sweet potato vines can be used as forage to secure livestock production (Aniekwe, 2014). Khalid *et al*. (2013) empirically fed lactating Nubian goats with sorghum vulgar, clitoria and fresh sweet potato vines and concluded that sweet potato vines have greater potential to increase milk protein, milk fat and total solids. Unfortunately, Khalid *et al*. (2013) did not give details about the economic way of gathering such fresh sweet potato vines from the field.

Many farmers have limited land to produce fodder in mixed crop-livestock systems; hence vine pruning can secure livestock production with development of dual-purpose sweet potato cultivars (Niyireba *et al.*, 2013). Relatively high vine yield and quick re-growth after pruning make sweet potato superior than other fodder crops such as *Sesbania grandiflora* (Lam and Ledin, 2004). However, information about dual-purpose (contemporary food and fodder producing) attributes of sweet potato varieties and vine harvesting regimes to optimize yield of fodder without disturbing root yield is limited (Niyireba *et al.*, 2013).

Sweet potato can be pruned but the practice should not negatively alter the crop's performance in terms of both the storage roots and the tops (Mulungu *et al.*, 2006). Vine pruning results in eventual root yield reduction due to reduced supply of photosynthates (Olorunnisomo, 2007). On contrary, Saraswati (2007) stipulated that young leaves which develop after re-growth are photosynthetically more efficient than older leaves.

In addition, vine pruning promotes income generation from sales of leaves as vegetable and vines as livestock feed but the concomitant decrease in photosynthesis may be detrimental to the growing storage roots. Storage root development and yield are largely influenced by the aboveground parts, and the accumulation of photosynthates from the tops is the initial sign of root bulking (Mulungu *et al.*, 2006).

However, greater foliage production is not always associated with higher root yield (Nedunchezhiyan *et al.*, 2012). Low root yield may also be associated with a vigorous plant which develops a dense tangle of vines (Mulungu *et al.*, 2006). When rainfall and temperature are favourable, sweet potato may grow vigorously and produces large quantities of vines in the expense of the storage roots (Nedunchezhiyan *et al.*, 2012). As a result, part of the vine can be pruned and utilized as planting material, leaf vegetable or animal feed (Satapathy *et al.*, 2006; Nedunchezhiyan *et al.*, 2012). Shortage of planting material causes farmers to cut the vines from the existing fields prior to root maturity in order to plant new plots (Low *et al.,* 2009). However, Low *et al.* (2009) did not outline the levels at which the vines are cut and their respective impact on final storage root and vine yields.

Belehu, (2003) stipulated that assimilate production by the leaves and capacity of sink (storage root) to absorb assimilates both have influence on yield of storage roots. He concluded that the leaves (source) have greater influence in the early growth period than the sink, and their influence is equal after initiation of root bulking.

**2.11 Storage root development**

Nodes on buried section of stem cutting develop adventitious roots from which the lateral roots arise to form the sweet potato root system. Depending on the level of liginification, adventitious roots develop into fibrous roots (less than 5mm in diameter), pencil roots (5-15mm in diameter) or storage roots (Belehu, 2003). The induction phase in storage root formation is indicated by appearance of anomalous cambia (Solis-Sarmiento, 2012). The initial step in storage root bulking is the thickening of an adventitious root followed by circular primary vascular cambium, and the cambia cells divide several times to form a starch storage tissue. Increase in size and weight of storage root is induced by accumulation of sucrose translocated from photosynthesizing leaves, and the sucrose splits into hexoses which are transformed into glucose-1 phosphate for starch synthesis (Rukundo *et al.,* 2013).

Storage root formation in sweet potato is influenced by genetic and environmental factors involving tuberizing hormones such as cytokinin and jasmonic acid, non-tuberizing hormones like auxin as well as enzymes for carbohydrate metabolism (Solis-Sarmiento, 2012). During early stages of storage root formation, levels of auxin and cytokinin are high for primary growth but abscicic acid and cytokinin are responsible for secondary growth (Noh *et al.*, 2012).

