Effects of Aqueous and Ethanolic Extracts and the Concentrations of Four Agrobotanicals and Gibberellic Acid (GA_3) on the Shelf Life of the White Guinea Yam *Dioscorea rotundata*

[1] S.C. Eze, [1]J. E. Asiegbu, [1]B. N. Mbah, [2] G. C. Orkwor, [3]R. Asiedu
[1] Department of Crop Science, University of Nigeria Nsukka.
[2] National Root Crops Research Institute Umudike, Nigeria
[3] International Institute of Tropical Agriculture, Ibadan, Nigeria

Corresponding author: S.C. Eze, Department of Crop Science, University of Nigeria Nsukka.

Abstract

An investigation was carried out to determine the effects of four agrobotanical extracts and gibberellic acid (GA_3) on the post-harvest losses of yam (D. rotundata) during storage. The yam cultivar, 'Nwaopoko', used for the study was grown at the National Root Crops Research Institute Umudike research farm, and the storage studies were conducted in the Institute's improved yam barn. The agrobotanicals constituted of Azadiractha indica (leaf), Xylopia aethopica (fruit), Occimum graticimum (leaf) and Zingiber officinale (stem tuber) which were applied as aqueous and ethanolic crude extracts at two levels of concentration of 250 mg/ml and 500 mg/ml. GA_3 treatment was at 150 mg/litre of water. The parameters studied included length of tuber dormancy, sprouting, sprout growth rate, sprout relative weight, tuber weight loss and rotting incidence. Tuber dormancy was extended significantly with GA_3 compared with the agrobotanical treatments applied at both 250 and 500 mg/ml concentrations. Length of tuber dormancy was extended by 5-19 days when the agrobotanicals or GA_3 were applied. The percentage number of tubers that suffered soft or dry rot was generally high (41-51%) for the aqueous extracts and higher (52-57%) for the ethanolic extracts, irrespective of the concentration. GA_3 and control treatments depressed rot incidence markedly. Tuber percentage weight loss and relative sprout weight were higher with the untreated control than with the agrobotanical and GA_3 treatments. Ethanolic extract extended tuber dormancy more than aqueous extracts. The agrobotanical extracts sustained dormancy periods that were similar to that of GA_3 treatment.

Keywords: Agrobotanicals, Gibberellic acid, *Dioscorea rotundata*, Dormancy,

Introduction

Yam (Dioscorea spp.) is a major staple food in the yam belts of tropical Africa. It is one of the tuber crops supplying a substantial proportion of the populace in these regions with energy. After harvest, yam tubers are stored for consumption or as planting materials for the following season. Storage period can be for three to eight months before new yam tubers are harvested.

Losses during storage of the tubers have been put at 20-50% (Oyeniran and Adesuyi, 1983). Investigations into the causes of storage losses have implicated such factors as respiration, sprouting, attack by rot-causing organisms, rodents and moisture loss (Okafor, 1966; Coursey, 1967; Adesuyi 1973). During storage, dormancy is broken after about 40-90 days depending on cultivar, age at harvest and storage treatment/environment and sprouts appear principally from the head region (Okwuowulu *et al*, 1995). In the yam producing areas of Nigeria, the most common practice is to remove the sprouts as soon as possible before they become too long. In advanced storage technology, chemicals and other treatments may be applied to suppress sprouting in order to extend the shelf life of the tuber. Tuber dormancy is helpful in maintaining tuber quality. During sprouting, the tubers undergo deterioration and pathogenic agents multiply (Passam and Noon, 1977; Passam, 1982). The growth of sprouts increases the respiration rate of the tuber (Passam *et. al*, 1978) and causes considerable dehydration and dry matter loss. By using GA_3, Igwilo (1988) was able to reduce the fresh weight loss by 14% but the dry matter loss was only reduced by 3% after 6 months of storage in *D.alata* yam species. Recent studies, Girardin *et.al.* (1998) showed that it was possible to prolong dormancy period of yam using GA_3 at a low concentration of 75mg L^{-1}. FAO (1988) surveys have shown that food preservation techniques such as the use of radiation or storage at low temperatures (15^0 C) can be effective. However, the high cost and the usual decentralized storage practiced by growers would make such techniques unattainable.

