

Original Research Article

Yield performance, market tuber quality and evaluation of sugar and starch activity of two Ghanaian varieties of sweet potato (*Ipomoea batatas* (L) lam) as influenced by chicken manure and inorganic fertilizer

ABSTRACT

Two field experiments were conducted at the University of Education, Winneba, Mampong-Ashanti campus to investigate the responses of the growth, yield and tuber market quality of two varieties of sweet potato (*Apomuden* and *Okumkom*) to chicken manure and inorganic mineral fertilizers. The application of chicken manure in combination with inorganic fertilizer enhanced the growth and yield of both sweet potato varieties. However, the application of amended treatments to both varieties decreased tuber market quality (tuber crack, deformed and diseased) during the major season in 2012, increased rotten, forked and pest infested tubers in minor season in 2011. *Okumkom* treated with 15-30-30 kg/haNPK +5t/ha CM and 30-30-30kg/haNPK recorded no tuber sprout in both seasons. Generally, the importance of using chicken manure and inorganic fertilizer either alone or in combination as soil amendment to enhance tuber market qualities at harvest over control was clearly demonstrated in both studies.

Okumkom grown on amendment and control plot had increased tuber sugar and starch content at harvest in both seasons. Both varieties, whether treated or untreated had decreased starch content at 12 weeks in storage than at harvest in both seasons. Pit storage showed the most effective storage method in terms of root starch and sugar content in both seasons followed by ash and grass storage methods.

INTRODUCTION

Sweet potato (*Ipomoea batatas* (L.) Lam) is an important tuber crop grown in the tropics, subtropics and warm temperate regions of the world. It is commonly referred to as subsistence food security or famine relief crop and income earner in the Southern Africa. Sweet potato is grown especially by women, for daily family consumption and for sale by the poorest among African communities [1; 2]. Despite its importance, the production as well as yield and tuber quality are low in Ghana which can be attributed to among others the low fertility of the soil. Sweet potato responds to phosphorus and potassium application under most conditions though the response rate and optimum dose varies with the cultivar and soil types. The inherent poor soil fertility of most soils in the tropics and subtropics constitute a major constraint in sustainable smallholder

crop production in the Sub-Saharan Africa [3]. This study was carried out to determine the fertilizer regimes for optimum yield and tuber quality in sweetpotato.

MATERIALS AND METHODS

Two field experiments were conducted at the multipurpose crop nursery of the University of Education, Winneba, Mampong-Ashanti campus during the minor and major rainy seasons from September, 2011 to January, 2012 and April to July, 2012 respectively. The soil type is the savanna ochrosol formed from the Voltaian sandstone of the Afram plains. Texturally, the soil is friable with a thin layer of organic matter and is deep and brown-sandy loam and well-drained. It however has a good water-holding capacity. The soil has been classified by FAO / UNESCO legend as Chronic Luvisol and locally as the Bediesi series with a pH range of 4.0-6.5. The weather conditions during the experimental periods are summed up in Tables 1 and 2. The chicken manure used for the research project for both seasons was four (4) months old (20.0% moisture content) and was obtained from the poultry farm of the College of Agriculture, University of Education, Winneba, Mampong- Ashanti campus and heaped under shade to dry before use. Sub-samples of the dried manure were taken for nutrient analysis. The decomposed and dried chicken manure was applied and worked into the soil two (2) weeks before planting of vines. Soil samples were taken prior to and after application of organic manure and fertilizers from the top 0-20 cm of plots for physico-chemical analyses. Soil samples and manure analyses were carried out at the soil research institute of CSIR laboratory, Kumasi. The characteristics analyzed for included particle size, pH in 1:1 soil: water ratio 1:2 soil: 0.01 CaCl_2 , Organic matter was determined by the Walkley and Black method and total nitrogen was determined by the micro Kjeldahl method. The available phosphorus was extracted by the Bray's method and exchangeable cations was determined by flame emission photometry. Three sweet potato roots were randomly selected from each treatment at harvest. The freshly harvested sweet potato samples (from each variety and fertilizer combinations) were washed with clean water, packaged in aluminum foil, labeled and stored at -4°C for starch and sugar analysis using Abbe Refractometer, model, 98-440, Novex-Holland. Additionally, sweet potato roots were randomly selected after three months storage from each of the storage method for similar analysis. The samples were shredded later with a plastic grater and made to pass through a 0.2 mm mesh. 10.0 g of each sample was placed in a cheese cloth and a few drops of the sap squeeze out and slowly onto the lens of the refractometer and closed with the cover. The eye piece was immediately focused to clearly see the graduation. The sugar content of each

sample (in Brix) was quickly recorded. This was repeated for the other treatments by using new cheese cloth. For the determination of starch, the refractive indices obtained from the samples were compared to a standard scale to obtain accurate values, that is the percentage mass of the starch was read from a chart corresponding to the value of refractive index. Precautionary measures such as cleaning of lens with a soft damp cloth after every reading and allowing sap to rest on the lens for at least 30 seconds before taking a reading were taken.



Table 1a: The Total Rainfall (Mm), Mean Temperature ($^{\circ}$ C) and Mean Relative Humidity (%) (Hour GMT) of Mampong-Ashanti during the Minor Rainy Season in 2011 Experimental Period

Month	Total month Rainfall (mm)	Mean monthly Relative humidity (%) (hour GMT)		Mean monthly Max. & Min. temperature ($^{\circ}$ c)	
		06.00	15.00	Min.	Max.
January	65.8	82	43	21.0	32.7
February	136.4	90	48	22.0	33.5
March	230.5	96	59	22.3	33.1
April	122.8	95	59	23.1	33.2
May	100.1	96	60	23.0	32.7
June	244.4	97	68	22.3	30.5
July	178.6	97	71	21.7	28.9
August	60.0	97	70	21.8	28.5
September	155.6	98	73	22.3	29.4
October	188.1	97	67	22.3	30.9
November	38.0	96	54	28.0	32.7
December	0.0	92	41	22.2	32.9

(Meteorological Department – Mampong Ashanti, 2011)

Table1b: The Total Rainfall (Mm), Mean Temperature ($^{\circ}$ C) and Mean Relative Humidity (%) (Hour GMT) of Mampong-Ashanti during the Major Rainy Season in 2012 Experimental Period

Month	Total month Rainfall (mm)	Mean monthly Relative humidity	Mean monthly Max. & Min.
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		(%) (hours GMT)		temperature (°c)	
		06.00	15.00	Min.	Max.
January	48.1	84	35	20.8	33.7
February	74.9	84	46	22.4	33.4
March	92.0	93	52	23.1	33.4
April	119.3	96	61	23.0	33.3
May	270.8	96	63	23.0	31.4
June	379.8	97	71	22.6	29.5
July	178.6	96	71	21.9	28.2
August	93.8	96	71	21.9	28.2
September	3.4	98	70	22.5	28.9
October	73.5	97	65	22.4	31.2
November	225.5	95	66	22.7	32.4
December	60.6	93	53	22.5	31.9

(Meteorological Service Department – Mampong Ashanti, 2012)

The experimental design was a 2 x 8 factorial arranged in randomized complete block design (RCBD) with four replicates made up of seven organic manure and fertilizer rates and the control (without any amendment) and two sweet potato varieties was assigned to each block. Each treatment plot measured 4.0 m x 3.0 m. Ridges were constructed 1.0 m between rows and planted at 0.3 m within row plants. Vine cuttings of two sweet potato varieties “*Apomuden*” and “*Okumkom*” of length 0.3 m topmost apical sections and other actively growing sections were planted two weeks after chicken manure application. Inorganic mineral fertilizer, NPK (15:15:15), Triple super phosphate and muriate of potash were applied two weeks after planting of vines at appropriate rates as per treatments. Percentage crop establishment was measured on eighteen plants from the two central rows at 4 weeks after planting (WAP). Vine length and vine girth, were measured on five plants from the two central rows. Fresh vine weight gain and dry matter accumulation were measured on three plants at four weeks after planting and at two weeks interval. Plants were destructively sampled and weighed for fresh vine weight accumulation at 2 weeks interval from 4 WAP to 12 WAP using an electronic weighing scale.

95 Mean values per treatment were then estimated. After destructive sampling for fresh vine weight
 96 gain, 200 g samples per plot were oven-dried at 72°C for 72 hours to remove all moisture. Dried
 97 samples were then weighed using an electronic weighing scale and the mean dry matter gain per
 98 treatment was subsequently estimated using the sample vine dry weight, the sample vine fresh
 99 weight and the total fresh vine weight. Marketable and unmarketable tuber weight per plot, yield
 100 and yield component including weight per tuber and marketable and unmarketable tuber
 101 diameter were estimated. Tuber diameter of less than 3cm was considered unmarketable and those
 102 with diameter more than 3cm as marketable. Tuber market quality including tuber cracks, tuber
 103 rot, sprouts in tubers, forked tuber, misshapen tubers, diseased and weevil infestation were also
 104 determined. The tubers harvested from eighteen plants of each plot were sorted into five
 105 categories using the recommended scale [4]. Each attribute was scored by relating the number of
 106 affected tubers to the total number of tubers per treatment plot. **Rating Scale.** None 1,
 107 ii. Slight.....2, iii. Moderate 3, iv. Severe.....4, v. Very Severe 5. Data Analysis was
 108 done using ANOVA and GenStat Release 9.2 (PC/Windows XP) statistical package. Least
 109 Significant Difference (LSD) was used to separate the means at 5 % level of probability.

