# Present and Future Roles of Yams *(Dioscorea* Spp.) in West Africa

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## Abstract

Yam production is labor intensive and requires large quantities of planting material. In regions where additional labor and inputs needed for staking and storage make production uneconomical. Yam production no longer competes favorably with less preferred, but cheaper foods such as cassava.

Survival of the yam as a staple food is dependent on breeding modern varieties which demand no staking and require less labor and planting material for production. The research needs necessary to accomplish this task are discussed.

## Introduction

**Present Role of Yams in West Africa.** Yams continue to be one of the most popular and prestigious staple foods in West Africa, where about 75 percent of the world's production is grown. Nigeria alone produces about 15 million tons annually on 1.4 million hectares (FAO, 1976). White yam (*Dioscorea rotundata* Poir) is the most favored species, but yellow yam (*D. cayenensis* Lam), water yam (*D. alata* L.) and cluster yam (*D. dumetorum* (Kunth) Pax) are also grown extensively. Cluster yam is particularly important in the Cameroon and in Central Africa. Aerial yam (*D. bulbifera* L.) and Chinese yam (*D. esculenta* (Lour.) Burk.) are less important.

The Asian species, *D. alata* and *D. esculenta,* were introduced in West Africa some 500 years ago, whereas the other four species are indigenous to Africa.

Yams have been utilized in West Africa since ancient times. The traditional systems of cultivation and utilization are firmly established and often intimately linked with socio-religious customs and ritual celebrations. Local varieties which have survived the long history of selection by nature and man tend to be well adapted to the climatic and agronomic conditions under which they are presently grown. Although their yields are often low, they have some resistance to many of the disease prevalent in the locality to which they are adapted and their large size, elongated shape, and culinary qualities conform to local preference.

However, traditional yam production is labor intensive and requires considerable inputs in the form of planting setts and stakes. As a consequence, the cost of yams in the market place increases as rural labor becomes more scarce and expensive and the prices of inputs rise. In some areas, yam is being displaced by less preferred but cheaper foods, cassava in particular, and to a lesser extent, rice and wheat bread. Cassava, although an inferior food to yam, requires less labor and fewer inputs to produce and the resulting lower priced products are insured a place in the diets of low income people; whereas the increasing cost of yam is rapidly making it a luxury food rather than a staple.

Although systems of yam cultivation vary with locality, some generalizations can be made about those aspects which affect the cost of production. Typically, yams are grown on mounds or ridges constructed by hand, and labor requirements for land preparation, weeding and harvesting are high. In the high rainfall forest areas the vines are supported on stakes. The cost of staking which is dependent on the materials used and their availability is always high. In Nigeria, the cost of staking materials – their transport and labor to erect them can, in some localities, amount to more than $3000/ha. However, when staking is omitted in these forest areas, the yields of traditional cultivars can be reduced by as much as 50%. Our experience suggests that much of this reduction can be attributed to the yam nematode, *Scutellonema bradys,* and various leaf spot diseases, all of which cause more damage on yams grown without stakes.

By contrast, in the drier Southern Guinea savannah areas, yams are often traditionally grown without staking, and the cost of their production is proportionately less. The fact that unstaked yams perform better in these areas can, in part, be attributed to the lower incidence of *Scutellonema* and leaf spot diseases. Another factor may be that in these areas, light intensity is not limiting and relative humidity is relatively low and, therefore, the optimum display of leaves is not critical.

In forest areas, storage losses are excessive due to various tuber rots with *Scutellonema* being a major contributor to these. Yams are stored in traditional barns, sometimes elaborately built, with tubers individually tied on vertical supports. And thus storage is an additional labor-consuming operation.

In contrast, storage losses in the savannah regions do not appear to be as high, probably due to the lower incidence of *Scutellonema.* Yams grown in this environment have higher dry matter content and cultivars grown have a longer endogenous dormancy. Because tubers tend to be smaller in size, there is less injury at harvest. Storage structures are less elaborate and tubers are usually stacked rather than tied and, as a consequence, labor requirements are less. In these areas, tubers can be left on the ground long after maturity which means that the harvest season labor peak is not so pronounced.

In both growing regions, the large amount of planting material required for propagation contributes to the cost of production either in terms of cash (if setts are purchased), or in terms of labor (for "milking" in the two-harvest system where the second harvest is used as planting material), or in terms of utilizing tubers for consumption. For *D. rotundata,* planting setts of 500 to 1000 g are typically used. At today's prices that can amount to as much as $3000/ha, generally, smaller setts of 150 g are used for *D. alata* and *D. dumetorum.*

Although the two ecological zones share the costs of planting material and field operations as mounding, weeding and harvesting, the added costs of staking and storage in the forest zone increase the cost of yam production to a point where it cannot compete favorably with less labor-intensive crops, particularly cassava. In the sub-humid savannah zone where the labor constraints to production are not so high, yams continue to be an economic crop.

