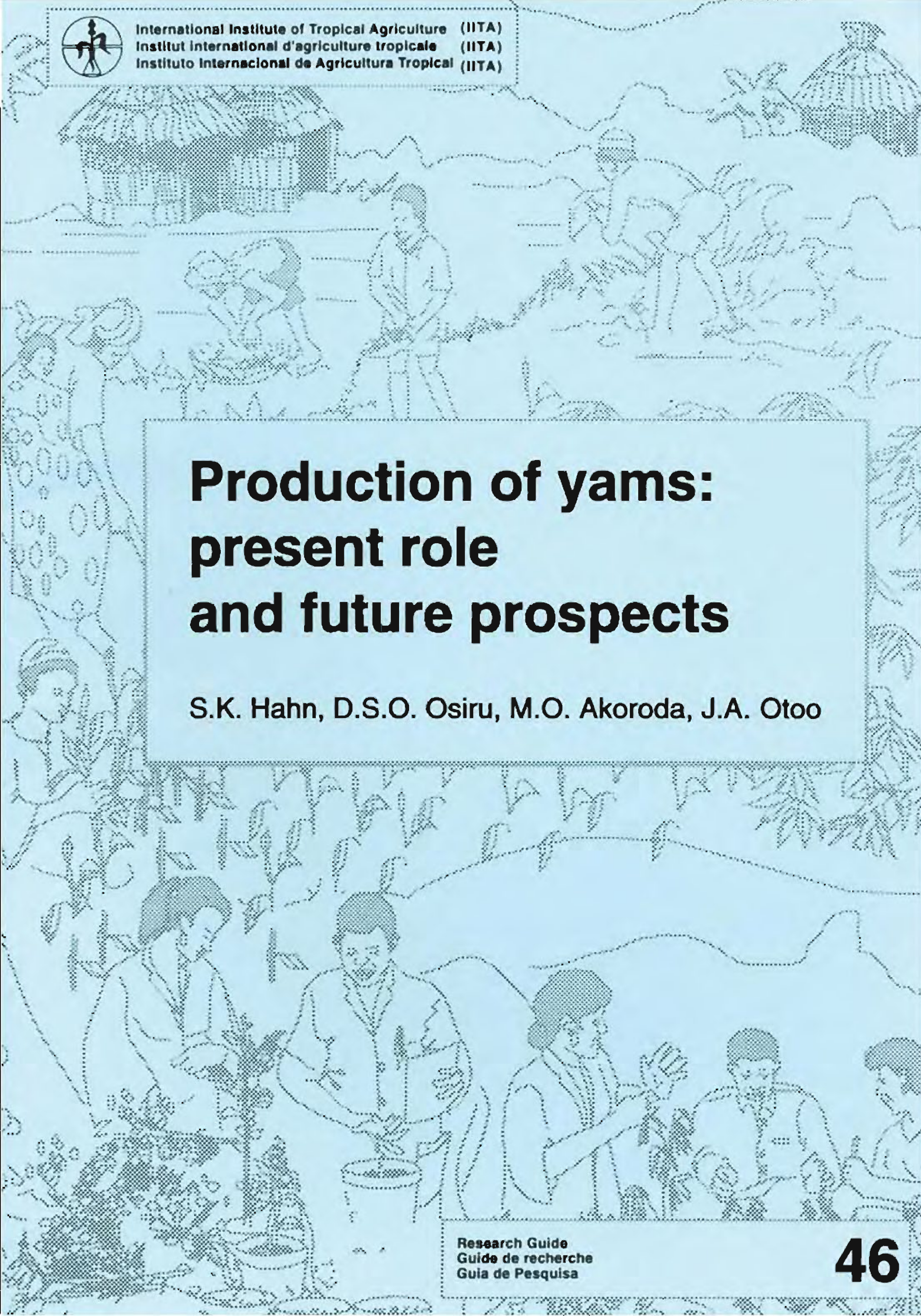
International Institute of Tropical Agriculture (IITA)
Institut international d'agriculture tropicale (IITA)
Instituto Internacional de Agricultura Tropical (IITA)



Production of yams: present role and future prospects

S.K. Hahn, D.S.O. Osiru, M.O. Akoroda, J.A. Otoo

Research Guide
Guide de recherche
Guia de Pesquisa

46

IITA Research Guide 46

Production of yams: present role and future prospects

S.K. Hahn, D.S.O. Osiru, M.O. Akoroda, J.A. Otoo

March 1995

Adapted with permission of Pergamon Press. Original reference: Hahn, S.K.; Osiru, D.S.O.; Akoroda, M.O.; Otoo, J.A. 1987. Yam production and its future prospects. Outlook on Agriculture 16: 105-110.

International Institute of Tropical Agriculture
Training Program
PMB 5320
Ibadan
Nigeria

Cable: TROPFOUND Ikeja
Telephone: (234-02) 241-2626
Fax (INMARSAT): 874-1772276
Email: Internet IITA @CGNET.COM
Telex: 31417 or 31159 TROPIB NG

IITA Research Guides

IITA Research Guides provide information and guidance to agricultural researchers, technicians, extension specialists, and educators conducting research and training essential for agricultural development. The Research Guides are periodically updated to meet advances in scientific knowledge.