110 RESULTS AND DISCUSSION

111 **Soil Nutrients Levels** after application of chicken manure and inorganic fertilizers in both 112 studies during the minor season, 2011 and the major season, 2012

113 Initial effects of manure application on some soil physical and chemical properties at the 2011
 114 and 2012 experimental site are shown in Tables 3 and 4. Both the untreated soil (no- manure)
 115 and manured supplemented soils were within the sandy loam textural range. 10t/ha chicken
 116 manure supplemented soil had higher levels of organic matter, exchangeable Ca, Mg and
 117 effective cation exchange capacity than the other manured soil and control. Both the untreated
 118 soil and manured soil had an acidic pH; however, 10t/ha CM supplemented soil had a slightly
 119 acidic pH. In general, the application of chicken manure increased organic matter content, water
 120 holding capacity of the soil, the soil pH and bulk density. The inorganic fertilizer supplemented
 121 plots improved only the chemical properties of the soil, but not the soil physical properties, such
 122 as, soil structure, bulk density and water holding capacity.

123

124 **Table 2: Physico- Chemical Properties of Soil and Soil Plus Manure Ap Horizon At 0-20**
 125 **cm depth for the minor season, 2011**

Property	Untreated Soil (Control)	Value Inorganic Fertilizer + Soil	10t/Ha Chicken Manure + Soil	5t/Ha Chicken Manure + Inorganic Fertilizer +Soil
Sand (%)	66.49	68.78	66.86	65.93
Silt (%)	27.51	27.22	25.14	26.07
Clay (%)	6.00	4.00	8.00	8.00
Organic carbon (%)	1.06	1.07	1.26	1.14
Total nitrogen (%)	0.13	0.14	0.17	0.15
Organic matter (%)	1.83	1.84	2.17	1.97
pH (1:1 H ₂ O)	5.44	5.44	6.45	5.77
Available p (ppm)	38.02	1018.78	334.04	436.10
Available k (ppm)	73.65	503.78	113.83	177.44
Bulk density (g/cm ³)	1.49	1.51	1.67	1.51
Exchangeable cations				
Ca ²⁺ (mg/100g)	2.49	2.97	12.80	6.14
Mg ²⁺ (mg/100g)	2.94	2.94	6.74	2.14
K ⁺ (mg/100g)	0.35	1.34	0.48	0.67
Na ⁺ (mg/100g)	0.13	0.13	0.17	0.18
Total Exchangeable bases	6.36	7.38	20.19	9.13
Effective Cation Exchange Capacity (E.C.E.C) Me/100g	7.11	8.13	20.34	9.58
Exchangeable Aluminium (Al ⁺ H)	0.75	0.15	0.15	0.45
Bases Saturation (%)	89.40	90.70	99.26	95.30

126
 127 **Table 3: Physico - Chemical Properties of Soil and Soil Plus Manure Ap Horizon at 0-20**
 128 **cm depth for the major season, 2012**

Property	Untreated Soil (Control)	Value Inorganic Fertilizer + Soil	10t/Ha Chicken Manure + Soil	5t/Ha Chicken Manure + Inorganic Fertilizer +Soil
Sand (%)	75.80	59.90	70.80	66.90
Silt (%)	15.20	31.30	22.00	26.60
Clay (%)	9.00	8.80	7.20	6.50
Organic carbon (%)	1.21	1.00	0.92	1.07
Total nitrogen (%)	0.13	0.21	0.32	0.16
Organic matter (%)	2.09	1.72	1.59	1.85
pH (1:1 H ₂ O)	6.73	5.42	6.19	6.02
Available p (ppm)	153.87	439.29	285.42	692.82
Available k (ppm)	43.96	74.40	71.01	87.92
Bulk density (g/cm ³)	1.51	1.49	1.49	1.49
Exchangeable cations				
Ca(mg/100g)	5.34	3.47	4.54	5.07
Mg	2.67	2.67	0.80	0.53
K	0.50	0.66	0.62	0.80
Na	0.17	0.22	0.21	0.25
Total Exchangeable bases	0.10	0.80	0.10	0.80
Effective cation Exchange Capacity (E.C.E.C) Me/100g	8.78	7.82	6.27	7.45
Exchangeable Aluminium (Al ⁺ H)	8.68	7.02	6.17	6.65
Bases saturation (%)	98.86	89.77	98.41	89.26

129

130 **GROWTH PERFORMANCE**

131 **Percentage Crop Establishment**

The percentage crop establishment during the minor and major growing seasons for the two sweet potato varieties (*Apomuden* and *Okumkom*) ranged from (59.2 – 78.8) and (53.5 – 85.5), respectively (table 4). Organic and inorganic fertilization either singly or in combination did not significantly influence crop establishment across both growing seasons and cultivars. The healthy and actively growing parts of vines used as planting materials might have accounted for the high percentage crop establishment. According to [5 and 6], there is the need to use healthy and actively growing portions of planting material (vines) and appropriate spacing as well as reduction in weed competition for good plant growth later during the seasons. Percentage crop establishment for *Okumkom* planted and supplied with 30 – 45 – 45 kg/ha NPK was lowest in both seasons. *Okumkom* grown on amended plots during the major season generally produced higher percentage crop establishment than those in the minor season. The high total monthly rainfall values recorded during the major season (April – July) as compared to minor season in 2011 (September – December), and cultivar differences might have contributed to such high percentage crop establishment

Table 4: Percentage Crop Establishment as Influenced by Poultry Manure and Inorganic Fertilizer during the Minor Season, 2011 and Major Season, 2012

	Percentage crop Establishment (%) - minor season 2011			Percentage crop Establishment (%) - major season 2012		
	Apomd	Okumk.	Mean	Apomd.	Okumk.	Mean
Fertilizer rate						
10t/ha CM	66.1	60.6	63.3	53.5	75.5	64.5
15-15-15kg/ha NPK + 5t/ha CM	75.2	63.7	69.5	73.9	63.2	68.6
15-23-23 kg/ha NPK+ 5t/ha CM	71.3	68.7	70.0	76.1	69.6	72.8
15-30-30kg/ha NPK + 5t/ha CM	59.2	70.6	64.9	63.5	75.5	69.5
30-30-30 kg/ha NPK	72.9	70.9	71.9	53.5	61.1	57.3
30-45-45 kg/ha NPK	71.3	59.8	65.5	85.5	61.1	73.3
30-60-60 kg/ha NPK	66.9	64.5	65.7	75.0	71.5	73.3
No fertilizer	78.8	69.2	74.0	80.6	72.6	76.6

Mean	70.2	66.0	70.2	68.8
LSD (0.05) Variety	7.7		NS	
LSD (0.05) Fertilizer	NS		NS	
LSD (0.05) Variety * Fertilizer	NS		NS	

VINE DIAMETER

Vine diameter of both sweet potato cultivars (*Okumkom* and *Apomuden*) grown on amended treatments were significantly higher than the control in both seasons (fig 1). This might be due to differences in soil fertility status through increased availability of nitrogen on manured plots. The results at both sites and growing seasons were similar to the findings of [7] who reported that in sweet potato, high nitrogen may cause luxuriant growth of the vines at the expense of storage root yield and that excessive N rates stimulate vine and root growth and delay tuber bulking and maturation. *Apomuden* and *Okumkom* grown on amended and control plots during the major season produced higher vine diameter than those grown under the same treatments during the minor season at 12 weeks after planting. The differences in sweet potato growth observed in the two seasons might be attributed to high rainfall during the major season coupled with slow and effective release of nutrients from manure applied during the major season. [8 and 9] observed that sweet potato response to nutrient input was greatly affected by other factors such as rainfall and number of cropping seasons. Significant decrease in vine diameter was observed in *Apomuden* and *Okumkom* grown on 10t/ha CM than other amended and the control plots during the minor season in 2011. This might be due to the initial relatively slow release of N in chicken manure as well as initial competition for nutrients by the soil microorganisms responsible for mineralization.

