Fungi Associated with Storage Decay of Yam in Nigeria

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ABSTRACT

Incidence of decay among five species of yam (*Dioscorea alata, D. cayanensis, D. dumetorum, D. esculenta,* and *D. rotundata*) was much greater in yams stack-piled on the floor than in those tied up on stakes in a barn.

Fungi associated with yam decay in storage were isolated and identified. They were reinoculated individually into sound yams. *Penicillium oxalicum* and *Aspergillus niger* were consistently isolated. Six other fungi isolated were *Aspergillus tamarii, Botryodiplodia theobromae, Fusarium* sp., *Cylindrocarpon radicicola, Cladosporium herbarum,* and *Rhizopus nigricans.*

Penicillium oxalicum and *Aspergillus niger* were the major organisms of decay in stored yam. *Aspergillus tamarii* and *Botryodiplodia theobromae* cause slight rotting in some species. The cluster yam (*D. dumetorum*) is resistant to *Penicillium oxalicum.*
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Yams, the tubers of various species of the genus *Dioscorea,* are important food in many tropical countries, most notably in West Africa, the Caribbean area, and parts of Southeast Asia. In Nigeria, this crop provides a staple food for most of the people from which they derive almost half their total calories (5).

Six species of *Dioscorea* cultivated in Nigeria, in order of importance, are *Dioscorea rotundata* (white yam), *D. cayanensis* (yellow yam), *D. alata* L. (water yam), *D. dumetorum* (cluster yam), *D. esculenta* (Chinese yam), and *D. bulbifera* (aerial yam). The latter two species are not popular in most parts of the country. Since yam harvest takes place during a limited period, the tubers are usually stored for several months so that they will be available for food at all times of the year.

In Nigeria, yams are stored in a variety of ways, (i) stacked in heaps on the floor or preferably on shelves or racks in sheds or huts; (ii) in a circular or rectangular trench dug in the soil; the yams are stack-piled in the trench and covered with earth; (iii) in a "yam barn" in which the yams are tied one by one on a framework of erect poles supported by horizontal poles tied to them (the best and most widely used method).

Of the World crop of about 20 million tons, about 1 million tons are lost annually by deterioration in storage (5). These storage losses constitute a major economic problem in districts where yam is a staple food.

The principal factors responsible for yam losses during storage are: the natural metabolic processes of the dormant tubers, which result in the conversion of starch of the tuber into carbon dioxide and water; evaporation of water from the tuber; sprouting; and infection by various fungi which decay the tuber (4).

The present paper assesses losses due to decay of five species of yam stored in a yam barn or stack-piled on the floor or on shelves in the University of Ibadan, Nigeria. Fungi associated with the yam decay were isolated and identified, and those responsible for the decay reported.

MATERIALS AND METHODS.—The experiments were conducted with 5 species of yam: *Dioscorea alata* L.; *D. cayanensis* Lam.; *D. dumetorum* Pax.; *D. esculenta* (Lour) Burkill.; and *D. rotundata* Poir.; all harvested from the Univ. of Ibadan Research Farm in August 1967.

Storage methods adopted were as follows: (i) the conventional type of yam barn in which the yams were tied to vertical stakes shaded from direct sunlight; and (ii) tubers stacked in heaps on the floor of a hut. Only in the case of *D. esculenta* were the tubers packed on a shelf erected 1 m high inside the hut. They were too small and tender to be left on the floor of the hut. Moreover, they could easily be carried away by rats.

The tubers were cut up 5 months later when they were to be used as yam "seeds" for planting, and examination was carried out to assess the degree of decay in each species of yam. Small tubers of *D. esculenta* were examined by exerting slight pressure on the surface with the fingers. Rotten tubers were detected by softness.

Isolation and identification of fungi occurring on decayed yam tubers.—Small portions (about 2 mm) of the advancing area of decay of the yam were removed with a flamed scalpel and placed, five pieces/dish, into recently cooled and poured water agar or potato-dextrose agar (PDA) medium. One hundred pieces were prepared for each yam species. The plated yam pieces were incubated at 25 C for 3 days, and the fungi that grew from them transferred to PDA and identified. Fungi that could not be identified directly in plates were subcultured on PDA and later identified as far as possible. Identifications were confirmed by the Commonwealth Mycological Inst., Kew, England. Frequencies of the isolated fungi were also determined.

Inoculation of yam tubers with isolated fungi.—The fungi were tested for pathogenicity by inoculation into sound yam tubers according to the method described by Okafor (8). Cylindrical cores 1 cm deep were removed from the "head", middle, and "tail" of each yam tuber with a 5-mm corkborer. Four-mm discs of 7-day-old fungal cultures were placed fungus first into the holes in the tubers, and the cores of yam from the tubers were replaced after 2-mm pieces had been cut off to compensate for the thickness of the agar inoculum. The replaced cores were then sealed with

molten petroleum jelly. Discs of noninoculated PDA were used as controls. Five tubers were inoculated with each fungus. The inoculated tubers were left in the laboratory at room temperature 25-27 C for 4 weeks, after which they were sliced through the site of the inoculation. Decay was measured in the head, middle, and tail regions of the tuber. Decayed portions from inoculated yams were placed on PDA or nutrient agar to confirm that decay was due to the inoculant.