Text processing	Kehinde Jaiyeoba
Art	Chiweta Onianwa
Layout	Nancy Jadu
Coordination	Rainer Zachmann

Hahn, S.K.; Osiru, D.S.O.; Akoroda, M.O.; Otoo, J.A. 1995. Production of yams: present role and future prospects. IITA Research Guide 46. Training Program, International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. 34 p. Third edition.

Production of yams: present role and future prospects

Objectives. This guide is intended to enable you to:

- explain the importance of yams;
- describe the peculiarities of yams;
- discuss the cultural roles of yams;
- discuss yam production and constraints;
- demonstrate yam storage;
- *describe research needs.*

Study materials

- Maps showing the "yam zone".
- Production statistics.
- Plants and tubers of different yam species.
- Pounded yam of different qualities.
- Yam fields and storage.

Practicals

- Observe the growth peculiarities of yams in the field.
- Evaluate different food preparations of yams.
- Practice planting, harvest and storage.
- Record the importance of yams in rural and urban areas, identify problems of production and utilization, and determine research priorities.

Questions

1 To what genus do food yams belong?
2 What are six important yam species?
3 What is the probable center of origin of the African food yam species?
4 What countries does the "yam zone" comprise?
5 What is the most peculiar characteristic of yam plants?
6 What is the yam tuber botanically?
7 What factors may be responsible for the drought tolerance of yams?
8 What is the role of "hand feeling" as opposed to "mouth feeling" in traditional food cultures?
9 What are the ideal ecological conditions for yam production?
10 What proportion of the yams produced is usually reserved for planting?
11 What are the problems of staking?
12 What are the advantages of producing small tubers?
13 What are major pest and disease problems of yams?
14 What are two kinds of storage problems?
15 How long do yam tubers remain dormant?
16 What are three essential requirements for a storage barn?
17 Why has technological development of yam production been slow?
18 What are important objectives of future yam research?

Production of yams: present role and future prospects

Abstract. Yam is an important food crop, especially in the 'yam zone' of West Africa. Total world production is about 20-25 million tons per annum, some 70 per cent of it grown in Nigeria. Although regarded mainly as a source of carbohydrate, some species are nearly as rich in protein as rice or maize. The increasing acceptability of smaller tubers provides an opportunity for extending the area of cultivation particularly in the humid savanna, but more research is needed on methods of propagation, disease control, and storage.

1 Importance of yams

Food yams are members of the genus *Dioscorea* and are grown principally for the carbohydrate they provide. The tubers which are their only edible part, have both a tremendous capacity to store food reserves and the ability to grow into the deeper layers of the soil. The latter enables yam plants in the wild to survive from one rainy season to another and escape the periodic burning which commonly happens to bushes in the traditional farming systems.

The top growth consists of twining vines that may be several meters long, depending on species and growing conditions. They are well adapted to climbing on bushes or forest trees. Cultivated yam plants are nearly always staked to ensure that their leaves spread well to intercept more sunlight and to reduce foliar diseases.

Although more than 600 species exist, only six are important as staples in the tropics. These are white yam *(D. rotundata)*; yellow yam *(D. cayenensis);* water yam *(D. alata);* trifoliate yam *(D. dumetorum);* aerial yam *(D. bulbifera);* and Chinese yam *(D. esculenta)*. Together, the six species account for over 90 per cent of all the food yams grown in the tropics.

Available evidence indicates that different yam species originated and were brought into cultivation in three independent areas of the tropics: South East Asia (for *D. alata* and *D. esculenta);* West Africa (mainly for *D. rotundata, D. cayenensis,* and *D. dumetorum),* and precolumbian tropical America (for *D. trifida)* .

In West Africa, domestication of the yam was associated with the people west of the Cameroon mountains to the Bandama river, in central Ivory Coast, an area generally referred to as the 'yam zone'. The diversity of genotypes observed in the yam zone suggests that the probable center of origin of the African food yam species might be along the Niger river valleys in Nigeria.

Growing yams requires skills in choosing land and variety, preserving planting material, and cultivation methods. Its domestication must have been associated with people who had special skills of growing and interest in the crop.

It is now recognized that long before the Europeans arrived in the yam zone, local people had a very highly organized social system, and they used yams in rituals and sanctioned social events as early as man started making use of the plant. Thus, ritual attachment' must have played a highly significant role in domesticating the yam. The crop's early movements were probably with people moving along the Niger river valleys. River beds, with deep fertile top soils that had eroded from high lands, provided ideal conditions for the production of large tubers.

In general, there was an east-to-west movement of yam species during the domestication process. For example, the Asiatic species *(D. alata; D. esculenta)* were transferred to Africa and America and are now grown widely in many parts of both continents. Similarly, the African species *(D. rotundata* and *D. cayenensis)* were taken westwards within West Africa and to America and have become important crops, particularly in the Caribbean region. Surprisingly, little movement of yam species seems to have taken place in the reverse direction.

Although yams are grown throughout Africa, present-day production is largely confined to the yam zone comprising Cameroon, Nigeria, Benin, Togo, Ghana, and Côte d'Ivoire. This zone produces more than 90 % of the total world production, which is estimated at 20-25 million tons per year. Nigeria alone produces about 70 % of the world total. There is a growing interest in yams in other African countries.

