

RESISTANCE TO POST-HARVEST MICROBIAL ROT IN YAM: INTEGRATION OF GENOTYPE AND STORAGE METHODS

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ABSTRACT

Post-harvest microbial rot is an important disease that causes severe losses in yam (*Dioscorea* spp.) storage. Rot from microbial infection of healthy yam tubers reduces their table quality and renders them unappealing to consumers. A study was carried out at Bimbilla in the Nanumba North District of Ghana to evaluate possible interactions of yam genotypes and storage methods for controlling internal rot in yam. Four local varieties (Labalkor, Kplondzo, Olordor and Fushiebila) were studied with four storage methods (barn, pit, platform and heap methods) in a 4 x 4 factorial arrangement. There were significant ($P < 0.001$) differences among genotypes for resistance to internal rot, with Olordor and Kplondzo recording the lowest internal microbial rot, suggesting their potential in resisting the disease. There were also significant differences ($P < 0.05$) among the storage methods, with barn and platform being most suitable in reducing the incidence of internal rot in yam. The interaction between yam genotypes and storage methods was not significant ($P > 0.05$).

Key Words: Barn, *Dioscorea* spp., internal rot

RÉSUMÉ

Le pourrissement microbien après la récolte est une maladie importante qui cause de pertes sévères dans le stockage des ignames (*Dioscorea* spp.). Le pourrissement dû à l'infection microbienne des ignames réduit leur qualité et la préférence des consommateurs. Une étude était menée à Bimbilla dans le District de Nanumba Nord au Ghana pour évaluer des interactions possibles des génotypes d'ignames et des méthodes de stockage pour le contrôle du pourrissement interne dans l'igname. Quatre variétés locales, (Labalkor, Kplondzo, Olordor et Fushiebila) étaient étudiées avec quatre méthodes de stockages (méthodes grange à igname, silo-fosse, plate forme et tassement) dans un arrangement factoriel 4 x 4. Aucune différence significative ($P < 0.001$) n'était observée parmi les génotypes en rapport avec la résistance au pourrissement interne, seuls Olordor et Kplondzo ayant présenté les taux les moins élevés de pourrissement microbien interne, suggérant ainsi leur potentiel de résistance à la maladie. Il n'y avait pas aussi de différences significatives ($P < 0.05$) parmi les méthodes de stockage, avec grange à igname et plate forme ayant été les mieux indiquées dans la réduction de l'incidence du pourrissement interne des ignames. L'interaction entre les génotypes et méthodes de stockage n'était pas significatif ($P > 0.05$).

Mots Clés: Grange à igname, *Dioscorea* spp., pourrissement interne

INTRODUCTION

Yam (*Dioscorea* spp.) constitutes an important staple food in the tropics; being a major source of carbohydrates, vitamins and dietary fibres

(Ogaraku and Usman, 2008). The crop is also known to contain medicinal properties for the treatment of diabetes mellitus and hypercholesterolemia (Okigbo and Ogbonna, 2006). Ghana exports about 12,000 tonnes of yam

annually which generates foreign revenue for the country (MIDA, 2012).

Despite the nutritional and economic importance of yam, its production is limited by pests and diseases. It has been estimated that an average of over 25% of the yield is lost annually to diseases and pests globally (Arene, 1987; Ezeh, 1998; FAO, 1998). One of the major diseases affecting yam production in the tropics is internal microbial rot. Internal rot is the condition that develops in yam tuber where the whole tuber appears wholesome and attractive, but has developed rapid and extensive breakdown of internal tissues. This condition, with time renders the whole tuber rotten. Several microorganisms have been associated with rot in yam. They include fungi *Aspergillus niger*, *Lasiodiplodia theobromae*, *Fusarium solani*, *Penicillium* spp., *Rhizopus stolonifer* and *Mucor* spp. (Ikuton, 1983a; Adimora *et al.*, 1989; Osai and Ikotun, 1994; Acholo *et al.*, 1997; Cornelius and Oduro, 1999; Okigbo and Ikediugwu, 2000). Tuber rot organisms produce a variety of extracellular enzymes and a host of metabolites that degrade cell wall polymers, resulting in maceration of parenchymatous tissues (Ikuton, 1983a, 1983b, 1984). Infection is introduced by a breakdown of tissues of the peridermal layer through wounds inflicted by rodents, nematodes and farm implements or improper handling of tubers (Ogaraku and Usman, 2008).

