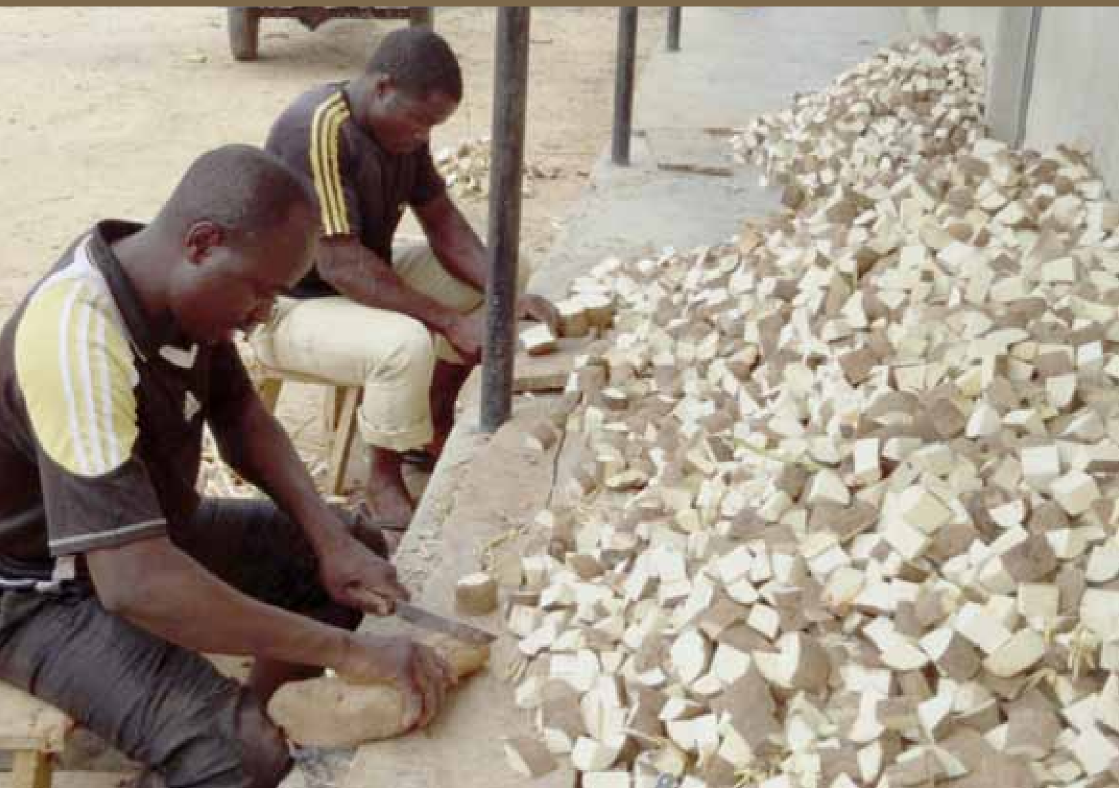
Seed yam production from minisetts:

A training manual

B.A. Aighewi, N.G. Maroya, and R. Asiedu



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International Institute of Tropical Agriculture (IITA)

2014

To Headquarters from outside Nigeria:
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26 Dingwall Road,
Croydon CR9 3EE, UK

Within Nigeria:
PMB 5320, Oyo Road
Ibadan, Oyo State

ISBN 978-978-8444-49-7

Correct citation: Aighewi B.A., N.G. Maroya, and R. Asiedu. 2014. Seed yam production from minisetts: A training manual. IITA, Ibadan, Nigeria. 40 pp.

Cover photo: Cutting ware yam into small pieces (minisetts).

Contents

Acknowledgements

The authors would like to express their sincere thanks to Professor Felix Nweke for his very valuable comments to enhance the quality of this manual.

Staff of the Communication Office of IITA also made an important contribution in editing the document.

Particular appreciation is expressed to the Bill & Melinda Gates Foundation for financing the YIIFSWA project which has the dissemination of improved methods of seed yam production as one of its major objectives.

Introduction

Yam is a tuber crop belonging to the family *Dioscoreaceae*. The species of economic importance include *Dioscorea rotundata, D. alata, D. cayenensis, D dumetorum, D. bulbifera*, and *D. esculenta*. In West Africa *D. rotundata*, also referred to as white yam or white guinea yam, is the most widely cultivated. In 2012, world production of yam was estimated at 58.7 million tons with West Africa producing more than 92 percent (FAOSTAT 2014). Nigeria and Ghana together produce about 66 percent of the world's yam supply.