Yam plants have several characteristics peculiar to themselves. Perhaps the most important is that the plants are dioecious; that is, the male and female reproductive organs are nearly always borne on separate plants. Female plants have a much longer vegetative phase and produce larger tubers, possibly because of longer leaf area duration.

During the domestication and evolution of the yam, large tubers were often selected for consumption, rituals, and sanctioned social events. Smaller tubers from male plants were used for planting, a practice which has reduced the female yam population considerably.

In IITA's breeding program, for example, 65 % of a collection of 1 000 lines were male plants, 25 % were female and 10 % were of the non-flowering type.

The yam is often referred to as stem tuber, because it is supposed to be a modified stem structure, but in fact it lacks the typical characteristics of a modified stem structure. For example, unlike the *solanum* potato, it has no preformed buds or eyes, no scale leaves, and no equivalent of a terminal bud at the distal end of the tuber. A study by Lawton and Lawton (1969) suggests that yam tubers originate from the hypocotyl, a small region of meristematic cells between the stem and the root.

Among crop plants, yams have the greatest sink capacity. Tubers will continue to grow and store food reserves throughout the growing season as long as conditions remain ideal. Individual tubers may weigh as much as 20-30 kg (Figure 1); yields as high as 33 kg per stand have been recorded. Thus the limitation to yield appears to be associated more with the photosynthetic system than with the plant's ability to store food reserves, so improving the photosynthetic capacity of the crop by manipulating agronomic factors can greatly increase yield.

Yet another peculiar characteristic of the yam plant is that the tubers exhibit dormancy; a physiological rest period with no sprouting. Although other root and tuber crops in the tropics exhibit dormancy, yam tubers have perhaps the longest dormant period. The length varies considerably among species (usually 10-15 weeks) and appears to be an adaptation to conditions prevailing in the region of origin. For example, species adapted to regions of prolonged drought *(D. rotundata)* have relatively longer dormancy, while those adapted to regions with short, dry seasons have correspondingly short dormancy *(D. cayenensis).*

Figure 1. Very large tubers (15-20 kg) of white yam, the most preferred and highly valued in West Africa.

Finally, yams are more tolerant to drought than many other crop plants. In traditional farming situations, they are usually planted immediately after harvest and the tubers may remain in the ground 2-4 months before the onset of rains. Even after sprouting, young plants have a remarkable ability to survive drought, and the following three factors may be responsible for this.

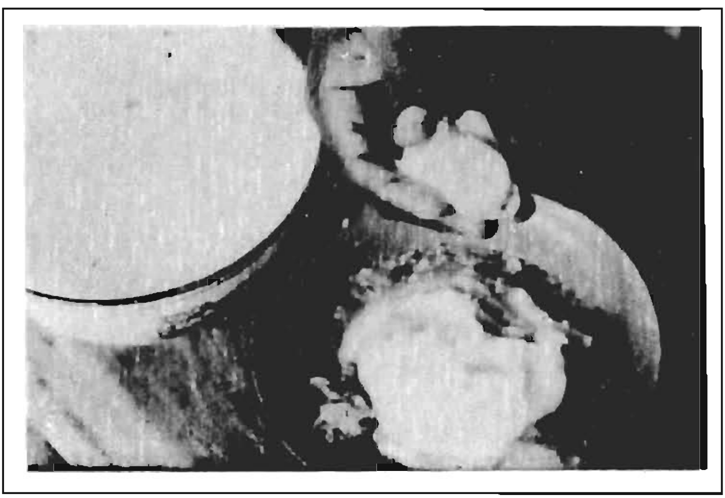
The first factor is that the planted sett contains an enormous amount of food reserve and moisture. During early development, the young plant can absorb sufficient moisture and food from the parent sett. Second, the first phase of growth is mainly concerned with developing an extensive root system; consequently, the plant is well equipped to exploit the available soil moisture. Third, the vine (young plant) is xerophytic often covered with a waxy bloom, and it is virtually devoid of expanded leaves with their large transpiring surfaces.

3 Roles of yams

In many parts of the tropics where yams are produced, the ethnocentric attachment to the crop is very strong. In Africa, particularly in the yam zone, they play vital roles in traditional culture, rituals, and religions, as well as in local commerce. In all these respects, white yam *(D. rotundata)* is the valued species. Large tubers (5-10 kg) are used as gifts or in marriages.

To appease the gods, special white yams are required. For example at Maku in Nigeria, an ancient white yam variety 'Ukoli' is used by local priests for sacrifices to the gods. No other type of yam can be used. Among the Igbo people of Nigeria, the yam is the totem of maleness, and women only peripherally engage in its cultivation.

Figure 2. Pounded yam together with soup containing vegetables and meat or fish is eaten by hand. 'Hand feeling' is more important than 'mouth feeling'.



Rich people use white yams to set standards of social status to which the poor aspire, thereby creating competition and struggle for attainment. This they do by virtue of the number, size and diversity of varieties offered during feasts, parties, chieftaincy meetings, marriage of additional wives, and during annual obeisance to royal rulers.