Cytokinins especially zeatin riboside (ZR) and trans-zeatin riboside (t-ZR) are produced in the root apex and play major role in the storage root bulking process through development and activation of primary cambium (Ravi *et al*, 2009). Auxins mainly indole-3-acetic acid stimulate root bulking through secondary growth in the vascular cambium and maintenance of cambial zone cells in meristematic state (Ravi *et al.*, 2009; Stoller *et al.*, 2012). Therefore, auxin to cytokinin ratio need to be maintained at a particular level to promote cell division which is followed by starch deposition to increase storage root size and weight (Stoller *et al.*, 2012). Bulking of storage root initiates with deposition of starch at the distal end of developing storage root and then continues upward to the proximal end to determine storage root length (Lewthwaite and Triggs, 2009).

However, storage root formation is a complex process which involves several steps like initiation of primary and secondary vascular cambia, stopping of root elongation, increase in radial growth, multiplication and expansion of cells as well as accumulation of massive starch and proteins ( Rukundo *et al.*, 2013). Remarkably, the first sign of storage root bulking is the accumulation of photosynthates from the tops (Mulungu *et al.*, 2006).

## CHAPTER THREE

## 3.0 MATERIALS AND METHODS

### 3.1 Study site description as a field trial

The experiment was conducted at Midlands State University which is located in Gweru, Zimbabwe. The site is located in Midlands Province under Zimbabwe's Agro-ecological region III, with average annual rainfall of 674 mm. The area lies 19°45'S and 29°48'E with an average temperature of 18°C. The altitude for the site is 1428 metres above sea level. Following the classification of soil by Nyamapfene (1991), the study site is characterized by sandy loam soil which falls under fersialitic group with dominant kaolinite clay minerals. The soil test before conduction of the experiment indicated a pH of 5.8.

### 3.2 Experimental design

A 3x3 factorial arrangement in a randomized complete block design (RCBD) with three replications was used. There were two factors (cutting position and vine pruning). Cutting position had three levels (apical, middle and basal). Vine pruning was expressed in percentage and it had three levels (0, 25 and 50%). The trial was blocked by shade.

### 3.3 Experimental procedure

#### 3.3.1 Land and bed preparation

The experimental plot was tilled to a depth of 40 cm using a disc plough. Twenty-seven ridges were aptly constructed using a spade. Length, width and height of each ridge were measured 120, 50 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 450kg/ha and covered with soil to a depth of 10 cm.

### 3.3.2 Cultivar selection

The variety, German 2 was selected for the trial. It was chosen due to its popularity for bearing higher storage root and vine yields, as well as its capacity to develop fast growing vines as compared to other varieties. The variety is characterised 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. Its sweet taste and long shelf-life make it popular at Gweru and Bulawayo vegetable markets (Mutandwa, 2008).

### 3.3.3 Planting material preparation and planting

Stems were cut into 30 cm pieces consisting of three different (apical, middle and basal) positions. Cuttings from each of the position were planted on nine ridges, making the total trial of 27 ridges. Cuttings were planted at a spacing of 30 cm along the ridge using looped planting orientation. Therefore, 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.

### 3.3.4 Vine pruning

Vine pruning was done at 50 days after planting. Each of the stem portions (apical cutting, middle cutting and basal cutting) received three treatments (vine harvesting levels of 0, 25 and 50%). To allow re-growth, vines were cut at 15 cm above ridge level. Vine pruning percentages were achieved through counting the number of stems per plant and number of leaves per stem. Hence, the number of stems to be cut was determined by the number of leaves per stem.

### 3.4 Non experimental management of the trial

The experiment was conducted under rain-fed system. Adventitious root initiation was facilitated by an overhead application of water using a watering can in the first two weeks after planting. The plots were kept weed free from planting till harvest to minimise weed to crop competition. Weeds were controlled manually by hoe weeding and hand pulling every week. Pests such as locusts were controlled through application of Carbaryl 85 WP using knapsack sprayer.

### 3.5 Data collection

Vine weight was measured at pruning (50 DAP) and at harvest (100 DAP), and added to make the total weight. Storage root weight, length and diameter were measured at harvest. Vine and root weights were measured using a digital scale and expressed in t/ha. Storage root length was measured in cm/root using a tape measure and a vernier calliper was used to measure storage root diameter and expressed in cm/plant.

