Original research papers

Assessment of different storage methods of sweetpotato (*Ipomoea batatas* [L.] Lam) root as influenced by chicken manure and inorganic fertilizer: Case of grass, ash and soil based approaches

Abstract

Storage of fresh roots of two sweetpotato varieties (*Apomuden* and *Okumkom)* for up to 12 weeks were conducted using three storage methods. Roots used for the storage experiment were obtained from sweetpotato grown for 16 weeks from the day of planting on the field after each harvest during the minor and major seasons to verify the storability of sweetpotato roots as influenced by chicken manure and inorganic fertilizer. The storage period was from January to March, 2012 for the minor season and August to October, 2012 for the major season. The experimental design used was randomized complete block design. The result shows that *Okumkom* grown under 15-30-30 kg/ha NPK + 5t/ha CM plot and stored in grass gave low pest infested roots in both seasons. *Okumkom* and *Apomuden* grown under amended and control plots and stored in pit, ash or grass had decreased root weight loss during the major season and low root sprout in ash and grass storage in the same season. *Okumkom* grown under 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.

Keywords: Sweetpotato, pit storage, grass storage, ash storage, *Apomuden*, *Okumkom*

INTRODUCTION

Sweetpotato (*Ipomoea batatas* [L.] Lam) is a perennial root. 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]. Sweetpotatoes grow well in tropical, subtropical, and temperate areas. In all, sub-Saharan Africa produces only 6% of the world's sweetpotato crop [5]. Past and current production trends suggest that sweetpotato output in developing countries is increasing, for example in Africa it is estimated that it is presently growing at about five percent per year [6]. In Ghana, the production of sweetpotato 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 central region [5]. Sweetpotato 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 [7]. As a fast growing root crop that can be grown in all regions of the country, giving yields of 20 to 25 tonnes per hectare within four months, sweetpotato 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 [7]. Sweetpotatoes are a nutritious food, low in fat and protein, but rich in carbohydrate. Roots and leaves are good sources of antioxidants [8] fiber, zinc, potassium, sodium, manganese, calcium, magnesium, iron, and vitamin C [9]. Orange-fleshed sweetpotatoes (OFSP) are also very good sources of vitamin A [8, 10]. Because of their high carotenoid content and good yields, OFSP have also been used in several small-scale studies to increase VA status [11, 12, 13, 14]. One of the serious constraints in large scale production and utilization of sweetpotato in Ghana is the short shelf 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 shocks even after harvesting of the crop. Farmers rely on preservation methods derived from indigenous knowledge systems for storing the harvested sweetpotato roots. Studies indicate that post-harvest losses due to pest and diseases attack can account for as much as 40-60% of crop output. Important techniques of preserving crops derived from indigenous knowledge have rarely been subjected to scientific enquiry. Despite nutritional importance of sweetpotato, the roots have a short storage life, generally less than four weeks in the tropics. Their skin is easily damaged during harvest and post-harvest handling leaving the crop highly perishable [15]. Insect damage of the leaves and root on the field, dehydration and rotting of the roots, high moisture content leading to its high perishability, 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 sweetpotatoes cultivated in Nigeria [16]. Cured sweetpotato can be stored for 4–7 months at 12.8–15.6°C and 85–90% relative humidity.

Non-cured sweetpotatoes 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. 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 sweetpotato 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 sweetpotato production and preservation.

MATERIALS AND METHOD

Sample Source

The root samples used for the storage study were obtained from four months old two sweetpotato varieties (*Okumkom* - a white-fleshed) and (*Apomuden* - a deep-orange-fleshed variety) grown under eight fertilizer treatments [(i) 10 t/ha chicken manure (CM), (ii) 30-30-30 kg NPK/ha, (iii) 15-15-15 kg NPK/ha + 5 t/ha CM, (iv) 30-45-45 kg NPK/ha, (v) 15-23-23 kg NPK/ha + 5 t/ha CM, (vi) 30-60-60 kg NPK/ha, (vii) 15-30-30 kg NPK/ha + 5 t/ha CM and (viii) No fertilizer (control)] in a field experiment conducted 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 season) and April to July, 2012 (major season). In both cropping seasons sweetpotato roots were stored for three (3) months after each harvest during the minor and major rainy seasons from January to March, 2012 (Minor season) and August to October, 2012 (major season) respectively. The weather conditions during the experimental periods are in Tables 1 and 2.