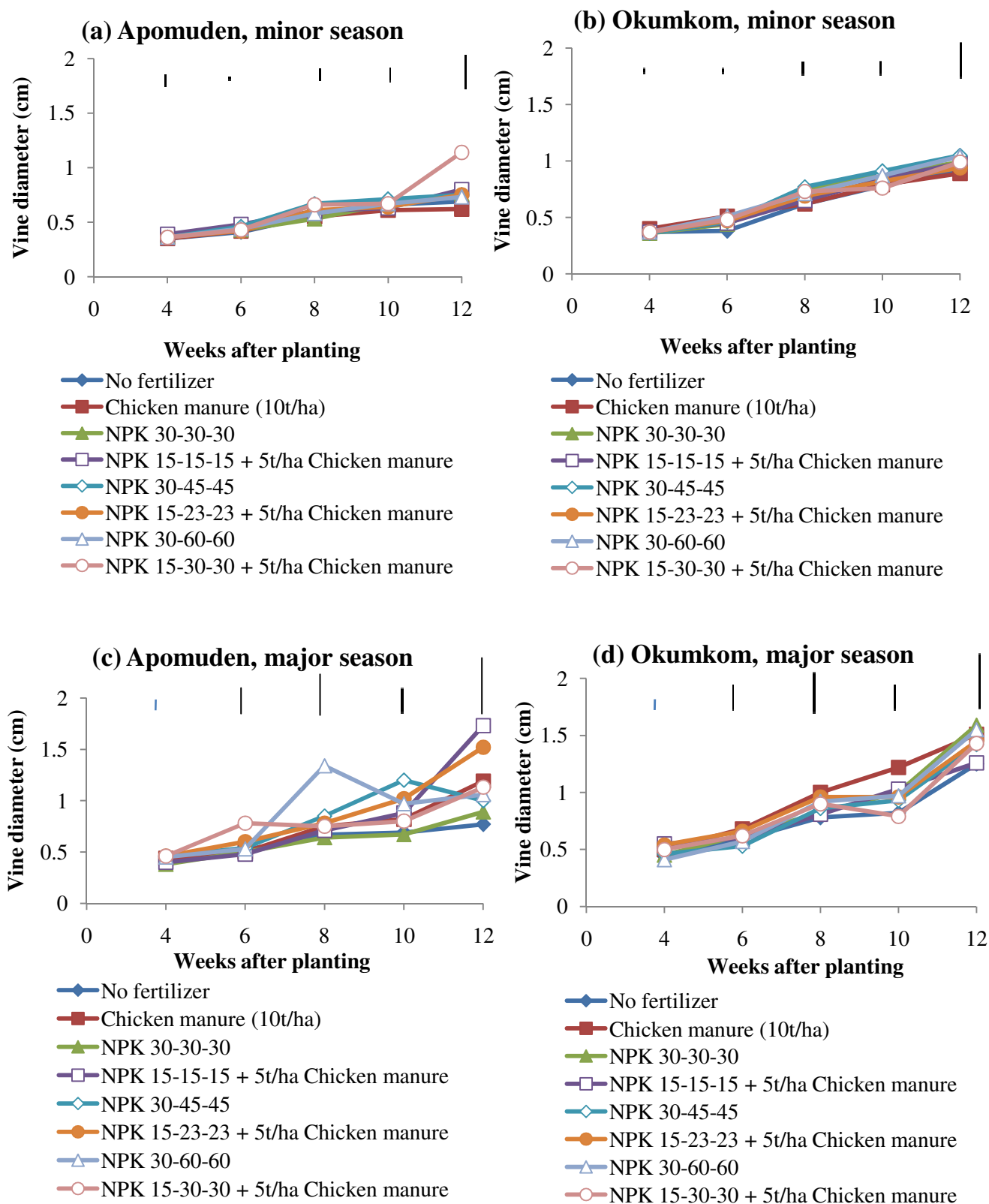
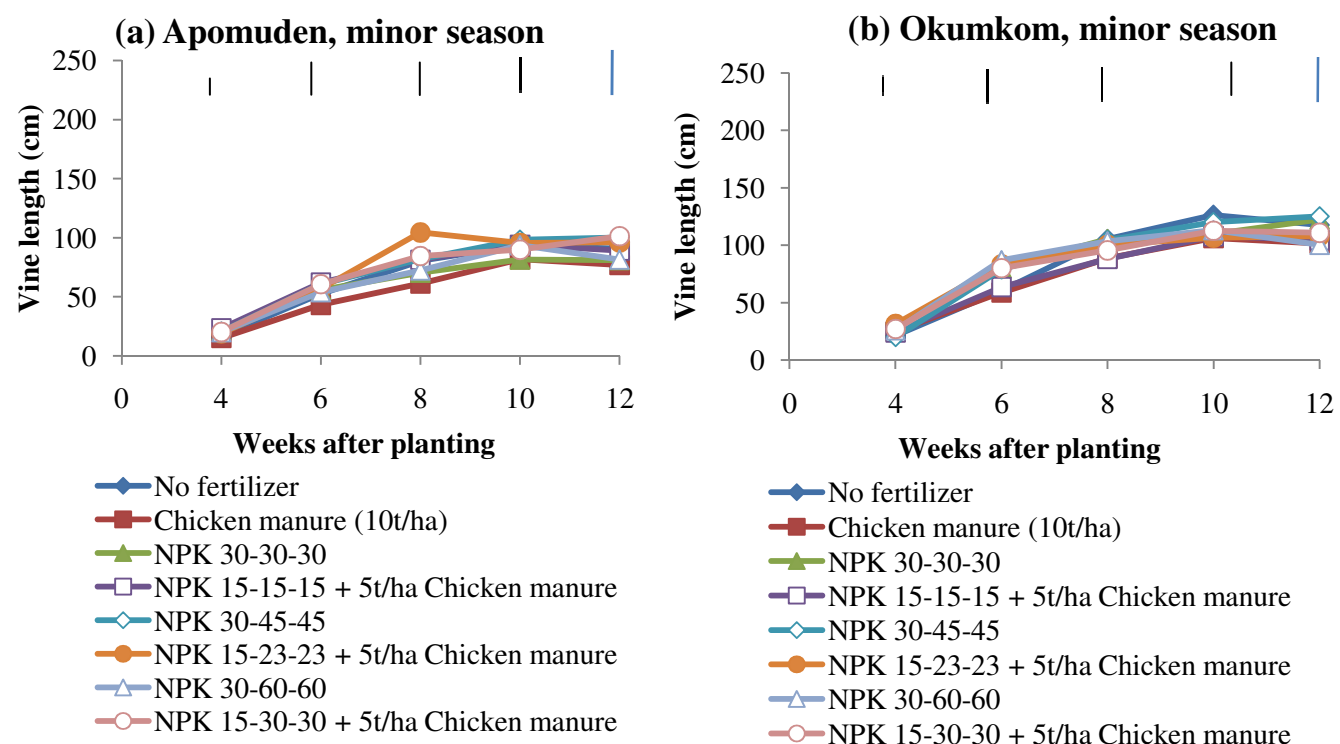


Fig. 1 Vine diameter as influenced by chicken manure and inorganic fertilizer during the minor season, 2011 (a, b) and major season, 2012 (c, d)

182 VINE LENGTH

183 Significant increase in vine length was recorded with the application of chicken manure and
 184 inorganic fertilizer either alone or in combination to *Okumkom* and *Apomuden* than the control in
 185 both seasons (fig 2). Significant increase in vine length occurred with application of chicken
 186 manure and inorganic fertilizer either singly or in combination to *Okumkom* than *Apomuden* in
 187 both seasons. [10] observed that the application of organic and inorganic fertilizer to two
 188 cultivars of sweetpotato resulted insignificant changes in vine growth due to differences in
 189 genetic composition of the sweet potato varieties. Growing *Apomuden* and *Okumkom* on
 190 amended plots during the major season in 2012 resulted in significantly longer vine length than
 191 those grown on the same treatments during the minor season in 2011 at 12 WAP. This might be
 192 due to good climatic conditions coupled with slow and effective release of nutrients, especially,
 193 potassium from the manure applied during the major season in 2012. [11] reported that vine
 194 length and growth habit of sweetpotato depend on cultivar and environment, particularly, the
 195 climate of the growing area available to the plant and the plant's nutrition.