Rot from microbial infection of healthy tubers reduces their table quality and renders them unappealing to consumers (Amusa and Baiyewu, 1999). Okigbo and Ikediugwu (2000) indicated that between 20 and 39.5% of stored tubers may be lost to rot; while Bonire (1985) estimated microbial postharvest losses in yam at 40%. According to Adesiyun and Odihirin (1975), over 60% of white yam varieties get rotten when stored for more than six months in Nigeria. Observations from farmer's field reveal that some farmers in Ghana lose as high as 70% of their stored yam to rot (Aidoo, 2007). Some white yam varieties such as 'dente', 'pona' and 'labreko' that are preferred by most consumers in Ghana, do not store for more than six months due to infection by rot microorganisms. As a result, farmers sell their produce immediately after harvest at low prices.

This practice also affects farmers' food security particularly during off-season.

Use of chemicals such as fungicides to control the rot has been reported variously (Mugnucchi *et al.*, 1984; Plumbley *et al.*, 1985; Nnodu and Nwankiti, 1986). Botanicals such as leaf extracts of *Ficus thonningii*, *F. saussureana*, *F. exasperate* and *F. sur* have been reported (Oyelana *et al.*, 2011). However, use of botanicals has not been effective against microbial rot in yam. On the other hand, use of chemicals is expensive and, thus not affordable by small-scale farmers. Also, there are concerns about health hazards and environmental pollution. Moreover, use of chemicals and botanicals has been associated with a number of deleterious and physiological effects on plant tissues (Amusa and Ayinla, 1997). Breeding for resistance to internal rot in yam has been regarded as the most economical and environmentally friendly way of controlling the disease. Natural host plant resistance to microbial rot in yam poses no risks to the consumer and environment.

The objective of this study was to understand the interaction between genotypes and farmers indigenous storage practices in resistance to microbial rot in yam.

MATERIALS AND METHODS

The study was carried out at Bimbilla in the Nanumba North District of Ghana, in 2012/2013 farming season. Rainfall of the area ranges from 1000 -1500 mm and temperature from 26 - 32 °C with generally sunny weather (Ghana Meteorological Services, 2012). Soil texture is sandy loam, with little pebbles.

The experimental design used was a 4 x 4 factorial laid out in a randomised complete block design, with four replications. The factors studied included four local yam genotypes (*Labalkor*, *Fushinbilla*, *Kplondzo* and *Olordor*) and four storage methods (dug-out pit, barn, platform and heap on the ground).

The yam seeds (sets) of the four local varieties were collected from local farmers in the district. The yam sets were planted in the field by burying them in the mounds of two meters in diameter. Weeding was performed along with the

removal of parasitic epiphytes every month. Five months after growing, the yam tubers were carefully dug out using hand hoes. Harvesting was done by gently digging out the yams to avoid bruises on the tubers.

The dug-out pit method consisted of four pits of 60 cm deep and 40 cm width, dug under a shade tree. The pits were lined with dry Guinea grass (*Panicum* spp). Half a milliliter of termitocot was sprayed in the pits to prevent attack of termites and other destructive insect pests. Twenty tubers (5 tubers from each yam genotype) were arranged on the straw of Guinea grass, with the tip of tuber facing downwards in each of the four pits. The tubers were then covered with soil and dry grass

on top to give some cooling effect as practiced by farmers.

Four medium sized yam barns were constructed using poles, fork sticks, ropes, zana mats and thatch grass. Plate 1 shows a structure of the barn. Twenty tubers (5 tubers from each yam genotype) were arranged horizontally with the heads of the tubers facing the same direction in each of the four barns.

