Original research papers

Effects of different storage methods and fertilizer rates on quality of sweetpotato (*Ipomoea batatas* L.) storage roots

Abstract

Storage of fresh roots of two sweet potato [E1]varieties (*Apomuden* and *Okumkom)* for up to 12 weeks was conducted from January to March, 2011 (minor cropping season) and from August to October, 2012 (major cropping season) using three storage methods by pit, ash, and grass. Roots were harvested at week 16 after planting. Sweet potato [E2]was previously amended by treatments of chicken manure (CM) and inorganic fertilizer (NPK). The experimental design used was ~~designed in a~~ randomized complete block. The result shows that *Okumkom* applied with 15-30-30 kg/ha NPK + 5t/ha CM and stored in grass gave lowest pest infested roots in both seasons. *Okumkom* and *Apomuden* stored in ash or grass had lower root weight loss and root sprout during the major season. *Okumkom* applied with 15-15-15 kg/ha NPK +5t/ha CM and 30 – 45 – 45 kg/ha NPK and stored in grass did not sprout at 12 weeks after storage in both seasons. *Okumkom* applied with 15-30-30 kg/ha NPK + 5t/ha CM and 15-15-15 kg/ha NPK +5t/ha CM and stored in grass produced the least pest infestation, lower root weight and root sprout than *Apomuden*. However, for lower rotten roots, the amended roots should be stored in pit than in grass or ash.

Keywords: Sweet potato, pit storage, grass storage, ash storage, *Apomuden*, *Okumkom*

INTRODUCTION

Sweet potato [E3](*Ipomoea batatas* L.) is a perennial plant. It is a member of the *Convolulaceae* family. Flowers can be white or purple, and leaves can be green or purple. The flesh can be white, cream, yellow, orange, or purple [1] with orange, white, and cream being the most commonly grown and eaten [2]. Sweet potatoes [E4]grow well in tropical, subtropical, and temperate areas. In all, sub-Saharan Africa produces only 6% of the world's sweet potato [E5]crop [3]. Past and current production trends shows that sweet potato [E6]output in developing countries are increasing. Sweet potato [E7]output in Africa is estimated to be growing at about five percent per year [4]. Sweet potato is one of the most important root crops in tropical Africa with domestic and industrial uses. In many parts of Africa, including Ghana, the crop is grown for its staple properties. The root is eaten boiled or as fried chips. It is also prepared into flour for various domestic uses and drinking juice can also be extracted from the root [5]. Despite nutritional importance of sweet potato, the roots have a short storage life, generally less than four weeks in the tropics. In Ghana, the production of sweet potato [E8]is concentrated almost entirely in the Northern, Upper East and Upper West regions where it is sometimes included in traditional food crop rotations. The crop is also frequently cultivated in the northern part of the Volta region, Ada-Sege areas in Greater Accra region and Komenda –Peposo areas in the ~~c~~Central region [3]. As a fast growing root crop that can be grown in all regions of the country, giving yields of 20 to 25 tons per hectare within four months, sweet potato [E9]has become an important food crop in Ghana. It is also gaining importance as an export crop in the Bawku East District of the Upper East Region. Farmers in the district export the crop to Burkina Faso, where good prices are obtained [5]. Sweet potatoes [E10]are a nutritious food, low in fat and protein, but rich in carbohydrate. Roots and leaves are good sources of antioxidants [6] fiber, zinc, potassium, sodium, manganese, calcium, magnesium, iron, and vitamin C [7]. Orange-fleshed sweet potatoes (OFSP) are also very good sources of vitamin A [6, 8]. Because of their high carotenoid content and good yields, OFSP have also been used in several small-scale studies to increase vitamin A status [9, 10, 11, 12]. One of the serious constraints in large scale production and utilization of sweet potato [E11]in Ghana is the short life of the harvested root. The crop is highly perishable and as such requires good storage technique. Lack of suitable storage facilities among small holder farmers continues to expose farmers to intermittent food shortages even after harvesting of the crop. Studies indicate that post- harvest losses due to pests and diseases ~~attack~~ can account for as much as 40-60% of crop output. Their skin is easily damaged during harvest and post-harvest handling leaving the crop highly perishable [13]. Some of the pre and post-harvest problems associated with sweet potatoes[E12] cultivation are insect damage of leaves and roots on the field, dehydration and rotting of the roots, high moisture content, lack of storage skills, sprouting and chilling injury during low temperature storage [14]. Cured sweet potato [E13]can be stored for 4–7 months at 12.8–15.6°C and 85–90% relative humidity. Non-cured sweet potatoes [E14]do not store well and have a much shorter shelf life. The post-harvest physiological processes that may affect storability include; respiration, evaporation of water from the product, sprouting, changes in chemical composition, diseases and damage by extreme temperatures. The relative importance of these processes differs with the storage environment. Farmers rely on preservation methods derived from indigenous knowledge systems for storing the harvested sweet potato [E15]roots. Important techniques of preserving crops derived from indigenous knowledge have rarely been subjected to scientific enquiry. There is knowledge gap in the science of these important indigenous techniques of preserving crops. This study is premised on the observation that local small holder farmers in Ghana use most preservation methods informally but not much is known about their efficacy from a scientific perspective. This study will also examine the different sweet potato [E16]storage technique to compare their efficacies and comparative effects on root quality. Information gleaned from these studies may help to fine-tune the indigenous technologies and popularize their use for improvement in sweet potato [E17]production and preservation.

