A Workshop Report in AJRTC (1996) Vol. 1 No. 2: Pages 38–42

Pests and pathogens of yams in storage

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Manuscript received 4 September 1995; accepted 17 January 1996

Abstract

Pests and pathogens in storage are frequently identified as constraints to yam (*Dioscorea* spp.) production in West Africa. At a one-day workshop (International Institute of Tropical Agriculture, Ibadan, May 1995), it was recognized that nematodes, a range of fungal pathogens and insect pests cause economic losses of both seed and ware yams in storage, although damage is often initiated prior to harvest. Yam scientists described examples of strategic and applied research on biotic constraints in storage that are being undertaken within the yam zone of West Africa. Working groups were subsequently established to develop research initiatives on the use of survey work to quantify the problems of pests and pathogens in storage, mechanisms of resistance and strategies for control. Despite the importance of yam as an indigenous staple food and also as a cash crop, the crop has received inadequate research and funding. It was, therefore, concluded that by forming cross-institutional linkages among yam scientists, it could be possible to present a stronger case to donor agencies for funding in yam research.

Key words: yams, *Dioscorea* spp., pests, pathogens, tuber storage

Introduction

At the work planning meeting of the Plant Health Management Division (PHMD) of the International Institute of Tropical Agriculture (IITA) held in January 1995, pests and pathogens on yam tubers (*Dioscorea* spp.) in storage were identified as key constraints to yam production in West Africa. Before developing research initiatives in this field, however, plant pathologists and breeders at IITA wished to obtain feedback from researchers from Nigeria on these issues:

- What are perceived as the major pest and pathogen problems related to yam storage?
- Have these constraints been quantified in different areas within the yam zone of West Africa?
- What aspects of strategic and applied research are being undertaken at present and what is planned for the future?
- What aspects of research have been neglected and how could these now be addressed?

It was proposed that a one-day workshop would provide an appropriate forum for interested scientists to both present their work and to make suggestions with respect to the above questions. In response to this recommendation, a workshop on pests and pathogens of yams in storage was coordinated by scientists from the Host Plant Resistance Program of PHMD and held at IITA, Ibadan on 25 May 1995. The workshop was attended by 50 researchers from national programs, non-governmental organizations, universities, overseas aid organizations, and IITA.

During the workshop, participating scientists gave brief presentations, in which they delineated their research goals and their principal activities relating to the diseases and pests of yam in storage. Participants considered that there were three themes which emerged repeatedly from the presentation sessions that warranted more detailed discussions:

- The use of survey work to quantify the problems of pests and pathogens of yams in storage.
- Mechanisms of resistance to pests and pathogens of yams in storage.
- Strategies for the control of pests and pathogens of yams in storage.

For each theme, a working group of scientists with common interests was initiated to discuss gaps in research and to establish working partnerships that could develop appropriate research initiatives.

Pests and pathogens of yams in storage: the current status

Seventeen discussion papers were presented:

1. Dr G.C. Orkwor (National Root Crops Research Institute [NRCRI], Umudike) gave an overview of: **Production constraints and available technologies for sustainable yam (*Dioscorea* spp.) production in the West African yam belt.** A range of available technologies for use in yam production were described. For example, the development of minisett technology (NRCRI/IITA) has increased the multiplication ratio of yam from 1:5 to 1:40. Other examples included the use of biotechnology for clean tuber production, modification of cultural practices, weed control strategies, IPM packages, the improved design of yam barns, and processing technologies. Dr Orkwor highlighted a number of constraints to yam production including large requirements for labor and planting materials, numerous pests and diseases, difficulties in yam breeding as well as the need for maintaining fertile soils, a long growing season, and evenly distributed rainfall. It was concluded that despite the importance of yam as an indigenous staple food and the potential for commercial production, the crop has received inadequate research and funding, and now requires donor support. In addition, the importance of germplasm conservation and biotechnology in the future of yam research was stressed.