The platform method also consisted of four raised platforms 30 cm from the ground, constructed with pieces of 5 cm x 10 cm of wood, nails and was roofed with thatch grass (*Imperata cylindrica* L.), (Plate 2). Twenty tubers (5 tubers from each yam genotype) were arranged

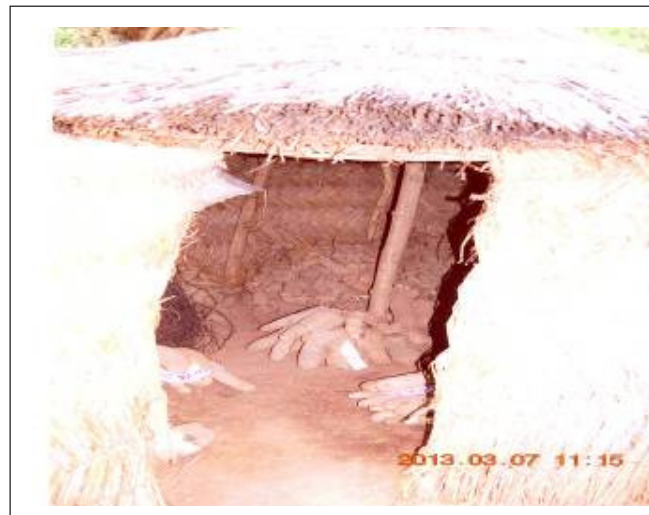


Plate 1. A barn used to store yam in northern Ghana.



Plate 2. A raised platform used to store yam in northern Ghana.

horizontally with the tuber heads facing the same direction in each of the four platforms.

The heap- on- the ground method involved identifying a well drained flat ground spot. Dried maize stocks were collected and placed on the ground. Twenty yam tubers (5 tubers from each yam genotype) were then piled upright in a triangular form in a heap on the dried maize material. Dried maize stocks were then used to cover the pile of tubers. There were four piled heaps.

At the end of five months storage of the tubers under the four different storage techniques, the tubers were taken for inspection of internal rot. This was done by a cross-sectional cut through each of the tubers. The number of tubers of each genotype without internal rot was recorded. The internal rot portions of tubers that were infected were scooped out with knife and spatula into a beaker and then weighed using a digital balance. The rotten free portions of each tuber was also cut into pieces and weighed. The percentages of rotten and rotten free portions of tubers were estimated in relation to the total weight of tubers as:

$$\% \text{ of rotten yam tissue} = \frac{\text{Weight of rotten tissue}}{\text{Weight of tuber (rotten + unrotten tissues)}} \times 100$$

The data obtained were analysed using Analysis of Variance (ANOVA) using GenStat ® 11th version (GenStat, 2008). Significant differences among the genotypic and storage method means were judged by using the Least Significant Difference (LSD) at $P < 0.05$.

RESULTS AND DISCUSSION

Significant differences were observed among the yam genotypes for resistance to post-harvest microbial rot (Table 1). The differential response of yam genotypes to microbial rot suggests that resistance to post-harvest microbial rot disease was under genetic control and should, therefore, be liable to genetic improvement. This provides an opportunity for selection of yam genotypes with higher resistance to internal microbial rot. The results found in the present study conform to the previous results of Apovugbaye (1989) and Kwoseh *et al.* (2007), who observed genetic variation in yam varieties for resistance to dry rot.

No incidence of microbial rot was recorded in yam genotype *Olordor* under all the four storage methods used (Table 1). A lower percentage of rotten tissue was recorded for the yam genotype *Kplondzo* compared with *Labalkor* and *Fushinbilla* under the pit and heap methods. No incidence of rot was observed for *Kplondzo* under the barn and platform methods of storage (Table 1). Thus, *Olordor* and *Kplondzo* are promising genotypes for resistance against microbial rot in yam. *Labalkor* showed the poorest resistance to the rot under all methods of storage (Table 1). Plate 3 shows internal rot of tissues of *Kplondzo* and *Labalkor* which were shown to be resistant and susceptible genotypes, respectively.