Table 1: Climate data for 2011 rainy season for Experiment one (1)

	Total rainfall (mm)	Mean relative humidity (%)		Mean Temperature (°c)	
Month		**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
Total	1520.3				

Source: Ghana Meteorological Agency – Mampong Ashanti, 2011

Table 2: Climate data for 2012 rainy season for Experiment one (2)

	Total Rainfall (mm)	Mean Relative Humidity (%)		Mean Temperature (°c)	
Month		**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
Total	1620.3				

Source: Ghana Meteorological Agency – Mampong Ashanti, 2012

The roots were harvested at four (4) months from the day of planting. After harvest, sweetpotato roots of 200-250 g were sorted to remove physically, and pest or disease damaged roots. The sorted roots were cured naturally in the sun for three days by spreading them on the ground (25-30 ^{0}C, RH 80-95%). The sweetpotatoes 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 experimental design used was randomized complete block design where the two varieties and fertilization constituted the treatments and were each replicated three times. 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 sweetpotato roots were stored in them. Layers of roots as per treatment were separated with about 1.0 kg dry spear grass (*Imperata cylindrica*). The sweetpotatoes 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 sweetpotatoes 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 potato under the various storage methods it was monitored for three months and data was collected every two weeks on weight loss in sweetpotato (as a % of the total weight stored), Sprouting of sweetpotatoes (%), Spoilage of sweetpotatoes (%), root shrinkage, pests and disease infested roots were the data collected.

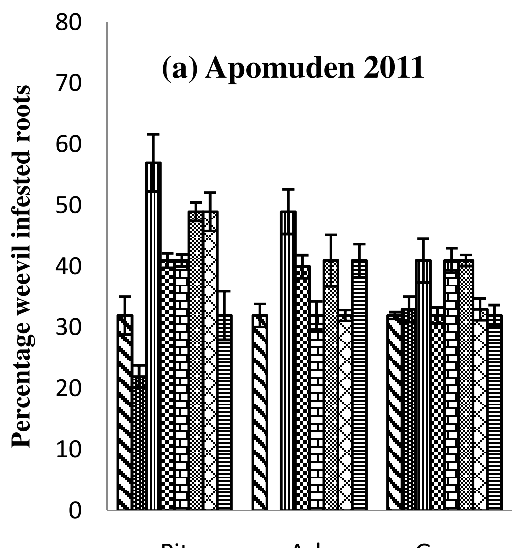
RESULTS AND DISCUSSION

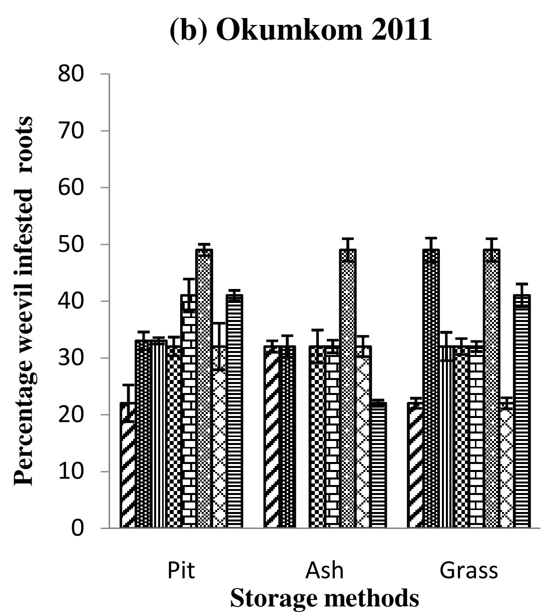
Percentage pest infested roots under grass, ash and pit storage