2. Prof. S.O. Adesiyan (University of Ibadan) described: **Two decades of research on the yam nematode *Scutellonema bradys* in Nigeria: achievements and future challenges.** Surveys in Nigeria revealed that both *Scutellonema bradys* and *Meloidogyne incognita* are important in yam tuber decay and that the severity of attack varies with locality, yam species, and cultivar. It was shown that *S. bradys* can reproduce rapidly in stored yams resulting in tubers which are inedible and also unsuitable for planting by the end of the storage period. *S. bradys* was usually found to a depth of 0.5 cm in tubers, causing symptoms of dry rot due to extensive disintegration of the epidermis by the action of pectic enzymes. Infection resulted in losses of up to 75% and a reduction in food quality due to the hydrolysis of starch to simple sugars. Chemicals were effective for control but problematic because of toxic residues in tubers and limited availability to farmers. The technology of hot water treatment has potential but has not been transferred to farmers as yet. For the future, Prof. Adesiyan proposed the use of natural chemicals in nematode control.

3. Dr R. Dumont (CIRAD/IITA, Benin): **The nature and importance of tuber damage during yam storage in Côte d'Ivoire: improvements developed through research.** In Côte d'Ivoire, most damage on *D. alata* in storage was caused by insects, while losses of *D. cayenensis-rotundata* were largely attributed to fungal rots. In addition, internal brown spot caused serious damage to *D. alata* var. Bété Bété. It was shown that an insecticide/fungicide combination (permethrine, malathion, thiabendazole) markedly reduced tuber damage, particularly on *D. alata*, for four months. From an IDESSA/FAO experiment, it was concluded that the storage of yam tubers in pits reduced damage caused by pests and rodents but did not reduce rots or internal brown spot, and did not improve the efficacy of chemical control. It was concluded that the incidence and spectrum of different types of tuber damage increased when yams were produced commercially and when there was a shift towards sedentary agriculture.

4. Dr J.K.U. Emehute (NRCRI, Umudike): **Pests of stored yam tubers in Nigeria.** Yam mealybugs, scale insects, coffee bean weevil, yam moths, and rats were identified as major pests of stored yams in Nigeria. It was noted that storage losses could often be minimized by phytosanitary practices and periodic removal of damaged tubers, together with dipping/spraying with suitable insecticides. For future work, Dr Emehute proposed a nationwide survey for proper assessment of pest damage in storage, correct taxonomic identification of causal agents, and studies on parasitoids of mealybugs.

5. Dr N.O.A. Ezeh (NRCRI, Umudike): **Storage constraints of yam farmers in Abia and Imo States of Nigeria: some survey data.** Dr Ezeh reported on a postharvest survey of yam farmers in Abia and Imo states of Nigeria conducted in 1994. Barn structures were the most common type of storage system found, although a few farmers used shade, trees, or baskets. Pests and pathogens (principally termites and rot-causing organizms) ranked highest among the storage constraints identified. The median annual loss for farmers due to storage loss was estimated at 300 naira, although 14% of farmers incurred losses in excess of 1000 naira.

6. Dr E.C. Nwauzor (NRCRI, Umudike): **Nematodes as pests of yam in storage.** Survey results showed that 70% of farmers are aware of nematode symptoms, although few farmers realize that the symptoms indicate a problem. Some farmers can, however, identify crop combinations that aggravate the situation. Work being undertaken to address the problem includes the use of chemicals, hot water therapy, antagonistic cover crops, screening for resistance, and dipping tubers in commercial bleach before storage. For the future, Dr Nwauzor suggested research on breeding for resistance, intercropping, crop rotation, soil organic matter amendments, and the use of botanicals for the control of nematodes.

7. Rev. Sr N. McNamara and Mr M. Acholo (Diocesan Development Services, Kogi State): **Problems of yam storage in Kogi State, Nigeria - findings from the DDS yam storage project.** A project commenced in 1993 to examine the causes of yam tuber damage in relation to different types of cultivation and storage in Kogi Stage. Pests and pathogens were in evidence irrespective of storage type, although damage was particularly prevalent in field clamps in non-riverine areas. The condition of yams in storage appeared to be stable for a few months, but when temperature and humidity increased after the harmattan, severe deterioration commenced. Rotting was always associated with some form of macroscopic damage, particularly that caused by the field yam beetle. The major fungal pathogens were *Fusarium* spp. Insecticide treatment (Damfin® or Actellic®) significantly reduced the severity of tuber damage and the incidence of various types of damage. In contrast, phytosanitary practices had no effect on mean damage scores or on the spectrum of damage types.

