African Journal of Biotechnology Vol. 12(16), pp. 1962-1967, 17 April, 2013
Available online at http://www.academicjournals.org/AJB
DOI: 10.5897/AJB12.754
ISSN 1684–5315 ©2013 Academic Journals

Full Length Research Paper

Effect of some botanical extracts on post-harvest losses of yam (*Dioscorea rotundata*) in improved yam barn in Nigeria

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Accepted 26 September, 2012

Two storage experiments in an improved yam barn were carried out simultaneously at two locations in southern Nigeria to determine the influence of cultivar, botanical storage treatments and storage environments on the shelf life of yam (*Dioscorea rotundata*). The experiments were conducted from January to July. The temperature use efficiency (TUE) of the storage barn in Umudike increased with increase in time of storage up to April and then declined. At Nsukka, the TUE also increased with increase in time of storage even at a higher rate than what was recorded in Umudike. Dormancy period of yam tubers varied significantly (P ≤ 0.05) in the two locations with or without botanical storage treatments. Similarly, botanical treatment effects on the dormancy varied significantly (P ≤ 0.05) with *Casia alata* taking the lead in Umudike while *Azadiracha indica* had the highest effect (dormancy extension) in the Nsukka location. The mean rot incidence was lowest where *C. alata* was applied in the two locations followed by *A. indica* while mean rot incidence was highest with no treatment control. In this study, *C. alata* and *A. indica* leaf extracts showed outstanding performance in their potential abilities on reduction of post-harvest losses of yam.

Key words: Dormancy, weight loss, plant extracts, yam cultivar, improved barn.

INTRODUCTION

Yam (*Dioscorea* spp.) is an important indigenous staple food crop grown in the humid and sub-humid tropics. World yam production amounts to 30 million metric tons annually and 90% are grown in the yam belt of West Africa (FAO, 2002). The nutritional value of yam varies greatly between different species and amongst varieties of the same species. Variations are also subject to other factors such as cultivation method, climatic and soil characteristics, the stage of maturity reached by the tuber at harvest and the length of the storage or the processing technique used (Treche, 1998).

Investigations into the causes of storage losses have implicated such factors as respiration, sprouting, attack by rot-causing organisms, rodents and moisture loss among others as responsible (Okafor, 1996). During storage, dormancy is broken after a time, and sprouts appear principally from the head region. In the yam producing areas of Nigeria, the most common storage practice is to remove the sprouts as soon as possible after they appear before they become too long.

In advanced storage technology, chemicals and other treatment may be employed to suppress sprouting in order to extend the life of the tuber. Dormancy appears to be essential for maintaining tuber quality. It has been reported that growth of sprouts increases the respiration rate of the tuber (Tschannen, 2003) and causes considerable dehydration and dry matter loss. By using gibberellic acid (GA_3), Igwilo and Okoli (1998) was able to reduce the fresh loss was only reduced by 3% after 6

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months storage of *Dioscorea alata*.

Recent studies by Eze et al. (2006) showed that it was possible to prolong dormancy period of yam using GA_3 at a low concentration of 75 mg/L. A major step in the preservation of yam is the extension of dormancy period and reduction of rot causing organisms. Over the years, farmers in the southeastern Nigeria had been using some botanicals as preservatives during storage of cocoyam. The objective of the present study therefore, was to screen and five plant extracts were evaluated namely: *Azadiracha indica, Xylopia aethiopica, Occimum gratissimum, C. alata* and *Zingiber officinale* for their effectiveness in controlling post-harvest losses of yam tuber in storage.

MATERIALS AND METHODS

Two storage experiments were carried out simultaneously at the National Root Crops Research Institute (NRCRI) Umudike and the University of Nigeria, Nsukka in the year, 2010. Umudike is located between latitude 05° 29'N and longitude 07° 33'E in the tropical rainforest zones at 122 m above sea level while Nsukka is at latitude 060 52'N and longitude 070 24'E and at 447 m above sea level and is characterized by low land humid conditions. The yam cultivars were sourced from the multiplication trials at NRCRI while the botanical extracts were sourced locally from both locations. Yam cultivars were Nwaopoko, Pepa, Ezakwukpolo, Amula and Danacha whereas the botanicals were *A. indica, X. aethiopica, C. alata, Z. officinale, O. gratissimum* and no treatment (control).