MATERIALS AND METHODS

Sample Source

Two sweet potato[E18] varieties (*Okumkom* and *Apomuden*) were grown under eight fertilizer treatments [(i) 10 t/ha chicken manure (CM), (ii) 30-30-30 kg/ha NPK, (iii) 15-15-15 kg/ha NPK + 5 t/ha CM, (iv) 30-45-45 kg/ha NPK, (v) 15-23-23 kg/ha NPK + 5 t/ha CM, (vi) 30-60-60 kg/ha NPK, (vii) 15-30-30 kg/ha NPK + 5 t/ha CM and (viii) No fertilizer (control)] at the Multipurpose nursery research fields of the College of Agriculture Education, University of Education, Winneba, Mampong-Ashanti campus from September, 2011 to January, 2012 (minor cropping season) and April to July, 2012 (major cropping season). The experimental design was a 2 x 8 factorial arranged in randomized complete block (RCBD) with four replicates made up of eight organic manure and fertilizer rates and two sweetpotato varieties. In both cropping seasons sweet potato [E19]roots were stored for three months after each harvest during the minor and major rainy seasons from January to March, 2012 and from August to October, 2012, respectively. Climate data were sourced from Ghana Meteorological Agency, Ashanti-Mampong.

The roots were harvested at month 4 after planting. After harvest, the sweet potato [E20]roots weighing approximately ~~from~~ 200-250 g~~ram~~ were sorted to physically remove pest or disease damaged roots. The sorted roots were then cured naturally in the sun for three days by spreading them on the ground (25-30 ^{o}C, RH 80-95%). The sweet potatoes from each treatment were divided into three portions. For each storage condition or method (pit, ash and grass) the roots were divided into sixteen treatments, each containing seven roots. The experiment was arranged in a randomized complete block with three[E21] replications where treatment factors are two varieties, three storage methods and three? fertilization combinations. A simple random sampling technique was used to select roots from each treatment and replicate. The random sampling approach was to ensure that the parameters under observation are taken from representative universe of units from each replicate and treatment.

Storage Methods

The various storage methods were set up as follows:

Pit Storage Method

Storage in pit (50 x 50 x 50 cm) with alternate layers of grass and finally covered with soil. Pit store was constructed (under a shade to prevent rain water from entering the storage pit) by digging circular pit of 0.5 m diameter at the top, 0.5 m depth and 0.5 m wide at the base. The size of the pit was chosen to suit local climatic conditions and is modification of traditional pits. Pit was lined with dry plantain leaves before the sweet potato [E22]roots were stored in them. Layers of roots as per treatment were separated with about 1.0 kg dry spear grass (*Imperata cylindrica*). The sweet potatoes [E23]roots were finally covered with dry spear grass before covering them with approximately 2.0 kg of soil. The grass acted as an insulating material and ensured cool condition in the pit (17^{O} C, RH 95-100%).

Ash Storage Method

Storage in wood ash packed in a basket (50 x 50 x 70 cm) and roots alternated with layers of grass and finally covered with grass. A basket measuring 0.5 m at the base, 0.5 m high and 0.7 m wide at the top was lined with dry plantain leaves before roots were stored in them. Roots as per treatment were thoroughly coated with wood ash by mixing them with two (2) kg of wood ash and roots were then alternated with 1.0 kg of dry spear grass The ash acted as an absorbent to moisture and has a repelling effect on pests. Wood ash has alkaline properties, which are not conducive to development of diseases.

Grass Storage Method

Roots were stored in grass packed in a basket (50 x 50 x70 cm) with roots alternating with layers of grass and finally covered with a grass. A basket measuring 0.5 m at the base, 0.5 m high and 0.7 m wide at the top was lined with plantain leaves before roots were placed in them. Layers of roots as per treatment were separated with about 1.0 kg dry spear grass (*Imperata cylindrica*). The sweet potatoes [E24]were then finally covered with dry spear grass at the top.