As food, yam plays an important role by providing cash and dietary carbohydrate to millions of people. It has a better keeping quality than most other tropical root and tuber crops because of the tubers have an extended period of dormancy during which physiological activity is at a minimum. Yam can therefore serve as an important food security crop. Despite the large quantity produced in West Africa, there is no formal seed yam production or marketing system to take care of farmers' needs.

Data on seed yam production are not readily available. However, the quantity required to plant fields in Nigeria and Ghana, the largest producers in West Africa, is estimated at 7 to 10 million tons (FAOSTAT 2014). For many farmers in Nigeria, seed yam are inherited from parents, bought, or acquired as gifts. The seed yam are multiplied over and over until productivity becomes very low from continuous exposure to pests and diseases.

Yam has a low rate of multiplication so increasing the area under production could be a major challenge. For farmers venturing into production for the first time, the availability of seed yam is critical because of the high cost. Hence, the problem of the limited supply of affordable good quality planting material continues to be cited in literature as responsible for low productivity (Ironkwe et al. 2007; Udoh et al. 2008; Ogbona et al. 2011; Asumugha and Ogbona 2013).

Seeds are a strategic input, and yam production cannot expand without propagation technologies to address issues of rapid multiplication of seed yam, quality, and price. The benefit of technologies that address these issues will be evident in increased productivity, which will translate to improved income for producers and utilization opportunities for the crop. A systematic and continuous practice of using only clean seeds will reduce the level of pests and diseases that attack the crop in the field as well as improving the storage life of tubers.

This document contains information for the understanding of some basic principles of seed yam production which is lacking in other manuals on this subject. For example, Eke-Okoro et al. (2006), Ezulike et al. (2006), and Ironkwe et al. (2008) have produced manuals on seed yam multiplication

Yam market in West Africa.

using the minisett technique which provided the procedure from planting to harvest. However, the information is not detailed enough for the proper understanding and teaching of the principles involved. The manuals recommended the use of minisett dust (a mixture of fungicide, insecticide, and nematicide) for the chemical treatment of minisetts. The minisett dust is not readily available; this will not help in promoting the adoption of the technique if farmers do not know how or where to get the components.

Varieties recommended listed in these manuals are mostly found in the southeast of Nigeria. There are several popular landraces in other yam-producing regions which are also suitable for seed yam production using minisetts. Using a series of questions and answers in French accompanied by many pictures to facilitate understanding, Dossou et al. (2007) gave a more detailed coverage of the technique from the selection of mother tubers to storage. The authors also discussed the marketing of seed yam and the profitability of the technique. However, the document was intended for a limited audience in the Republic of Benin and there is no English translation which is the language of a larger population in the yam belt of West Africa.

The earlier mentioned manuals and other reference materials, such as NRCRI (1983), Chinaka (1999), and Otoo et al. (2001), are not readily available to farmers or extension officers who need to improve their knowledge base and be in a position to train others adequately. This current document provides information on the minisett technique that can be applied at the farmers' level to multiply seed yam rapidly and maintain good quality. It is intended to fill the information gaps in available literature on the technique and also serve as a useful guide to trainers and extension agents.

What is 'Seed Yam'?

The distinction between 'yam seed' and 'seed yam' can be confusing when the words are used interchangeably. Yam plants produce flowers (Figs. 1 and 2) and set seeds in fruits (Fig. 3); breeders use the seeds, which are referred to as 'yam seeds', 'true yam seeds' or 'botanic yam seeds' to produce new varieties. In regular production, yam is propagated vegetatively by planting the tubers or 'seed yam' which could be small whole tubers or pieces (setts) cut from larger tubers (Fig. 4).

Figure 1. Male inflorescence of D. rotundata.
Figure 2. Female inflorescence of D. rotundata.
Figure 3. Yam seeds.
Figure 4. Seed yam ready for planting.

Tubers produced from seed yam are genetically identical to the mother seed material, while those produced from yam seeds have an identity different from the parent material.

Traditional Methods of Producing Seed Yam

In West Africa, farmer-saved seeds are the predominant source of planting material (Nweke et al. 2011). There are three major ways by which yam farmers obtain their seeds. First, the same plant is harvested twice in double harvesting or milking. The first harvest is done between the fifth and seventh month of growing, when the tuber which is mostly used for food is carefully cut off below the coronal roots to avoid damage to the root system. The roots are then covered with soil and a second harvest of the same plant is done at the end of the season for use as seed yam (Fig. 5).