There were also significant ($P < 0.05$) differences among storage methods in the amount of rotten tissues. Less rotten tissue occurred in

TABLE 1. Percentage weight of rotten tissue of yam varieties under four storage methods in Ghana

Yam variety	Storage method			
	Pit method	Heap	Barn	Platform
Labalkor	68.5	48.0	0.80	5.63
Kplondzo	5.8	9.1	0.00	0.00
Olordor	0.0	0.00	0.00	0.00
Fushinbilla	17.5	16.2	0.07	1.00
LSD (0.05)	4.74	6.93	0.053	2.75

the barn and platform methods indicating their potential to reduce the incidence of microbial rot in yam. FAO (1998) also considered barn and platform methods of storage of yam to reduce the risk of attack by termites or rotting. It was, however, stated that the barns are effective for yam storage during the dry season, but once the rainy season starts, tubers stored in barns tend to deteriorate rapidly with the constantly moist environment enhancing the rotting of the tubers. The platform method was, therefore, the most suitable method of storage of yam during rainy

season. The higher amount of rotten tissues observed in the pit and heap methods of storage could be due to lack of ventilation and direct contact of the tubers with one another. This causes the stored produce to become heated up and, thus rot. Similar observations were reported by Ofori *et al.* (2010), that poor ventilation was one of the causes of microbial rot in yam during storage.

Figure 1 shows the variation in wholesome tubers of the genotypes under the different storage methods. The resistance of *Kplondzo*

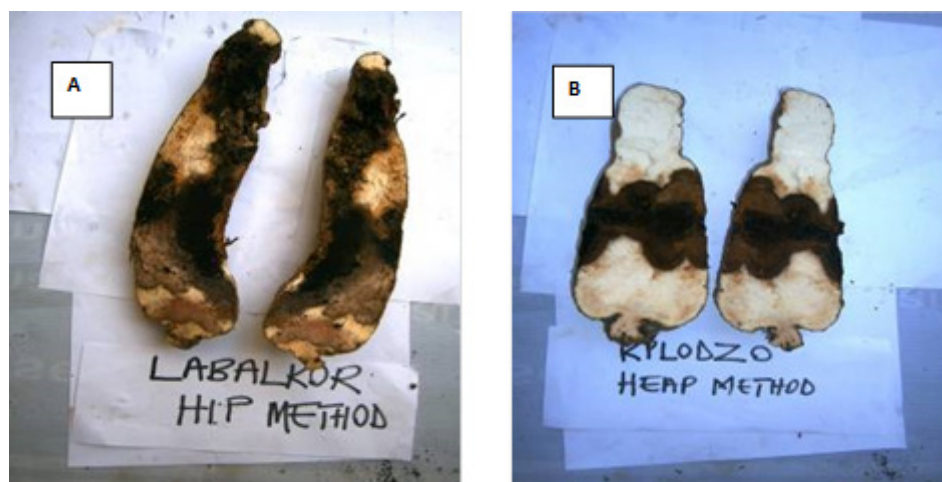


Plate 3. Rotten tissues of susceptible (A) *Labalkor* and resistant (B) *Kplondzo* yam genotypes of Ghana.

