Influence of Number of Buried Nodes and Sources of Potassium Fertilizers on Sweet Potato Growth and Yield in Dodoma, Tanzania.

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Abstract
Inadequate knowledge on appropriate number of nodes of sweet potato vines to be planted and sources of potassium fertilizer to be used are among major factors resulted into low sweet potato productivity in central part areas of Tanzania. This research aimed at evaluating the effects of four levels of nodes buried and three potash fertilizer sources on growth and yield of three sweet potato varieties. Split-split plot field experiment in complete randomized block design was conducted at Hombolo, Dodoma during 2013/2014 cropping season. Main plot were three sweet potato varieties, Kiegeya, Mataya, and Ukerewe. Sub plot were, four level of buried nodes, (two above ground), five buried nodes (three above ground), seven buried nodes (three above ground) and eight buried nodes (four above ground). The sub - subplot treatments were potash fertilizer sources i.e control no fertilizer used, Potassium chloride (KCl), Potassium nitrogen phosphate (NPK) and Farm yard manure (FYM). Results indicated that there were no significant effects on the yield among varieties used. The number of tubers increased significantly in fertilized plots compared to control. The lowest number of tuber roots (3 tubers) was from control treatment while the highest number of tuber roots (6) was from KCl treatment. The effect of potassium fertilizer sources on root yield were also significant, use of KCl resulted to highest yield (18.84 t ha^{-1}), followed by NPK (17.51 t ha^{-1}), FYM (11.33 t ha^{-1}) and control treatment where no fertilizer applied (8.82 t ha^{-1}). Plating of different number of nodes resulted into significant increase in yield where the highest yield of (15.91 t ha^{-1}) was from eight buried nodes and lowest total yield (11.68 t ha^{-1}) was from four buried nodes. Seven and eight buried nodes with KCl and NPK fertilizers appeared to be appropriate for optimum sweet potato growth, yield and tuberous root quality in the study area and are therefore recommended.

Keywords: Fertilizer types; number of buried nodes; sweet potato yield

1.0 Introduction

Sweet potato (Ipomoea batatas [L.] Lam) is an important staple crop in many parts of the tropics. It is known for its drought resistance, being grown under various environments. The crop ranks the world's seventh most significant food crop after maize (Zea mays L.), wheat (Triticum aestivum L.) rice (Oryza sativa L.), round potato (Solunum tuberosum L.), barley (Hordeum vulgare L.) and cassava (Manihot esculentum L.) (FAO, 2009). The potential of sweet potato to guarantee food security is under-estimated as its use is often limited to a substitute food in African countries. Sweet potato is valued for its tuber roots which are boiled, fried, baked or roasted for humans or boiled and fed to livestock as a source of energy. The tubers can also be processed into flour for bread making and used as raw material for industrial starch and alcohol (Uwah et al., 2013). The leaves are used as vegetables and are rich in proteins, vitamins and various minerals. Sweet potato tubers are rich in vitamins A, B and C which are very important in growth. It also contains significant amount of essential minerals including manganese, copper, iron and potassium (Mtunda et al., 2007). It can therefore be a high value-added food particularly for children and pregnant women who are more often exposed to vitamin A deficiency in sub-Saharan Africa (Uwah et al., 2013). The production of sweet potato worldwide is about 107 million ton per annum where the highest producer is China (more than 80 million tons) and other Asian countries, including Indonesia, Japan and Korea. The crop is an important supplementary staple in the eastern and southern parts of Africa (Tumwegamire et al., 2004). In Tanzania, sweet potato reported to be the third most significant tuberous root crop after cassava and round potato and is mainly produced by women as a food security crop as well as a source of income.

The crop is important in the western, lake, central, eastern and southern highland zones of the country (Kapinga, 2007).

Declining soil fertility, potassium in particular and appropriate number of nodes on vines to be planted are among production challenges facing sweet potatoes farmers in Dodoma and resulted into low yield. The yield of sweet potatoes in Tanzania is 4.5 t ha^{-1} which is low compared to that of African and global yield of 6 t ha^{-1} and 14 t ha^{-1} respectively. (Mukhtar et al., 2010). The crop is similar to other roots and tuberous crops that have high demands for K since leaves, vines, stems and tubers habitually remove considerable amount of K from the soil (CFFA, 2011). Sweet potato yield is low in soils with K deficient. In Japan, it was anticipated that a tuberous yield of 13 t ha^{-1} removes about 70 kg N ha^{-1}, 20 kg P ha^{-1} and 110 kg K ha^{-1} from the soil depending on the variety, crop duration and agro-climatic region. Comparisons of this kind are rare for tropical countries including Tanzania (Degras, 2003). In the Hubei province of China, the most advantageous K rate varied from 150-300 kg K_2O ha^{-1} (Jian-wei et al., 2001), whereas in India, the mean optimum requisite was 120 kg K ha^{-1} and the highest was 160 kg K ha^{-1} with a yield response (16.7 t ha^{-1}) (Trehan et al., 2009). Sweet potato response to applied K is considerably influenced by the variety grown (Uwah et al., 2013). The varietal response to applied K is often related to its yield potential and the number of large sized tuber roots it can produce. Generally, rapid bulking varieties producing large sized tubers respond more to K than do the varieties with small tubers (Trehan and Grewal, 1990). The study conducted by Hatibu et al. (1995) and Kabanza (2003) in some parts of Dodoma reveals the declining of potassium from high > 0.8 $cmol_c$ kg^{-1} to medium < 0.8 $cmol_c$ kg^{-1} which is low for the sweet potato requirement. On the other hand, the farmers usually planting sweet potatoes using vine of 30 cm length with variable number of nodes depending on the internode's length of the variety (Belehu, 2003), but there is limited information on the specific number of nodes to be buried during planting.