Figure 5. Seed tubers from a double harvested crop.
Figure 6. In multiple tubering varieties, the small tuber is used as seed yam and large tuber for food.

Figure 7. Cut setts weighing 300 - 500 g obtained from large tubers (junking).

The second method involves the use of small whole tubers (sorting method). Some varieties have the capacity to produce both seed sized and ware sized tubers from a single stand (Fig. 6). At harvest, the small sized tubers are sorted and retained for planting while the larger tubers will be used for food. With this method there is usually a high risk of selecting seed sized tubers that are small due to disease, especially viruses, since the symptoms are typically not visible on the tubers (Nweke 2014).

A third method of getting planting material is to cut large ware tubers of up to 2 kg into seed sized setts of 300-500 g (Fig. 7). This is referred to as 'junking'. This method reduces substantially the quantity of tubers that could be used for food because when seed sized tubers are in short supply, larger tubers are converted to seed yam by being cut into setts. Usually such setts do not sprout evenly when planted. Some varieties such as 'Macakusa', which is in high demand in the major yam producing region of the middle belt of Nigeria, do not produce many seed yam tubers so larger tubers are cut to get enough seeds.

A less widely used method involves cutting ware sized tubers during the first harvest of milking, and burying them in the soil at the base of the plant. These setts are dug up during the second harvest and planted immediately in a newly prepared field for the next crop (Aighewi 1998). This production method is practiced by some farmers in the yam growing regions of Nigeria and Ghana. Faced with serious seed yam shortages, some farmers in Southern Kaduna, Nigeria, plant the same sett twice. After a planted seed yam has formed roots, vines, and leaves, the same seed yam is carefully detached and replanted in a new mound.

With these methods of obtaining seed yam, the multiplication ratio is low (1:5), the cost is high and the quality is not guaranteed. The low rate of multiplication implies that many generations of cropping are required to obtain enough seed yam to plant 1 ha, so the area under production is often limited by the amount available. Since specialized production is uncommon, the quantity in the market is usually low and most farmers use farm-saved seeds. The quality of seed yam sold in the markets is often poor because farmers would generally select the best to plant their fields and sell only those left over.

The Minisett Technique

Researchers in Nigeria of the National Root Crops Research Institute (NRCRI), Umudike, and IITA, Ibadan, developed the minisett technique to overcome the critical problem of the unavailability of good quality seed yam by improving the rate of multiplication of white yam (IITA 1985). With the technique, the multiplication ratio can increase from the traditional 1:5 to 1:30 (Orkwor et al. 2000).

The minisett technique involves the cutting of 'mother' seed tubers into small setts (minisetts) of 25-100 g which must possess a reasonable amount of peel (periderm) from which sprouting can occur. The minisetts are treated with chemicals to prevent damage from diseases and pests, planted, and managed to produce small whole seed tubers; these in turn are planted to produce ware tubers for food.

There is a positive correlation between the size of the minisett and the size of the seed yam produced. This means that minisetts should be cut for a targeted seed tuber size. There are varietal differences in the performance of minisetts; therefore the same size of different varieties may perform differently (Aighewi 1998).

Advantages of Using the Minisett Technique for Seed Yam Production

The minisett technique has been shown to have several advantages over traditional methods of seed tuber production. Some of the advantages are listed below.

1. Fewer ware tubers are used as seeds.
2. A few tubers of a desired variety can be multiplied rapidly as planting materials for use, sale, or distribution (for example, after periods of natural disasters such as floods).
3. The technique is easy for subsistence farmers or seed yam entrepreneurs to carry out.
4. From minisetts, tubers in a range of sizes are produced which could be put to different uses – planting material, fresh or processed food, and export. The minisett size can be chosen to produce tubers of the size required for export as food.
5. The small tubers produced are better as planting material than cut setts because they do not have cut surfaces and are thus less likely to rot when planted.
6. Production of seed tubers from minisetts can be more easily mechanized than other methods of production. With a uniform size of minisetts, equipment used in the production of crops such as potato can be adapted for use in planting minisetts and harvesting seed yam.
7. Researchers can rapidly multiply new varieties for distribution or evaluation.
8. Crop emergence and establishment are faster with whole seed tubers (such as those produced from minisetts) than from cut seed tubers.
9. The whole seeds such as those from minisetts tend to produce stands that are more uniform both in percentage emergence and growth characteristics; this results in a more efficient use of inputs.