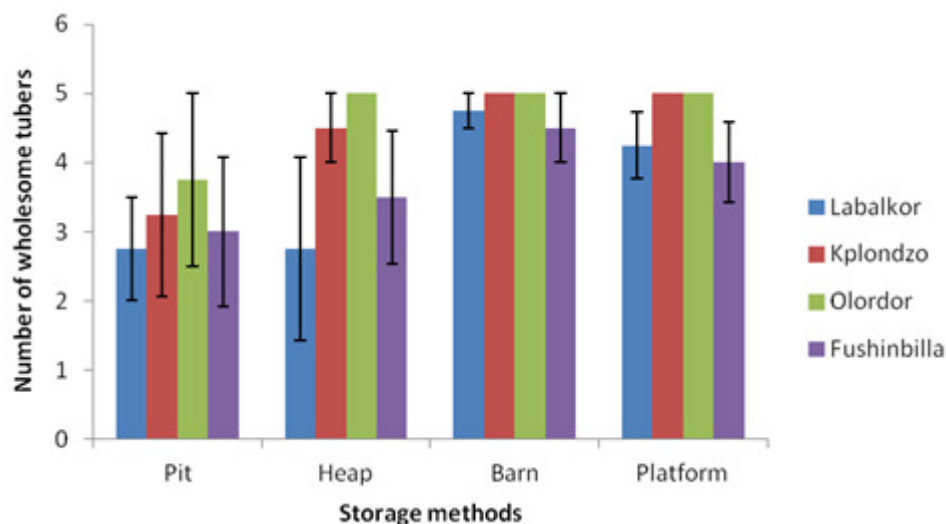


Figure 1. Number of wholesome tubers for yam genotypes under different storage methods in Ghana.

TABLE 2. Mean squares from a combined analysis of variance for four yam varieties evaluated for percentage weight of rotten tissue under four storage methods

Source	df	Mean squares
		% weight of rotten tissue
Replication	3	322.2
Genotype	3	2778.7***
Storage method	3	2140.9**
Genotype x storage method	3	1004.8ns
Error	45	349.7
CV (%)		46.3

*** = $P < 0.001$ and ** = $P = 0.001$

and *Olondor* yam genotypes and the suitability of the barn and platform methods of storage to reduce the incidence of rot were shown by the significantly higher values. However, the pit method, which recorded the highest incidence of microbial rot, could be used extensively in identification of resistant varieties, during screening.

The interaction of yam genotypes with the methods of storage was not significant ($P > 0.05$) (Table 2). The non-significant genotype x storage method interaction means that similar trends of rot manifest in all the genotypes for the various methods. All genotypes recorded the least rot in the barn method followed by the platform, heap and pit methods. This reduces the need to screen for resistance using different storage methods and thus saving resources and time.

CONCLUSION

Kplondzo and *Olondor* present evidence of resistance to microbial rot in yam. This attribute could constitute the beginning of more focused effort in breeding for host plant resistance. Also, use of barn and platform methods of storage could help reduce the incidence of internal rot in yam. The non-significance of genotype x storage method interaction in this study should greatly help in yam breeding programmes for continued search for resistance to post-harvest microbial rot in *Dioscorea* species under all storage methods.

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REFERENCES

- Acholo, M., Morse, S., Macnamara, N., Flegg, L. and Oliver, R.P. 1997. Aetiology of yam (*Dioscorea rotundata*) tuber rots held in traditional stores in Nigeria: Importance of *Fusarium* spp and yam beetle. *Microbial Research* 152 (3):293-298.
- Adesiyi, S.O. and Odihirin, R. A. 1975. Histopathology studies of the yam tuber (*Dioscorea rotundata* Roir) infected with *Scutellonena bradys* (Steiner and Hettew). *International Biodeterioration Bulletin* 11:48-55.
- Adimora, L.O., Oduro, K.A. and Dampsey, L. O. A. 1989. Studies of causal agents of rot in *Dioscorea rotundata* Poir vars. Gboko (White Yam). *Ghana Journal of Science* 29-30:101-106.
- Aidoo, K.A. 2007. Identification of yam tuber rot fungi from storage systems at the Kumasi Central market. A dissertation submitted to Faculty of Agriculture, Kwame Nkrumah University; of Science and Technology. 205pp.