**This is of course, very much an oversimplification of a complex situation, but it does, I think provide clues to researchers who are faced with the challenge of improving the yam to insure its survival.**

**Future Potential of Yams in West Africa.** The future potential of yams in West Africa depends primarily on the success of breeders in creating cultivars which can meet the requirements of tomorrow's farmers. If yam production is to remain economically viable and not continue to decline, varieties which have all the conventional attributes of high yield, disease and pest resistance, storage and culinary quality must be bred. In addition, they must possess characteristics which, 1) eliminate the need for staking; 2) reduce manpower requirements; and 3) reduce the amount of planting material required.

**Elimination of Staking.** To accomplish the first, varieties which perform well without staking even in areas of high rainfall must be selected. We know very little about the optimal plant types for no-stake culture, but as pointed out previously, high levels of resistance to *Scutellonema* nematode and to the leaf spot diseases, are essential. Also, it appears that plants which leaf early and have short internodes are superior to the typical climbing types with long internodes and a tendency to delay leafing until the vines have reached the tops of their supports. Presumably, an ideal plant architecture would be one with a stiff lower stem which would hold the vine off the ground and shrub-like, although no such plant type has yet been identified.

**Reduction of Manpower Requirements.** To reduce labor requirements, tuber types which permit easier hand harvesting with less injury must be selected. This means tubers which are regular in shape, have a reduced length: width ratio, and are somewhat smaller in size.

In the long term, partial or complete mechanized planting and harvesting may be possible in those locations where the edaphic and socio-economic conditions are suitable. The feasibility of such mechanized harvesting is dependent on the breeding of clones with tubers which are set near the soil surface, are oval and/or round and are regular in shape. Tubers must be tough-skinned to reduce damage during harvest and postharvest handling. Plants which produce their yield in several small tubers rather than single large one are required. A mechanized system is also dependent on the development of efficient marketing channels and a variety of processed products to permit rapid utilization of mechanically harvested tubers which will be difficult to store. This demands that varieties with a range of maturity available to provide a continuous supply of raw material and that such characteristics as ease of peeling and qualities required for specific processed products be considered.

**Reduction of Plant Material.** To reduce the amount of planting material required, uniform hybrids, synthetics or composites which could be propagated by the farmer from true seeds would have to be bred. This would take advantage of the fact that it is more efficient to establish a crop from true seeds than from sett tubers. A 500 g planting sett of *D. rotundata*, even at high yields of 20 tons/ha, will return only 2000 g, a 4-fold increase; whereas a seed which weighs only 0.01 g can, in the first year, produce a yield of 500 g or more, a remarkable 50,000-fold increase.

Even if production from seeds required two years, i.e., seeds to setts in the first year, setts to marketable tubers in the second year, it would still release into food channels a substantial portion of the yam crop which is presently being reserved for planting material. Or it would replace the labor intensive method of "milking" to produce planting setts. Propagation through true seeds would also break the virus and nematode cycles, which is an obvious advantage.

Propagation of true seeds by farmers is a long-term goal, for although the technology for growing planting setts from seeds has been developed, the genetically uniform populations of seed required for such a system will take many years to develop. Their development depends on how successful breeders are at inbreeding yam, a dioecious, highly polyploid genus which may prove very difficult to handle in this respect.

Another approach which merits consideration is that of breeding varieties which produce bulbils or aerial tubers in addition to well-formed subterranean tubers – a hypothetical hybrid between *D. bulbifera* and *D. rotundata.* The aerial tubers, which are nematode-free and store well, would be utilized as planting setts and the subterranean tubers would be consumed. Alternatively, methods of chemically inducing aerial tubers for propagation should be investigated.

**Other Species**. Although *D. rotundata* will continue to dominate the scene because the high viscosity of its starch makes it ideal for pounding into the highly regarded fufu, two other species, *D. alata* and *D. dumetorum* are perhaps more compatible to modernization. In both species, there are clones already available among the local cultivars which produce tubers with shapes suitable for mechanical harvesting. Both species can produce satisfactory yields without staking in high rainfall areas probably because of their higher levels of nematode resistance and, at least in the case of *D. alata,* earlier leafing. *D. alata* tends to store better than *D. rotundata,* as would *D. dumetorum* if a solution were found to the problem of postharvest hardening of the flesh. *D. alata* has the potential for higher yields than other species.