8. Prof. C. Iloba (University of Nigeria, Nsukka): **Fungi as causal agents in yam biodeterioration.** Prof. Iloba stressed the economic and cultural significance of yam but noted that the deficit in yam production could not be easily overcome, due to disease problems in the field and in storage. Losses due to fungal damage are difficult to quantify, although it is known that farmers start to utilize tubers immediately after harvest in order to avoid the problem of biodeterioration. Prof. Iloba listed eleven pathogens that were routinely isolated from symptoms of soft rot on diseased tubers, but argued that establishing the role of these fungi in tuber biodeterioration would be an important step towards control. It was emphasized that the distinction between field and storage problems is artificial, since systemic infection could commence in the field and continue in storage, particularly for pathogens such as *Fusarium, Botryodiplodia,* and *Colletotrichum.*

9. .Prof. R.O. Ogbuji (University of Nigeria, Nsukka): **Studies on the resistance/susceptibility of yam cultivars to *Meloidogyne incognita*.** Research results indicated that there were differences within and between yam species with respect to susceptibility to the nematode *Meloidogyne incognita.* Cultivars of *D. rotundata* were the most susceptible, followed by *D. alata.* The species *D. cayenensis, D. bulbifera,* and *D. esculenta* had greater resistance to infection than *D. alata* and *D. rotundata.* Infected yams were warty, had extensive root growth, and rapidly became infected with fungal species during storage. Rotting was followed by shrinkage due to loss of water and sugars. In contrast, nematode-free

tubers remained healthy until the planting season. It was concluded that plant parasitic nematodes play an important role in yam rotting; they provide infection sites and reduce starch substrates to simple sugars, thus providing ideal conditions for fungal development.

10. Dr C.L.A. Asadu (University of Nigeria, Nsukka): **Traditional field/storage practices intended to promote the shelf-life of yam in southeastern Nigeria.** During 1986 and 1987, observations were made and informal interviews and discussions were held with yam growers in four locations known for yam production in southeastern Nigera. The study revealed that yam growers in the areas have more than 15 techniques which they considered helped them directly or indirectly to prolong the shelf-life of their tubers. Some of the techniques done in the field, while others follow yam harvest. Some of the methods such as the provision of a ventilated cool environment through shading were widespread, while others such as curing were observed only in two locations. The most widespread storage problems were dry or wet rot caused by either bacteria or fungi, and lesions caused by nematodes. Evaluation of the observed techniques in terms of the extent of use, effectiveness, economics, and potential for alternatives and improvements was strongly recommended.

11. Ms M. Otusanya (University of Agriculture, Abeokuta): **Studies on yam (*Dioscorea* spp.) tuber rot caused by *Aspergillus niger* van Tiegh.** Studies were conducted in a U.K. laboratory on the response of *Dioscorea* spp. to infection by *A. niger*. Ten isolates of *A. niger* obtained from diverse hosts (including yam) and geographical sources were inoculated onto yam tubers from different countries. All the isolates were pathogenic when artificial wounds were present and environmental conditions were conducive for fungal development. Rot severity was influenced markedly by the incubation temperature. Rot development was assessed in inoculated tubers of *D. rotundata*, *D. alata*, and *D. esculenta* under long-term storage conditions. *D. esculenta* was the most susceptible (attributed to a thinner periderm and less compact inner tissues) while *D. alata* was the most resistant. Treatment with fungicidal compounds (benzoic acid at 500 ppm) significantly reduced ($P = 0.05$) the severity of rot. Inoculation of tubers with *A. niger* before planting in the field reduced shoot emergence and retarded vine development; delays in emergence due to infection led to a reduction in leaf formation and overall tuber yield.