In each basket and pit 112 roots were placed and subjected to the experimental conditions. These quantities of roots were obtained from the field experiments after harvest. After setting up the sweet potato [E25]under the various storage methods it was monitored for three months and data were collected every two weeks on weight loss in sweet potato [E26](as a % of the total weight stored), sprouting of sweet potatoes [E27](%), spoilage of sweet potatoes [E28](%), root shrinkage, and pests and disease infested roots.

RESULTS AND DISCUSSION

The weather conditions during the experimental periods show that differences in climatic factors (rainfall, temperature and relative humidity) were observed between both cropping seasons (Tables 1 and 2). The total monthly rainfall in the minor rainy season was 429.8 mm and it occurred from September, 2011 to January, 2012 with the peak in September and October (Table 1). The mean monthly temperature of the area for the minor cropping season ranged between 22.2 °C to 32.9 °C with the highest daily of 33.7 °C occurring in January, 2012. The mean monthly relative humidity ranged from 35 to 98 % with the peak occurring between September and November. The bimodal rainfall pattern of Mampong-Ashanti gave the area two seasons; the major cropping season occurred between March and July and the minor cropping season from September to November with one month drought spell in August [15]. In the major rainy season (2012), the total monthly rainfall was 948.5 mm and it occurred from April to July, 2012 with the peak in May and June (Table 2). The mean monthly temperature of the site for the major season ranged between 21.9° C to 31.4° C, with the highest daily of 33.3° C occurring in April. The mean monthly relative humidity ranged from 61 to 97 % with the peak occurring between April to July [16].

Table 1: Climate data in 2011 minor cropping season

	Total rainfall (mm)	Mean relative humidity (%)		Mean Temperature (°C)	
Month		**06.00**	**15.00**	**Min.**	**Max.**
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
January, 2012	48.1	84	35	20.8	33.7
Total	429.8				

Source: Ghana Meteorological Agency – Mampong Ashanti, 2011

Table 2: Climate data in 2012 major cropping season

	Total Rainfall (mm)	Mean Relative Humidity (%)		Mean Temperature (°C)	
Month		**06.00**	**15.00**	**Min.**	**Max.**
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
Total	948.5				

Source: Ghana Meteorological Agency – Mampong Ashanti, 2012

Percentage pest infested roots under grass, ash and pit storage

Apomuden applied with grown under 15-15-15 kg/ha NPK +5t/ha CM and stored under pit and ash had the highest percentage pest infested root at 12 weeks of storage during the minor cropping growing season. Similarly, *Apomuden* applied with grown under 15-23-23 kg/ha NPK +5t/ha CM and stored under pit, ash and grass gave the highest percentage pest infested root at 12 weeks of storage during the major cropping growing season (Fig. 1). The high pest infestation in *Apomuden* grown under amended plots and stored under pit and ash during both growing seasons might be due to varietal differences in terms of high susceptibility of *Apomuden* to weevil attack and their response to different storage conditions. This agrees with Capinera, [17] that *Cylas puncticollis* is a serious pest for susceptible varieties of sweet potato[E29]. *Apomuden* and *Okumkom* applied with grown under 30-30-30 kg/ha NPK and 15-15-15 kg/ha NPK +5t/ha CM, respectively and stored under ash did not store well at 12 weeks of storage during the minor cropping growing season. *Apomuden* and *Okumkom* grown under amended and the unamended plots and stored in pit, ash and grass during the major season had higher percent pest infested roots compared with the minor season (Fig. 1). This might be due to the low total monthly rainfall combined with high relative humidity during the day and relatively low maximum temperature during the storage period during the major season compared with the minor cropping season storage period. CIP [4] indicated that wet and warm conditions increased the likelihood of serious pest infestations.

Okumkom grown under 15-30-30 kg/ha NPK + 5t/ha CM plot and stored in grass had the lowest pest infested roots at 12 weeks after storage (WAS) in both seasons (Fig. 1). The good keeping quality in terms of least pest infestation in *Okumkom* might be attributed to differences in cultivars and their response to manure treatment and storage conditions. *Apomuden* grown under amended plots and stored in pit at 12 WAS recorded the highest pest infested roots followed by *Apomuden* under ash storage with the least recorded by *Apomuden* under grass storage at 12 WAS in both seasons. The high pest infestation of *Apomuden* grown under amended plots and stored in pit might be due to the manure treatments on the roots and their response to different storage conditions. [E30] Ahn [18] indicated that the effectiveness of different storage treatments is closely linked with the conditions under which the crop was grown. In the course of the study it was observed that under the pit storage condition, apart from sweet potato [E31]weevils which were the common pest identified among all the three storage conditions cricket and millipede were also identified, especially during the major cropping season which produced the result obtained.