Current food yam roles center on fresh tuber consumption as the main source of carbohydrates. The crop remains the most preferred by millions of people in Africa, particularly those in the yam zone. The preferred method of preparation is boiling and pounding to improve the 'feel' of the food in the hand and for easy swallowing (Figure 2). It is believed that 'hand feeling' is more important than 'mouth feeling' in the traditional food culture.

The preference for swallowing as opposed to chewing by West Africans probably developed from the use of yams. There have been some attempts to market a range of dried products that simulate fresh-pounded yam (Figure 3). Although some technical success has been achieved, the developed products are not yet competitive with the fresh-pounded product because of higher costs and inferior hand feeling' and taste.

Yams are now exported primarily from West Africa and Caribbean countries to areas in Europe and North America with sizeable populations of yam eaters, who use the yams as they are used in those regions. Tubers are cooked into pottage and eaten with soup that include meats, fish, assorted vegetables, and oils, usually palm oil. Frying in oil and roasting are also important cooking methods.

Although yams are used mainly as a source of carbohydrates, some species are only marginally inferior to maize and rice in protein value. Of particular interest is that some less popular *(D. dumetorum)* and wild species are richer in essential amino acids than commonly grown species. So a genetic base exists for improving the amino acid content of the more popular species. Many species also contain substantial amounts of vitamins (thiamin, riboflavin, niacin, and ascorbic acid) and some minerals like calcium, phosphorous, and iron.

Figure 3. 'Elubo'; parboiled and sun-dried yam chips are milled into flour. Elubo can be preserved for a year or longer.

4. Yam production and constraints

Yam can be produced in nearly all tropical countries provided water is not a limiting factor. Ideal conditions include at least 1 000 mm of rain spread over five to six months and deep, friable, well-drained soils to allow for proper tuber growth and development.

Throughout the yam zone rainfall decreases steadily with distance from the coast, so the wetter south is forest and the northern flank is savanna. The forest belt clearly provides ideal conditions for productions, particularly for 5-10 kg ceremonial tubers.

In Nigeria, a decade ago more food yams came from villages in the forest belt, which is now experiencing increasing population pressure and shortages of arable land. So, the middle belt, with its wet-savanna to dry-forest vegetation, is increasingly becoming the major ware-yam producing area. Farther north in the savanna, where the rainfall is low and less reliable, the crop performs poorly and yields are generally low.

In general, little has been done to improve yam-cultivation techniques, which still depend largely on excessive hoe-and-cutlass labour (Figure 4). Many aspects of production - planting, weeding, staking, and harvesting require much labour.

Actual physical inputs, however, vary across different agroecological zones, depending on the size of tubers desired and, consequently, the type of land preparation and the type and height of stakes used. Consumer preference has considerable implications for many aspects of production.

Figure 4. Digging holes for planting yam setts after burning the bush. This system is practised in areas with loose, fertile soils and low water tables.

Figure 5. Ware-yam tubers (5-10 kg) in the back, for consumption and ceremony; seed yam tubers (1-1.5 kg) in the foreground for planting to produce ware yams.

Large tubers are preferred in the forest belt of the yam zone, and they necessitate using large planting setts. Farmers plant setts (whole or cut pieces) ranging from 100-1 500 g in weight depending on the size of tuber envisaged. Around 25-33 % of the yams produced are usually reserved for planting (Figure 5), which accounts for 38-45 % of the total cost of production. Lack of sufficient good quality setts limits production.

Large setts produce plants with extensive shoot systems that require staking. In the forest belt, with relatively low radiation intensities and high humidity, staking is required to obtain high yields. Thus, in Nigeria, they are staked up to 4 m in the forest belt near the coast line (Figure 6), where it is wet and cloudy, but in the wooded savanna there is virtually no staking.

Figure 6. Staking yams as high as 4 m is common in the forest belt.

The benefit of staking decreases with improved solar radiation. Beyond latitude 8° 30' N in Nigeria, tuber yields do not respond significantly to staking so the plants climb or are trained on sorghum stalks usually less than 1 m high. Staking is labour-intensive, costly, and difficult to mechanize. In addition, it depends on local availability of bush sticks. Increased deforestation is making stakes scarce even in the forest belt.

Production of large tubers also requires large mounds (Figure 7). Except for a few areas where soils are deep and yams may be grown on flat ground, they are invariably planted on hand-made mounds, as much as 1-2 m in height and with a radius of 2-3 m. Making mounds is laborious. In commercial production, mechanized ridges are now used.

Figure 7. Large mounds (1-2 m high and 2-3 m wide) are prepared for planting yam setts in the areas where soils are relatively poor and hard, and the water table is high.

Finally, harvesting large tubers is an extremely tedious, time-consuming process because the tubers must be excavated from considerable depths without bruising them, which would shorten their shelf life. Obviously, farmers must exercise great care in harvesting.

As noted earlier, increasing population pressure and the resulting shortage of arable land in the forest zone is shifting yam production into the savanna region. Smaller tubers (1-2 kg) are increasingly being accepted for the table by urban populations, and this means great opportunities for extending production into the savanna.