12. Dr L. Kenyon[1] and Dr A. Nwankiti[2] (Natural Resources Institute, UK[1] and University of Agriculture, Makurdi[2]): **Recommendations for seed-yam production from minisetts.** Dr Kenyor gave a summary of sources of yam planting material and causes of loss in storage. Factors influencing the microbial decay of yams were discussed, including yam variety, the level of maturity at harvest, the environment used for yam cultivation, and storage practices. It was reported that a pre-planting treatment of yam minisetts with benomyl, thiabendazole, or imazilil could lead to an increase in germination and subsequent yield but did not reduce decay in storage. Recommendations for seed yam production from minisetts were: (i) select large, clean, sound tubers; (ii) treat minisetts with fungicide then cure overnight; (iii) pre-germinate in sawdust and select the most vigorous plants; (iv) rogue out virus infected/diseased plants; (v) avoid damage to seed yams at harvest; (vi) select only clean, sound seed yams for storage; (vii) treat yams with fungicide or bleach before storage; and (viii) ensure storage area is clean, well ventilated, shade, and rodent-proof. Remove any rotten yams.

13. Dr M.O. Akoroda (University of Ibadan): **Observations on yam in storage.** In yam breeding and clonal trials, many tubers of clones are stored between harvest and the next planting time. Observations during this interval include shrinkage and weight reduction of tubers resulting from physiological processes (e.g., sprouting) compounded by damage due to nematodes, insects, and rodents. A number of storage technologies that require further research in order to evaluate their suitability for farmers (in terms of efficacy, feasibility, and relative costs in relation to benefits) were discussed, including the control of environmental conditions during storage, tuber inspection, tuber curing, pest control, and the use of permanent structures to reduce the costs of storage.

14. Dr B.O. Ugwu (IITA/COSCA, Ibadan): **Yam storage systems and losses in three major yam-producing areas of southeastern Nigeria.** The results of survey work that was undertaken as part of the Regional Market Demand (Eastern Nigeria) Study, were described. Yam is important in the study areas since it is a food security crop, it has a socio-cultural value, and it is a cash crop. It was shown that the percentage distribution of resources (land, labor, and capital) allocated to yam by the average household in 1984–85 was high relative to other crops, and that 30–55% of cash income could come from the sale of yam. The importance of yam justifies the commitment of resources to research on yam storage. Hence, there is a need to undertake a survey of yam storage systems in major yam-producing areas within the yam production belt; quantify storage losses due to factors such as pests/diseases, sprouting, dehydration, etc.; conduct on-station and on-farm studies which can result in improved and cheap storage techniques that are within the reach of individual households.

15. Dr P. Speijer (IITA, Uganda): **Hot water treatment: A possible strategy for farmer groups and NGOs.** Dr Speijer outlined ideas for research on yam nematology to be undertaken by the Plant Health Management Division at IITA, together with the Root and Tuber Improvement Program. Strategic research would involve investigation of the nematode species profile for yams in Nigeria (researchers in South Africa to assist with identification) and assessment of levels of damage attributed to different species in the field and in storage. On control, the importance of developing standard rapid methods for screening yam germplasm for nematode resistance was stressed, In addition, the need for clean planting material was emphasized. It was proposed that hot water treatment should be made available at the NGO, ADP, cooperative or community level, for the treatment of seed yams. Similar initiatives that had been developed successfully for the treatment of *Musa* planting material were described.

16. Dr R. Asiedu and Dr N. Wanyera (IITA, Ibadan): **Yam storage: Problems from a breeder's perspective.** It was

explained that the early obstacles to the hybridization of yams have been overcome through acquired knowledge of the reproductive biology of cultivated yams. Instead, it is now storage losses that represent a major challenge to yam breeders. While some losses are advantageous to the selection process by eliminating materials that are most susceptible to pests and diseases, a large proportion of losses represent a constraint to yam breeding research (e.g., rotting of valuable germplasm for genetic studies). Dr Asiedu noted that good postharvest keeping quality of the tuber is essential attribute to target in breeding programs and called for a multidisciplinary approach to ensure efficiency in selection and to enable a reduction in storage losses where necessary.