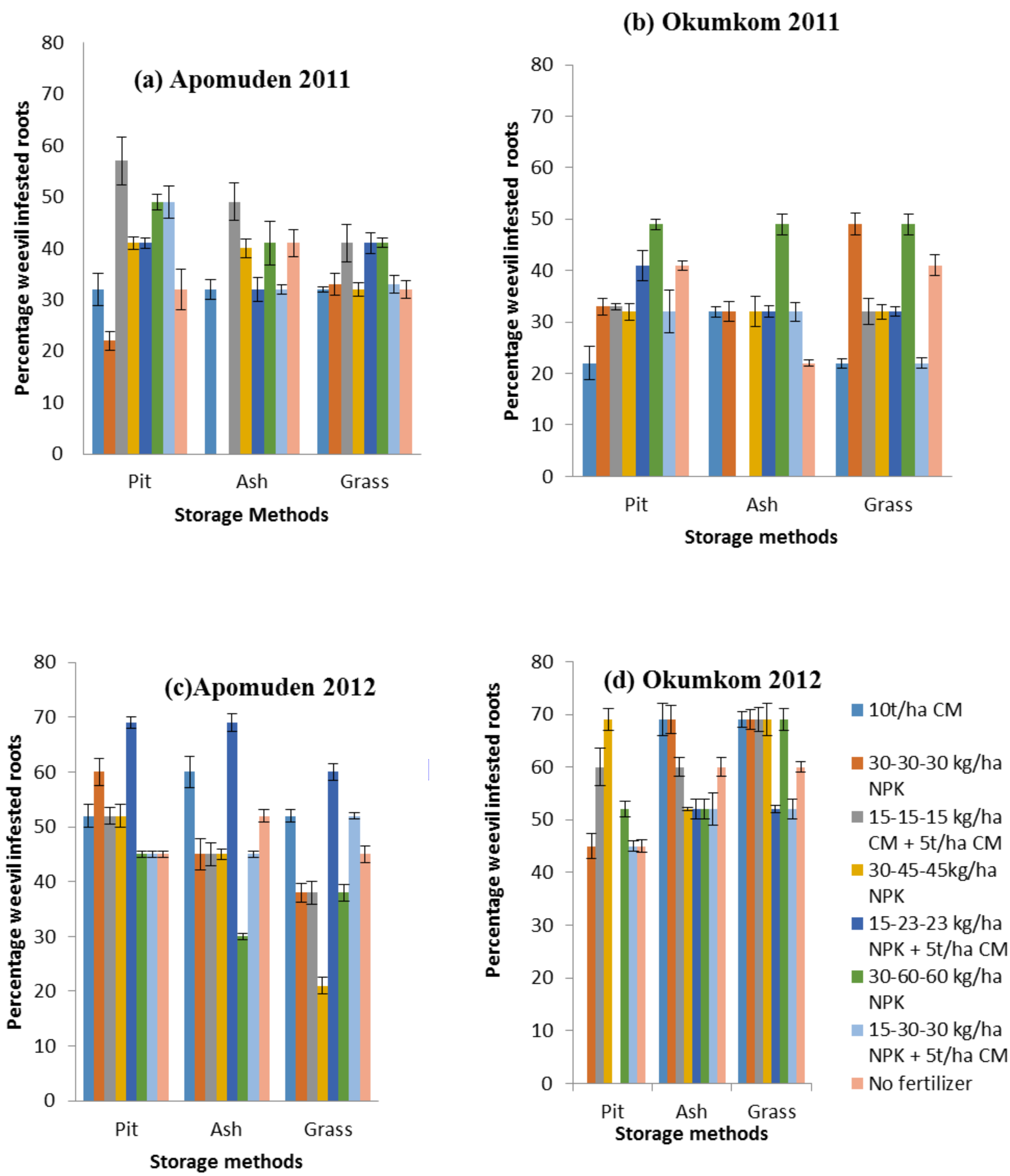


Figure 1: Percentage weevil infested roots of sweet potato [E33]varieties as influenced by storage methods and organic and inorganic fertilizers during (a, b) minor cropping season, 2011 and (c, d) major cropping season, 2012.

Percentage rotten roots under grass, ash and pit storage

Apomuden applied with grown under 30-45-45 kg/ha NPK plot and stored in ash and pit had the highest number of rotten roots at 12 WAS during both storage periods and differed significantly from those grown under amended and control plots (Fig. 2). The highest severity of decay in *Apomuden* applied with grown under 30- 45- 45 kg/ha NPK plot and stored in ash and pit compared with the other treatments might be due to high weevil damage, especially in pit storage at 12 WAS. However, *Okumkom* grown under amended plots and stored in grass at 12 WAS during the minor cropping season had no zero rotten roots (Fig. 2). *Apomuden* and *Okumkom* grown under amended and control plots and stored in grass had higher number of rotten roots followed by storage in ash with the least number recorded in pit storage during the major croppin season than during the minor cropping season. The severity of decay under grass storage condition might be due to the high temperatures that existed during the long-term storage period coupled with high weevil infestation. This result is similar to those found by Mutandwa and Tafara [19] that if quality of the stored crop and weight variation of roots is considered, then use of soil banks is the most effective. According to Tortoe *et al.*, [20] grass based technique involves the use of dry grass to create dry and cool conditions within the storage area which help to avoid the development of fungal diseases that normally thrive under humid and warm conditions.