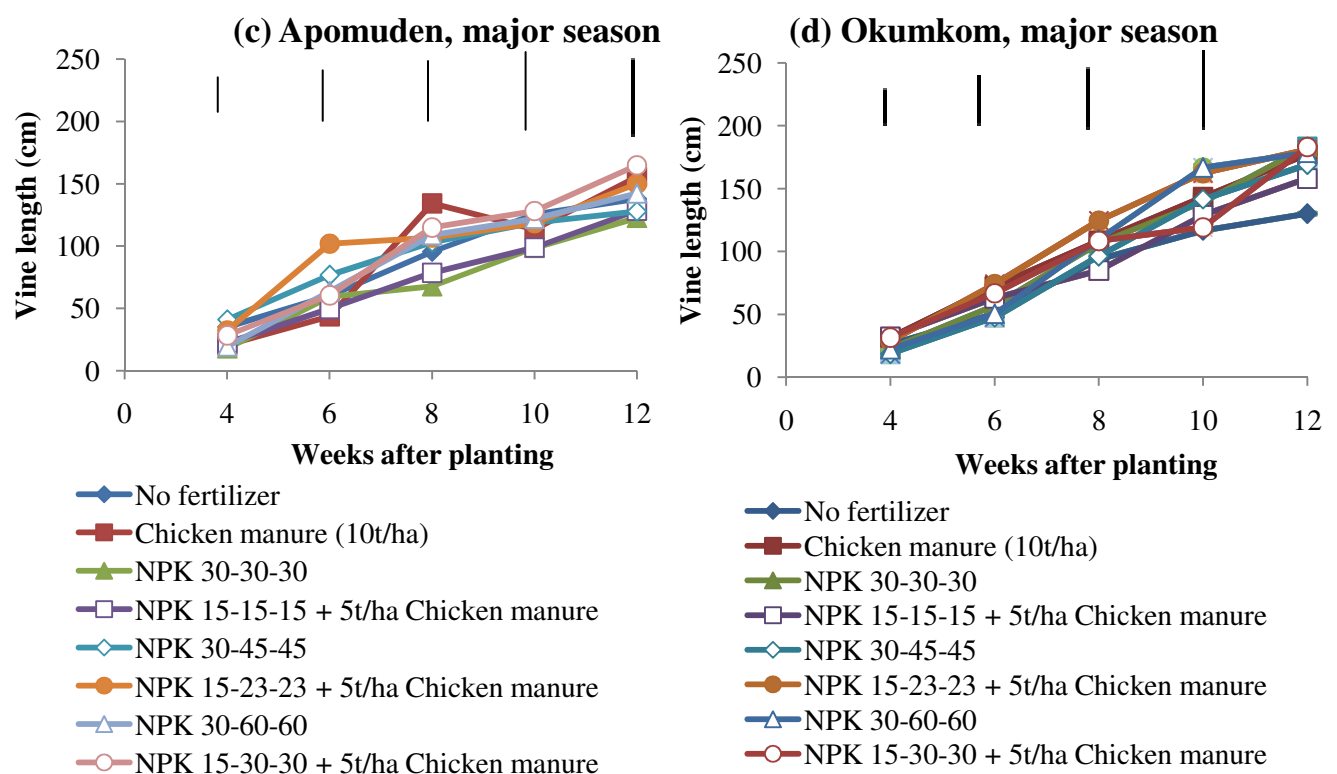


Fig. 2 Vine length as influenced by chicken manure and inorganic fertilizer during minor season, 2011 (a, b) and major season, 2012 (c, d)

Yield and yield components of sweet potato

Marketable Tuber Weight Per Plot

There was no significant difference in marketable tuber weight per plot between *Apomuden* and *Okumkom* grown on amended and the control plots during the minor growing season (table 5). Application of 15-30-30 kg/ha NPK + 5t/ha CM to *Apomuden* produced significantly higher marketable tuber weight per plot than the other manured and the control plots during the major season. *Apomuden* and *Okumkom* grown on amended plots during the major season had significantly higher marketable tuber weight per plot than in the minor season. This observation might be due to the high nitrogen in chicken manure. [12] observed that when the soil nitrogen level is zero or low increasing nitrogen fertilization affects the weight of tuberous roots.

Table 5 Marketable tuber weight per plot as influenced by poultry manure and inorganic fertilizer during (a) minor season, 2011 and (b) major season, 2012

Weight of marketable tubers per plot (g)–minor season, 2011		Weight of marketable tubers per plot (g) –major season, 2012	
	Mean		Mean

	Apom.	Okumk.	Apomd.	Okumk.		
Fertilizer rate						
10t/ha CM	2.13	1.65	1.89	6.47	3.93	5.20
15-15-15 kg/haNPK + 5t/ha CM	3.33	1.53	2.43	8.73	2.90	5.82
15-23-23kg/ha NPK + 5t/ha CM	3.30	3.00	3.15	7.23	7.00	7.12
15-30-30 kg/ha NPK + 5t/ CM	3.15	2.63	2.89	12.23	3.23	7.73
30-30-30 kg/ha NPK	3.18	1.95	2.56	7.03	3.83	5.43
30-45-45 kg/ha NPK	3.75	2.80	3.28	5.80	4.23	5.02
30-60-60 kg/ha NPK	3.43	2.68	3.05	6.97	6.23	6.60
No fertilizer (control)	2.98	3.05	3.01	2.80	1.93	2.37
Mean	3.15	2.41		7.16	4.16	
LSD (0.05) Variety	0.64			0.23		
LSD (0.05) Fertilizer	NS			NS		
LSD (0.05)Variety x Fertilizer	NS			NS		

215

216

217 Unmarketable Tuber Weight

218 No significant difference in unmarketable tuber weight per plot was observed between
 219 *Apomuden* grown on amended and the control plots in the minor season (table 6). *Apomuden*
 220 grown on amended and the control plots produced significantly higher unmarketable tuber
 221 weight in the minor season than *Okumkom* grown on the same plots for the same season.
 222 Significant increase in unmarketable tuber weight per plot occurred between *Apomuden* grown
 223 on 30-60-60 kg/ha NPK and 15-23-23 kg/ha NPK +5t/ha CM during the major growing season.
 224 *Okumkom* grown on amended plots except 10t/ha CM, 30-30-30 kg/ha NPK and 15-15-15kg/ha
 225 NPK-+ 5t/ha CM and the control differed significantly from *Apomuden* grown on the same plots
 226 in the major season. The significant increase in unmarketable tuber weight per plot in *Okumkom*
 227 compared to *Apomuden* might be attributed to differences in genetic composition of both
 228 varieties. *Okumkom* grown on amended plots and the control plots during the major season had

229 significantly higher unmarketable tuber weight per plot than *Okumkom* on same plots during the
230 minor season.

231
232 **Table 6: Unmarketable tuber weight per plot as influenced by poultry manure and**
233 **inorganic fertilizer during minor season, 2011 and major season, 2012**
234

	Weight of unmarketable tubers(g)-minor season, 2011			Weight of unmarketable tubers(g)-major season, 2012		
	Apomu	Okum.	Mean	Apumu.	Okum.	Mean
Fertilizer rate						
10t/ha CM	0.50	0.30	0.40	0.23	0.20	0.22
30-30-30 kg/ha NPK	0.33	0.33	0.33	0.55	0.22	0.38
15-15-15 kg/ha NPK + 5t/ha CM	0.37	0.27	0.32	0.31	0.18	0.25
15-23-23 kg/ha NPK + 5t/ha CM	0.13	1.73	0.93	0.32	0.22	0.27
15-30-30 kg/ha NPK + 5t/ha CM	0.57	1.13	0.85	0.26	0.13	0.20
30-45-45 kg/ha NPK	0.23	0.73	0.48	0.30	0.31	0.30
30-60-60 kg/ha NPK	0.67	1.23	0.95	0.44	0.16	0.30
No fertilizer (control)	0.27	0.27	0.27	0.37	0.18	0.27
Mean	0.38	0.75		0.35	0.20	
LSD (0.05) Variety		0.23			0.07	
LSD (0.05) Fertilizer		NS			NS	
LSD (0.05) Variety x Fertilizer		NS			NS	

235
236
237 **Average Tuber Weight**
238 A significant difference occurred between *Apomuden* grown on amended plots except 15-15-15
239 kg/ha NPK + 5t/ha CM and 15-23-23 kg/ha NPK+ 5t/ha CM from *Okumkom* in average tuber
240 weight in both seasons (table 7). *Apomuden* on 10 t/ha CM, 30-30-30 kg/ha NPK and the control
241 recorded the same average tuber weight during the minor season in 2011. Application of 15-30-
242 30 kg/ha NPK+ 5 t/ha CM to *Apomuden* resulted in slightly higher average tuber weight

compared to the other manured and the control plots during the major season in 2012. Generally, *Apomuden* and *Okumkom* under amendment and unamended plots during the major season produced higher average tuber weight than during the minor season. This observation might be due to differences in genetic composition of the sweet potato varieties and their response to soil nutrients coupled with better climatic condition during the major cropping period.