Sweet potato planting methods and fertilization differ from zone to zone in Tanzania. These differences are mainly in land preparation, number of nodes buried, planting depth and types and amount fertilizers (Kanyeka et al., 2007). In western zone, farmers prepare land by plowing followed by ridging. This is contrary to other regions such as Dodoma where farmers practiced zero tillage "kubelega". Some farmers however, plough back where by crop residues are buried in the soil during ridging and then planting and some using cuttings that are shorter than 30 cm and planting on flat land which normally resulted into poor yield (Nyambok, 2011). In Tanzania, the information on the rate of potassium fertilizer sources to be used as well as the number of nodes per vine to be planted are limited. (Kuoko et al., 2007). Little attention has so far been given to crop yield improvement of sweet potato leading to low tuber roots yield in Tanzania. In order to obtain good yield, research must focus on improving mainly agronomic practices such as the appropriate source of potassium to be used in production and appropriate number of nodes to be planted for high yield and further to all food value chain of the crop (Kapinga, 2007). Therefore, this study was conducted to access the effect of number of nodes of vines planted and different K fertilizer sources on crop growth and yield.

2.0 Materials and Methods

2.1 Location of the study

The experiment was conducted at Hombolo Agricultural Research Centre in Dodoma region, Tanzania. this Centre is located at latitude 2º 54' S and longitude 35º.57' E at an altitude of 1062 masl (Hatibu et al. 1995). The area had unimodal rainfall pattern, with annual rainfall and temperature ranges from 500 and 610 mm and 20 to 32 ºC respectively (TMA, 2013). Rains usually start at the second week of December and proceeds to the end of January. The rainfall ceases in February and resume on second week of March and continues up to the end of April. The soil type that cover experimental area is sand clay loam which consisted of grasses, bushes and short trees vegetation. (Hatibu et al. 1995).

2.2 Experimental Materials

Three sweet potato varieties: Kiegeya, Mataya and Ukerewe were used in the experiment. These varieties were obtained from Kibaha Agricultural Research Centre in Coast Region of Tanzania. Inorganic fertilizers used were potassium chloride (60% K), NPK (10 % N, 18 % P, 24 % K) bought from agrochemical supplier Balton in Arusha Tanzania and Farm yard manure collected from farmers' bomas close to Hombolo Agricultural Research Centre.

2.3 Soil sampling and analysis

Pre-planting soil sampling at both research sites was done in mid-November, 2014 using the random soil sampling method. An aggregate of eight soil samples was gathered from each site and the composite soil sample from each location was prepared by quartering method. Analysis of physical and chemical soil characteristics was conducted at the Department of Soil and Geological Sciences laboratory of the Sokoine University of Agriculture. Soil analysis included particle size distribution for textural class by Hydrometer method, soil pH by pH meter in 1:2.5 soil-water, organic carbon by Walkley- Black Method, total nitrogen by micro-Kjedahl digestion method, available phosphorus by Bray and Kurtz 1, exchangeable cations (K^+) by NH4-acetate filtrates by Ammonium Acetate Saturation.

2.4 Characterization of farm yard manure

Nutrients content of FYM were analyzed for chemical characteristics including pH, N, P, K, Mg, Ca and Na before its application. The pH of farm yard manure was determined in manure to water suspension 1:2.5. Total nitrogen was determined using Micro Kjeldahl method. Phosphorous extract was determined using Bray and Krutz 1method and exchangeable bases were determined using Atomic Absorption Spectrometer, all methods for FYM determination were described by Peters (2003).

2.5 Experimental layout and treatments applications

A split-split plot experiment in randomized complete block design (RCBD)were used where three sweet potato varieties Kiegeya Mataya and Ukerewe were the main factor, the number of modes were the sub factor with four levels; (1) four nodes buried (two above ground), (2) five nodes buried (three above ground), (3) seven nodes buried (three above ground) and (4) eight nodes buried (four above ground). The sub-sub factor were potassium fertilizer sources; (1) Potassium chloride (KCl) (2) Nitrogen phosphate potassium (NPK) (3) Farm yard manure and (4) Control no fertilizer used. All sources of potassium fertilizer were applied at recommended rate of 120 kg K ha $^{-1}$ with the exceptional of the control plots. The main plot size of 453 m^2, sub plot size of 36 m^2 and sub–subplot size of 9 m^2 were used. Before ridge construction, 15.3 kg farm yard manure was spread and incorporated into soil in sub-subplots using hand hoe. A furrow of 30 cm diameter and 15cm depth was constructed 3 days after planting (DAP) to facilitate irrigation. Water was applied twice per week up to 115 DAP and the quantity of water supplied was calculated using the following formula as described by Anton (1982).

$$Wq\ (m^3) = FCS\ (m^2)\ X\ \frac{\text{Water distance covered (m)}}{\text{Time (min)}}\ X\ \text{Irrigation time (min)}$$

Where; WQ = Water quantity, FCS = furrow cross section

2.6 Data collection

Daily rainfall (mm), minimum and maximum temperature (ºC) and percentage relative humidity (RH %) were recorded from the Tanzania Meteorology Agency (TMA) at ARI–Hombolo station. Data on Crop vegetative growth and developmental stages from sprouting to vine formation were recorded at interval of 45 DAP as described by Maniyam et al. (2012). Data collected included vine length (cm), number of leaves, number of roots formed and vine fresh and dry weight (kg), tuber root diameter and length (cm). All data were collected on per plant basis. Leaf area index was determined by taking five plants from the middle ridges of each plot and LAI was determined using graph paper as described by Gregory et al. (2003). Leaf area index was then calculated using the following ratio relationship.

$$\text{Leaf area index} = \frac{\text{Total leaf area } (m^2)}{\text{Total ground area } (m^2)}$$

Number of branches and length of vine was determined by counting branches and measuring vines by metre ruler from five plants of the central ridge and recorded. The Number of roots per plant was also determined by uprooting and counting roots from five plants in the middle ridges and average taken. The following relationship was used to calculate roots average

$$\text{Average number of roots} = \frac{\text{Total number of roots/five plants}}{\text{Number of plant sampled}}$$

Number of tubers was determined by counting tuber roots from each plant among five randomly selected plants per plot and the average was taken.