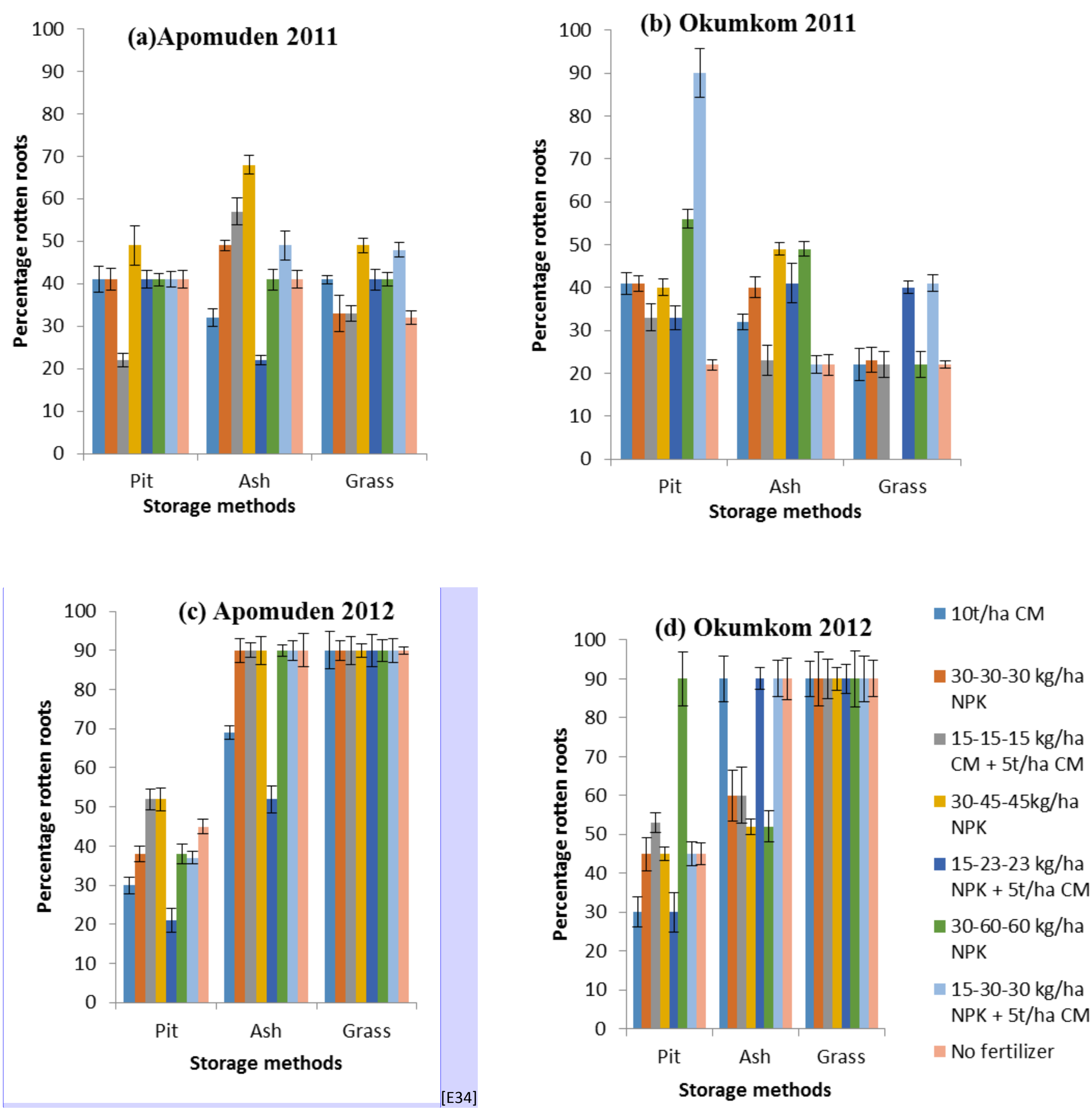


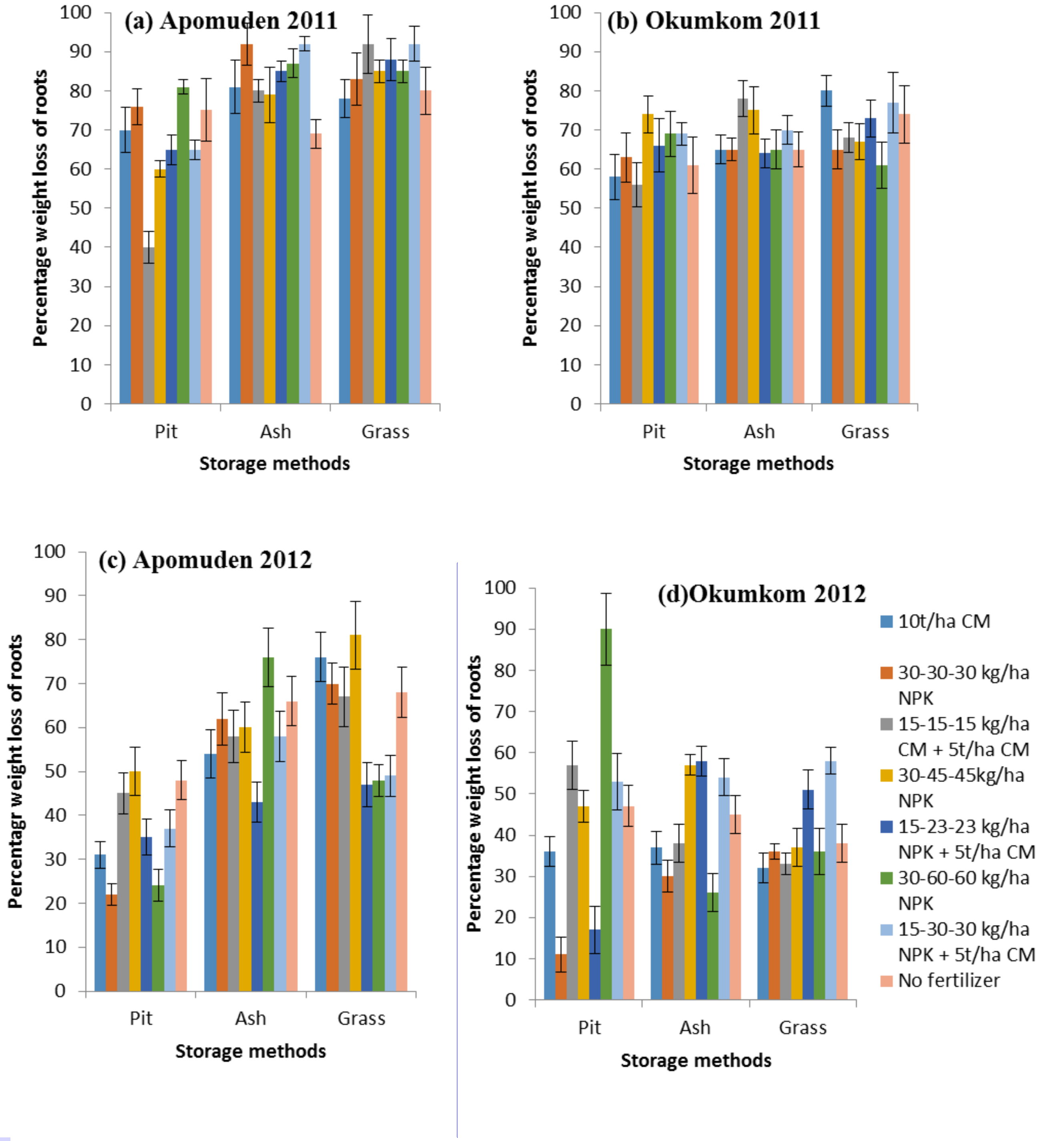
Figure 2: Percentage rotten roots of sweet potato [E35]varieties as influenced by storage methods and organic and inorganic fertilizers during (a, b) minor cropping season, 2011 and (c, d) major cropping season, 2012.

Percentage weight loss of roots under grass, pit and ash storage

There was a significant difference between *Apomuden* and *Okumkom* grown under amended and control plots and stored in ash, grass and pit in weight loss of roots in both seasons (Fig. 3). The significant effect on root weight loss might be due to cultivar differences as influenced by mineral fertilizer and organic manure application during growth combined with the differences in storage conditions. Weight loss of roots for both *Apomuden* and *Okumkom* grown under amended and control plots and stored in ash, grass and pit increased linearly from the beginning of storage in both season. This result is similar to those found by Amoah [21] that weight loss of sweet potato [E36]roots stored in an evaporative cooling barn with three different pre-storage treatments (ash, brine and *Lantana camara* extract) increased linearly from the inception of storage. *Okumkom* applied with 15-15-15 kg/ha NPK + 5t/ha CM and stored in ash had the highest root weight loss at 12 WAS in both season. This observation might be due to combined effect of organic and inorganic fertilizers applied during growth coupled with application of ash during storage. This result agrees with those found by Biswas *et al.*, [22], Mutandwa and Tafara [19] that application of ash to sweet potato [E37]roots act as an absorbent to moisture resulting in low