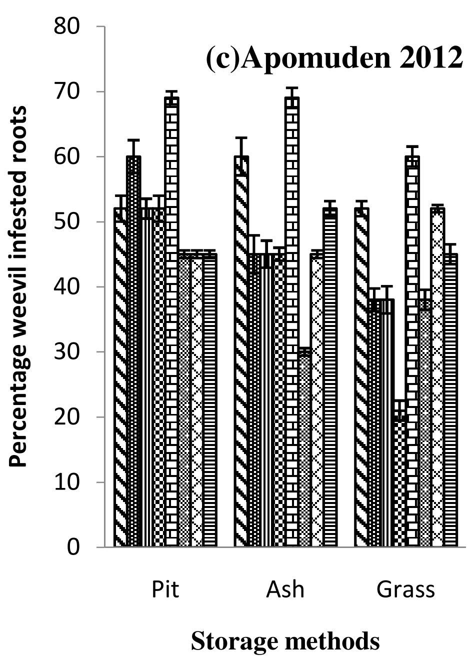
Apomuden grown under 15-15-15 kg/ha NPK +5t/ha CM and stored under pit and ash had the highest percentage pest infested root at 12 weeks of storage during the minor growing season. Similarly, *Apomuden* grown under 15-23-23 kg/ha NPK +5t/ha CM and stored under pit, ash and grass gave the highest percentage pest infested root at 12 weeks of storage during the major 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 and their response to different storage conditions. Although both varieties were grown under high level of potassium before storage, the differences in variety and their response to different fertilizer application and storage conditions might have also resulted in high pest infestation. This result however contradicts the report by [19] and [20] that potassium nutrition influences storage quality of roots. [22] reported that storage room above 19^{o} C results in loss of root quality and marketability. *Apomuden* and *Okumkom* 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 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).

The low total monthly rainfall combined with high relative humidity during the day and relatively low maximum temperature during the storage period in the major season compared with the minor season storage period might have accounted for this result. [6] 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 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. The relatively high K from chicken manure and inorganic fertilizer used to treat roots before storage might have also contributed to the least pest infestation. [22] reported that K promotes the thickening of root cell wall and growth of meristematic tissues and thus prevents penetration of the epidermis by parasites. *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. [23] 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 sweetpotato weevils which were the common pest identified among all the three storage conditions cricket and millipede were also identified, especially during the major season which produced the result obtained.







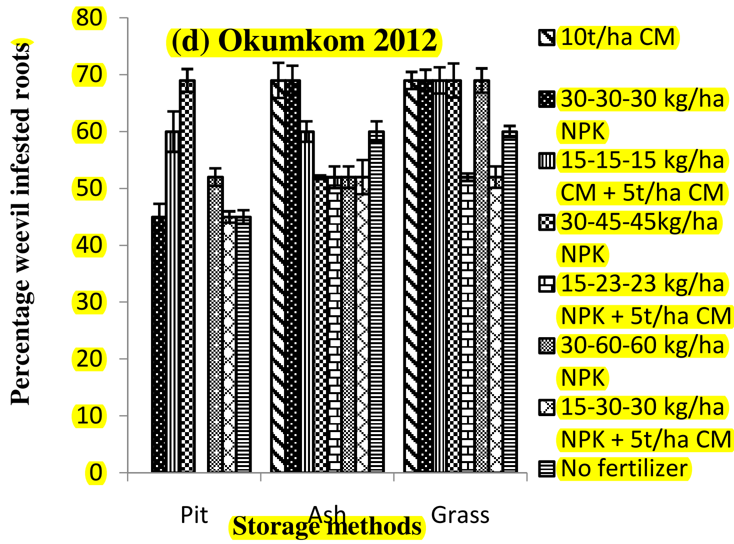


Figure 1: Percentage weevil infested roots of sweetpotato varieties as influenced by storage methods and organic and inorganic fertilizers during (a, b) minor season, 2011 and (c, d) major season, 2012.