2.7 Data analysis

Data collected were subjected to analysis of variance (ANOVA) using GENSTAT statistical model.
$Yijk = \mu + R_i + Vj + (Ea)_{ij} + (F)k + (VF)_{jk} + (Eb)_{ik} + (N)_l + (VN)_{jl} + (FN)_{kl} + (VFN)_{jkl} + (Ec)_{ijkl}$
Where; Y_{ijkl} = Response, μ = General mean,R_i = Replication effect (ith)$(V)_j$ = jth effect of varieties, (factor a), $(Ea)_{ij}$ = Main plot error (error a) $(F)_k$ = ith effect of number of nodes, (factor b), (VF)jk = Interaction of varieties and number of nodes (a*b), $(Eb)_{ik}$ = sub–plot error (error b)(N)i = number of fertilizers (factor c), $(VN)_{jl}$ = interaction of varieties and fertilizers (a*c), $(FN)_{kl}$ = Interaction of fertilizer and number of nodes (b*c), $(VFW)_{jkl}$ = Interaction of varieties, Fertilizer and number of nodes (a*b*c), $Ec)_{ijkl}$ = Experimental error (error c). The mean separation tests were done by using Tukeys Test at $P \leq 0.05$.

3.0 Results and Discussions

3.1 Soil characteristics

The results on soil physical and chemical analysis of samples collected from the experimental area at a depth of 0 – 25 cm are presented in Table 1. According to Landon (1991), the textural class of the soil was sand clay loam, with bulk density of 1.3 g/cm^3 and has medium porosity. Such soil is recommended for sweet potato production as it allows soil aeration which influence root growth, root penetrations, water and nutrients uptake. The availability of pore space resulted into good and quality tuber roots formation (Maniyam et al., 2012). The soil pH was found to be medium with a value of 6.01 at depth of 0 – 25 cm which fall between the optimum range of pH (6-7) for sweet potato production. (Benny 2013). Such soil (pH) fovours availability and uptake of macro nutrients required by the crop. Also, it allows root growth and elongation (Nyambok, 2011).

The percentage of total nitrogen (N) was 0.07%, which is equivalent to 2.275 kg ha^{-1} which is very low (Landon, 1991). Sweet potato requires 65-80 kg N ha^{-1} as recommended for optimized tuber yield (Uwah et al., 2013). Total N reported in this study may be associated with environmental factors such as low rainfall as a limit for organic material decomposition and poor agronomic practices that leads to soil mining due to crop removal without replacement of nutrients. Nitrification, di-nitrification, overgrazing, vegetation burning and limited addition of soil amendments such as the use of organic or inorganic fertilizers also usually result into low N.

The available P in the soils at the site was 3.09 mg kg^{-1} (equivalent to 6.18 kg P ha^{-1}). This value is rated as low P according to Landon (1991). Sweet potato P requirements in East Africa including Tanzania is 60 kg P ha^{-1} (Kuoko et al., 2007). The low P at the experimental area may have been caused by surface water runoff, soil attached P, erosion and leaching (Frank and Knuden, 1974). Therefore, the current results indicate that soils used would not satisfy the P requirement by the crop. Such condition calls for additional P to such soils for enhancing sweet potato crop growth and yield.

The exchangeable K in the soil was found to be 0.057 $cmol_c$ $^{(+)}$ kg $^{-1}$ this amount is equivalent to 44.46 kg K ha^{-1} which is rated as low Landon (1991). The recommended amount of K ha^{-1} for sweet potato tuber formation in tropical countries such as Nigeria, Malawi, Zimbabwe, Ethiopia and Egypt have been reported to be 100-132 kg K ha^{-1} (Uwah et al., 2013). In Tanzania there is a limited of document on K recommended rate for sweet potato (Kuoko et al., 2007). Thus, the soil K value of 44.46 kg K ha^{-1} soil at the experimental site is low in relation to sweet potato requirements. The low K at the investigational area may have been caused by soil mining through sweet potato vegetative removal with 70 kg K $ha^{-1}$from the soil, fixation by clay minerals and leaching which have been probably caused by rain fall and irrigation (Osmond et al., 2005). Therefore, there is a need to use potash fertilizers for sweet potato growing at Hombolo especially at the area of an irrigation scheme.

The organic carbon content in the soil was found to be 0.67 %, equivalent to 21.78 kg OC ha^{-1}. This value is rated as very low (Landon, 1991). This amount of OC is an indicator that at the experimental area has deficiency of organic matter as resulted in low CEC. The low OC determined from this study may have been caused by low rate of organic matter decomposition because of inadequate rainfall vegetation burning and over grazing. To improve soils condition for crop production, amendment of the soils should be done through incorporating manure and plants residuals in the soil. Cation exchange capacity (CEC) of the experimental area was 6.8 $cml_c^{(+)}$ kg,$^{-1}$ the values is rated as being low according to Landon (1991). The low CEC of the soils recoded in this study could have been due to the low organic matter content. The results recorded from the experimental area call for addition of organic matter by incorporating soil with vegetation and minimizing crop soil mining by crop removal and vegetation burning.