The aim of the present study was to identify natural botanicals that could have similar effects as gibberellic acid in extending the storage life of fresh yam tubers. Consequently, the easily available and non-toxic *Azadiractha indica, Occimun graticimum, Xylopia aethiopica* and *Zingiber officinale* which have been shown to posses antimicrobial, insecticidal and anti-feedant properties (Oliver-Beever, 1986) were selected for use to compare with GA_3.

Materials and Methods

Dioscorea rotundata (Nwaopoko) yam tubers which were harvested from the National Root Crops Research Institute, Umudike, research farm were used for the storage study. The yam tubers were harvested 8 months after planting. Tubers without wound were selected for storage in an improved yam barn. The improved yam barn was made of corrugated aluminium sheets and the ceiling constructed of bamboo and raffia mats. The sides of the barn were made of a dwarf cement wall (1m high) while 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.

Preparation of agrobotanicals and gibberellic acid (GA_3) solution: Four agrobotanicals known to be non-toxic to humans were used as the treatment. Those agrobotanicals included *Azadiractha indica* (leaf), *Xylopia aethiopica* (fruit), *Occimum gratissimum* (leaf) and *Zingiber officinale* (stem tuber) which were sun dried and milled into powder. Extraction was made by dissolving 500 g of each powdered agrobotanical in one litre of distilled water and allowed to stand for 24 hours. The supernatant aqueous extract was decanted and diluted to two concentrations of 500 and 250 mg/ml. Similarly, another extraction was done using 75% ethanol. The ethanolic extracts were at two concentrations of 250 and 500 mg/l as in the aqueous extracts. The GA_3 concentration was at 150 mg l^{-1} of water.

The different chemical preparations were each mixed with top soil obtained at 0-20 cm soil depth to obtain a paste. The soil paste of the agrobotanical extracts (Bot-soil) and those of Gibberellic acid (Ga-soil) were applied on the tubers according to the treatment scheme. Before treatment application, the tuber head stump was removed from the yam tuber or a fresh cut made if the head stump was removed during harvesting. The proximal sections of the yam tubers were covered with the Bot-soil or Ga-soil at the various concentrations. Untreated tubers were used as control. The experiment was laid out in a completely randomized design with three replications. The data collected were analysed using the SAS statistical software (SAS 1999) according to the procedure for a completely randomized design.

Results

GA_3 was superior to all the agro botanicals (250 mg/ml) in extending the dormancy period of the tubers (Table 1). *A. indica*, *Z. officinale* and *O. gratissimum* did not differ significantly in their individual effects in extending the dormancy of the tubers employed in this study. The trend was similar with 500 mg/ml aqueous extracts, which did not show a marked departure from the values obtained at 250 mg/ml concentration of the agrobotanicals. With ethanolic extracts, *A. indica* and GA_3 were more effective in extending tuber dormancy than did other treatments. Tubers that were not treated with agrobotanicals or GA_3 were comparatively less effective in extending tuber dormancy when applied at 250 mg/ml or 500 mg/ml concentration.

Untreated tubers (control) were the first to sprout (after 70 days in storage) with the highest percentage of sprouting tubers in relation to the other treatments, whereas those treated with GA_3 were the last to start sprouting (after 91 days in storage) (Fig. 1a). This trend prevailed whether the tubers were treated with aqueous extracts (Fig. 1a) or with ethanolic extracts (Fig. 1b).

Over 50% of tubers had started rotting after six months of storage, whether in aqueous or ethanolic extracts of the agrobonicals or GA_3 (Table 2). Rot incidence was always significantly highest with *Z. officinale* agrobotanical treatment irrespective of the concentration, or whether with aqueous or ethanolic extracts. Surprisingly, rotting of tuber seemed to increase with agrobotanical concentration and by use of ethanolic extracts.

Rotting commenced started after two months in storage irrespective of treatment. However, as from three months after storage, *A. indica* treatment tended to depress rotting whereas Z.officinale an opposite effect (Fig. 3 a & b). Untreated (control) tubers showed significantly greater tuber weight loss compared with GA_3, *A. indica* and *Z. officinale* treatments at 250 mg/ml but not at 500 mg/ml of aqueous as well as ethanolic extracts(Table 3).