Percentage rotten roots under grass, ash and pit storage

Apomuden 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* grown under 30- 45- 45 kg/ha NPK plot and stored in ash and pit compared with 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 season had 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 season than during the minor 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 [24] that if quality of the stored crop and weight variation of roots is considered, then use of soil banks is the most effective. This result however contradicts those found by [25] that 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.

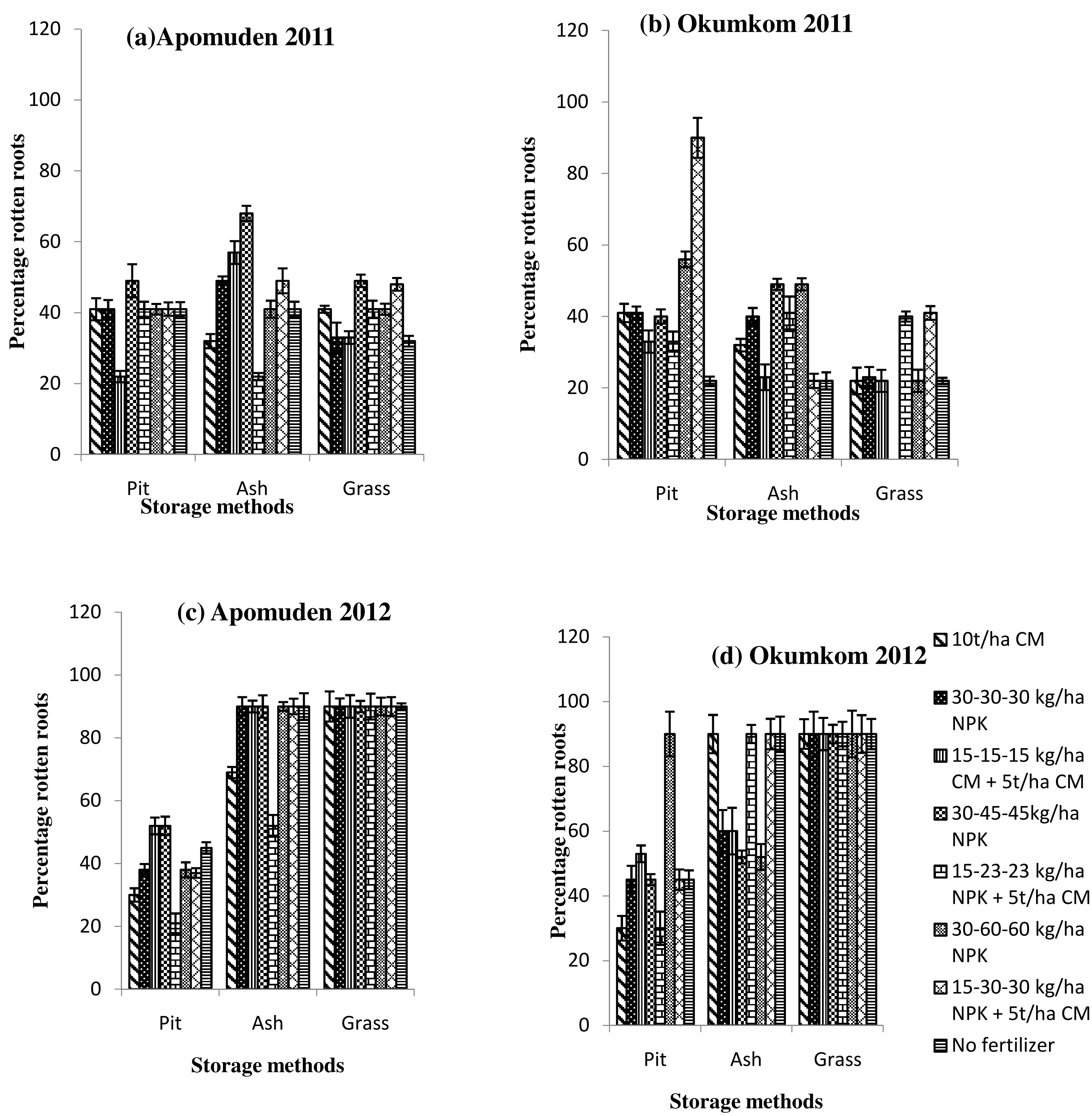


Figure 2: Percentage rotten roots of sweetpotato varieties as influenced by storage methods and organic and inorganic fertilizers during (a, b) minor season, 2011 and (c, d) major season, 2012.