10. The use of whole seed tubers eliminates the cost of cutting and reduces the spread of disease.

Yam Multiplication Using the Minisett Technique

Materials needed for preparation of minisetts:

- Clean and healthy 'mother' tubers
- Sharp knife
- Container (bucket, basin, plastic bag) to hold chemical treatment
- Net bag or basket
- Chemical for treatment (insecticide, fungicide, nematicide)
- Water, stirrer
- Gloves, protective nose guard

Selecting good quality 'mother' tubers to produce seed yam

Many varieties of yam are available and they possess different characteristics so a decision on what variety to produce should be based on market and/or home preferences. It is critical to select good quality 'mother' tubers of the right variety that are healthy, of the proper physiological age and size.

For farmers who reserve seeds from a previous crop, selection should start from the field by roguing diseased plants or tagging strong clean plants for use as seeds. This is because the symptoms of viral diseases are usually not obvious on tubers, and seed selection from the harvest of an entire field may not be effective in eliminating virus infected tubers

Viruses play a very significant role in the degradation of seed tubers and the reduction of their productivity. If a diseased tuber is cut for the purpose of multiplication, the disease will be multiplied also by the same proportion. Since the cost of production, harvesting, and storage will be the same regardless of the seed quality, a careful selection of seed tubers is essential in optimizing returns on investment. Other types of diseased and off- type plants should not be used for seed yam production. Pest infested tubers should also be avoided (see pictures in the annex of pests and some symptoms on tubers).

The chronological age (days after harvest) of seed tubers is less critical than the physiological age (internal age resulting from biochemical changes within the tuber). In normal production, the tuber is considered mature when the foliage senesces naturally. For many varieties, the tuber is dormant at this stage and will not grow when planted. At the right physiological age, tubers come out of dormancy and sprouting starts at different periods depending on variety. Tubers with small/short sprouts are considered young tubers and can be planted at this stage (Fig. 8). When a young seed yam is planted, emergence of the crop may be slow, but the bulking period will be longer and the size at harvest will be larger than if older seeds are used. The old seeds have stayed in storage for a longer period and the vines have either grown too long or been desprouted several times, thus exhausting the nutrients stored in the tubers (Fig. 9).

Figure 8. Sprouting of young tubers.
Figure 9. Tuberization of an old tuber in storage.

The young sprout is dependent upon the energy stored in the seed tuber for survival until it can generate a root system to source nutrients in the soil. Old seed tubers produce weak vines and plants that lack vigor due to the depletion of nutrients from multiple desprouting. The size of the sprout or vine on a seed tuber that has not been desprouted can more easily indicate the age of the tuber than where desprouting has been done several times in storage. With prolonged storage, the tuber may produce a new small tuber even without being planted (Fig. 9). Most of the seed tubers found in the market towards the end of the planting season (late May to June) are old and their field performance is usually less than optimal, except in the rare situation where the seeds were stored under favorable conditions. It is recommended that only healthy mother tubers of 800-1000 g that have broken dormancy (Fig. 4) should be selected. Larger tubers produce uneven and delayed sprouting because of lower meristematic activity.

Cutting and size of minisetts

Since the purpose of the technique is to produce small whole tubers (150-300 g) for planting, it is important to know the appropriate size to cut to obtain the desired size of seed yam because research has shown that with minisetts a range of seed yam sizes is produced (Aighewi 1998). The bigger the minisett, the bigger the seed yam that it will produce.

A sharp knife should be used to cut minisetts to avoid dislodging the peel of the tubers, which plays an important role in sprout formation. The mother tuber should first be cut into 2-5 cm rings depending on the circumference of the tuber. Each ring should be cut vertically to produce pieces of the desired weight with each piece possessing a skin area that is sufficient for sprouting (Fig. 10).

Treatment of minisetts

After being cut, the minisetts need treatment with a mixture of a suitable broad spectrum fungicide (e.g., Z-Force: active ingredient is mancozeb 80% WP) and insecticide

Figure 10. Freshly cut minisetts.

(e.g., ActForce gold: active ingredient is chlorpyrifos 48% EC) to prevent rots and damage by pests after planting. There are many types of chemical products available that could be used. If you are not sure which chemical and what quantity to use, an Agricultural Extension Officer in your locality will provide useful advice. It is essential to read all instructions carefully on the appropriate handling and disposal of chemicals to safeguard human and animal health, as well as the environment. The mixture could be in liquid or powder form. If it is a liquid, a perforated basket or net bag is used to immerse the minisetts in the solution for 5-10 minutes (Fig 11); if it is a powder, the minisetts should be placed in a plastic bag or bucket with a lid and shaken carefully until they are well coated.