Discussion

The four agrobotanicals evaluated in this study showed variable potentials in prolonging the period of tuber dormancy of yams. There is paucity of literature regarding the use of agrobotanicals as sprout suppressant on fresh yam tubers. The order of dormancy extension in tuber following treatment with the GA_3 or the aqueous or ethanolic extracts of the agrobotanicals was GA_3. > *A. indica* > *Z. Officinale* >*O. gratissimum* > *X. aethiopica* > control. The ability of the agrobotanicals to prolong dormancy of yam tubers sugests that they probably posess some natural sprout growth inhibitors. Hashimoto *et al* (1972) identified a group of natural growth inhibitors such as batatasin as possesing good potential . The variable effects of the agobotanicals on tuber dormancy could be that they contain different levels of growth inhibitors or that the concentration or extraction method should not be the same for all the agrobotanicals. Ireland and Passam (1984) had similarly reported that exogeneous application of the plant growth inhibitors showed varying effects on dormancy of yam during storage.

Gibberelllic acid as a check in this study was superior to the agrobotanicals in tuber dormancy extension. However, the 17 to 20 days dormancy extended by the GA_3 was less than 47 to 59 days for different concentrations, 26 to 43 days for different soaking times and 27 to 37 days for repeating the soaking of tubers in GA_3 studies by other workers (Girardin *et al*, 1998; Martin, 1977 and Wickham *et al* 1984). Among the possible explanations for the differences may include cultivar differences, age at harvest and other environmental variables. The same reasons including method of extraction and rates of application may also account for short period of dormancy extension exhibited by the agrobotanical treatments in this study. Okwuowulu *et al*, (1995) reported that yam cultivar and age at harvest significantly affected weight loss and sprouting during storage of the white Guinea yam, *D. rotundata*.

Table 1: Effects of concentrations of aqueous and ethanolic extracts of agrobotanicals and gibberellic acid (GA_3) on dormancy period (days) of white yam (*D. rotundata*)

Treatments	Dormancy period			
	Aqueous extract concentration		Ethanolic extract concentration	
	250 mg/ml	500 mg/ml	250 mg/ml	500 mg/ml
A. indica	92.2	95.6	100.5	101.0
O. gragtissimum	90.2	92.0	96.1	98.4
X. aethiopica	89.4	93.0	94.6	94.6
Z. officinale	91.0	93.4	96.0	96.8
GA_3 (150 mg/l)	104.0	103.0	102.2	105.6
Control	85.0	84.6	84.3	86.2
s.e.d	1.45	1.52	1.70	1.95