Table 7: Average tuber weight as influenced by poultry manure and inorganic fertilizer during minor season, 2011 and major season, 2012

	Average weight per tuber (kg) minor season- 2011			Average weight per tuber (kg)major season- 2012		
	Apom	Okum.	Mean	Apom.	Okum.	Mean
Fertilizer rate						
10t/ha CM	0.22	0.16	0.19	0.36	0.23	0.29
15-15-15kg/ha NPK + 5t/ha CM	0.15	0.23	0.19	0.35	0.19	0.27
15-23-23 kg/ha NPK + 5t/ha CM	0.24	0.18	0.21	0.31	0.30	0.30
15-30-30 kg/ha NPK + 5t/ha CM	0.26	0.16	0.21	0.53	0.21	0.37
30-30-30 kg/ha NPK	0.22	0.16	0.19	0.37	0.24	0.31
30-45-45 kg/ha NPK	0.30	0.17	0.23	0.38	0.26	0.31
30-60-60kg/ha NPK	0.23	0.16	0.20	0.43	0.23	0.33
No fertilizer(control)	0.22	0.21	0.21	0.28	0.19	0.23
Mean	0.23	0.18		0.37	0.23	
LSD (0.05) Variety	0.04			0.06		
LSD (0.05) Fertilizer	NS			NS		
LSD (0.05) Variety x Fertilizer	NS			NS		

Total Tuber Weight Per Plant

There was non significant increase in tuber weight per plant in both varieties in response to fertilization during both cropping seasons (table 8). This could be because there traits are much

more influenced by the inherent characteristics of the crop than the application of fertilizers. Total tuber weight per plant for both varieties grown on amended plots during the major season was higher than during the minor season. Significant decrease in total tuber weight during the minor cropping season could be explained mainly in terms of the harsh climatic factors. High temperature affects photosynthates availability through enhanced leaf senescence. Differences in vegetative growth and soil nutrients experienced during the cropping period might have also decreased total tuber weight per plant. Even though a significant decrease in total tuber weight was observed during the minor season than during the major cropping season, tuber yields were higher and tuber numbers were also higher. [5], indicated that mean tuber weight is inversely proportional to the number of tubers.

Table 8: Total tuber weight per plant as influenced by poultry manure and inorganic fertilizer during minor season, 2011 and major season, 2012

	Total weight of tubers per plant (kg)- minor season,2011		Mean	Total weight of tubers per plant (kg)-major season, 2012		Mean
	Apom.	Okum.		Apom.	Okum.	
Fertilizer rate						
10t/ha CM	2.36	1.85	2.11	6.97	4.23	5.60
15-15-15 kg/ha NPK + 5t/ha CM	3.64	1.71	2.67	9.10	3.17	6.13
15-23-23 kg/ha NPK + 5t/ha CM	3.63	3.22	3.43	7.37	8.73	8.05
15-30-30 kg/ha NPK + 5t/ha CM	3.42	2.76	3.09	12.80	4.37	8.58
30-30-30 kg/ha NPK	3.73	2.17	2.95	7.37	4.17	5.77
30-45-45 kg/ha NPK	4.05	3.11	3.58	6.03	4.97	5.50
30-60-60kg/ha NPK	3.87	2.84	3.35	7.63	7.47	7.55
No fertilizer (control)	3.35	3.23	3.29	3.07	2.20	2.63
Mean	3.52	2.61		7.54	4.91	
LSD (0.05) Variety	0.65			1.43		
LSD (0.05) Fertilizer	NS			NS		
LSD (0.05) Variety * Fertilizer	NS			NS		

Dry Matter Accumulation

The relatively higher soil fertility status, especially, the organic matter in manured plots might have accounted for higher dry matter accumulation in cultivars grown on both organic and inorganic fertilizer. The beneficial effect of organic manure on dry matter accumulation might be due to increase in organic matter rate caused by the generation of carbon dioxide during manure decomposition and improvement of the soil structure conditions which encouraged the plant to have a good root development [13]. *Apomuden* and *Okumkom* grown under amended plots, especially, 15 – 15 – 15kg/ha NPK + 5t/ha CM and 15 – 23 – 23 kg/ha NPK+ 5t/ha CM treatments had substantially higher dry matter accumulation during the major season than the minor season at 12 WAP (table 9). The increase in dry weight observed could be attributed to better climatic conditions during the major cropping season. Perhaps the higher total monthly rainfall values during the major cropping period (April – July) in 2012 than during the minor season cropping period (September – December) in 2011 which ranged from 938.5 mm and 381.7mm respectively might have contributed to significant fresh and dry weight gains during the major season. This indicates the need for supplementary irrigation at the early growth stage, especially, at the tuber formation stage during drought periods. According to [5] sweet potatoes need uniform irrigation water per week for normal growth, especially, during transplant establishment and root development to reduce incidence of disease. [11] also indicated that the growth potential of sweet potato and for that matter differences in dry weight depend on cultivar and environment. Generally, the high percentage crop establishment coupled with increased number of leaves and chlorophyll content of leaves in manured plots might have also contributed to the high dry matter accumulation.

Table 9: Tuber dry matter accumulation at harvest as influenced by poultry manure and inorganic fertilizer during minor season, 2011 and major season, 2012

	Tuber dry matter accumulation at harvest (kg)-minor season,2011			Tuber dry matter accumulation at harvest (kg)major season,2012		
	Apom.	Okum.	Mean	Apom.	Okum.	Mean
Fertilizer rate						
10t/ha CM	0.74	0.76	0.75	1.71	1.12	1.41
30-30-30 kg/ha NPK	1.11	0.72	0.91	1.28	1.57	1.43

15-15-15 kg/ha NPK + 5t/ha CM	1.10	0.72	0.91	1.80	0.86	1.33
15-23-23 kg/ha NPK + 5t/ha CM	1.21	1.36	1.29	1.92	2.63	2.27
15-30-30 kg/ha NPK + 5t/ha CM	1.09	1.17	1.13	3.08	1.51	2.29
30-45-45 kg/ha NPK	1.21	4.81	3.01	1.83	1.32	1.57
30-60-60 kg/ha NPK	1.11	1.07	1.09	1.53	1.97	1.75
No fertilizer (control)	1.24	1.43	1.34	0.55	0.71	0.63
Mean	1.10	1.51		1.71	1.46	
LSD (0.05) Variety	NS			NS		
LSD (0.05) Fertilizer	NS			0.85		
LSD (0.05) Variety x Fertilizer	NS			NS		

295

296 Tuber Market Quality of Sweet Potato at Harvest

297 Percentage Cracked and Forked Tuber

298 During the major season, a relatively higher percentage of tuber crack was recorded for both
 299 *Apomuden* and *Okumkom* grown on amended and control plots than during the minor season
 300 (table 10). The slow and effective release of N especially from amended plots coupled with high
 301 total monthly rainfall values during the cropping period (April-July) might have accounted for
 302 these observations. According to [14], excessive amounts of N may encourage excessive vine
 303 growth and result in cracked and poor storage quality. [5] also reported that over watering of
 304 sweet potato late in the cropping season may cause the tuber to crack. There was significant
 305 difference between varieties grown on amended and control plots in forked tubers across both
 306 experimental sites. The significant difference between varieties in forked tubers might be
 307 attributed to differences in genetic composition of the sweet potato varieties.

308 *Okumkom* grown on 15 – 15 – 15 kg/ha NPK+ 5t/ha CM had the highest forked tubers in both
 309 seasons. The organic and inorganic fertilizer input in terms of high N from chicken manure in the
 310 soil might have accounted for the result obtained. According to [14], excessive amounts of N
 311 may cause excessive vine growth, mishapen roots and poor storage quality. A significantly high
 312 numbers of forked tubers were produced during the minor season by both varieties planted on

313 amended and control plots than during the major season. This observation might be attributed to
314 difference in climatic conditions and soil nutrient levels especially nitrogen [14].

315

316

317 **Table 10: Percentage Cracked and forkedTubers As Influenced By Chicken Manure And Inorganic Fertilizer During Minor**
318 **Season, 2011 And Major Season, 2012**

	Percentage cracked tubers (%)-2011			Percentage cracked tuber (%) -2012			Percentage forked tubers (%)-2011			Percentage forked tubers (%)- 2012		
	Apom.	Okum.	Mean	Apom.	Okum.	Mean	Apom.	Okum.	Mean	Apom.	Okum.	Mean
Fertilizer rate												
10t/ha CM	4.4	8.1	6.3	13.55	13.59	13.57	14.4	21.4	17.9	0.0	2.99	1.50
30-30-30 kg/ha NPK	2.8	3.0	2.9	14.70	12.04	13.37	14.7	23.0	18.8	0.0	7.73	3.86
15-15-15 kg/ha NPK + 5t/ha CM	9.7	8.9	9.3	7.51	11.42	9.47	18.7	28.8	23.8	2.30	13.69	8.00
30-45-45 kg/ha NPK	5.8	9.7	7.7	12.44	6.44	9.44	19.2	20.4	19.8	0.0	8.49	4.25
15-23-23 kg/ha NPK + 5t/ha CM	5.1	5.3	5.2	11.39	7.64	9.52	19.0	23.3	21.1	6.47	8.30	7.38
30-60-60 kg/ha NPK	7.1	2.3	4.7	12.59	9.80	11.19	15.9	26.7	21.3	0.0	4.43	2.21
15-30-30 kg/ha NPK + 5t/ha CM	3.2	0.0	1.6	16.78	11.76	14.27	17.0	23.3	20.2	3.03	2.84	2.94
No fertilizer (control)	0.0	7.5	3.8	8.66	11.05	9.86	17.5	18.6	18.1	0.0	13.46	6.73
Mean	4.8	5.6		12.20	10.47		17.0	23.2		1.48	7.74	
LSD (0.05) Variety		NS			NS			3.74			2.95	
LSD (0.05) Fertilizer		NS			NS			N S			NS	
LSD (0.05) Variety * Fertilizer		NS			NS			NS			NS	

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320
321

Percentage Rotten and Deformed Tuber

A relatively higher percentage of rotten tuber was recorded, especially, on the amended plots during the minor season for both varieties than during the major season (table 11). Although total monthly rainfall values during tuber initiation (October – November) in the minor season were relatively high, the long dry period of drought coupled with high maximum temperature might have resulted in higher tuber rot during the minor season than in the major season. [5] indicated that under favourable conditions (optimum temperature of 30 – 34⁰ C) soil-borne bacteria destroy tuberous root that result in soft or wooly forms of rot. *Okumkom* grown on amended and control treatments during the major season recorded no tuber rot. Similarly, *Apomuden* and *Okumkom* grown on 15 – 30 – 30 kg/ha NPK + 5t/ha CM had no rotten tubers in both seasons. These results might be attributed to differences in genetic composition of cultivars and their responses to manure treated soil and environmental adaptation.