Figure 11. Treatment of minisetts in fungicide + insecticide solution.

In the absence of commercial chemical treatment, wood ash is used as a solution or dust. Ash with a high content of potassium, such as that obtained from burning the inflorescence of oil palm, has been recommended for its effectiveness (Wilson 1989). After treatment, the minisetts should be spread out in a shaded airy place for 12 to 24 hours for cut surfaces to dry and cure before being placed in a nursery for pre-sprouting or planted directly in the field.

Pre-sprouting of minisetts

The prepared minisetts can be pre-sprouted in containers such as boxes, trays, and baskets or on beds before being transplanted in the field. The sprouting medium can be good loamy soil, sawdust, shredded coir, carbonized rice husks, or a combination of good loamy soil and other types of media. These media, except the carbonized rice husks, should be sterilized using simple methods such as solarization. The medium should be light to make the lifting of sprouted setts easy. To carbonize rice husks, dry husks should be placed in a metal drum. The drum is placed on the fire and the husks are stirred continuously to ensure they burn slowly and evenly until they are black but not completely burnt. The carbonated husks should be removed and cooled immediately to prevent them burning into ash.

When large quantities are handled, it is better to pre-sprout the minisetts in nursery beds, which should be 1-1.2 m wide, 10-15 cm high, and of any convenient length. The beds must have good drainage to prevent water standing on them. A moist medium 3-5 cm thick should be placed on the bed and the minisetts spread on it with the skin part placed downward in good contact with the medium. The minisetts should be covered with another layer of the medium. An additional layer of minisetts could be placed on this before a final layer of the medium. If the medium is wet, watering immediately after placing the minisetts is not necessary. Water should be applied 3-4 days after the placement of minisetts, since watering earlier than this may wash off some of the protective chemical on the cut surfaces. If pre-sprouting is done during hot and dry weather, a shade should be provided over the nursery bed or the bed should be located under a shady tree.

When small quantities are pre-sprouted, containers with openings for proper drainage and ventilation should be used. The minisetts and the medium should be arranged in a similar manner as for nursery beds described above. The containers should also be under shade and the medium kept moist but not wet. Sprouting starts 2-4 weeks after planting, depending on the variety and conditions in the nursery. Sprouted minisetts must not be allowed to grow excessively in the nursery before being transplanted; roots and shoots become prone to damage during handling and transportation. Whatever method is used for pre-sprouting, the nursery should be easily accessible and near a good source of water for watering.

Advantages of pre-sprouting minisetts include the following:

- In areas where rainfall at the beginning of the cropping season is erratic or the rainy season is not long enough for a complete crop cycle, pre-sprouting can be planned such that the sprouted setts are planted in the field only when the rains are well established.
- A more uniform crop is established in the field since only sprouted setts are transplanted.

- Operations such as weeding, fertilizer application, staking, and earthing-up can be done systematically because of the uniform crop.
- The length of time that the crop stays in the field is reduced hence weedings are done less often than in direct planting.
- Tuber maturity and size are more uniform.

Pre-sprouting however incurs extra cost for materials used in the nursery, and labor to monitor sprouting and sort for planting at different times. During transportation and planting, sprouted minisetts are more difficult to handle than those not sprouted; it is therefore advisable to have the nursery for pre-sprouting as close as possible to the field.

Selection of field for planting minisetts

One of the objectives of the technique is to produce clean disease-free seed yam, hence a field should be selected that is free from soil-borne diseases and pests, especially nematodes, mealybugs, and scale insects. Land that has been under continuous cultivation of yam should be avoided. The soil should be loamy, well drained, and free from stones. Fertile land that has been under fallow will produce a good yield. Minisetts can be planted on soils that are of lower fertility or are too shallow for use in ware yam production.

Land preparation

Land to plant minisetts is prepared as is customary for growing yam; although smaller mounds can be used, ridges are recommended. For large-scale production, land preparation can be mechanized by plowing, harrowing, and ridging.

Direct planting of minisetts

This should be done only when the rainy season is fully established. However, where irrigation facilities are available, it could be done at any time when the setts are ready for planting. Minisetts should be planted in well prepared mounds or ridges with the skin section placed in firm contact with the soil at a spacing of 25 × 100 cm and about 10 cm deep to give 40,000 plants/ha. The plant spacing could be increased or reduced depending on the size of the minisetts and the size of seed yam desired. A double row planting with 25 cm intra-row on ridges spaced 1 m apart will give 80,000 plants/ha (Otoo et al. 1987). However, the average weight of seed yam produced under high plant population will be lower.