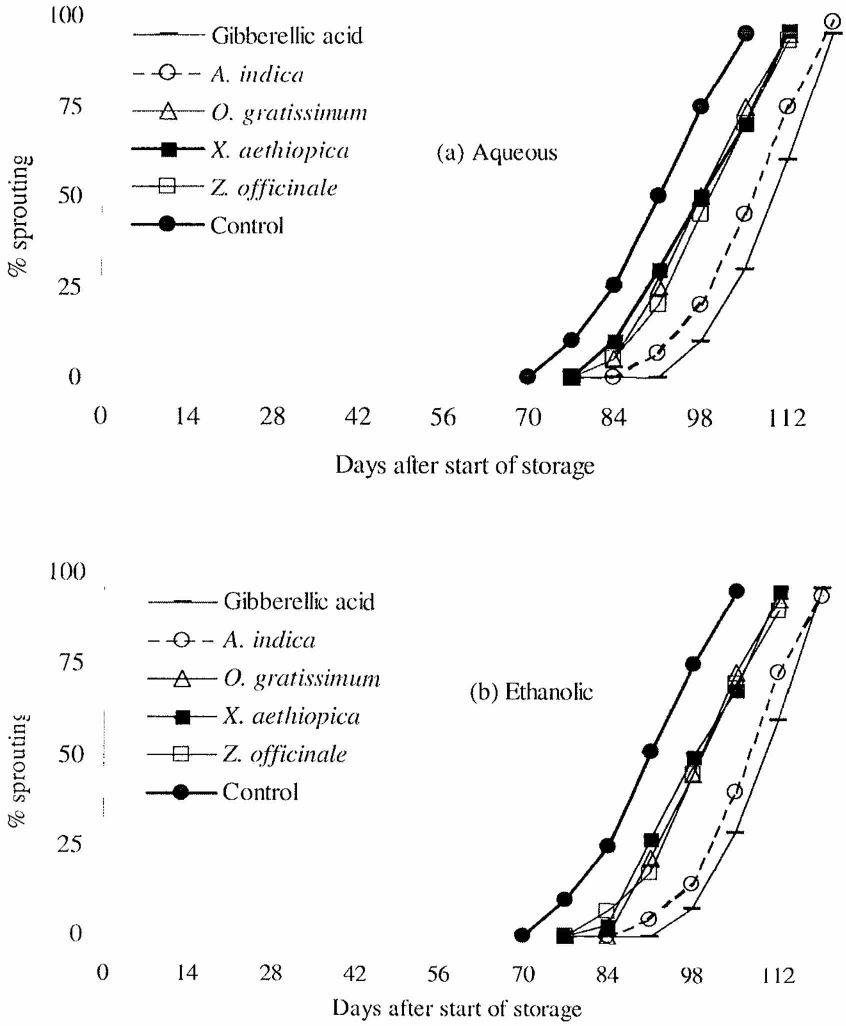

Figure 1: Sprouting (%) of *D. rotundata* treated with (a) aqueous agrobotanical extracts and (b) ethanolic agrobotanical extracts in storage.

Table 2: Effects of concentrations of aqueous and ethanolic extracts of agrobotanicals and gibberellic acid (GA_3) on tuber rot (%) of white yam (*D. rotundata*)

Treatments	Per cent tuber rot			
	Aqueous extract concentration		Ethanolic extract concentration	
	250 mg/ml	500 mg/ml	250 mg/ml	500 mg/ml
A. indica	50.2	51.0	51.0	53.1
O. gragtissimum	49.4	51.0	52.4	53.8
X. aethiopica	50.2	51.6	52.4	53.8
Z. officinale	54.0	56.0	56.0	54.2
GA_3 (150 mg/l)	**51.0**	50.2	52.0	52.3
Control	49.6	52.0	52.5	53.0
s.e.d	1.50	1.90	2.10	1.75