Percentage deformed tubers was varied depending on the composition of NPK in the compound fertilizer. *Apomuden* grown on 30-45-45 kg/ha NPK had the highest number of deformed tubers with the lowest deformed tubers on plots treated with NPK 30-30-30 in both seasons. Increased potassium nutrition in the soil might have accounted for the observed outcome. [15] reported that sweet potato grown under higher K concentration results in stress at the early part of tuber bulking that leads to absorption of water due to the osmotic effects of increased tissue salt concentration and low specific gravity that result in high level of internal and external defects resulting in misshapen tubers. *Okumkom* and *Apomuden* grown on both amended and the control plots during the major season gave substantially higher percentage of deformed tubers than during the minor season. A relatively slow and effective release of nutrients from amended plots in the soil combined with better climatic condition during the major cropping period could have accounted for this observation.

351 **Table 11: Percentage Rotten and Deformed Tubers as Influenced by Chicken Manure and Inorganic Fertilizer during Minor**
 352 **Season, 2011 and Major Season, 2012**

	Percentage rotten tubers (%) - minor season, 2011			Percentage rotten tubers (%) - major season, 2012			Percentage deformed tubers (%) - minor season, 2011			Percentage deformed tubers (%) - major season, 2012		
	Apom.	Okum.	Mean	Apom.	Okum.	Mean	Apom.	Okum.	Mean	Apom.	Okum.	Mean
Fertilizer rate												
10t/ha CM	6.3	0.0	3.2	0.0	0.0	0.0	17.0	17.5	17.2	17.41	18.82	18.17
30-30-30 kg/ha NPK	6.7	6.2	6.4	2.17	0.0	1.08	12.0	14.5	13.3	12.66	14.53	13.60
15-15-15 kg/ha NPK + 5t/ha CM	0.0	3.9	1.9	0.0	0.0	0.0	14.8	15.2	15.0	15.30	17.07	16.19
30-45-45 kg/ha NPK	2.1	4.1	3.1	0.0	0.0	0.0	19.2	16.3	17.7	19.19	19.57	19.38
15-23-23 kg/ha NPK + 5t/ha CM	3.6	3.7	3.7	0.0	0.0	0.0	15.6	12.0	13.8	16.06	15.34	15.70
30-60-60 kg/ha NPK	2.1	3.9	3.0	2.04	0.0	1.02	14.0	14.8	14.4	15.16	23.34	19.25
15-30-30 kg/ha NPK + 5t/ha CM	0.0	0.0	0.0	0.0	0.0	0.0	17.0	11.9	14.5	18.72	16.77	17.75
No fertilizer (control)	0.0	0.0	0.0	2.11	0.0	1.06	17.2	18.3	17.7	17.78	19.05	18.42
Mean	2.6	2.7		0.79	0.00		15.9	15.1		16.54	18.08	
LSD (P 0.05) Variety	NS			NS			NS			NS		
LSD (P 0.05) Fertilizer	NS			NS			NS			NS		
LSD (P 0.05) Variety * Fertilizer	NS			NS			NS			NS		

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Percentage Pest Infested Tuber

The level of pest infestation of tubers of *Apomuden* grown on amended and control plots was more severe than *Okumkom* in both seasons which may be attributed to differences in variety, cultural and environmental adaptation. Generally, the level of pest infestation of *Apomuden* and *Okumkom* grown on amended and control plots during the minor season was higher than during the major season except for *Apomuden* grown on 15 – 30 – 30 kg/ha NPK + 5t/ha CM treated plot (table 12). Although total monthly rainfall values were relatively high during the initial cropping period (September – October) during the minor season intermittent long periods of drought during root development might have resulted in high incidence of pest infestation during the minor season. [16] indicated that weevil attack is most serious when drought persists for a long time, more especially, in the minor season and also when wet and warm conditions increase the likelihood of serious pest infestations respectively.

Table 12: Percentage pest infested tubers at harvest as influenced by poultry manure and inorganic fertilizer during minor season, 2011 and major season, 2012

	Percentage pest infested tuber at harvest (%)-2011			Percentage pest infested tuber at harvest (%) -2012		
	Apom.	Okum.	Mean	Apom.	Okum.	Mean
Fertilizer rate						
10t/ha CM	24.1	9.7	16.9	14.3	5.3	9.8
15-15-15 kg/ha NPK + 5t/ha CM	28.3	14.4	21.3	23.8	15.2	19.5
15-23-23 lg/ha NPK + 5t/ha CM	37.4	17.4	27.4	24.9	9.2	17.0
15-30-30 kg/ha NPK + 5t/ha CM	20.1	12.1	16.1	25.6	11.5	18.5
30-30-30 kg/ha NPK	29.6	16.0	22.8	14.7	6.1	10.4
30-45-45kg/ha NPK	30.1	16.9	23.5	21.4	5.8	13.6
30-60-60 kg/ha NPK	27.4	15.7	21.6	21.6	9.6	15.6
No fertilizer (control)	28.8	11.2	20.0	18.2	5.0	11.6
Mean	28.2	14.2		20.6	8.5	

LSD (0.05)	Variety	5.94	5.22
LSD (0.05)	Fertilizer	NS	NS
LSD (0.05)	Variety x Fertilizer	NS	NS

Percentage Diseased Tuber

In the minor season application of 15-23-23 kg/ha NPK + 5t/ha CM to *Apomuden* had the highest percentage diseased tubers with the lowest recorded by 15-30-30 kg/ha NPK + 5t/ha CM treatment (table 14). There was no significant difference between treatments. *Okumkom* grown on amended plots had no diseased tubers except on 15-15-15 kg/ha NPK + 5t/ha CM plot which gave the highest percentage diseased tuber. *Apomuden* differed significantly from *Okumkom* in percentage diseased tubers with the latter recording significantly lower percentage diseased tuber. In the major season *Apomuden* grown on 15-30-30 kg/ha NPK +5t/ha CM plot recorded the highest percentage diseased tubers with the lowest recorded by 15-15-15 kg/ha NPK +5t/ha CM treatment. There was no significant difference between treatments in percentage diseased tubers. In the case of *Okumkom* plants grown on 30-45-45 kg/ha NPK plot recorded the highest percentage diseased tubers (8.19%) followed by 15-15-15 kg/ha NPK +5t/ha CM plot (8.03%). The 10t/ha CM and the control plots recorded no diseased tubers (0.0 %).

The level of disease infection for *Apomuden* and *Okumkom* grown on amended plots during the major season was slightly higher than during the minor season except for *Okumkom* planted on 10t/ha CM which did not record diseased tubers in both seasons. Differences in soil fertility coupled with high total monthly rainfall during the major cropping season (April – July) might have contributed to this result. According to [17], high soil organic matter content coupled with humid, wet weather once the vines cover the ground can encourage tuberous root diseases with superficial conditions caused by a fungal disease which produces sweet potato roots covered with black lesions.