Table 1: Some of the physical and chemical properties of the soils 0 – 25 cm depth at Hombolo

Soil characteristic	Method	Value	Remarks*
Physical characteristics			
Soil particle analysis			
Sand %	Bouyocous hydrometer-	63	Textural class
Silt %		5	Sand clay loam
Clay %		32	
Bulk density	Core Method	1.3 g $cm^{3\ -1}$	Medium
Chemical characteristics			
Soil pH	Electrometrical in 1:2.5 soil H_2o	6.01 (H_2O)	Medium
Total Nitrogen	Micro Kjeldhl	0.07 %	Very Low
Available Phosphate	Bray 1	3.09 mg kg $^{-1}$	Low
Potassium (K^+)	Flame photometer	0.057 cmolc kg $^{-1}$	Low`
Organic carbon		0.67 %	Very low
Cation exchange capacity	Buffer ammonium acetate	6.8 cmolc $^{(+)}$ kg $^{-1}$	Low
Exchangeable Bases			

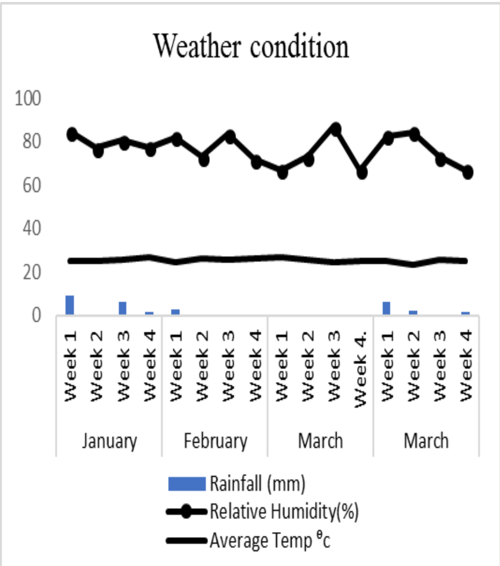
Calcium (Ca^{2+})	Atomic absorption spectro photometer (ASS)	3.26 cmolc $^{(+)}$ kg $^{-1}$	High
Magnesium (Mg^{2+})		1.3 $cmol_C$ $^{(+)}$ kg $^{-1}$	Medium
Sodium (Na^{+})	Flame photometer	0.14 $cmol_C^{(+)}$ kg $^{-1}$	Low

3.2 Weather condition

Weather condition during experimental duration were shown in Figure 1. The total monthly rainfall was 16.9 and 3.2 mm in January and February 2013, respectively. The rainfall distribution had low impact on crop and establishment and crop growth in all treatments. However, the situation got worse in March 2013 when total monthly rainfall was 0 mm. Sweet potato normally grows and develops well to the optimal yield when supplied with well distributed rainfall of 500 to 1200 mm (Nyambok, 2011). This situation calls for addition amount of water to supplement the quantity required, which was done through irrigation which was done twice per week.

The average temperature ranged from 19.6 to 31.9 °C. The highest temperature was recorded in February, 2013 where it averaged 31.3 °C with the month's minimum value being 20.4 °C as presented in Table 3. Minimum and maximum temperature values during the growing season ranges from 20 to 32 °C, respectively which is within the range of the crop requirement (Nyambok, 2011) Low temperature (20 °C) is suitable during the night for tuber roots formation and high temperature (30 °C) is appropriate during the day for sweet potato vegetative growth (Stephen, 2004).

The RH at the research site for the whole research period ranged from 73.4 to 79.9 %, with the average of 76.9 %. The highest RH value was 79.9 %, recorded in January 2013 which probably influence rainfall availability in terms of its amount and distribution compare to other months. The values of RH recorded had no negative effect on the development sweet potato fungal diseases since no signs of fungal diseases were recorded. It was also reported that sweet potato fungal diseases such as rust (Coleosporium ipomoeae), white rust (Albugo ipomoeae), leaf sport (Alternaria spp), stem rot (F. oxysporum), grow optimally at very high RH between 85 and 100 % (Bello et al. 2012), the values that were not recorded during this study.



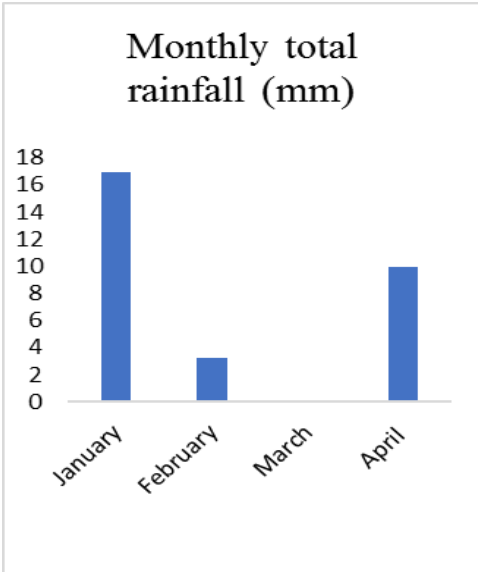


Figure 1: Weather condition during experimentation period 2013/2014 cropping season

3.3. Chemical characteristics of farm yard manure

Chemical characteristics of FYM used in this study is shown in Table 2. The pH was 8.3 while total nitrogen, phosphorus and potassium were 0.9%, 0.48 % and 0.69 % respectively. According to Kimbi and Semoka (2004), FYM pH is rated as medium, while the rest of the nutrient contents were rated as low. This study indicates that 17 tons of FYM will supply 91 kg N ha^{-1}, 30 kg P ha^{-1} and 120 kg K ha^{-1}. The low nutrients observed from FYM may have been caused by types of animal breeds, low food quality used for livestock feeding and inappropriate FYM handling and storability as resulted in loss of essential plant nutrients such as N, P and K (Ogendo et al., 2008).