### 3.6 Data analysis

The data was analysed 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 Effect of cutting position and vine pruning level on the mean length of storage roots

There was no significant interaction (p>0.05) between cutting positions and vine pruning levels on the storage root length. The differences among mean root length effects of all pruning levels (0, 25 and 50%) were not significant (p>0.05). However, significant differences in storage root length (p<0.001) were observed among cutting positions. The shortest roots were obtained from basal cuttings and they had a mean length of (11.98 cm/root) which is significantly different from (15.87 cm/root) recorded on the middle cuttings. The longest storage roots (16.20 cm/root) were obtained from apical cuttings but they were not significantly longer than (15.87 cm/root) recorded from middle cuttings (Table 1).

**Table 1. Effect of cutting position on the mean storage root length**

| **Treatment** | **Mean storage root length (cm/root)** |
|---|---|
| Basal cutting | 11.98[a] |
| Middle cutting | 15.87[b] |
| Apical cutting | 16.20[b] |
| CV % | 3.2 |
| LSD | 0.4647 |
| P-value | <0.001 |

### 4.2 Effect of cutting position and vine pruning level on mean storage root diameter

There was significant interaction (p<0.001) between cutting positions and vine pruning levels on the storage root diameter. The thickest storage roots were obtained from middle cutting at 25% pruning level and they had a mean diameter of 36.1 cm/plant, while basal cutting pruned at 50% had the thinnest roots of 21.5 cm/plant in mean diameter. At all pruning levels, the root diameter difference between apical and middle cuttings was not significant. 50% pruning level performed worst in all cutting positions (Fig.1).

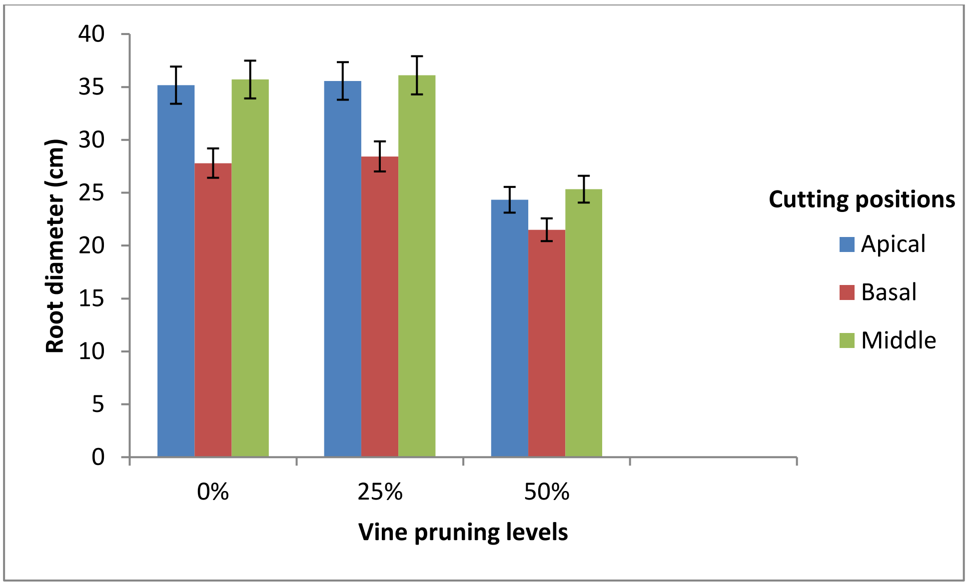


**Fig.1: Effect of cutting position and vine pruning level on storage root diameter (cm/plant)**

### 4.3 Effect of cutting position and pruning level on the storage root weight

There was significant interaction (p<0.001) between cutting positions and vine pruning levels on the storage root weight. The highest storage root yield (32.263 t/ha) was obtained from middle cutting at 25% vine pruning. However, the lowest root yield (21.621 t/ha) was recorded from basal cutting with 50% of vines pruned. At all pruning levels, the root diameter difference between apical and middle cutting was not significant. Basal cuttings indicated lowest root weight at all pruning levels (Fig.2).