17. Mr W.I. Okoye and Mr J.F. Afolabi (Nigerian Stored Products Research Institute, Ilorin and Ibadan): **Situation report on pests and pathogens of yam in storage.** Due to the importance of yam in the Nigerian economy, yam storage is one of the major research areas of the Nigerian Stored Products Research Institute. Several species of fungi that could act alone or in combination with other agents to cause spoilage in stored yam were listed. Insect infestation was not considered a serious problem on yam tubers, although it was reported that certain insect species are major pests in the storage of dried yam chips (especially *Dinoderus porcelus*). Past efforts to address storage problems included the use of irradiation, chemicals including limewash and wood ash slurry, a reduction in storage temperatures, and modifications to the design of the traditional yam barn. These measures have all had some degree of success. Ongoing research involves the development and evaluation of chemicals for the control of sprouting and rotting using local materials. It was also suggested that for longer-term storage, tubers should be processed into yam chips and dried to a moisture content of 13%.

Research initiatives

Working group 1: The use of survey work to quantify the problems of pests and pathogens of yams in storage.

Chaired by Dr B.O. Ugwu

- The group concluded that more survey work was needed in order to characterize yam storage systems and to quantify the problems of pests and pathogens of yams in storage. Interested organizations included Diocesan Development Services, Kogi State; NRCRI, Umudike; and IITA.
- Previous surveys undertaken by a range of organizations in Nigeria have considered aspects of yam storage in different areas. Before embarking on surveys, it is vital to collate and review the information from previous work of this type. In addition to evaluating the results, it would be necessary to clarify and standardize methodology. It was suggested that the collation and review process could be facilitated by IITA in collaboration with DDS and NRCRI, and should form the basis of future survey work.
- In planning future survey work, the following ideas should be incorporated:

(a) The survey work should be conducted by a multi-disciplinary team.
(b) Surveys should incorporate indigenous technical knowledge (ITK).
(c) It should be acknowledged, however, that some farmers may not necessarily recognize that certain storage problems exist and this factor should be taken into consideration when designing appropriate sampling strategies.
(d) In addition to the farmers who store yams, it will be important to talk to the end-users who purchase and consume the yams, since they who determine what level of rotting on yam is acceptable.
(e) Traders and, to a lesser extent, consumers are also more involved in extensive storage of yam; technology development towards efficient yam storage systems should also address the needs of these people.

- In the first instance, survey work should be limited to the yam zone of Nigeria, but could later be extended to other yam-growing countries of West Africa. The information obtained would assist in setting research priorities, e.g., for crop protectionists, breeders, and postharvest technologists, and could potentially highlight important differences in storage problems in various yam-growing areas of the country.

Working group 2: Mechanisms of resistance to pests and pathogens of yams in storage

Chaired by Prof. A. Osagie

Participants in this group identified topics which they considered warranted the development of research initiatives:

1. **Calcium fertilization and infiltration**
- Evaluate the role of calcium in yam rot
- Study several levels and types of calcium nutrition with respect to yam rot during storage.
- Determine the levels of calcium that confer "resistance" to storage losses in yam varieties.
- Study treatment methods, e.g., (i) foliar or soil applications (preharvest treatments), and (ii) soaking or infiltration (postharvest treatments).

2. **Gall formation**
- Investigate the interaction of hormones (indole-acetic acid and giberellic acid) in gall formation and the manipulation of galling.
- Study the pre- and post-storage application of hormones, since galling occurs largely during growth.

3. **Enzyme interaction**
- Study the process of starch breakdown during storage.
- Funding required to study target enzymes in stored yams.
- Study the inheritance of enzyme action and/or gall formation.
- Study the biochemical basis of enzyme interaction.

4. **Host plant resistance**
- Understand the basis of resistance at the biochemical, physiological, and molecular levels.
- Undertake gene transfer from wild yams after a preliminary survey and evaluation for storage quality.