Production of smaller tubers will decrease production costs through the use of smaller mounds or ridges, less staking, and smaller setts for planting. In addition, transportation and processing will be easier, and storage losses reduced.

Weeds in yam plots are a problem in the first four months of growth. Weed competition during this period may reduce yield by as much as 43 %.

In many yam species, emergence is extremely slow and staggered, particularly in commercial plots where a mixture of heads, middle and tail portions of the tuber may be used as planting setts. Emergence may begin about two weeks after planting and continue for two to three months. This characteristic of yams makes it extremely difficult to choose and use herbicides efficiently because timing of the application is difficult.

In addition, many cultivars develop leaves slowly and do not cover the ground in the first four months, particularly in traditional farming situations with low plant populations. Thus, weed control during the early stages is imperative, and at least three weedings are needed during the first two to four months to ensure high yields.

Surprisingly, yams are attacked by relatively few diseases and pests, except anthracnose or necrosis that is extremely serious on *D. alata* in West Africa. The disease reduces the effective photosynthetic surface and duration of the crop and is particularly serious when it attacks the plant immediately after tuber initiation, or during bulking. No control measure is yet available but field resistance/tolerance has been identified at IITA in some cultivars. For example, TDa 291 and TDa 297 of *D. alata* , and TDr 131 and TDr 156 of *D. rotundata* have shown high tolerance to the disease.

Froth beetle *(Criceris livida)* and the yam-tuber beetle *(Heteroligus spp.)* are the only pests of some importance in the field. Froth beetle feeds on young shoots and leaves but seriously damages them only when it attacks at an early stage when the plants are establishing. Chemical control of the pest does not seem economical. Yam tuber beetle is important in some parts of the yam zone. In eastern Nigeria where the pest occasionally reaches economic levels, applying Thiodan or Carbofuran is recommended.

Repeated use of the same fields and planting setts infested with nematodes build up nematode populations. Experience at IITA indicates that nematodes, particularly root-knot and yam nematodes, can greatly reduce tuber yields, and drastically increase storage losses and market value. Control measures so far available are to plant nematode-free setts on new land and to adopt a rotation that includes a fallow period.

8. Storage

Yam storage problems are of two kinds. The first involves the direct effects of pests, diseases, nematodes, and mechanical damage that leads to rotting and losses in quality and marketability. The second involves sprouting of the tubers. Under normal situations, tubers remain dormant for 10-15 weeks and then start sprouting, leading to loss in food reserves which reduces both the weight and quality of the tubers. Effective storage systems are needed to ensure minimum postharvest losses from both causes.

Infection of tubers by pests, diseases, and nematodes in the field can greatly increase storage losses and should be prevented as much as possible. Yam tubers contain high moisture (70-80 %) particularly if harvested before they are physiologically mature. This high moisture content favours attacks by microorganisms during storage. Timing of the harvest is therefore, particularly important to reduce postharvest deterioration. Similarly, harvesting and postharvest handling must be done as carefully as possible to avoid injuring tubers, which may lead to infections and the deterioration of quality.

Tubers are usually cured before storage, spreading them out evenly in the shade 2 or 3 days after harvest. This permits wounds to heal, toughens the peel, and slightly reduces moisture content, thus improving storability and prolonging shelf-life. Other pre-storage treatments, such as pesticidal dips or gamma irradiation, also prolong storage life. Experience at IITA and elsewhere indicates that postharvest application of gibberellic acid (GA_3) extends the dormant period and prolongs tuber shelf life of many cultivars of *Dioscorea*.

However, extended dormancy depends on, *inter alia,* the concentration of GA3 used and immersion time. For a given batch of tubers, the more GA3 applied, the more dormancy is extended. Secondly, different species or cultivars respond differently to the postharvest application of the same level of GA3. Thirdly, the physical and physiological conditions of the tubers are important. GA3 is most effective when applied immediately after harvest or before curing starts. However, GA3 is expensive, thus uneconomic to the resource-poor farmers.

Storage systems vary considerably, depending on the environment. The most important traditional system is use of shaded barns where tubers are tied- up on racks or poles (Figure 8), but the care needed to tie the tubers on the poles makes the system tedious and laborious. IITA recently developed a modified system using simple, open-work shelving inside a barn. Its advantage is that placing tubers on the shelves requires less time and labour and damaged tubers can easily be removed.

Whatever the storage system, however, there are three essential requirements for a barn. The first is adequate ventilation: the barn must be located in an open position to allow for easy air flow. The second is adequate shade (usually of live trees), ensuring that only diffuse light reaches the tubers. The third is providing protection from direct rain, to avoid spread of bacterial infection and discourage early sprouting.

Postharvest losses may be further reduced by developing storable processed forms of yam so that only a small fraction of the total harvest is stored fresh. Processed forms are not only less prone to spoilage but are also lighter, less bulky and easier to store and transport. Some good examples are 'Elubo', sun-dried chips that are milled into flour and 'instant yam' flour which is being developed and marketed by Cadbury (Nigeria); the flour can be reconstituted as a paste very similar to pounded yam.

Figure 8. Traditional yam storage. Yam tubers are tied-up in racks or trunks of live trees with light canopy. The storage system provides good ventilation and diffuse light.