RESULTS.—Decay was greater in yams stack-piled on the floor of the hut than those tied up on stakes in the barn (Table 1). Incidence of decay was rather low in the case of the cluster yam, *D. dumetorum*, whereas in the other four species it varied from average to high, especially in the case of *D. esculenta* (Chinese yam), in which up to 59% decay was recorded in yams stack-piled on shelves. Most of such yams had been eaten or damaged by rats.

TABLE 1. Incidence of decay in yam (*Dioscorea*) species stored in a barn or stack-piled for 5 months

Species of yam	No. tubers stored	% Decay	Type of storage
D. alata	166	9.0	Barn
	182	52.2	Stack-piled
D. cayanensis	200	6.0	Barn
	180	42.2	Stack-piled
D. dumetorum	110	1.8	Barn
	198	11.1	Stack-piled
D. esculenta	120	20.0	Barn
	288	59.3	Stack-piled
D. rotundata	150	20.7	Barn
	122	39.5	Stack-piled

Penicillium oxalicum Currie & Thom. and *Aspergillus niger* van Tiegh. occurred consistently in all yam species except *D. alata* and *D. esculenta*. Six other fungi less commonly isolated were: *Aspergillus tamarii* Kita.; *Botryodiplodia theobromae* Pat.; *Fusarium* sp.; *Cylindrocarpon radicicola* Wollenweber; *Cladosporium herbarum* Link ex Fr.; and *Rhizopus nigricans* Ehrenb. (Table 2). The decay organisms in yam are mainly *Penicillium oxalicum* and *Aspergillus niger*. *Botryodiplodia theobromae* and *Aspergillus tamarii* caused rotting and light brown decay in those species susceptible to them. The remaining four fungi were unable to induce decay in any yam species (Table 3).

The cluster yam (*D. dumetorum*) was resistant to *Penicillium oxalicum*. A thin, hard, purplish-brown barrier formed at the point of inoculation, and the fungus was unable to cause any damage.

In cases where decay occurred, the inoculated fungi were recovered.

DISCUSSION.—The incidence of decay varied with the species and also with the type of storage. The markedly higher incidence of decay in the yams stack-piled in heaps on the floor of the hut over that of yams tied up on stakes in a barn might have resulted from visible physical damage resulting from rodent attack as well as the possible humid conditions resulting from stack-piling of the tubers on the floor.

Apart from damage due to rats, damage resulting from bruising and careless cuts during harvest or preharvest nematode attack on the tubers facilitates the invasion of the tubers by decay organisms.

Fusarium sp., *Rhizopus nigricans*, *Cylindrocarpon radicicola*, and *Cladosporium herbarum* caused no decay under the experimental conditions. They may be

TABLE 2. Fungi isolated from decayed yams (*Dioscorea*)

Fungi	*D. alata*	*D. cayanensis*	*D. dumetorum*	*D. esculenta*	*D. rotundata*
Aspergillus niger	0[a]	13	85	0	15
A. tamarii	9	0	0	71	13
Botryodiplodia theobromae	8	0	0	0	3
Cladosporium herbarum	0	0	0	0	2
Cylindrocarpon radicicola	11	0	0	0	2
Fusarium sp.	6	11	0	29	3
Penicillium oxalicum	57	76	15	0	60
Rhizopus nigricans	9	0	0	0	2
Total isolations	106	110	108	102	120

[a] Figures represent frequency of occurrence given as a percentage of the total isolations.

TABLE 3. Effect of inoculating yam tubers (*Dioscorea*) with selected fungi

Fungi	*D. alata*	*D. cayanensis*	*D. dumetorum*	*D. esculenta*	*D. rotundata*	Nature of rot
Aspergillus niger	1.6[a]	1.4	1.7	2.1	2.0	Purple-brown
A. tamarii	0.3	0.6	0	3.6	0.5	Light-brown
Botryodiplodia theobromae	2.8	3.0	0	3.2	3.4	Wet-rotting
Penicillium oxalicum	3.8	3.2	0	3.7	4.1	Brown

[a] Figures represent average measurement of distance of decay from site of inoculation (cm) from head, middle, and tail regions of the 5 tubers used/species of yam after 4 weeks.

secondary organisms colonizing the tuber following decay by the primary organisms. One species of *Fusarium*, however, rotted yams in the Ivory Coast (2). *Botryodiplodia theobromae* has been reported as causing a rot of yam in Ghana (3, 6), the Ivory Coast (7), and Nigeria (1, 8); *Fusarium solani* in the Ivory Coast (7); *Penicillium scleretigenum* in China (9); *Hendersonula toruloidea, Macrophomina phaseoli,* and a bacterium, probably *Serratia* sp., in Nigeria (8).

This is the first record of the ability of *Aspergillus niger* and *Aspergillus tamarii* to cause decay in stored yam.

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