397 **Table 14: Percentage Diseased and Sprouted tubers as Influenced by Chicken Manure and Inorganic Fertilizer during Minor**
 398 **Season, 2011 and Major Season, 2012**

		Percentage diseased tubers(%) - minor season, 2011			Percentage diseased tubers (%) - major season, 2012			Percentage sprouted tubers (%) - minor season, 2011			Percentage sprouted tubers - (%) - major season, 2012		
		Apom.	Okum.	Mean	Apum.	Okum.	Mean	Apom.	Okum.	Mean	Apom.	Okum.	Mean
Fertilizer rate													
10t/ha CM		10.8	0.0	5.4	13.73	0.0	6.87	4.39	0.00	2.19	0.0	0.0	0.0
30-30-30 kg/ha NPK		11.8	0.0	5.9	16.97	5.45	11.21	0.00	3.41	1.70	0.0	0.0	0.0
15-15-15 kg/ha NPK + 5t/ha CM		5.2	3.9	4.6	3.27	8.03	5.65	0.00	0.00	0.00	6.46	0.0	3.23
15-23-23 kg/ha NPK + 5t/ha CM		13.2	0.0	6.6	11.15	2.72	6.94	2.55	0.00	1.27	3.95	0.0	1.98
15-30-30 NPK + 5t/ha CM		3.1	0.0	1.5	18.71	2.77	10.74	0.00	0.00	0.00	2.14	0.0	1.07
30-45-45 kg/ha NPK		4.4	3.4	3.9	8.55	8.19	8.37	2.91	3.74	3.33	2.63	0.0	1.32
30-60-60 kg/ha NPK		4.7	0.0	2.4	6.22	5.26	5.74	0.00	0.00	0.00	0.0	1.78	0.89
No fertilizer (control)		4.5	0.0	2.3	14.48	0.0	7.24	4.53	0.00	2.27	0.0	0.0	0.0
Mean		7.2	0.9		11.63	4.05		1.80	0.89		1.90	0.22	
LSD (0.05)	Variety	4.02			NS			NS			NS		
LSD (0.05)	Fertilizer	NS			NS			NS			NS		
LSD (0.05)	Variety * Fertilizer	NS			NS			NS			NS		

399

400

Percentage Tuber Sprout

Mean sprouted tuber for *Apomuden* grown on amended and control plots was higher than *Okumkom* in both seasons (). Generally, *Apomuden* grown on amended plots during the major season had higher sprouted tuber than during the minor season. Differences in variety, climatic condition and soil temperature might have accounted for this result. According to [18], high moisture content leading to high perishability of tubers, lack of storage skills which discourages production, sprouting and chilling injury during low temperature storage are some of the pre and post harvest problems associated with sweet potato.

Changes in Starch and Sugar Content in Two Varieties of Sweet Potato Tubers at Harvest

Apomuden and *Okumkom* grown on amended and the control plots had higher sugar content at harvest during the minor season than in the major season (table 15). The relatively high total maximum temperature values during the cropping season (September to December) in the minor season compared to the major season might have resulted in the higher tuber sugar content at harvest. The higher organic carbon content of the soil from the minor season site implies a higher capacity for the synthesis of carbon and subsequently sugar in both varieties. Results in both seasons elicit significant effect of the chicken manure and inorganic fertilizer either alone or in combination on starch content of tubers for both varieties at harvest. The significant difference in starch content on both varieties and for the two cropping seasons might be explained in terms of differences in cultivar and climatic variations during the year and cropping season. Metabolic activity is temperature dependent for the formation of starch based on the cultivar. In both seasons significantly higher starch content was produced by *Okumkom* than *Apomuden* grown on amended and control plots at harvest although application of 30-45-45 kg/ha NPK and 15-30-30 kg/ha NPK+ 5t/ha CM to *Okumkom* did not show any significant effect from *Apomuden* in the major season. This observation could be due to differences in cultivar and their responses to soil nutrient for the formation of starch during tuber bulking.

In both seasons there was a significant difference between *Okumkom* grown on amended plots from *Apomuden* in tuber starch content at harvest (table 15). This observation might be due to differences in cultivar. *Apomuden* and *Okumkom* grown on amended and control plots except *Okumkom* grown on 30-30-30 kg/ha NPK and 30-45-45 kg/ha NPK had higher tuber starch

432 content at harvest in the minor season than in the major season. The relatively higher rainfall
433 during the major season than the minor season combined with the amended plots might have
434 supported faster plant growth in terms of leaf appearance during the major season. Excessive
435 rainfall might have accounted for the excessive vine growth and delayed tuber bulking and
436 maturation which resulted in low starch content during the major season.

437 **Table 15: Percentage Sugar and Starch Content of Tubers at Harvest as Influenced by Chicken Manure and Inorganic**
 438 **Fertilizers during Minor Season, 2011 and Major Season, 2012**
 439

	Percentage Sugar of harvest at harvest- (%) 2011		Mean	Percentage Sugar of tuber at harvest (%t-2012		Mean	Percentage Starch of tuber at harvest (%) - 2011		Mean	Percentage Starch of tuber at harvest (%) - 2012		Mean
	Apom.	Okum.		Apom.	Okum.		Apom.	Okum.		Apom.	Okum.	
Fertilizer rate												
10t/ha CM	11.7	24.5	18.1	8.0	11.0	9.5	13.3	27.9	20.6	9.6	12.4	11.0
15-15-15 kg/ha NPK + 5t/ha CM	12.1	19.0	15.5	11.0	11.5	11.2	14.3	21.6	17.9	12.0	13.0	12.5
15-23-23 kg/ha NPK + 5t/ha CM	13.5	18.5	16.0	9.7	11.7	10.7	14.9	20.9	17.9	10.8	13.2	12.0
15-30-30 kg/ha NPK + 5t/ha CM	13.0	16.5	14.7	10.7	11.0	10.8	14.9	18.6	16.7	12.0	12.4	12.2
30-30-30 kg/ha NPK	10.5	17.7	14.1	10.0	12.0	11.0	11.9	20.4	16.1	12.0	13.7	12.8
30-45-45 kg/ha NPK	10.0	20.0	15.0	11.7	12.0	11.8	11.2	23.2	17.2	13.2	13.8	13.5
30-60-60 kg/ha NPK	11.0	23.0	17.0	10.0	12.0	11.0	13.2	25.7	19.4	11.0	13.8	12.4
No fertilizer (control)	12.1	17.0	14.5	9.7	11.7	10.7	16.8	19.6	18.2	10.8	13.2	12.0
Mean	11.7	19.5		10.1	11.6		13.8	22.2		11.4	13.1	
LSD (0.05)	Variety	0.08			0.43			0.17			NS	
LSD (0.05)	Fertilizer	0.17			0.86			0.34			NS	
LSD (0.05)	Variety * Fertilizer	0.24			1.21			0.48			NS	

440

Starch content of tubers at 12 weeks under pit, ash or grass storage

Apomuden and *Okumkom* under 30- 45-45 kg/ha NPK and stored in pit had the highest tuber starch content during the major season compared to the minor season table 16. The increased starch content in both varieties under NPK 30-45-45 and stored in pit during the major season might probably be due to high moisture level coupled with relatively low temperature under the pit during the major season as well as the influenced of P and K in the chicken manure applied during crop cultivation. Starch synthesis increased with increasing K concentration up to an optimum tuber concentration of 1.8% [5], indicated that P tends to increase starch synthesis and hasten maturity. Tubers stored in pit showed the most effective storage method with regard to tuber starch content followed by ash and grass storage in that order at 12 weeks in storage in both seasons. The inability of tuber to store well under grass storage conditions might probably be due to high temperatures in the storage conditions during storage. [19] indicated that post-harvest physiological processes that may affect storability include evaporation of water from the product, changes in chemical composition, and damage by extreme temperatures. *Okumkom* and *Apomuden* grown on amended and control plots and stored in pit for 12 weeks for both seasons had a relatively low starch content compared to the starch level at harvest. The high respiration rate due to long term storage condition for tubers of both varieties stored in pit probably might have contributed to this result. Starch content of tubers tends to reduce during long term storage as a result of high respiration rate and is in conformity with Ray and [20] who found that respiration and transpiration contribute to weight loss and alteration of internal and external appearance of potatoes, because starch is used as a respiratory substrate, the starch content decreased during storage and subsequent the dry matter also decreased.

Sugar content of tubers at 12 weeks under pit, ash or grass storage

Application of chicken manure either alone or in combination with inorganic fertilizers to *Okumkom* and stored in pit had higher sugar content than *Apomuden* at 12 weeks in storage in both seasons (table 17). The significant increase in sugar content in *Okumkom* over *Apomuden* might be due to differences in cultivar and their ability to respond to compositional change based on manure treatment and storage condition. *Apomuden* grown on amended and control plots and stored in pit during the major season had better storability with higher sugar content than during the minor season at 12 weeks in storage. The high relative humidity and water content in tuber

471 coupled with low temperature in the pit during the major season storage period might have
472 accounted for the results obtained. According to [21], higher humidity during long-term storage
473 are likely and that the extent of enzyme amylase activity depends on temperature and tuber water
474 content. Pit storage was the most effective storage method followed by ash with grass storage
475 being the least in sugar content for both cultivars at 12 weeks in storage in both seasons. [22]
476 indicated that if quality of the stored crop and weight variation of tubers is considered then the
477 use of soil banks (pit) is the most effective compared to ash and grass.