*D. dumetorum* flowers and sets seed and the seedlings are easy to rear. Even the narrow germplasm base available in Nigeria, hybridization has produced wide variability for tuber and cluster shapes, hairiness, flesh color and reduced postharvest hardening (IITA, 1978), indicating that there are opportunities for selecting improved types.

It is generally reported that *D. alata* is non-flowering and consequently cannot be improved through conventional breeding. However, in the IITA germplasm collection, six male clones and three female clones have been identified. Profuse flowering has been achieved and a very limited number of seeds produced (IITA, 1978). Natural seeds have been observed and collected in Indonesia (S. Sastrapradja, personal communication) and presently a small number of seedlings are being grown from seeds of these two sources.

## Research Needs

Presented are some ideas on research needs. These are in no way exhaustive, nor are they necessarily presented in order of priority.

**Genetic improvement**. A major need in yam research is the development of improved varieties through repeated recombination and continuous selection. Because it is not possible at present, to move vegetative materials across national boundaries, and because it is necessary to select varieties which are adapted to specific locations, it is advisable to establish a breeding program in each nation where yams are an important crop. In such a breeding program, the first step is to assemble and evaluate a germplasm collection of local cultivars so that the best material already available can be multiplied and distributed. Flowering clones from the local collection, together with promising genotypes introduced as seed from international sources would form the basis for a genetic improvement program based on selection of superior clones from segregating seedling populations. Sufficient seed of *D. rotundata* and *D. dumetorum* is available for this approach.

The goals of each breeding program will need to be tailored to its locality, but "modernization" of the yam should be an important aim of any program with long term goals. Because of the strong localization of cultural methods, diseases, pests and quality preferences, it is probably more realistic to breed varieties which are adapted to specific ecological zones rather than to search for varieties with wide adaptation across diverse environments.

**Meristem culture.** The present efforts to develop techniques for culturing and indexing disease-free plantlets from meristems must be intensified and channels for moving such materials safely and efficiently through Plant Quarantine need to be established. This will permit the rapid dissemination of improved materials and provide the only means of exchanging germplasm which does not flower. Meristem culture as a tool for rapid multiplication of improved materials and for the storage of germplasm should also receive attention and the possibility of somatic hybridization needs to be explored.

**Flower induction.** To permit utilization of a greater range of germplasm in genetic improvement programs, research is required to find methods to induce flowering in non-flowering clones of *D. rotundata* and *D. alata* and to alter sex expression in the male species, *D. cayenensis* and *D. esculenta.* This would also permit the efficient collection, preservation and exchange of germplasm in seed form.

**Dormancy control.** More efforts should be directed along the lines of the work done by Passam (1977, 1978) and IITA (1978) who have been testing various physical and chemical means for controlling tuber dormancy. The development of methods to break or shorten dormancy would permit breeders to accelerate generation turnover and to multiply elite materials during the dry season. It would also make off-season yam production by farmers possible and this would help alleviate the fluctuations in supply and price associated with seasonal production. Lengthening dormancy would retard sprouting and thus extend the storage life of tubers.

**Diseases and pests.** Yams are attacked by a wide variety of diseases and pests, but to date, the nematodes, yam virus and *D. alata* "scorch" (generalized necrosis of leaves and vines) are the only ones in West Africa which have been given attention. There is a need for a comprehensive survey of yam diseases and pests to determine their distribution throughout the yam growing regions. Pathogens and pests must be identified, accurate descriptions of their symptomatology formulated, and yield losses attributed to each accession. This will greatly assist in the establishment of realistic priorities in breeding programs.

**Quality.** More research effort is needed to determine which factors contribute to the quality of fresh and processed yam products and to develop rapid methods of screening for these factors. Such screening methods must utilize only small quantities of tuber if they are to be useful for selection during early stages of testing.

Yams have been reported to contain from 6.3 to 13.4% crude protein on a dry weight basis (Martin and Thompson, 1971), sufficient quantities to be significant in the diet. There is evidence that the crude protein content varies not only between species but within species between clones. It may then be possible to select from seedling populations clones which are improved for protein. Certainly, at the least, it is necessary to monitor breeding populations to be certain that clones which are lower in nutritional value than traditional cultivars are not selected. Variation in protein quality also needs to be investigated and utilized.

**Storage.** Storage remains one of the most critical problems demanding attention. Most discussions of improving yam storage have failed to bring forth ideas for intermediate technology. There appear to be no improvements between the best traditional storage presently practiced by the farmers and the large scale, advance technology improvements which would not be operational in present day Africa. For example, controlled temperature storages and gamma irradiation (Adesuyi, 1978) would appear to have long term application as part of the marketing system in bulk storages at collection points, but they would be difficult to apply on a small or intermediate scale.