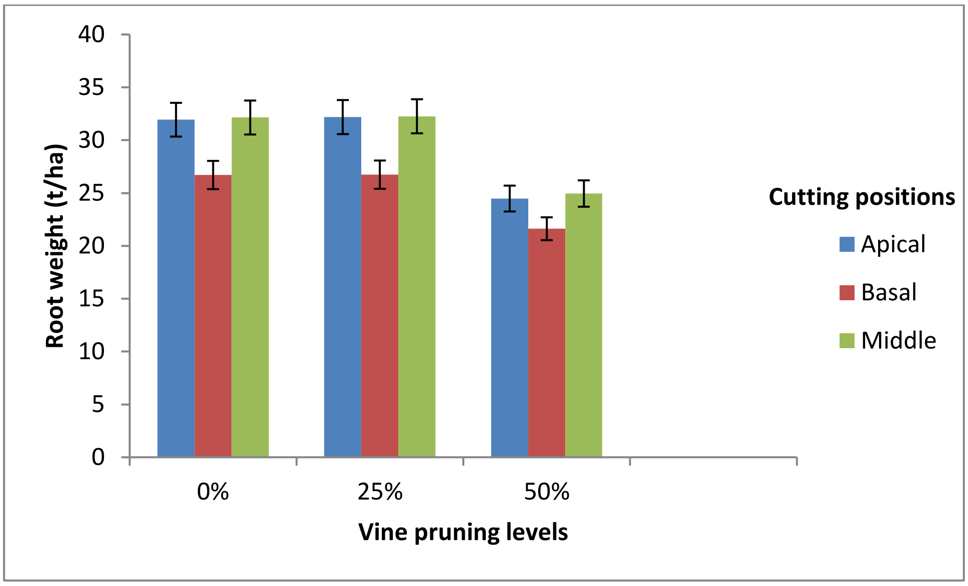


**Fig.2: Effect of cutting position and vine pruning level on storage root weight (t/ha)**

### 4.4 Effect of cutting position and vine pruning level on total vine weight

There was significant interaction (p=0.002) between cutting positions and vine pruning levels on total vine weight. The highest vine yield (23.551 t/ha) was obtained from middle cutting at 50% vine pruning level, while the lowest yield (14.885 t/ha) was recorded from basal cutting at 0% vine pruning. At 0% pruning all cutting positions produced statistically same vine weight. As pruning increased there was a general increase in vine weight in all cutting positions (Fig.3).