relative humidity in the storage condition with resultant high water loss through the root skin surface. Generally, amended roots of *Apomuden* stored in ash, grass and pit during the minor cropping season storage at 12 WAS gave higher root weight loss than during the major cropping season storage (Fig. 3). This might be attributed to differences in cultivar, low relative humidity coupled with relatively high temperature during the storage period in the minor cropping season than during the major cropping season ~~storage period~~. Generally, *Apomuden* had lower dry matter content and therefore more weight loss compared with *Okumkom*. Metabolic activity of sweet potato [E38][E39]is temperature dependent for the formation of starch based on the cultivar[E40]. Degras [23] reported that there is a significant role of starch content for determination of fresh and dry matter with the range dependent on cultivar for its classification.

High temperature under storage condition are likely to result in high rates of respiration, increased rates of metabolic breakdown which could result in increased levels of root weight loss. Woolfe [24] and Degras [23] reported that during the storage period of sweet potato [E41]roots, roots loss weight owing to respiration and transpiration.



[E42]

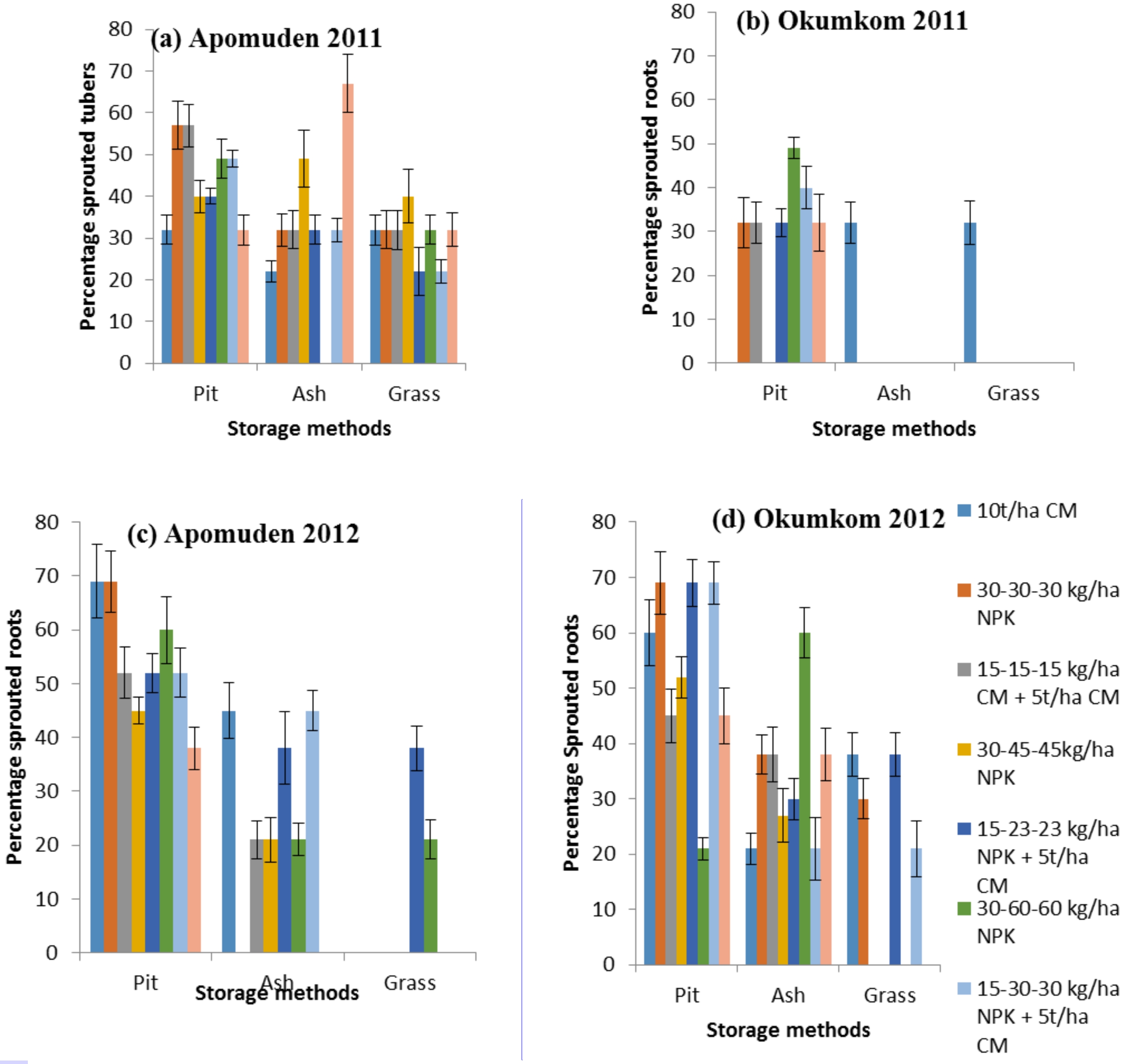
Figure 3: Weight loss percentage of sweet potato roots as influenced by two varieties, three storage methods and fertilizer combinations during minor cropping season, 2011 (a, b) and major cropping season, 2012 (c, d)