The storage structure

The experiments were conducted in improved yam barns at each of the locations. The roof of the improved barn was made of corrugated aluminum sheets with ceiling of bamboo and raffia mats for heat insulation. The sides of the barn consisted of a dwarf wall (1 m high) made of cement blocks and a wire netting extended from the top of the dwarf wall to the roof of the barn. This feature enhanced air circulation and excluded rodents. Inside the barn, wooden shelves were constructed on which the tubers were placed. Inside the barn, the temperature and relative humidity gadgets were installed.

Preparation of the botanical extracts

Five consumable and medicinal (Oliver, 1986) plants parts, namely- *A. indica* (leaf), *X. aethiopica* (fruit*), O. gratissimum* (leaf), *C. alata* (leaf) and *Z. officinale* (stem tuber) were the plant materials used. The different plant parts were air dried and milled in harmer mill into powder. Four kilograms of each powdered plant parts were extracted using Peak and Tray (1956) method. The extraction was repeated two more times using 1200 ml in each case. Each solution was heated under reduced pressure and solid materials of different weights were obtained. About 25.5 g of each plant extract was dissolved in 24 L of deionized water in a plastic bowl giving a concentration of 2.10 g L^{-1}.

Experimental design

At each location, a factorial experiment was laid out in a randomized complete block design (RCBD) with four replications. The wooden shelves arranged in stacks in the yam barn served as blocks. Treatments comprised of five cultivars of white yam (*D. rotundata*)-Nwaopoko, Danacha, Pepa, Amula, and Ezakwukpolo; five plant extracts of *A. indica*, *X. aethiopica*, *O. gratissimum, C. alata* and *Z. officinale*, and control (no treatment). Each replicate contained 30 treatment combinations (plots). Each plot or treatment unit contained 10 tubers, which were labeled and weighed individually before treatment application. A total of 1200 tubers were used for the study in the two locations.

Treatment application

The primary nodal complexes at the heads of the tubers were removed to create freshness in that part of the tuber. Fresh cut was made on the tuber if the primary nodal complex disappeared during harvest or handling. This is to ensure effective movement or exchange of materials between the tuber and the prepared extracts solution. The apical sections of the tubers were soaked to 6cm depth of the appropriate plant extracts for 90 min. After soaking, tubers were air dried and then placed on the appropriate racks in the yam storage barn according to design for subsequent observation and records.

Measurements

Temperature (T°C) and relative humidity (RH) of the storage environments were monitored at 10.0 am and 4.0 pm sessions daily using a thermocouple. The daily temperature and RH was obtained by average of the two sessions. Consequently, monthly temperature and RH were also obtained by average of the daily readings in each location. The fresh weights of the tubers were taken with a top loading scale before storage and subsequently at intervals of 4 weeks during the storage. The duration of complete dormancy was determined as defined by Ireland and Passam (1985) which was given as the number of days from the start of the first visible sign of sprouting.

$$\text{Rotting (\%)} = \frac{R_0 - R_1}{R_0} \times 100$$

Where, R_0 is the number of tubers with no symptom of rots before storage and R_1 is number of tubers with symptoms of rots after storage.

$$\text{Weight loss (\%)} = \frac{W_1 - W_2}{W_1} \times 100$$

where, W_1 is the weight of tubers before storage and W_2 is the weight after storage. Temperature use efficiency of the storage barn (TUE) was calculated thus: T_0 - T_i, where, T_0 is the temperature reading value outside the barn and T_i is the temperature inside barn. Relative humidity use efficiency (RHUE) of the storage barn was also calculated thus: $RH_i - RH_0$, where, RH_i is relative humidity inside barn and RH_0 is the relative humidity outside barn.

Data analysis

All the data collected from each location were subjected to analysis of variance (ANOVA) according to the procedure for a randomized complete block design using the SAS statistical software (SAS, 1999). Treatment means were tested using standard error (S. E) of the means at 5% probability level.

Table 1. Temperature and relative humidity variations in the storage environments of the two locations.