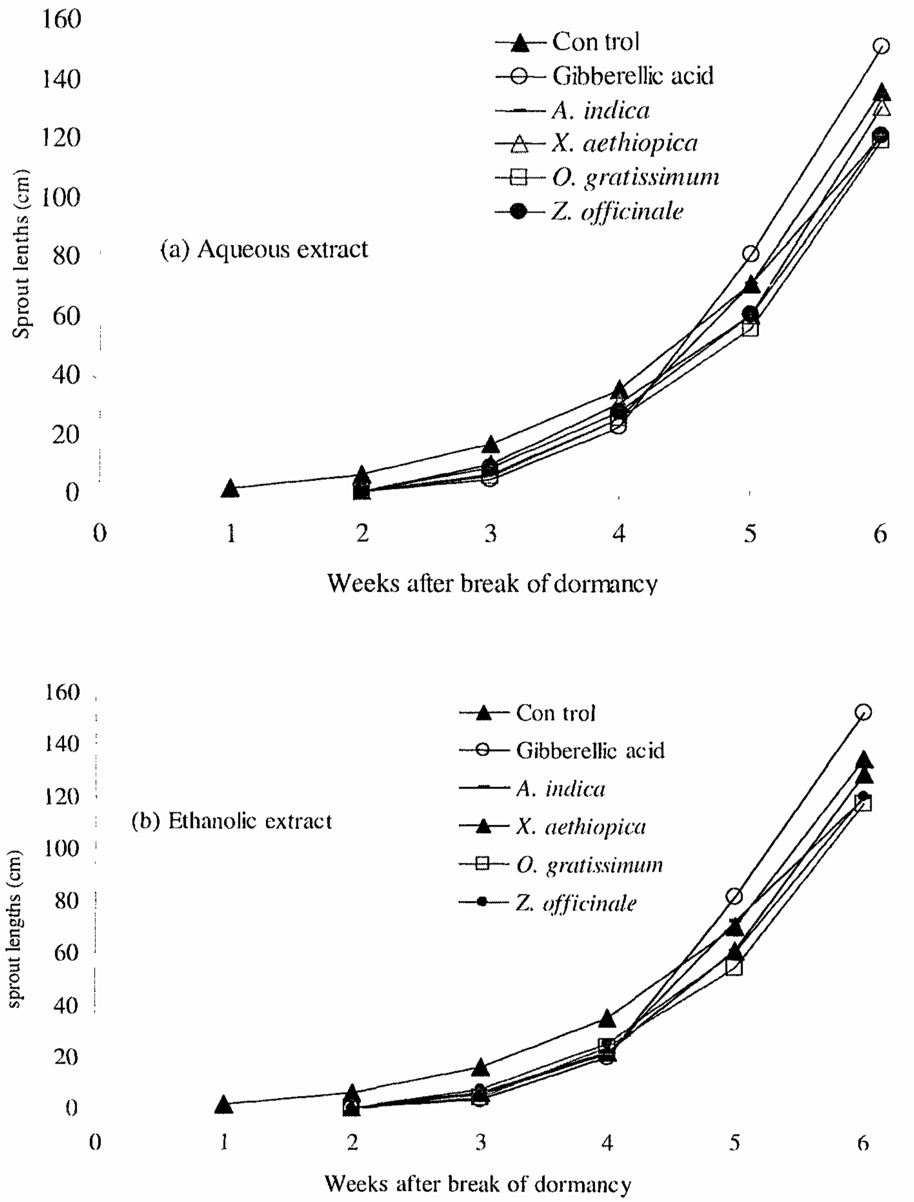

Figure 2; Effects of aqueous agrobotanical extracts (a) and ethanolic extracts (b) on sprout length of white yam

Table 3: Effects of aqueous and ethanolic extracts of agrobotanicals and gibberellic acid (GA_3) on tuber weight loss (%) of white yam (*D. rotundata*)

Treatments	Tuber weight loss			
	Aqueous extract concentration		Ethanolic extract concentration	
	250 mg/ml	500 mg/ml	250 mg/ml	500 mg/ml
A. indica	32.4	33.0	34.4	34.0
O. gragtissimum	33.6	33.2	33.6	34.4
X. aethiopica	33.3	32.0	32.8	32.6
Z. officinale	32.4	34.0	34.0	32.4
GA_3 (150 mg/l)	31.8	32.1	31.8	31.1
Control	35.4	34.2	38.8	35.2
s.e.d	1.20	1.40	1.95	1.35