Percentage root sprouting under grass, ash and pit storage

Apomuden under amended plots except 15-15-15 kg/ha NPK +5t/ha CM and the control and stored in pit gave higher root sprouting than *Okumkom* grown under the same plots and under similar storage condition at 12 WAS in both seasons (Fig. 4). This might be due to differences in cultivar and its response to fertilizer before storage and resultant physiological changes during storage. Sweet potato [E43]cultivars differ very markedly in the tendency to sprout during storage. *Apomuden* and *Okumkom* grown under amended and control plots and stored in pit during the major season storage period differed significantly from ash and grass storage at 12 WAS in root sprout (Fig. 4). The relatively low temperature, high relative humidity and relatively high rainfall during the major cropping season storage ~~period~~ compared with the minor cropping season storage ~~period~~ might have resulted in humid and cool storage condition in pit. According to NSPRI [14] low temperature storage can result in sprouting which is one of the post-harvest problems associated with sweet potato [E44]cultivated and stored in Nigeria. Slight accumulation of water in the pit due to relatively high rainfall observed during the latter stage of the major cropping season storage ~~period~~ might have also contributed to high root sprout in pit storage. This result is similar to those found by Dandago and Gungula [25] that accumulation of moisture in soil based technique which involves digging of pits at a certain level of inclination could lead to sprouting of roots.

Okumkom grown under amendment treatments, especially 15-15-15 kg/ha NPK +5t/ha CM and 30 – 45 – 45 kg/ha NPK and stored in grass did not record root sprout at 12 WAS in both seasons (Fig. 4). This might be due to differences in cultivar and their response to amended treatment during growth combined with the dry grass used during storage of root. Biswas *et al.*, [22] and Setiawati [26] reported that the effectiveness of different storage treatments is closely linked with the conditions under which the crop was grown and that storage conditions are more effective when the roots have matured in dry soils. Similarly, root damage is lower if the roots are covered with humid rice straw mulch, although the roots tend to sprout. Probably the dry grass used to store root reduced or caused no root sprout in grass storage due to the dry storage condition. *Apomuden* and *Okumkom* grown under amended and control plots and stored in pit gave higher root sprout than under ash and grass storage at 12 WAS in both seasons (Fig. 4).

Sprouting was initiated in pit storage at two weeks of storage. This might be due to humid grass straw mulch as a result of high relative humidity in pit storage condition substantiating the finding of Setiawati [26]~~ that root damage is lower if the roots are covered with humid rice straw mulch, although the roots tend to sprout~~. Amoah *et al.*, [21] also reported that sprouting of sweet potato roots was initiated after 4 weeks of storage.



[E45]

Figure 4: Percentage sprouted root of sweet potato varieties as influenced by storage methods and organic and inorganic fertilizers during minor cropping season, 2011 (a, b) and major cropping season, 2012 (c, d)

CONCLUSION

For minimum pest infestation of sweetpotato ~~potato~~ roots, farmers should grow *Okumkom* and apply 15-30-30 kg/ha NPK + 5t/ha CM and store the roots in grass during the minor cropping and the major cropping seasons. Farmers are to store *Okumkom* and *Apomuden* in pit, ash or grass for decreased root weight loss during the major cropping season. For minimum root sprout farmers should store sweetpotato ~~potato~~ roots in ash and grass than in pit during the major season. The high rainfall experienced during the major cropping season storage ~~period~~ combined with low temperature might have resulted in lower root weight loss with high dry matter content[E46]. This might have led to the production of high root sprouts in pit during the major season. Farmers are encourage to store *Okumkom* grown under amendment treatments, especially 15-15-15 kg/ha NPK +5t/ha CM and 30 – 45 – 45 kg/ha NPK in grass as roots did not sprout at 12 weeks after storage in both seasons.

Apomuden grown under amendments should be stored in ash or grass than in pit since the latter produced higher root sprout at 12 WAS in both seasons.

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