Table 2: Farm yard manure chemical characteristics

Characteristic	Value	Remarks*
Farm yard manure pH (H_2O)	8.3	Slightly alkaline
Total Nitrogen (%)	0.9	Low
Organic carbon (%	0.87	Low
Total phosphate (%)	0.48	Low
Calcium (%)	2.87	Low
Magnesium (%)	0.4	Low
Total potassium (%)	0.69	Low
Sodium (%)	0.9	Low

*According to Kimbi and Semoka (2004)

3.4 Effect of sweet potato varieties on yield components and yield

There was no significant increase on number of tubers (NT), tuber diameter (TD), tubers fresh weight (TFW), tuber dry weight (TDW) and tuber yield (TY) when different varieties used (Table 3). Ukerewe and Kiegeya varieties had significantly higher (P=0.008) tuber length (TL) compared to Matanya. The lowest TL (15.31 cm) was recorded from Mataya variety whereas the highest (17.66 cm) from Ukerewe. The difference in TL may have been caused by genetic characteristic of the varieties and its interaction on the environmental factors (Huaman, 1999).

Table 3: Yield components and yield of different sweet potato varieties

Treatmen	T/	T (cm	TD (cm	TF (k	TDW(k	T (t/h
Kiegeya	4.81a*	17.18b	4.17a	0.35a*	0.21a	15.44a
Mataya	4.52a	15.31a	4.18a	0.31a	0.19a	13.65a
Ukerewe	4.27a	17.66b	4.45a	0.29a	0.19a	13.28a
CV%	5.80	6.90	3.50	9.10	9.50	9.10
SE±	0.21	0.39	0.34	0.02	0.01	1.05
FPr	0.146	0.008	0.141	0.205	0.529	0.205

*Means followed by the same letter in the same column for each treatment factor are not significantly different at P< 0.05 Tukeys' Test

3.5 Effect of number of buried nodes on yield component and yield

The number of buried nodes showed significant effect (P<0.05) on yield and yield components (Table 4). Lowest NT (3.47 $plant^{-1}$), TDW (0.14), TFW (0.26) and total yield (11.68 t ha^{-1}) were recorded from four buried nodes whereas, the highest values were recorded from seven and eight buried nodes.

The highest values of yield and yield components in seven and eight buried nodes treatments might have been due to higher tuber root formation when higher number of nodes used. It was also observed that, using seven and eight node vines resulted into early and rapid growth and development of tubes to four and five node vines. This finding is similar the one reported by Belehu

(2003) which showed that, six buried nodes resulted into high yield compared to three buried nodes. Maniyam et al. (2012) working in India also had similar observation where five buried nodes resulted into high yield of 26 t ha $^{-1}$ than with three buried nodes which resulted into 14 t ha $^{-1}$.

Table 4: Effect of number of buried nodes on yield components and yield of sweet potato

Treatments	N T/p	TL (cm)	TD (cm)	TFW (kg)	TDW(kg)	TY (t/ha)
4 nodes	3.47a	16.51a	4.2a	0.26a	0.14 a	11.68a
5 nodes	4.27b	17.03a	4.3a	0.29a	0.18 b	13.11a
7 nodes	5.167c	17.00a	4.18a	0.35b	0.23 b	15.80b
8 nodes	5.20c	16.33a	4.37a	0.36b	0.24 b	15.91b
CV%	5.10	4.60	3.30	5.50	8.80	5.50
SE±	0.18	0.63	0.11	0.01	0.01	0.63
Fpr	<.001	0.631	0.476	0.001	0.003	0.001

*Means followed by the same letter in the same colum for each treatment factor are not significantly different at P< 0.05 Tukeys' Test

3.6 Effect of fertilizers on sweet potato yield components and yield

The types of K fertilizers applied had significant effect (P<0.001) on yield and yield components. Lowest number of tubers (2.81 plant^{-1}), TDW (0.1 kg plant^{-1}), TD (3.44 cm), TFW (0.19 kg), yield (8.82 t ha^{-1}) was form control treatment while the highest values of 6.03 plant^{-1}, 0.29 plant^{-1}, 4.81 cm, 19.03 cm, 0.42 kg and 18.84 t ha^{-1} for number of tubers, TDW, TD, TFW and yield respectively, were form KCl treatment(Table 5). Although KCl scored the values of yield component and yield but it had no significant effect when compared to NPK fertilizer, and this suggests the use of either of the two fertilizers in sweet potato production for increased yield.

Application of potassium fertilizer at the rate of 120 kg K ha^{-1} is recommended for tropical countries as it increases both the size and number of tubers. The biological and economic yield differences obtained from this research justify the functioning of potash fertilizes. These findings are similar with that reported by Trehan et al. (2009) and Soenarto, (1994) which indicated that the K application influence the formation of large sized tubers and lustrous appearance of the surface of the tuber roots (indicators of quality) and hence high yield. Potassium is very important in physiological processes in the crop such as opening and closure of stomata and other enzymatic functioning which enables appropriate water use efficiency for the functioning of cells and tissue of the crop. The fates of all these physiological processes resulted into translocation of synthesized carbohydrates to the tuberous roots (Soenarto, 1994).