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 [26] that weight loss of sweetpotato 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* grown under 15-15-15 kg/ha NPK + 5t/ha CM plot 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 to the root during growth coupled with application of ash during storage. This result agrees with those found by [27, 24] that application of ash to sweetpotato 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 season storage at 12 WAS gave higher root weight loss than during the major 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 season than during the major season storage period. 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. [17; 28] reported that during the storage period of sweetpotato roots, roots loss weight owing to respiration and transpiration.

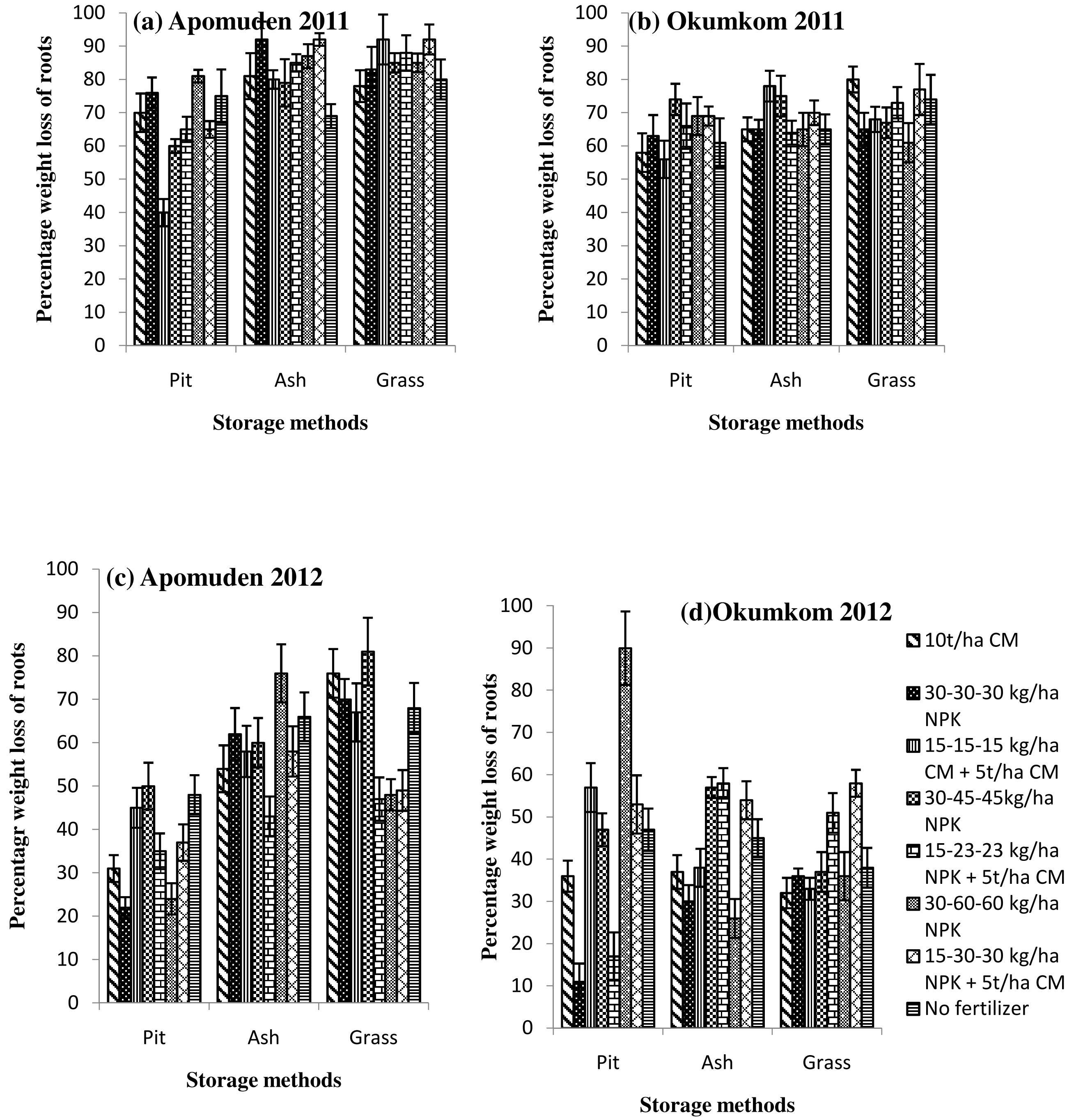
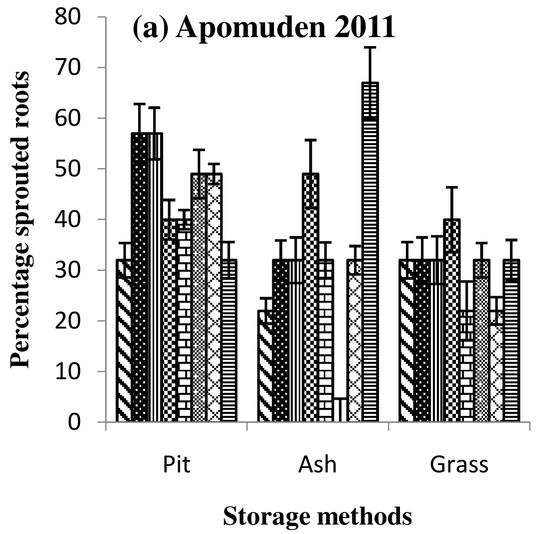