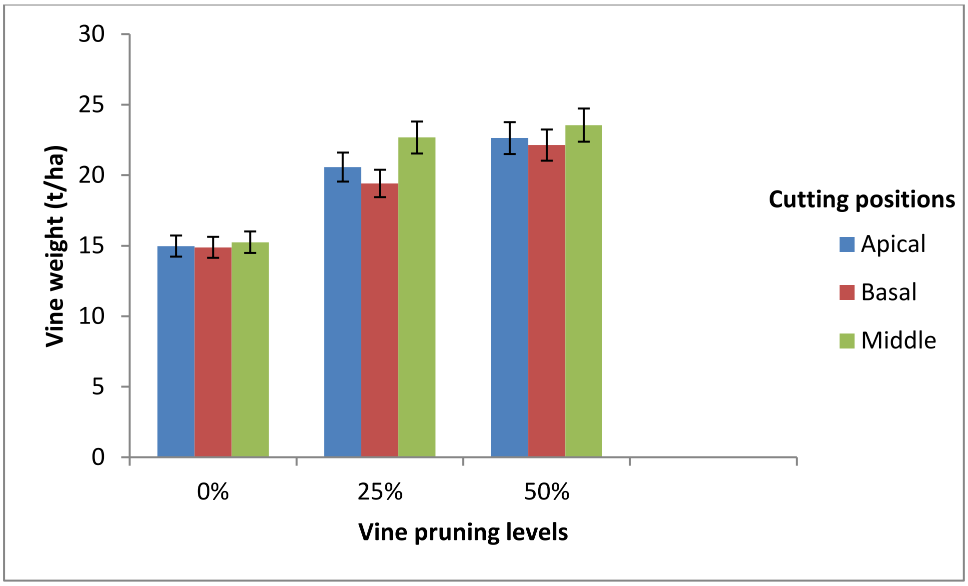


**Fig.3 Effect of cutting position and vine pruning level on total vine weight (t/ha)**

# CHAPTER FIVE

## 5.0 DISCUSSION

### 5.1 Effects of cutting position and vine pruning level on mean storage root length

There was significant difference ($p<0.001$) on average root length among cutting positions. The longest roots were obtained from apical cuttings and this could be a result of fast root establishment on apical cuttings. Unlike basal cuttings, apical cuttings have new and active cells which support the development of lateral roots through the supply of auxin from growing apical point. 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 cutting also quickly grow and support growth of new shoots that in turn photosynthesize to supply roots with photosynthates (Mulungu *et al.*, 2006). This is in agreement with Belehu (2003) who stipulated that young nodes near the vine apex result in fast growing lateral roots that bulk to form storage roots. Belehu's argument was supported by Nedunchezhiyan *et al.* (2012) who reported that basal portion of the vine usually provide thick and woody cuttings which are characterised by poor root establishment and growth.

Therefore, 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. This is because storage root bulking initiates with the accumulation of starch at the distal end of lateral root, proceeding upwards to the proximal end. 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. This is in agreement with Lewthwaite and Triggs (2009) who inferred that bulking of sweet potato storage root begins with deposition of carbohydrates near the root apex and the deposition continues upward to the lower end of root stalk called storage root shoulder.

### 5.2 Effect of cutting position and vine pruning level on mean storage root diameter.

There was significant interaction between cutting positions and vine pruning levels on storage root diameter. Thickest roots were obtained from middle cuttings and this could be probably a result of development of more stems as compared to apical and basal cuttings, hence more leaves for photosynthesis and more apical shoots for auxin production. 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 cutting, middle cutting has no growing tip resulting in complete suppression of apical dominance during cutting preparation and this enhances development of many shoots. These results tallies with Rasco and Amante (2000) who concluded that middle cuttings can perform slightly better than the apical cutting especially in cultivars with fast growing vines resulting from apical dominance.

Basal cutting had the thinnest roots and this could be caused by limited photosynthesis since it probably 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. Basal cutting could also probably developed fewer and shorter roots as compared to apical and middle cuttings and this might contributed to the reduction in storage root diameter due to limited water and nutrient uptake. This concurs with Belehu (2003) who stipulated that basal cutting has a poor root establishment.

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 a result of development of new and more stems due to partial suppression of apical dominance. International Potato Centre (2009) reported that vine pruning is normally done at 40-60 days after planning and it is a multiplicative tool for generating more and new shoots to enhance photosynthesis. This was supported by Saraswati (2007) who inferred that photosynthetic ability of sweet potato leaves is affected by age, with higher rate of photosynthesis being found in young leaves.

However, vine pruning at 50% resulted in thinnest roots and this 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. 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. This tally with Stoller *et al.* (2012) who reported that growth of roots occurs at a certain ratio of auxin to cytokinin.

### 5.3 Effect of cutting position and vine pruning level on the mean storage root weight

There was significant interaction between cutting positions and vine pruning levels on the root weight. The highest root yield was obtained from the middle cuttings and this could be due to development of more stems on the middle cutting as compared to apical cutting which is affected by apical dominance. Apical dominance is excluded from middle cutting during cutting preparation by removal of apical tip; hence more stem shoots develop and this enhance photosynthesis and auxin production. Although the apical tip was removed during the preparation of basal cutting, it had the lowest root yield and this could be probably due to failure to develop many stems as a result of senescence and lignification. These results concur with Belehu (2003) who 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% has resulted in the highest storage root yield. This could be due to partial suppression of apical dominance for the development of many new shoots which are favourable for photosynthesis and auxin synthesis. Pruning vines at 50% has resulted in the lowest root yield and this might be an impact of 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 photosynhates between roots and the aboveground parts after re-growth. These results are in agreement with Ravi *et al.* (2009) who inferred that 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.