478

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480

481 **Table 16: Percentage Starch Content of Tubers 12 Weeks in Pit or Ash Storage as Influenced by Chicken Manure and**
 482 **Inorganic Fertilizers During Minor Season, 2011 and Major Season, 2012**
 483

	Percentage Starch of tuber 12 weeks in storage (%) - (Pit)-, Minor season 2011			Percentage Starch of tuber 12 weeks in storage (%) - (Pit)- Major season 2012			Percentage Starch of tuber 12 weeks in storage (%) - (Ash)-major season 2012		
	Apom.	Okum.	Mean	Apom.	Okum.	Mean	Apom.	Okum.	mean
Fertilizer rate									
10t/ha CM	10.8	15.6	13.2	12.0	13.0	12.5	0.0	0.0	0.0
15-15-15 kg/ha NPK + 5t/ha CM	10.8	12.0	11.4	11.7	13.2	12.4	0.0	0.0	0.0
15-23-23 kg/ha NPK + 5t/ha CM	9.0	13.6	11.3	11.0	13.4	12.2	11.7	0.0	5.8
15-30-30 kg/ha NPK + 5t/ha CM	11.5	0.0	5.7	11.0	12.0	11.5	0.0	0.0	0.0
30-30-30 kg/ha NPK	0.0	0.0	0.0	11.0	-0.0	5.5	0.0	13.2	6.6
30-45-45 kg/ha NPK	10.4	0.0	5.2	13.2	13.8	13.5	0.0	14.0	7.0
30-60-60 kg/ha NPK	0.0	0.0	0.0	11.0	0.0	5.5	0.0	13.8	6.9
No fertilizer (control)	11.5	0.0	5.7	11.0	12.0	11.5	0.0	0.0	0.0
Mean	8.0	5.1		11.49	9.67		1.46	5.12	
LSD (0.05) Variety		0.60			0.45			0.14	
LSD (0.05) Fertilizer		1.21			0.91			0.29	
LSD (0.05) Variety x Fertilizer		1.72			1.29			0.42	

484 **Table 17 Percentage Sugar Content of Tubers 12 Weeks in Pit And Ash Storage as Influenced By Poultry Manure And**
 485 **Inorganic Fertilizer During Minor Season, 2011 and Major Season, 2012**

	Percentage Sugar of tuber 12 weeks after storage (Pit)			Percentage Sugar of tuber 12 weeks after storage (Pit)			Mea n	Percentage Sugar of tuber 12 weeks after storage (Ash)		
	Apum.	Okum.	Mean	Apom	Okum.			Apum	Okum	mean
Fertilizer rate										
10t/ha CM	9.6	14.2	11.9	11.0	11.6	11.3		0.0	0.0	0.0
15-15-15 kg/ha NPK + 5t/ha CM	9.7	11.0	10.3	10.5	11.7	11.1		0.0	0.0	0.0
15-23-23 kg/ha NPK + 5t/ha CM	8.2	13.0	10.6	10.0	11.8	10.9		0.0	0.0	0.0
15-30-30 kg/ha NPK + 5t/ha CM	10.0	0.0	5.0	10.0	11.0	10.5		0.0	0.0	0.0
30-30-30 kg/ha NPK	0.0	0.0	0.0	10.0	0.0	5.0		0.0	11.7	5.8
30-45-45 kg/ha NPK	9.3	0.0	4.6	11.7	12.0	11.8		0.0	12.1	6.0
30-60-60 kg/ha NPK	0.0	0/0	0.0	10.0	0.0	5.0		-0.0	12.0	6.0
No fertilizer (control)	10.2	0.0	5.1	10.0	11.0	10.5		0.0	0.0	0.0
Mean	7.1	4.7		10.4	8.6			0.0	1.31	
LSD (0.05) Variety	0.58			0.41				0.14		
LSD (0.05) Fertilizer	1.16			0.82				0.29		
LSD (0.05) Variety x Fertilizer	1.64			1.16				0.42		

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CONCLUSION

The application of chicken manure and inorganic fertilizer as mineral supplements either singly or in combination affected the yield of sweet potato in both vegetative biomass and fresh tuber production and enhanced sugar as well as starch content of tubers at harvest and after three months storage. Market qualities of tubers at harvest and physiological changes or qualities of tuber during storage of the two varieties of sweet potato under three different storage conditions (pit, ash and grass) across both seasons were also improved. *Apomuden* and *Okumkom* grown on amended plots produced higher percent tuber cracks and disease infected tubers at harvest during the major season than during the minor season. Similarly, higher percentage of deformed tubers was produced at harvest with *Okumkom* and *Apomuden* during the major season than during the minor season. *Apomuden* and *Okumkom* grown on amended and control plots produced higher tuber starch content at harvest during the minor season than the major season except for *Apomuden* grown on 30-30 -30 kg/ha NPK and 30-45-45 kg/ha NPK treatments which recorded lower values. However, higher starch content at harvest was obtained with *Okumkom* compared to *Apomuden* grown on amended and the control plots in both seasons. This suggests the influence of variety and nutrient supply on starch production in sweet potato and also that starch production in the tubers is better in the minor season than the wet season. Farmers may significantly improve yields of sweet potato through the application of chicken manure in combination with inorganic fertilizer. However for increased tuber market quality farmers should manure their plots but rather reduce supplementary irrigation during tuber bulking stage. Similarly, for enhanced tuber starch content farmers should plant *Okumkom* and store tubers in pit.

REFERENCES

1. Hakiza,J.I.,Taryamureeba,G.,Kakuhenzire,R.M.,Odongo,B.,Mwanga,R.M.,KanzikwerA, R.and Adipala ,E.(2000) Potato and sweetpotato improvement in Uganda;A historical perspective. *African potato Association Conference Proceedings* 5: 47-58
2. Scott, G. J., Rosegrant,M. and Ringler, C. (2000).Roots and tubers for the 21st century. Trends, projections and policy for developing countries,food, agriculture and the environmental discussion paper. International Food Policy Research Institute (IFPRI). Washington D. C. USA.

3. Smailing, E.M.A., Nandwa, S.M. and Janssen, B.H. (1997) Soil Fertility in Africa. 47-61 pp Madison, W.I. USA: SSSA Special Public No. 51.
4. Crop Research Institute (2003), Council for Scientific and Industrial Research. Ghana. Annual Report.
5. Degras, L. (2003). Sweet Potato: The tropical Agriculturist. Macmillan publishers Ltd. Lima Peru.
6. Janseens, M. (2001). Crop production in tropical Africa. CIP Royal Library Albert I. Brussels pp 204, 220-221.
7. Bradbury, J. H. and Holloway, W. D. (1988). Chemistry of tropical root crops: significance for nutrition and agriculture in the Pacific. ACIAR Monograph 6, Australian Centre for International Agricultural Research.
8. Hartemink, E. A., Johnson, M., O'Sullivan, J. N. and Poloma, S. (2000a). Nitrogen use Efficiency of taro and sweetpotato in the humid lowland of Papua New Guinea, Agriculture, Ecosystems and Environment, 79: 271-280.
9. Hartemink, E. A., Poloma, S. Maino, M., Powell, K. S., Egenae, J. and O'Sullivan Hileman, L. H. (2000b). The Fertilizer Value of Broiler litter. Arkansas Agricultural Exp. L Station, Report Series 158: 3-7.
10. 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 Fertilizer. World Journal of Agricultural Sciences 6 (4): 370-373
11. [11] Raemaekers, R.H. (2001). Crop production in tropical Africa. CIP Royal Library Albert I Brussels pp 204, 220-221.
12. Soil Research Institute of Council for Scientific and Industrial Research, Ghana (2003) Soil Nutrient (Mineral) Content.
13. Arisha, H.M.E., Gad, A. A. and Younes, S.E. (2003) Response of some pepper cultivars to organic and mineral nitrogen fertilizer under sandy soil conditions. Zagazig J. agric. res., 30: 1875-1899
14. Lerner, B.R. (2001) The sweet potato. Purdue University cooperative extension service. Vegetables HO-136.W. West Lafayette.
15. Bergmann, W. (1992): Nutritional Disorders of Plants. Gustav Fischer Verlag, New York. pp 111-141.

16. Sowley, E.N.K. (1999) Etiology of Storage Root of Sweet Potato (*Ipomoea batatas* (L) Lam) and its Control by Curing. A thesis presented to the Department of Crop Science, University of Ghana, Legon, pp. 120
17. [1Maynand, A.A. and Hill, E.V. (2000) How to grow sweet potatoes in Connecticut. The Connecticut Agricultural Experimental station. New Haven. CT 06504
<http://www.ct.gov/caes>
18. IITA (1996). Sweet potato. In sustainable food production in sub-Saharan Africa 1; International Institute of Tropical Agriculture (IITA) contribution. pp. 79-83
19. Bechoff, A., (2011) Effect of drying and storage on the degradation of total carotenoids in orange fleshed sweet potato cultivars. International Journal of food Science and Technology
20. Ray, R.C. and Ravi, V, (2005) Post harvest spoilage of sweet potato in Tropics and control measures. Critical reviews in food science and nutrition 45 23-64
21. Tumuhimbise G. A., Namutebi A1 and Muyonga, J. H. (2010) Changes in microstructure, beta carotene content and *in vitro* bioaccessibility of orange-fleshed sweet potato roots stored under different conditions. African journal of food nutrition and development. Vol. 10 (8)
22. Mutandwa, E. and Tafara G. C. (2007) Comparative Assessment of Indigenous Methods of Sweet Potato Preservation among Smallholder Farmers: Case of Grass, Ash and Soil based Approaches in Zimbabwe." *African Studies Quarterly* 9, no. 3