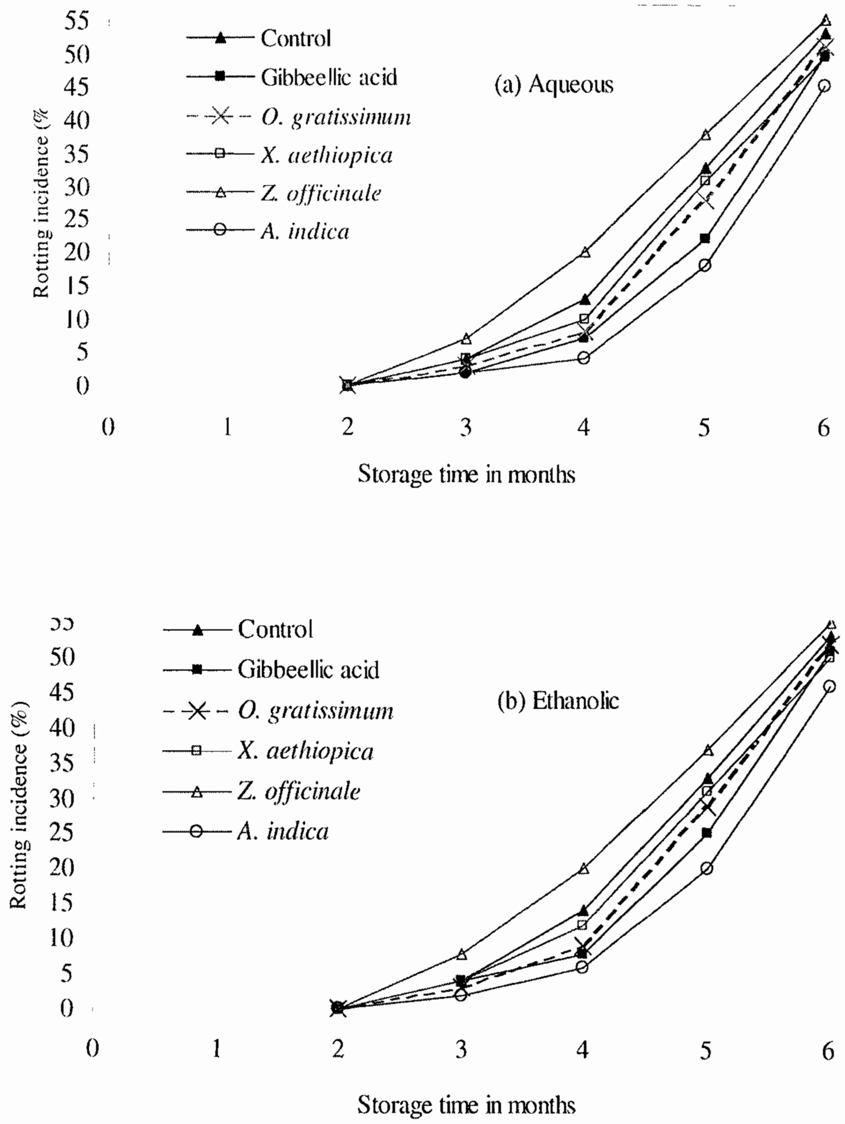

Figure 3 : Effects of aqueous agrobotanical extracts (a) and ethanolic extracts (b) on rotting incidence of white yam.

Within the second and fourth months of storage, tubers with no agrobotanical or GA_3 treatments clearly maintained longer sprout lengths. This observation suggests that the agrobotanical or GA_3 treatment effects that induced dormancy extension in tubers probably reduced sprout growth rate for a few days after dormancy. Though the active ingredient in the agrobotanicals have not been identified, Tarno *et al* (1995) noted that after breaking of dormancy in yams, gibberellins played a role in enhancing sprout growth.

Among the agrobotanicals, only the *A. indica* was effective in reducing rot in stored tubers. It was expected that all the agrobotanicals would reduce rotting incidence in the stored yams as they are known to have anti-microbial and anti-feedant properties (Oliver-Beever, 1986). Okigbo (1995) identified the principal micro-organisms associated with the rot of yams in Nigeria, most of which were fungi. The anti-fungal and anti-microbial activities of the agrobotanicals probably are more effective in humans and animals. The lower rates of rot incidence obtained with the *A. indica* or GA_3 treated tubers could be attributed to the ability of these chemicals to extend yam dormancy. Girardin *et al* (1998) observed that yams were less susceptible to fungal attack during dormancy than after breaking of dormancy. Igwilo (1998) observed that when GA_3 was applied to yam tubers early in storage, the tubers were less susceptible to rot than the untreated tubers.

Sprout is the only visible source of weight loss in stored tubers. The lower tuber weight loss obtained with the agrobotanical treatments compared with the control was probably due to the delay in sprouting when agrobotanicals or GA_3 were applied. Jenkins (1981) had reported that the physiological losses through respiration and evaporation of moisture were increased by sprouting. The use of chemicals like GA_3 in reducing post-harvest losses of fresh yam tubers in storage by the local farmers is limited by availability and cost. The use of agrobotanical extracts for storage of yam seems attractive enough for adoption. Though, the ethanolic extracts were more efficacious in delaying the initiation of sprouting, the aqueous extracts of the agrobotanical was as good as the ethanolic extracts. The aqueous extracts should therefore be used since it is cheaper, easier to use and would have no adverse effects on tuber quality. Similarly, the higher concentration of both aqueous and ethanolic extracts was not significantly better than the lower concentration and so the lower concentration should be used.