Table 5: Influence of fertilizer types on sweet potato yield components and yield of sweet potato

Treatments	N T/p	TL (cm)	TD (cm)	TFW (kg)	TDW(kg)	TY (t/ha)
Control	2.81a	12.86a	3.44a	0.19a	0.10a	8.82a
KCl	6.03c	19.03c	4.81c	0.42b	0.29 c	18.84b
NPK	5.67c	18.87c	4.71c	0.39b	0.26 c	17.51b
FYM	3.64b	16.11b	4.12b	0.26b	0.14 b	11.33a
Mean	4.53	16.71	4.27	0.32	0.19	14.13
CV%	4.20	1.70	2.50	5.40	6.30	4.00
SE±	0.15	0.23	0.21	0.02	0.01	0.74
Fpr	0.001	0.001	0.001	0.001	0.001	0.001

*Means followed by the same letter in the same column for each treatment factor are not significantly different at P< 0.05 Tukeys' Test

3.7 Interaction effect of sweet potato varieties, number of buried nodes and fertilizers on yield and yield components

The use of four nodes without application of fertilizers resulted into lowest yield and yield component across all varieties while the highest values of yield components and yield in across all varieties were observed when seven and eight nodes used under application of KCl and NPK fertilizers (Table 6). The highest yield of varieties used ranges from 21.0 to 25.5 t/ha when seven and eight nodes used KCl and NPK fertilizers while the lowest yield ranges from 6 to 10.2 t/ha when four nodes used without application of fertilizer. The highest yield of 25.5 t/ha was recorded by Kiegea variety with seven bared nodes under application of KCl. Followed by Ukerewe variety 24.4 t/ha with eight bared nodes and 21.0 t/ha from Matanya variety with seven nodes under application of KCl. The increase in TDW must have been influenced by early bulking of tubers for those roots initiated earlier from seven and eight buried nodes. The results from this study shows the importance of using higher number of nodes on vines (seven to eight) along with application of potassium fertilizer at recommended rate (120 kg K/ha) in sweet potato production maximizing tubers yield.

Table 6: Interactions effects for varieties, number of nodes and fertilizers

			N T/p	TL (cm)	TD (cm)	TFW (kg)	TDW(kg)	TY (t/ha)
Kiegea	4nodes	KCl	4.0 a-f	4.7 d-i	19.6 klm	0.4 b-j	0.2 a-h	15.7 b-j
		NPK	4.0 a-f	4.6 c-i	19.2 j-m	0.4 b-j	0.2 a-h	16.0 b-j
		FMM	4.0 a-f	4.0 a-i	15.4 a-l	0.3 a-f	0.1 abc	11.9 a-f
		FO	3.0 abc	3.2 a	11.8 a	0.2 ab	0.1 a	8.0 ab
	5nodes	KCl	5.3 a-i	4.7 d-i	20.5 m	0.5 f-k	0.3 d-j	20.6 f-k
		NPK	5.7 d-i	4.8 e-i	18.4 h-m	0.4 d-k	0.3 c-j	19.3 d-k
		FMM	4.3 a-g	3.9 a-h	17.9 g-m	0.3 a-h	0.1 a-f	13.0 a-h
		FO	3.3 a-d	3.2 a	12.8 a-f	0.2 abc	0.1 a	8.9 abc
	7 nodes	KCl	7.7 i	5.0 hi	20.9 m	0.6 k	0.4 ij	25.5 k
		NPK	6.7 ghi	4.6 c-i	20.1 lm	0.5 h-k	0.3 g-j	21.8 h-k
		FMM	4.3 a-g	3.7 a-d	17.0 d-m	0.3 a-f	0.1 a-f	12.0 a-f
		FO	3.7 a-e	3.3 a	12.3 a-d	0.2 abc	0.1 ab	9.4 abc
	8 nodes	KCl	7.0 hi	4.9 f-i	18.5 i-m	0.5 h-k	0.3 f-j	21.7 8-k
		NPK	7.0 hi	4.8 e-i	19.0 j-m	0.5 g-k	0.3 e-j	21.0 g-k
		FMM	4.0 ab-f	3.8 a-g	17.6 f-m	0.3 a-f	0.2 a-g	11.8 a-f
		FO	3.0 abc	3.6 a-d	13.8 a-i	0.2 a-d	0.1 ab	10.5 a-d
Matanya	4nodes	KCl	5.0 b-g	4.6 c-i	16.0 a-m	0.3 a-i	0.2 a-h	14.0 a-i
		NPK	3.7 a-e	4.6 c-i	16.8 c-m	0.3 a-h	0.2 a-h	13.0 a-h
		FMM	2.3 a	3.9 a-h	13.8 a-i	0.3 a-f	0.2 a-g	11.9 a-f
		FO	2.7 ab	3.6 abc	12.0 ab	0.2 a-d	0.1 abc	10.6 a-d
	5nodes	KCl	6.0 e-i	4.4 b-i	18.6 i-m	0.3 a-i	0.2 a-i	14.5 a-h
		NPK	5.0 b-h	4.2 a-i	17.7 g-m	0.3 a-h	0.2 a-h	13.0 a-h
		FMM	3.3 a-d	4.0 a-i	15.4 a-l	0.2 a-d	0.1 a-d	10.5 a-d
		FO	2.7 ab	3.2 a	13.0 a-g	0.2 a-e	0.1 a-d	10.9 a-e
	7 nodes	KCl	7.0 hi	4.6 c-i	17.3 e-m	0.3 g-k	0.3 g-j	21.0 g-k
		NPK	6.6 ghi	4.6 c-i	17.4 e-m	0.4 e-k	0.3 c-j	19.6 e-k
		FMM	4.0 a-f	3.8 a-g	15.0 a-k	0.3 a-g	0.2 a-h	12.4 a-g
		FO	2.7 ab	3.0 a	11.9 a	0.2 ab	0.1 a-d	8.4.0 ab
	8 nodes	KCl	7.0 hi	4.9 ghi	16.0 a-m	0.4 e-k	0.3 f-j	19.7 e-k
		NPK	7.0 hi	4.9 ghi	17.2 d-m	0.4 c-k	0.3 b-i	17.8 c-k
		FMM	4.0 a-f	4.6 c-i	14.3 a-j	0.3 a-e	0.2 a-f	11.0 a-e
		FO	2.6 ab	3.4 ab	11.9 ab	0.2 abc	0.1 ab	9.52 abc
Ukerewe	4nodes	KCl	4.0 a-f	5.0 hi	20.6 m	0.3 a-g	0.2 a-f	12.7 a-g
		NPK	3.6 a-e	4.8 f-i	20.8 m	0.3 8a-e	0.2 a-g	11.5 a-e
		FMM	3.0 abc	4.5 a-i	17.6 f-m	0.2 ab	0.1 a	8.7 ab
		FO	2.2 a	3.5 abc	14.3 a-j	0.1 a	0.1 a	6.0 a