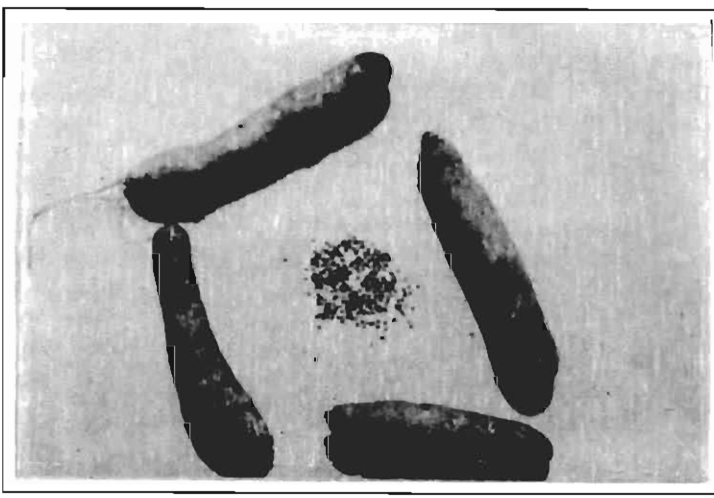
6 Research needs

Despite the importance of yams in the tropics, comparatively little research has been devoted to them. Consequently, technological development has been slow and in many cases, has had little impact on farmers production techniques.

Countries with significant yam culture are mostly poor and often unable to sustain meaningful research programs, especially as research on yams is extremely difficult. The long growth period produces only one crop a year and breeding work is often hampered by the lack of knowledge on its reproductive biology including the irregular sexuality of yam plants.

Yams are difficult to store and their multiplication rate is low. Many researchers are reluctant to devote appropriate efforts to improve the crop, and funding for yam research is also lacking.

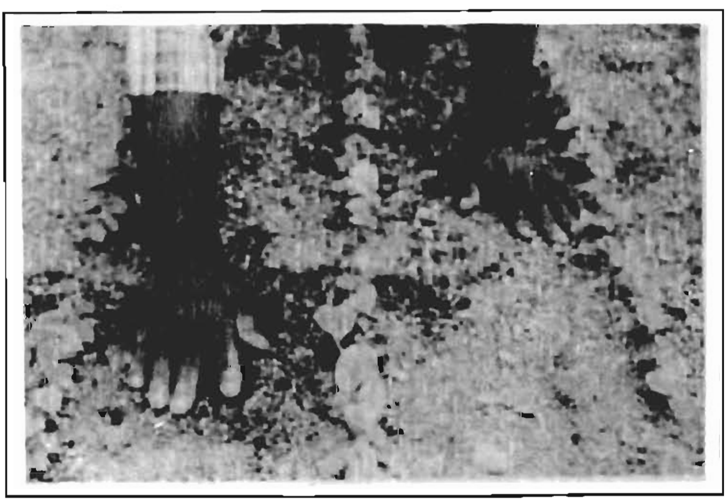
Figure 9. Botanical true seeds of yams in center and tubers of seedlings resulting from the seeds.



During the past 15 years or so, however, both the National Research Institutes and International Centers have shown considerable research interest in food yams. At IITA, for example, research on yams started soon after the institute was established. Initial research was devoted to understanding the flowering habit, developing hybridization techniques, and improving seed germination in nursery beds (Figures 9 and 10). Later efforts were devoted to population improvement in a maternal recurrent selection breeding program.

The overall objective of the research program on food yams at IITA is to develop cultivars that are high yielding, resistant to leaf necrosis and nematode, and have good culinary qualities. Significant progress has been made in all respects, and elite new genotypes have

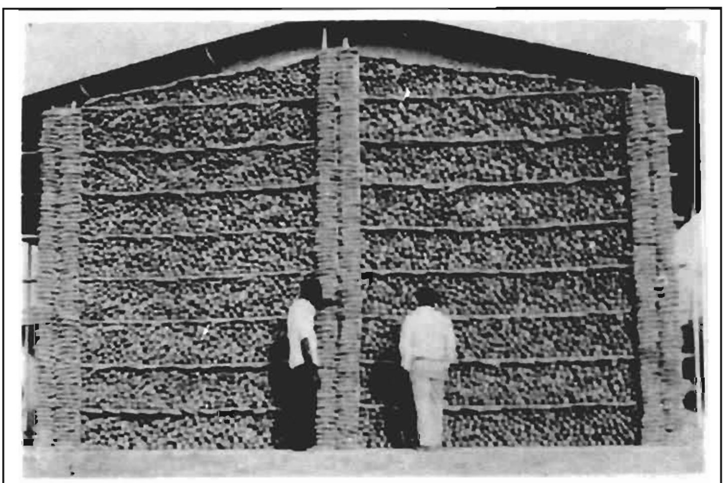
Figure 10. Seedlings raised from hybrid seeds in nursery beds.



been identified. For example cultivars TDa 291 of water yam is a high yielding, poundable variety fairly resistant to necrosis disease. Cultivars TDr 131 and TDr 156 of white yam are high yielding and show resistance to necrosis.