- Amusa, N.A. and Ayinla, M. A. 1997. The effect of tecto (Thiabendazole) on the activities of yam rot causing fungi and on sprouting of yam set. *International Journal of Tropical Plant Diseases (India)* 14:113-120.
- Amusa, N.A. and Baiyewu, R.A. 1999. Storage and market disease of yam tubers in southwestern Nigeria. *Ogun Journal of Agricultural Research (Nigeria)* 11: 211-225.
- Apovugbaye, T. 1989. Varietal resistance of yam (*Dioscorea* spp.) tuber to tuber infecting fungi. MSc Thesis, University of Ibadan, Ibadan, Nigeria. 150pp.
- Arene, O.B. 1987. Advances integrated control of economic diseases of cassava in Nigeria. pp. 167-175. In: Hahn, S.K. and Cavenes, F.E. (Eds.). Integrated Pest Management for Tropical Root and Tuber Crops.
- Bonire, J.J. 1985. Preventing yam rot with organotin compounds. *Nigeria Journal of Sciences* 19:145-152.
- Cornelius, E.W. and Oduro, K. A. 1999. Storage diseases of white yam (*Dioscorea rotundata*), causes, varietal susceptibility and control. *Journal of the Ghana Science Association* 3:45-52.
- Ezeh, N.O. 1998. Economics of production and Post-harvest Technology. pp. 187-214. In: Orkwor, G.C., Asiedu, R. and Ekanayake, I.J. (Eds.). Food yam; Advances in research International Institute of Tropical Agriculture, Nigeria.
- FAO 1998. Food and Agriculture Organization Production Year Book FAO Rome, Italy.
- GenStat, 2008. Introduction to GenStat for Windows®. GenStat, 11th Edition, Lawes Agricultural Trust, Rothamsted Experimental Station, UK.
- Ikuton, T. 1983a. Reduced germinability of planted setts caused by microbial deterioration. *Fitopatologia Brasileira* 8 (3):455-459.
- Ikuton, T. 1983b. Postharvest microbial rot of yam tuber in Nigeria. *Fitopatologia Brasileira* 8 (1):1-7.
- Ikuton, T. 1984. Production of oxalic acid by *Penicillium oxalicum* in culture and infected yam tissue and interaction with macerating enzyme. *Mycopathologia* 88 (1): 9-14.
- Kwoseh, C.K., Plowright, R.A., Bridge, J. and Asiedu, R. 2007. Search for *Scutellonema bradys* resistance in yams (*Dioscorea* spp). *Journal of Science and Technology* 27(3):33-42.
- Mugnucchi, J. S., Kok, C. D. E., Santiago, M., Green, J., Hepperly, P.R., Velez, H. and Torres-Lopez, R. 1984. Yam (*Dioscorea* spp.) management for control of tuber decay. pp. 607-613. In: Proceedings of the Sixth Symposium of the ISTRC, Lima, Peru, International Potato Centre.
- Nnodu, E.C. and Nwankiti, A.O. 1986. Chemical control of post-harvest deterioration of yam tubers. *Fitopatologia Brasileira* 1(4):865-871 148.
- Ofor, M.O., Oparaeke, A. M. and Ibeawuchi, I.I. 2010. Indigenous knowledge systems for storage of yams in Nigeria: Problems and Prospects. *Researcher* 2(1):51-56.
- Ogaraku, A.O. and Usman, H.O. 2008. Storage rot of some yams (*Dioscorea* spp.) in Keffi and environs Nasarawa State Nigeria. *Production and Agricultural Technology* 4:22-27.
- Okigbo, R.N. and Ogbonnaya, U.O. 2006. Antifungal effects of two tropical plant extracts (*Ocimum gratissimum* and *Aframomum melegueta*) on post-harvest yam rot. *African Journal of Biotechnology* 5(9):727-731.
- Okigbo, R.N., and Ikediugwu, F.E.O. 2000. Studies on biological control of postharvest rot in yams (*Dioscorea* spp.) using *Trichoderma viride*. *Journal of Phytopathology* 148:351-355.
- Osai, E.O. and Ikuton, T. 1994. Microbial rot of yam minisetts. *Fitopatologia Brasileira* 94:408-412.
- Oyelana, O.A., Durugbo, E.U., Olukanni, O.D. and Ayodele, E.A. 2011. Antimicrobial activity of ficus leaf extracts on some fungal and bacterial pathogens of *Dioscorea rotundata* from South west Nigeria. *Journal of Biological Sciences* 11(5):359-366.
- Plumbley, R.A., Cox, J., Kilminster, K., Thompson, A.K. and Donegan, L. 1985. The effect of imazalil in the control of decay in yellow yam caused by *Penicillium sclerotigenum*. *Annals of Applied Biology* 106 (2):277-284.