5nodes	KCl	5.0 b-g	5.1 i	19.8 klm	0.3 a-i	0.2 a-h	14.2 a-i
	NPK	5.3 c-i	4.9 ghi	19.6 klm	0.3 a-i	0.2 a-i	15.0 a-i
	FMM	3.0 abc	4.8 e-i	17.0 b-m	0.2 abc	0.1 a-d	9.6 abc
	FO	2.0 a	3.7 a-f	13.6 a-h	0.2 ab	0.1 a	7.6 ab
7 nodes	KCl	6.7 ghi	4.8 e-i	20.6 m	0.5 h-k	0.4 hij	22.0 h-k
	NPK	6.0 f-i	4.8 e-i	20.3 lm	0.4 e-k	0.3 c-j	19.6 e-k
	FMM	4.0 a-f	4.1 a-i	17.0 d-m	0.4 a-d	0.1 a-e	10.6 a-d
	FO	2.3 a	3.6 abc	14.1 a-i	0.2 ab	0.1 abc	7.4 ab
8 nodes	KCl	7.7 i	4.9 f-i	19.5 klm	0.6 jk	0.4 j	24.4 jk
	NPK	7.0 hi	4.8 f-i	19.8 klm	0.5 ijk	0.4 hij	22.5 ijk
	FMM	3.0 abc	4.6 e-i	17.0 d-m	0.3 a-g	0.2 a-g	12.2 a-g
	FO	2a	3.5 abc	12.7 a-e	0.2 ab	0.09a	8.5 ab
	CV	17.30	7.90	7.70	18.80	6.80	18.80
	F value	0.70	0.83	0.94	0.95	0.001	0.9

*Means followed by the same letter in the same colum for each treatment factor are not significantly different at P< 0.05 Tukeys' Test, V= Varieties F= Fertilizers, FM = Farm yard manure, C= Control, N= Number of nodes, T/ha =tones per hector (kg), TD= Tuber diameter (cm) Tuber length (cm) TFW= tuber fresh weight, TDW = tuber dry weight (kg) CV= variation of coefficient, SE = Standard error

4.0 Conclusion and Recommendations

4.1 Conclusions

Based on the information obtained from this research, the following conclusions are made:

1. Sweet potato varieties planted had no significant effect on number of tubers, marketable tubers and total yield. On the other hand, seven and eight buried nodes produced a good number of tubers plant^{-1}(5.16 and 5.2), and total yield t ha^{-1} (17.51 and 18.84) respectively.
2. Among tested fertilizers, Potassium nitrogen phosphate and potassium chloride appears to be of the high efficient on increasing number of tubers, marketable tubers and total yield. Furthermore, potassium nitrogen phosphate and potassium chloride resulted into high quality tuberous root (tuber length, tuber diameter and weight)

4.2 Recommendations

This study recommends the following:

1. Vines cuttings with seven or eight buried nodes with the internodes length 2 cm vine are potential for maximum sweet potato growth and yield. Should be used in Dodoma so as to improve yield and quality of sweet potato tuberous root.
2. Potassium nitrogen phosphate and potassium chloride at 120 kg K ha^{-1} should be encouraged in soils with low mineral K contents so as to improve the fertility status especially for poor resource farmers. These will enable farmers to increase yield and quality of sweet potato to meet consumers' requirement and consequently raise their income.
3. Any variety can be grown by the famers, as it resulted into no significant yield difference, therefore farmers should select variety based on palatability and marketability.