- Characterize laminar and cell-wall structures in relation to tuber storability.
- Test the performance of identified resistant varieties in other environments.

5. Physiology and biochemistry

- Study the position of tubers in barns during storage, in relation to rotting.
- Quantify the effects of temperature and other environmental factors on tuber physiology in storage.
- The biochemistry and dormancy process is to be further studied and controlled.
- Understand the hormonal balance during dormancy to better manipulate dormancy induction and/or termination.
- Investigate the potential for reduced sizes of tubers for storage and/or shipment.
- Model sprouting periods to better control tuber dormancy.

Working group 3: Strategies for the control of pests and pathogens of yams in storage

Chaired by Dr E.C. Nwauzor

Participants identified available technologies for the control of pests and pathogens of yams in storage, research gaps associated with these technologies, and institutes which have an interest in developing research initiatives (Table 1).

Conclusions

The main benefit of the workshop on pests and pathogens of yams in storage was the assemblage of scientists from national agricultural research stations, universities, international research institutes and non-governmental organizations to discuss common problems, to examine current research, to determine research gaps and to identify researchable topics. There was insufficient time during the workshop to identify all of the topics that warrant research, thus participants were encouraged to provide feedback to other members in the group concerning any ideas raised after the workshop.

The workshop helped to identify researchers with common interests who could subsequently form smaller groups that would be effective in developing research proposals on specific topics. It was stressed that these working groups should obtain farmer and socioeconomic input and should consider how the results from the planned research could be effectively transferred to the level of the farmer. Finally, it was emphasized that by forming cross-institutional linkages, it would be possible to present a stronger case to donor agencies for funding in yam research.

Table 1. Technologies for the control of pests and pathogens of yams in storage

Technology	Research gap	Interested institutes
1. Planting material		
Clean seed yam		
- Tissue culture	Reinfection rate	IITA, NRCRI, UNN, Reading
- Farmers' selection	Multi-site testing of farmers' selected varieties	NRCRI, UNN, IITA, Lafia
- Minisett technology	Low rate of adoption, need for survey	NRCRI, IITA, UI
- Minituber production	Research ongoing	IITA, NRCRI
- Treatment of planting materials (sett/seed):		
(i) Botanicals/wood ash (dry or slurry)	Source and application method	NSPRI, NRCRI, UI
(ii) Calcium infiltration/ fertilization	No adequate technology	Abeokuta, UI, NSPRI, UniBen
(iii) Hot water therapy	Technology not yet available to farmers	NRI, NRCRI, Makurdi, IITA, UI, and Agricultural Development Programs and Extension groups
2. Storage of seed yams		
- Curing before storage	Curing period not clear	NRCRI and Lafia to standardize
- Crown removal (removal of crown close to breakage of dormancy delays sprouting)	Limited information available	
- Use of botanicals	Screening for useful materials for yam preservation, followed by toxicology of promising ones	NSPRI, UI, NRCRI, UNN, Lafia, Makurdi
- Use of sorghum panicle	Limited information available	IITA (Cotonou)/CIRAD
- Chemical use	Limited information available	
- Low doses of herbicide (dipping head ends of tubers in very low concentration of herbicides (e.g., glyphosate) delays sprouting	Limited information available	Lafia, NRCRI

Technology may also be appropriate for ware yams as well as seed yams, but further screening may be necessary

Key: Abeokuta: University of Agriculture, Abeokuta; CIRAD: Centre de Coopération Internationale Agronomique pour le Développement; IITA: International Institute of Tropical Agriculture; Lafia: Plateau State College of Agriculture, Lafia; Makurdi: University of Agriculture, Makurdi; NRCRI: National Root Crops Research Institute, Umudike; NRI: Natural Resources Institute, Chatham, UK; NSPRI : Nigerian Stored Products Research Institute, Ibadan and Ilorin; Reading: University of Reading, UK; UI: University of Ibadan; UniBen: University of Benin; UNN: University of Nigeria, Nsukka.