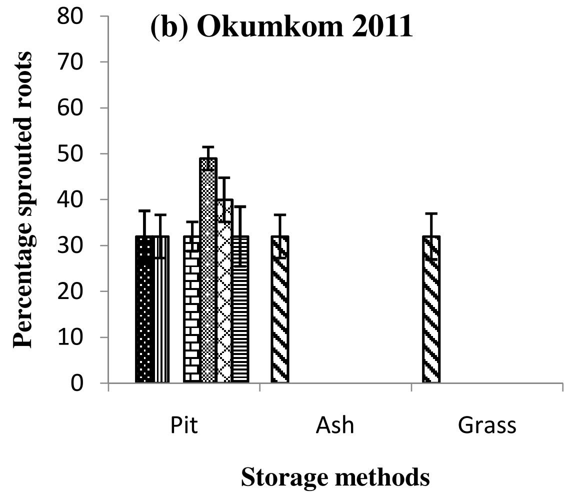
Figure 3: Percentage weight loss of roots of sweetpotato varieties as influenced by storage methods and organic and inorganic fertilizers during minor season, 2011 (a, b) and major season, 2012 (c, d

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). They might be due to differences in cultivar and its response to fertilizer before storage and resultant physiological changes during storage. Sweetpotato 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 season storage period compared with the minor season storage period might have resulted in humid and cool storage condition in pit. According to [16] low temperature storage can result in sprouting which is one of the post-harvest problems associated with sweetpotato 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 season storage period might have also contributed to high root sprout in pit storage. This result is similar to those found by [18] 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. [27; 29] 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 rootous 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 [29] that root damage is lower if the roots are covered with humid rice straw mulch, although the roots tend to sprout. [26] also reported that sprouting of sweetpotato roots was initiated after 4 weeks of storage.