Location	Month	Temperature (°C)			Relative humidity (%)		
		Outside barn	Inside barn	TUE	Inside barn	Outside barn	RHUE
Umudike	January	34.0	31.1	2.9	92.1	57.5	34.6
	February	33.8	29.8	3.2	89.2	60.0	29.0
	March	34.0	30.9	3.1	82.6	57.4	25.2
	April	33.7	30.0	3.7	82.8	66.8	16.0
	May	32.2	30.4	1.8	78.0	70.0	8.0
	June	30.1	29.8	0.3	80.1	67.5	12.6
	July	30.0	26.4	3.6	79.6	68.9	11.0
Nsukka	January	32.0	28.4	3.6	90.1	65.4	24.7
	February	33.5	29.0	4.5	92.5	68.2	24.3
	March	34.0	29.4	4.6	89.6	72.1	17.5
	April	33.0	28.9	4.1	85.7	74.4	11.3
	May	31.0	28.8	2.2	84.3	75.4	8.9
	June	29.2	27.9	1.3	81.9	70.0	11.9
	July	28.5	28.3	0.9	77.8	65.9	11.9

TUE, Temperature use efficiency of the storage barn; RHUE, relative humidity use efficiency of the storage barn.

RESULTS

Average monthly temperature and relative humidity of the two locations varied with Nsukka location having lower temperatures and lower relative humidity in the months of January, February and March than that were recorded in Umudike (Table 1). From April to July, there appeared to be a reversal change of weather conditions where Nsukka had higher temperature and higher RH than Umudike. TUE of the storage barn in Umudike increased with increase in time of storage up to April. At Nsukka location, the TUE also increased with increase in time of storage even at a higher rate than what was recorded in Umudike. Conversely, the relative humidity use efficiency (RHUE) of the storage barns decreased with increase in time of storage in both locations with Umudike storage environment having higher HRUE than Nsukka Environment between January and May while an increase was observed between May and June in both locations (Table 1).

Dormancy period of yam tubers varied significantly ($P \leq 0.05$) in the two locations with or without botanical storage treatments (Table 2). Similarly, botanical treatment effects on the dormancy varied significantly ($P \leq 0.05$) with *C. alata* taking the lead in Umudike while *A. indica* had the highest effect (dormancy extension) in Nsukka. Yam cultivar effect also varied significantly ($P \leq 0.05$) among the different yam cultivars. Nwaopoko cultivar consistently maintained longer dormancy periods in the two locations followed by Danacha.

Botanical storage treatment effects on rotting incidence varied significantly ($P \leq 0.05$) among the botanicals (Table 3). The mean rot incidence was lowest where *C. alata* was applied in the two locations followed by *A. indica* while mean rot incidence was highest with no treatment control compared to where botanicals were applied in both locations. Cultivar effects on rot incidence varied significantly ($P \leq 0.05$) among the cultivars with Ezakwukpolo consistently maintained the highest percentage rot in incidence in both locations while Pepa had the least mean value of rot incidence.

Botanical extracts treatment effects on weight loss of tubers in storage varied significantly ($P \leq 0.05$) among the botanical extracts and no treatment control (Table 4).

The botanical extracts of *C. alata* and *A. indica* significantly ($P \leq 0.05$) reduced weight loss of yam tubers in storage compared with other botanicals and no treatment control. On the contrary, *X. aethiopica* significantly ($P \leq 0.05$) increased weight loss of tubers compared with other botanical extracts and no treatment control in the two locations. Cultivar effects on tuber weight loss also varied among the cultivars with Nwaopoko maintaining the least value of percentage weight loss in the two locations. Amula and Pepa exhibited some inconsistency in the rate of weight loss in both locations.

DISCUSSION

Storage in barns has always aimed at modifying the temperature (T°C) and relative humidity (RH) of the storage environment which have been common practice in most yam growing areas. A preliminary survey that preceded this study revealed that in the southeastern Nigeria, most farmers store their tubers in the traditional

Table 2. Effects of botanical extracts, cultivar and location (environment) on the dormancy period (days) of yam tuber in storage.

Botanical extract	Location		Mean
	Umudike	Nsukka	
Control	61.4	56.4	58.9
C. alata	72.4	71.8	72.1
A.indica	68.0	79.10	68.6
O. gratissimum	64.0	64.3	64.2
X. aethiopica	59.8	60.0	59.9
Z. officinale	53.0	55.1	54.1
Mean	63.10	62.7	62.94
S.E.	2.60	1.98	
Pr > F	*	*	
Cultivar			
Amula	58.0	59.1	58.6
Danacha	70.7	70.8	70.8
Ezakwukpolo	65.9	65.4	65.7
Nwaopoko	72.3	79.1	75.7
Pepa	45.3	48.0	46.6
Mean	63.7	64.6	64.2
S.E.	2.40	2.60	
Pr > F	*	*	

S.E., Standard error of the means; *significance at P ≤ 0.05.