5.0 References

1. FAO, 2009. Food and Agriculture Organization, Rome, Italy [http: www.apps. fao.org] site visited on 29 /04/ 2012.

2. Uwah, D. F. U., ndie, U. L., John, N. M. and Ukoha, G. L. 2013. Growth and yield response of improved sweet potato (Ipomoea batatas L.) Varieties to Different Rates of Potassium Fertilizer. Journal of Agricultural Science. 5: (7): 1916-9760.
3. Mtunda, K. J., Msolla, S. N., Muhanna, M. A., Ngereza, E., Masumba, G. and Larsen, A. 2007. Evaluation of sweet potato for early maturity in the eastern agro-ecological zone of Tanzania. In Proceedings of the 9th Triennial symposium jointly organized by the ISTRC-AB and Kenya Agricultural Research Institute (KARI) 76pp.
4. Tumwegamire, S., Kapinga, R., Zhang, D., Crissman, C. and Agilo, S. 2004. Opportunities for promoting orange fleshed sweet potato as a mechanism for combating vitamin A deficient in sub-saharan Africa. African Crop Science Journal. 12(3): 141-252.
5. Kapinga, R., Tumwegamire, S., Lemaga, B., Andrade, M., Mwanga, R., Mtunda, K., Ndolo, J. 2005. Development of farmer-based seed systems for healthy planting materials pp 23-89.
6. Mukhtar, A. A., Tanimu, B., Arunah, U. L. and Babaji, B. A. 2010. Evaluation of the agronomic characters of sweet potato varieties grown at varying levels of Organic and inorganic Fertilizers: World Journal of Agricultural Science (4):370-373.
7. CFFA 2011. Plant nutrients- potassium. California Foundation for Agriculture 13pp
8. Degras, L. 2003. Sweet potato the tropical Agriculturalist. Iran International Journal of Agriculture and Crop Sciences. 5(18) :2033-2040
9. Jian-wei, L., Fang, C., You-sheng, X., Yun-fan, W. and Dong-bi, L. 2001. Sweet potato response to potassium. Journal of Applied Sciences Research, 5(11): 1966-1976, 2009.
10. Trehan, S. P., Pandey, S. K. and Bansal, S. K. 2009. Potassium nutrition of potato crops. The Indian Scenario sp vol (19) 2- 9.
11. Trehan, S. P. and Grewal, J. S. 1990. Effect of time and level of potassium application on tuber yield and potassium composition of plant tissue and tubers of two cultivars. In Potato production, marketing, storage and processing. Indian Journal of Agricultural Research Institute 12(45):67-79
12. Hatibu , N., Mahoo, H. F., Kayombo, B., Mbiha, E., Senkondo, E. M., Mwaseba, D. 1995. Soil water management in semi-arid Tanzania research project final report. 49 pp.
13. Kabanza, K. A. 2003. Assessment of residual tied ridges and farm yard manure application on sorghum yield in semi-arid areas in Dodoma. Dessertation for award of MSc degree at Sokoine University of Agriculture, Morogoro, Tanzania, 43 pp.
14. Belehu, T. 2003. Effect of cutting characteristics on yield and yield components of Sweet Potato. University of Pritoria 140 pp.
15. Kanyeka, E., Kamala, R. and Kasuga, R. 2007. Improved Agricultural Technologies in Tanzania. First Edition. The United Republic of Tanzania. (Ministry of Agriculture Food Security and Cooperatives. 125 pp.
16. Nyambok, D. 2011. Good agronomic practices for Sweet-potato in Western Kenya Training manual for Trainers pp. 4 -23.
17. Kuoko, S. S., Mgonja, A., Urio, F. and Ndondi, T. 2007. Agronomic and Economic benefits of sweet potato response to application of nitrogen and phosphorus fertilizers in the northern highlands of Tanzania. Horticulture Research institute. African Crop Science conference proceedings 8: 1207-1210.
18. Kapinga, R. 2007. Sweet potato in Tanzania farming and food system implications for research. International potato centre, 47 pp.
19. TMA 2013. Weather data during cropping season. United Republic of Tanzania 22 pp.
20. Peters, J. (2003). Recommended methods for manure analysis, University of Wisconsin extension United State 57pp.
21. Anton, J. H. 1982. Water Management in potato production. International potato center 22 pp.

22. Maniyam, N., Gangatharan, B., Susantha, K. J. 2012. Sweet potato Agronomy. Fruit, Vegetable, Cereal Science and Biotechnology, Regional Centre of central tuber crops Research institute india. 8pp.
23. Gregory, P. A., Jonathan, M. O. S. and Jeffrey, A. H. 2003. Global synthesis of leaf area index observations: implications for ecological and remote sensing studies. Journal of Global Ecology and Biogeography 12: 191–205.
24. Benny, G. 2013. Mississippi Sweet Potato Crop Report. Mississippi State University 6 pp.
25. Landon, J. R. 1991. Booker Tropical soil Manual: A Handbook for Soil Survey and Agricultural Land Evaluation in the Tropics and Subtropics. John Whiley and Sons. New York., 155 pp.
26. Frank, K. and Knudsen, D. 1974. Understanding your soil test phosphorus and potassium. University of Nebraska, cooperative extension Lincoln. 31pp.
27. Osmond, D. L., Evans, R. O., Hardy, D. H., Price, L. and Johnson, A. M. 2005. Soil facts. North Carolina cooperatives extantion 439-456 pp.
28. Stephen, L. L. 2004. Storage root production in sweet potato. Thesis presented on partial fulfillment of the requirements for the degree of doctor of philosophy in plant science at Massey University News Land. 183pp.
29. Bello, I. M., Suberu, H. A., Kuta, F. A. and Daudu, O. A. Y. 2012. Influence of Temperature and Relative Humidity on the Culture of Fungi Isolated from Rotting of Sweet Potato (Ipomoea batatas L.) Nigeria journal. 4(1, 2): 51 – 56.
30. Kimbi, G.G. and Semoka, M. R. 2004. Effect of storage duration and grazing system on nutrient contents of cattle manure in three district of Tanzania, Uniswa research Journal volume 7: 1017-7442.
31. Ogendo, R .O., Isutsa, D. K. and Sigunga, D. O. 2008. Interaction of farmyard manure and plant population density effects on soil characteristics and productivity of mulched strawberry in a tropical climate. Afican Journal of Horticulture Science. 1:100-115.
32. Huaman, Z. 1999. Selecting a Peruvian sweet potato core collection on the basis of morphological ecological pest and disease reaction date. Theoretical Applied Genetics, 98:840-844.
33. Soenarto, M. 1994. Sweet potato response to shading and potassium. A thesis submitted in partial fulfilment of the requirements for degree of master of science the University of British Columbia. 194 pp.