For farm-level storage, it would seem that the best approach is to attack the problem piecemeal. Although each improvement may not be dramatic, an accumulation of modest improvements may result in a quantum jump. Such an approach would include breeding clones which are highly resistant to nematodes and tuber rot pathogens and which produce tubers with shapes which are easy to remove from the soil without injury. Tubers which have longer endogenous dormancy to reduce sprouting in storage are needed. Alternatively, exogenous control of dormancy with chemicals may have some application. The findings of Passam, *et al.* (1976) and Been and Perkins (1977) on post-harvest, pre-storage curing of tubers to heal wounds using high temperatures and relative humidities need to be adapted for use on a wider scale.

**Cultivation.** Methods and equipment must be developed for mechanical ridging, planting and harvesting. Herbicides are urgently needed to reduce the labor requirements for weeding.

**Other species.** Some attention must be given to *D. alata* and *D. dumetorum* and perhaps to *D. esculenta* since, as previously mentioned, these species may be easier to adapt to mechanization. In *D. dumetorum,* conventional breeding based on selection from sexually propagated populations should be initiated with special emphasis on developing varieties suitable for mechanized harvesting and free from toxins and postharvest hardening. This will require extensive basic research to isolate and identify the toxins in this species and to develop quick and easy tests to screen for low quantities. Work on hardening has been started in the Cameroons (Treche and Delpeuch, 1978) and needs to to be continued.

In West Africa, the range of variation for *D. alata* and *D. esculenta* is narrow and since they generally do not produce seeds, the most rapid improvement will be achieved by the testing of a large selection of cultivars introduced from their centers of diversity. This, of course, awaits the time when success in producing disease-free meristem cultures opens the door for the international distribution of vegetative material. Careful attention needs to be given to plant and tuber characteristics suitable for no-stake culture and to mechanized harvest, and quality characteristics must receive adequate attention. There are, for instance, clones of *D. alata* which can be pounded into fufu which is not inferior to that made from *D. rotundata.*

Exploration should be continued in Indonesia and nearby areas to secure more seeds and clones of flowering *D. alata.* Large variation in *D. esculenta* has been reported to exist in southeastern Asia, particularly New Guinea (Martin, 1974). A thorough search should be made there for female clones. Often, I think our impressions that flowering types are infrequent in most species of yam comes from the fact that we have not looked hard enough.

**Small-Scale farmers.** In this discussion of modernizing the yam, the emphasis on developing varieties suitable for mechanized agriculture is not meant to imply that there is no room for improving traditional yams which are appropriate for systems of agriculture where the yam will continue to be treated as a horticultural crop. It is probable that for a long time to come, small-scale, labor intensive farming systems will exist side by side with modern production, particularly in forest regions where large-scale mechanization is often inappropriate. Therefore, a sizeable portion of the breeding effort must be aimed at developing improved varieties for these systems. In fact, many of the breeding goals mentioned here for modernization will be equally beneficial to the small-scale farmer if incorporated into varieties tailored to meet his needs.

## References

ADESUYI, S.A. 1978. The application of advanced technology to the improvement of yam storage. IFS, Provisional Report No. 3: Yams, Igname. Buea, Cameroon: 387-398.

BEEN, B. O. & C. PERKINS. 1977. Yam curing for storage. Acta Horticulturae, 62: 311-316.

FAO. 1976. 1975 Production Yearbook. FAO, Rome, Italy.

IITA. 1978. Annual Report. International Institute of Tropical Agriculture (in print).

MARTIN, F. W. 1974. Tropical yams and their potential. Part I. *Dioscorea esculenta*. U. S. Dept. Agric. Agric. Handbook, 457, 18 pp.

MARTIN, F. W. and A. E. THOMPSON. 1971. Crude protein content of yams. Hort Sci., 6(6): 545-546.

PASSAM, H. C. 1977. Sprouting and apical dorminance of yam tubers. Tropical Sci., 19(1): 29-39.

PASSAM, H. C. 1978. Dormancy of yams in relation to storage. IFS Provisional Report No. 3: Yams, Igname. Buea, Cameroon: 357-366.

PASSAM, H. C., S. J. READ and J. E. RICKARD. 1976. Wound repair in yam tubers: The dependence of storage procedures on the nature of the wound and its repair. Tropical Sci., 18(1): 1-11.

TRECHE, S. and F. DELPEUCH, F. S. ADESUYI. 1978. Le durcissement de *Dioscorea dumetorum* au Cameroon. IFS, Provisional Report No. 3: Yams, Igname, Buea, Cameroon, 371-386.