Acknowledgements

The authors are very grateful to the European Union (INCO-DC ERBICI18-CT98-0302) for providing Fund for this research. We also thank the National Root Crops Research Institute (NRCRI) Umudike for administrative and technical assistance. The facilities for laboratory and data analyses were provided by the International Institute of Tropical Agriculture (IITA) to which we are most grateful

References

Adesuji, S.A. (1973). Curing Technique for reducing the incidence of rot in yams. *Rep.Nigerian Stored Prod. Inst. Report.* No.9: 57-63.

Coursey, D. G. (1967). Yams. An account of nature, origin, cultivation and utilization of the useful members of the Dioscoreaceae, 230 pp London: Longmans.

Coursey D.G. and Book R.H. (1977). Post- harvest problems of non-grain stalpes. *Acta horticulturae.* 53: 23-33.

FAO (1988). Food and Agriculture Organization of the United Nations. Root and Tuber Crops, Plantains: Challenges and Opportunities. *FAO plant production and plant protection paper*, No. 87.FAO. Rome

Girardin . O., C. Nindjin, Z. Farah, F. Escher; P. Stamp and Otokore, D. (1998). Use of gibberellic acid to prolong traditional storage of yams. *J. Sci. Food Agric.* 77: 172-178.

Hashimoto, T., Hasegawa, K. and Kawarada, A. (1972). Batatasin: New dormancy-inducing substances of yam bulbils. *Planta* 108-374.

Igwilo, N. (1988). Inhibition of sprouting by gibberellic acid in the preservation of seed and ware yam *BeitrTrop. Land-wirtsch Veternarmed* 26:145-154

Ireland , C.R. and Passam, H.C. (1984). The level and distribution of phenolic plant growth inhibitors in yam tubers during dormancy. *New phytologist* 99: 233-242.

Jenkins, P. D. (1981). Losses in Sweet potatoa (Ipomea batatas) stored under traditional conditions in

Martin F.W .(1977). Prolonging the storage life of yams by removal of shoots and by treatment with gibberellic acid and waxes. *Trop Root Tuber Newsletter* 10:39.

Okafor, M. (1966). Microbial rotting of stored yams (Dioscorea spp.) *Nigeria Expt. Agric.*2:179-182.

Okigbo. R.N. (1995). Rot of yams (Dioscorea spp) in storage and studies on its biological control. Ph.D Thesis. University of Benin, Nigeria

Okwuowulu, P. A., E.C. Nnodu, A. U. Udensi and M.U.A. Opara (1995). Some effects of time of fertilizer application and age at harvest on the storability of edible yams. *Trop .Sci.* 1995 35, 58-63.

Oliver Bever B. (1986). *Medicinal plants of Tropical West Africa.* Cambridge University press London p. 375

Oyemiran, J.O. and S.A. Adesuji (1983). Preliminary experiment on the chemical preservation of yam. *Ann. Rep.Nig.Stored Prod. Res.Inst.Tech.Rep.* No.6: 63-77

Passam . H. **C.** (1982). Dormancy of yam in relation to storage in yams, *Ignames.* Ed. Miege J and Lyonga .S.N E. Clarendon press, Oxford, UK. Pp. 285-293.

Passam. H .C. and Noon, R.A.(1977). Deterioration of yams and cassava during storage. Proceedings of the Association of Applied Biologists 85, 436-439.

Passam H. C. ;S. J. Read and J. E. Rickard (1978). The respiration of yam tubers and its contribution to storage losses. Trop. Agric (Trinidad) vol 55, No 3 July 1977

SAS Institute (1999). SAS/STAT user's Guide, release 6. 12. SAS Institutes, Inc., Cary, Nc, USA

Tarno N, Tanno, M., Yokota. T., Abe, M., and Okagami, N. (1995). Promotive and inhibitory effects of Uniconazole and prohexadione on the sprouting of bulbils of Chinese yam. *Dioscorea opposita. Plant growth Regula* 16: 129-134.

Wickham, L. D., Passam, H.C., and Wilson, L. A. (1984) Dormancy responses to post-harvest application of growth \ regulators in *Dioscorea spp.* J. Agric. Sci. 102 433-436.