### 5.4 Effect of cutting position and vine pruning level on total vine weight

There was significant interaction between cutting positions and vine pruning levels on total vine weight. The highest vine yield was recorded from middle cuttings and this might be 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. This is in agreement with Rasco and Amante (2000) who 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 and this could be due to highly lignified cells of the cutting that probably resulted in poor root system for water and nutrient uptake to support vine growth.

Among all cutting positions, vine pruning at 50% resulted in highest vine yield. This could be due to tremendous suppression of apical dominance to promote the development of more secondary stems as compared to 25% and 0% pruning levels. Un-pruned (0% pruning) plots had lowest vine yield and this could be due to apical dominance. Shedding of lower leaves on un-pruned plots due to senescence might also contributed to the results. These results concur with the report made by International Potato Centre (2009) which stipulated that vine pruning is a multiplicative tool for generating more vines.

# CHAPTER SIX

## 6.0 CONLUSION AND RECOMMENDATIONS

### 6.1 CONCLSION

The following conclusions were drawn from the study. Apical stem cutting had the longest storage roots as compared to middle and basal cuttings. Middle stem cutting 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%.

### 6.2 RECOMMENDATIONS

#### 6.2.1 Recommendations to farmers

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 dual-purpose (contemporary storage root and vine producing) attributes of sweet potato cultivars which develop long vines such as German 2.

#### 6.2.2 Recommendations to researchers

Further research should be done using 25% vine pruning regime in many cultivars as a way of selecting dual-purpose cultivars. Effect of different vine harvesting regimes in sweet potato nurseries on the future performance of nurseries needs to be evaluated through empirical study.

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## APPENDICES

### Appendix 1. Analysis of variance for storage root length

| Source of variation | d.f. | s.s. | m.s. | v.r. | F pr. |
|---|---|---|---|---|---|
| Blocks | 2 | 41.2652 | 20.6326 | 88.39 | |
| Pruning level | 2 | 1.2274 | 0.6137 | 2.63 | 0.103 |
| Cutting position | 2 | 99.1852 | 49.5926 | 212.46 | <.001 |
| Pruning level × Cutting position | 4 | 0.0081 | 0.0020 | 0.01 | 1.000 |
| Residual | 16 | 3.7348 | 0.2334 | | |
| Total | 26 | 145.4207 | | | |

### Appendix 2. Analysis of variance for storage root diameter

| Source of variation | d.f. | s.s. | m.s. | v.r. | F pr. |
|---|---|---|---|---|---|
| Blocks | 2 | 178.1163 | 89.0581 | 342.78 | |
| Pruning level | 2 | 531.8141 | 265.9070 | 1023.45 | <.001 |
| Cutting position | 2 | 227.0252 | 113.5126 | 436.90 | <.001 |
| Pruning level × Cutting position | 4 | 23.6059 | 5.9015 | 22.71 | <.001 |
| Residual | 16 | 4.1570 | 0.2598 | | |
| Total | 26 | 964.7185 | | | |

### Appendix 3. Analysis of variance for storage root weight

| Source of variation | d.f. | s.s. | m.s. | v.r. | F pr. |
|---|---|---|---|---|---|
| Blocks | 2 | 63.3626 | 31.6813 | 212.13 | |
| Pruning level | 2 | 265.1896 | 132.5948 | 887.83 | <.001 |
| Cutting position | 2 | 129.3069 | 64.6535 | 432.91 | <.001 |
| Pruning level × Cutting position | 4 | 7.3140 | 1.8285 | 12.24 | <.001 |
| Residual | 16 | 2.3895 | 0.1493 | | |
| Total | 26 | 467.5627 | | | |

**Appendix 4. Analysis of variance for vine weight**

| Source of variation | d.f. | s.s. | m.s. | v.r. | F pr. |
|---|---|---|---|---|---|
| Blocks | 2 | 18.7995 | 9.3998 | 41.23 | |
| Pruning level | 2 | 292.8828 | 146.4414 | 642.32 | <.001 |
| Cutting position | 2 | 13.0975 | 6.5488 | 28.72 | <.001 |
| Pruning level × Cutting position | 4 | 6.5863 | 1.6466 | 7.22 | 0.002 |
| Residual | 16 | 3.6478 | 0.2280 | | |
| Total | 26 | 335.0139 | | | |