Table 3. Effects of botanical extracts, cultivar and location on rotting (%) of yam tuber in storage.

Botanical extract	Location		Mean
	Umudike	Nsukka	
Control	40.2	39.0	39.6
C. alata	34.0	35.0	34.5
A. indica	35.5	34.8	35.2
O. gratissimum	37.0	38.0	37.5
X. aethiopica	36.4	35.6	36.0
Z. officinale	37.9	35.1	36.5
Mean	36.8	36.3	36.6
S. e	1.80	1.20	
Pr > F	*	*	
Cultivar			
Amula	39.7	36.8	36.3
Danacha	37.8	37.2	37.5
Ezakwukpolo	40.2	39.5	39.9
Nwaopoko	32.7	33.6	33.2
Pepa	31.8	34.0	32.9
Mean	36.4	36.2	36.3
S.E.	1.70	1.50	
Pr > F	*	*	

S.E., Standard error of the means; *significance at P ≤ 0.05.

Table 4. Effects of botanical extracts, cultivar and location of weight loss (%) of yam tuber in storage.

Botanical extract	Location		Mean
	Umudike	Nsukka	
Control	35.5	34.6	35.1
C. alata	33.4	33.0	33.2
A. indica	33.0	32.4	32.7
O. gratissimum	36.0	34.3	35.2
X. aethiopica	37.0	36.3	36.7
Z. officinale	39.4	38.1	38.8
Mean	35.7	34.8	35.3
S.E.	1.65	1.55	
Pr > F	*	*	
Cultivar			
Amula	39.3	37.4	38.4
Danacha	36.6	35.9	36.3
Ezakwukpolo	35.4	35.5	35.5
Nwaopoko	33.6	34.0	33.8
Pepa	39.3	38.7	39.0
Mean	36.8	36.3	36.6
S.E.	1.40	1.30	
Pr > F	*	*	

S.E., Standard error of the means; *significance at P ≤ 0.05.

yam barn while in the middle belt, harvested tubers were heaped and covered with dry leaves under shade (Orkwor et al., 2006). In other instances, tubers were left inside the soil on the farm and were harvested piece meal either for immediate consumption or for dry yam chip preparation for storage. The improved yam barns used in this study had roof and insulated material as ceiling which probably helped to reduce the barn temperature while higher RH probably resulted from moisture conservation due to less air movement inside the barn. This is similar to a report by Girardin et al. (1997) who compared storage in pits and shades, and found that the pits had lower temperature and higher RH than the shades.

The differences in the T°C and RH use efficiencies of the improved barns at the study environments could be related to their locations on the globe. The Nsukka location on higher latitudes and longitudes than Umudike expectedly had cooler environments at certain period of the year and this probably affected the efficiency of the storage barns. In the months of May and June, the T°C and RH use efficiency of the storage barns lowered drastically in the two locations. This phenomenon was not surprising since that was the peak period of physiological activities of the stored yam tubers. These activities include high rate of sprouting and respiration. It is likely that the carbon dioxide (CO_2) and heat energy released inside the barns by the respiring yams increased the temperature of the storage barns thereby reducing their efficiencies.

Significant differences in the dormancy periods of tubers exhibited by the cultivars used in this study were probably due to genetic differences amongst the cultivars. Girardin et al. (1998) earlier noted that in yam, length of dormancy was under genetic control being both cultivar and species dependent. They reported that age at harvest affected storability showing that late harvesting done at 8 months after planting was associated more with losses than those harvested six and seven months after planting. Eze (2005) had earlier reported that the readiness with which yam tuber sprouted depended on the physiological age of the tuber. Differences in the storage environments could also be important in accounting for any variance in the results obtained in the present study compared with those obtained by Girardin et al. (1998) especially with GA_3 treatment.

The lower incidence of rotting in *C. alata* treated tubers compared with the other plant extracts could be that its pesticide property was higher than others. Further research is therefore recommended to obtain the optimum concentration of *C. alata* leaf extracts for yam storage and also to obtain information on the chemical composition of this plant.

ACKNOWLEDGEMENTS

The authors are grateful to the European Union (INCO-DC) for providing the fund for this research. The fund was disbursed by the National Root Crops Research Institute (NRCRI) Umudike, Nigeria. The authors equally thank NRCRI for this service and other technical assistance that made this work possible

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