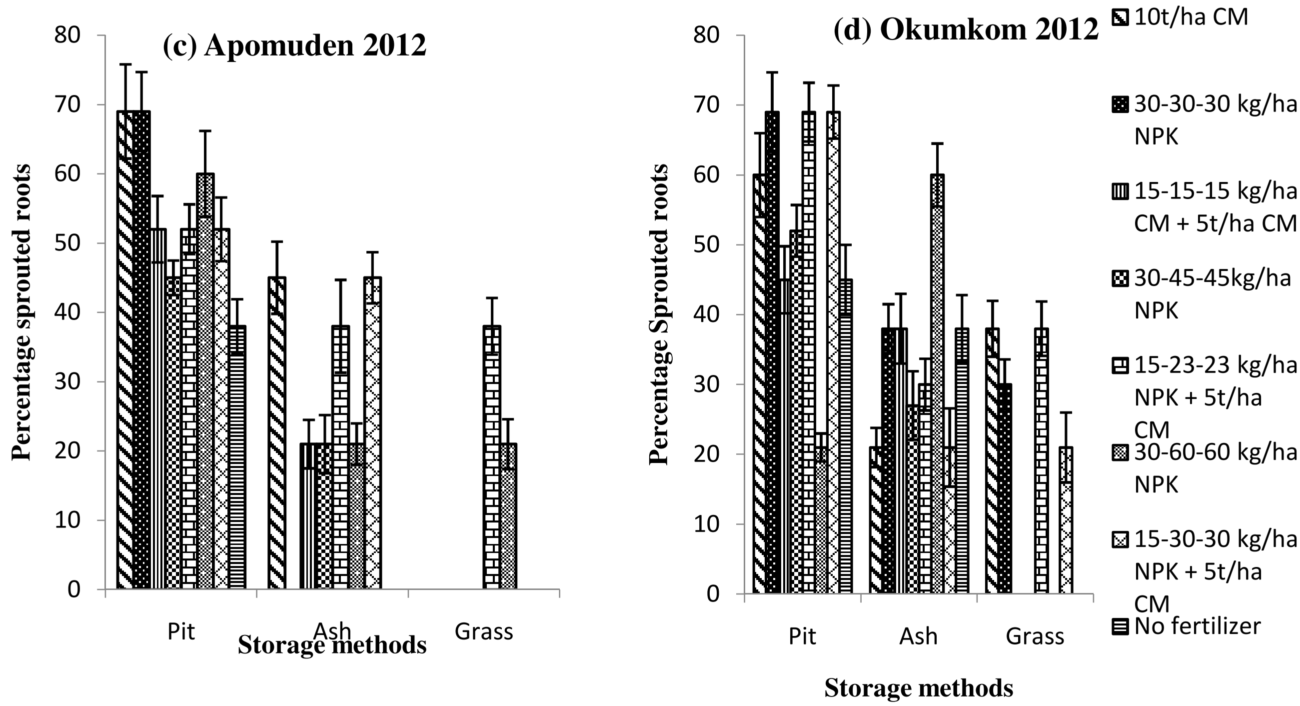


Figure 4: Percentage sprouted root of sweetpotato varieties as influenced by storage methods and organic and inorganic fertilizers during minor season, 2011 (a, b) and major season, 2012 (c, d)

CONCLUSION

For minimum pest infestation of sweetpotato roots, farmers should grow *Okumkom* under 15-30-30 kg/ha NPK + 5t/ha CM plot and store the roots in grass during the minor and the major seasons. Farmers are to store *Okumkom* and *Apomuden* in pit, ash or grass for decreased root weight loss during the major season. For minimum root sprout farmers should store sweetpotato roots in ash and grass than 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.

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