A second objective is to develop a cheap, reliable system for producing healthy seed yam (planting material) (Figure 11). The major constraint to production is the cost of planting material, representing 38-45 % of total cost. Seed yam production using the minisett technology, originally developed by the National Root Crop Research Institute in Nigeria and improved by IITA, was designed mainly to reduce seed yam costs.

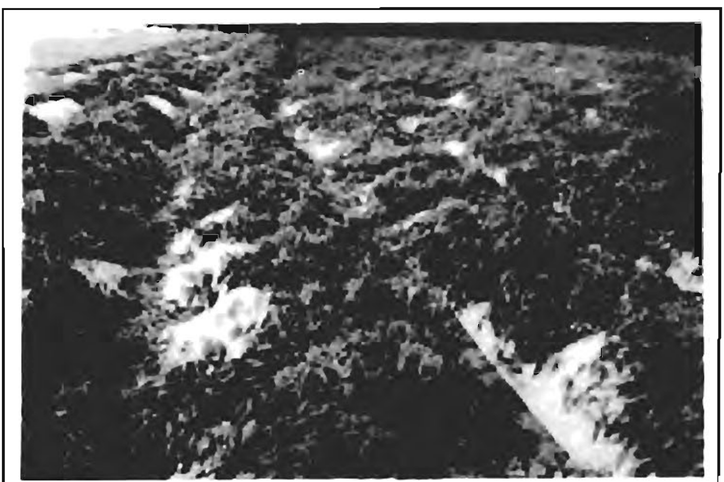
Figure 11. Seed yam tubers (0.5-1 kg) about 6 000 of which are required to plant 1 hectare of land.



The technology involves cutting selected 'mother seed' yam into pieces, treating them in a fungicide/insecticide suspension, and sprouting them in moist sawdust or soil. After three to four weeks, sprouted pieces can be transplanted into the main field on ridges, and harvested five to six months later. The technique is simple and cheap for farmers to adopt. Using the minisett technique, farmers can now produce 40 000 or more seed yams per hectare, enough to plant 4 hectares of ware yams.

Using plastic mulch has recently improved the minisett technology. This eliminates staking, conserves soil moisture and nutrients, regulates soil temperature, and checks weed growth (Figure 12). Yam's overall growth, development, and yield were up to 70 % better with than without plastic mulch, in experiments at IITA.

Figure 12. Plastic mulching reduces weed problems.



Development of the minisett technology was a significant breakthrough for three reasons. First, propagation of breeder materials for replicate tests is now much faster. Tubers of the first clonal generation from seeds can be cut into minisetts for further evaluation, thereby accelerating the breeding cycle. Hitherto it took half a decade to accumulate enough material to be multiplied for full evaluations. A plant breeder can now select plants with desired traits much sooner, so improved varieties can be rapidly multiplied and distributed to farmers.

Second, the shortage of planting materials, previously a major limiting factor to yam production, has been overcome. A recent survey showed a growing adoption of the technology which is a clear promise for a future boom in supplies of seed yam (Figures 13 and 14). Seed-yam farming may be largely adopted and used by small-scale yam growers to meet their own demands.

Figure 13. Seed yam production, Ilesha, 1985.

Alternatively, a few large-scale farmers may specialize in producing seed yam for sale to ware yam producers. Either way, wide adoption of minisett technology will considerably reduce overall production costs and improve farm income.

Third, minisett technology coupled with increasing urban acceptance of smaller tubers (1-2 kg) as table yams, promises to extend the northern limit of yam production into the less humid savanna. That is even more likely when farmers adopt sprouting of minisetts and use of plastic mulch.

However, large-scale use of plastic mulch may increase pollution of fields. A biodegradable mulch is needed so that disposal does not become a problem. Also imported plastic mulch may become too expensive for farmers to use. The possibility of producing plastic mulch locally needs to be explored.

Figure 14. Seed yam growing at Oyo, 1985.

Currently, plastic mulch is produced by a commercial firm in Nigeria.

Finally, development of the minisett technique brightens the prospects for mechanizing planting and harvesting of yams. Simple planters and harvesters, perhaps like those used for solanum potato, can be designed to plant sprouted minisetts and harvest seed yams. Mechanizing those operations would minimize labour bottle-necks and boost tuber production.

Detailed research is still needed to identify suitable physical characteristics of minisetts and harvestable tubers. Research is also needed to produce more uniformly shaped tubers with a thick periderm lying close to the surface. Such tubers minimize harvest injury thereby improving storability.

Without tissue-culture techniques, elite genotypes cannot be exchanged among yam breeders through international networks. The tissue-culture unit at IITA has multiplied breeding lines, produced virus-free materials, preserved germplasm and distributed materials to national programs for further evaluation. Funds, facilities and skilled personnel are needed to maintain high-quality research in tissue culture.

7 Bibliography

Ayensu, E.S.; Coursey, D.G. 1972. Guinea yams: the botany, ethnobotany, use and possible future of yams in West Africa. Econ. Bot. 26: 301 - 318 p.

Coursey, D.G. 1967. Yam. Longman, London. 230 p.

Hahn, S.K. 1984. Tropical root crops: their improvement and utilization. Paper presented at a conference on Advancing Agricultural Production in Africa, Arusha, Tanzania. Conference Paper 3, International Institute of Tropical Agriculture, Ibadan, Nigeria. 28 p.

International Institute of Tropical Agriculture (IITA). Annual Report 1981. IITA, Ibadan, Nigeria.

International Institute of Tropical Agriculture (IITA). Annual Report 1982. IITA, Ibadan, Nigeria.

International Institute of Tropical Agriculture (IITA). Annual Report 1985. IITA, Ibadan, Nigeria.

Lawton, J.R.; Lawton, J.R.S. 1969. The development of the tubers in seedlings of five species of *Dioscorea* from Nigeria. Bot. J. Linn. Soc. 62: 232 - 233 p.

Okigbo, B.N. 1977. Effects of cultivations, heights and directions of staking on yield and general performance of eight yam cultivars. p. 347-358. In: Leakey, C.L.A. (ed.). Proceedings 3rd Symposium International Society for Tropical Root Crops Africa Branch, Owerri, Nigeria.

Onwueme, I.C. 1978. The tropical tuber crops. John Wiley, Chichester. 234 p.

Osiru, D.S.O.; Hahn, S.K.; Lal, R. 1987. Effect of mulching material and plant density on the growth, development, and yield of white yam minisetts. p. 43-47. In: Terry, E.R.; Akoroda, M.O.; Arene, O.B. (ed.). Proceedings 3rd Symposium International Society for Tropical Root Crops, Africa Branch, Owerri, Nigeria.

Wilson, J.E. 1980. Careful storage of yams. Commonwealth Secretariat, London, England. 8 p.

8 Suggestions for trainers

If you use this Research Guide in training ...

Generally:

- Distribute handouts (including this Research Guide) to trainees one or several days before your presentation, or distribute them at the end of the presentation.

- Do not distribute handouts at the beginning of a presentation, otherwise trainees will read instead of listen to you.

- Ask trainees not to take notes, but to pay full attention to the training activity. Assure them that your handouts (and this Research Guide) contain all relevant information.

- Keep your training activities practical. Reduce theory to the minimum that is necessary to understand the practical exercises.

- Use the questions on page 4 (or a selection of questions) for examinations (quizzes, periodical tests, etc.). *Allow consultation of handouts and books during examinations.*

- Promote interaction of trainees. Allow questions, but do not deviate from the subject.

- Respect the time allotted.

Specifically:

- Discuss with trainees about the importance of yams at trainees' locations. Ask trainees about their experiences and perceptions with regard to the content of this Research Guide as listed on page 5 (10 minutes).

- Present, discuss and demonstrate the content of this Research Guide, considering the study materials listed on page 3 (45 minutes).

  Have real samples of yams and yam products, tools and equipment available so that each trainee can see, feel and taste. Show color slides of material that you cannot have available.

- Conduct demonstrations/practicals on yam propagation and production in groups of 3-4 trainees per group (2 hours). Make sure that each trainee has the opportunity to practice. Have resource persons available for each group and practical. Keep trainees busy.

- Organize a lunch or dinner offering different yam dishes.

- Conduct an informal survey with farmers and at markets to determine opportunities and constraints in yam production (½ day). You may assign different locations to different groups. Have resource persons available for each group. Ask groups to prepare, present, and discuss their findings.

International Institute of Tropical Agriculture (IITA)
Institut international d'agriculture tropicale (IITA)
Instituto Internacional de Agricultura Tropical (IITA)

The International Institute of Tropical Agriculture (IITA) is an international agricultural research center in the Consultative Group on International Agricultural Research (CGIAR), which is an association of about 50 countries, international and regional organizations, and private foundations. IITA seeks to increase agricultural production in a sustainable way, in order to improve the nutritional status and well-being of people in tropical sub-Saharan Africa. To achieve this goal, IITA conducts research and training, provides information, collects and exchanges germplasm, and encourages transfer of technology, in partnership with African national agricultural research and development programs.

L'Institut international d'agriculture tropicale (IITA) est un centre international de recherche agricole, membre du Groupe consultatif pour la recherche agricole internationale (GCRAI), une association regroupant quelque 50 pays, organisations internationales et régionales et fondations privées. L'IITA a pour objectif d'accroître durablement la production agricole, afin d'améliorer l'alimentation et le bien-être des populations de l'Afrique tropicale subsaharienne. Pour atteindre cet objectif, l'IITA mène des activités de recherche et de formation, divulgue des informations, réunit et échange du matériel génétique et encourage le transfert de technologies en collaboration avec les programmes nationaux africains de recherche et développement.

O Instituto Internacional de Agricultura Tropical (IITA) é um centro internacional de investigação agricola pertencendo ao Grupo Consultivo para Investigação Agricola Internacional (GCIAI), uma associação de cerca de 50 paises, organizações internacionais e regionais e fundações privadas. O IITA procura aumentar duravelmente a produção agrícola para melhorar a alimentação e o bem-estar das populações da Africa tropical ao sul do Sahara. Para alcançar esse objetivo, o IITA conduz actividades de investigação e treinamento, fornece informações, reúne e troca material genético e favorece a transferência de tecnologias en colaboração com os programas nacionais africanos de investigação e desenvolvimiento.