Transplanting minisetts

Minisetts should be handled carefully to avoid damage to young sprouts. Transplanting is best done when sprouts are still short and have not elongated into vines or produced broad leaves. It should also be done when rains are well established. To reduce transplanting shock, minisetts should be planted as soon as possible after they leave the nursery. If for some reason, such as a protracted period of drought, the minisetts have to overstay in the nursery and develop excessively long vines with many leaves, the leaves should be reduced before planting.

Figure 12. Seed yam intercropped with maize, cocoyam and cassava

Intercropping minisetts

Minisetts can be intercropped with maize; both crops are planted at the same time. A single maize seed can be planted at a spacing of 1 × 2 m between the minisetts on the ridge or at a spacing of 1 × 1 m by the side of the ridge (Fig. 12). The maize plants eventually provide support to the yam plants. Plants from minisetts of water yam grow more aggressively so only maize varieties with sturdy stalks will be able to support the weight of the foliage. Other crops found in mixtures with seed yam include cassava, vegetables, cocoyam, sorghum, millet, groundnut, melon, and beans. NRCRI has indicated that short-term crops such as maize, egusi-melon, and groundnut are compatible with yam minisetts (Ironkwe et al. 2008). In mixtures, yam is often planted before the other crops.

Field maintenance

Weed control: The seed yam field should be kept free of weeds as much as possible, especially during the first 8 to 12 weeks when the crop cover is low. Apart from using up soil nutrients, some weeds harbor pests and diseases which may affect yam plants. Weeding can be done manually using the hand-held hoe as practiced by farmers, or it can be done chemically with herbicides. After direct planting or transplanting of minisetts with small sprouts, pre-emergence herbicides such as Diuron, Flumeturon, Alachlor, or Premextra can be applied at recommended rates for the effective control of weeds. At high plant populations and without staking (common practice in the savanna region), vines will spread over the soil and provide some control of weeds from about 12 weeks after planting (WAP). Earthing-up of exposed minisetts, roots, and tubers is essential especially from the second or third weeding when some soil would have been washed off by rain.

Fertilizer application: In traditional systems most farmers do not apply fertilizer to yam, but plant the crop immediately after a fallow so that it benefits from the organic matter accumulated during the fallow period. Where there is need for fertilizer application, the recommendation for the location should be followed. NPK 20:10:10 or 15:15:15 at 400-500 kg/ha applied at 8-12 WAP in bands on both sides of the ridge for single row planting (Eke-Okoro et al. 2006), and double rows on each side of the ridge for double row planting could serve as a guide. If pre-sprouted minisetts are used, fertilizer is applied earlier at 4-8 WAP. The nutrient status of the yam field can be improved by following a good rotation plan (rotating with leguminous plants). A good soil management regime will ensure sustainable production.

Staking: In regions where yam is staked, plants from minisetts should also be staked. Since the plant foliage is smaller than that of ware yam, smaller stakes of 1-2 m will be adequate. Small sticks, split bamboos, or maize stalks can be used as staking material. Depending on the size, a stake can be placed against individual plants or several plants directed to a stake using strings; this is pyramidal staking (Fig. 13). Where stakes are not readily available, trellising can be done. Two poles are placed at the end of

Figure 13. Pyramidal staking of a seed yam crop

Figure 14. Staking seed yam plants with a trellis

the ridges and another pole or a rope is tied horizontally on top. Young yam vines are then directed to the horizontal pole with strings (Fig. 14). This is easily carried out when ridges or mounds are made in a straight line. Staked plants are better exposed to sunlight for enhanced photosynthesis and tuber yield. Staking also reduces the exposure of yam foliage to soil-borne diseases.

Disease and pest control: Yam diseases, especially viruses, can be spread from one plant to another through insects or by using contaminated seed yam. The chances of introducing disease into the field can be reduced by starting the crop with disease-free seed yam and by maintaining a weed-free field. Controlling viruses starts by inspecting the crop regularly to eliminate diseased plants through roguing and destroying the insect vectors. If roguing starts early, diseased plants will be removed before insects have a chance of spreading the disease to healthy plants. Symptoms of viruses that can be present on leaves or the entire plant include mosaic, vein banding, mottling, leaf distortion, 'shoe string,' and stunting (Figs. 15a and 15b).

Treating setts before planting helps to control pests and diseases. Land preparation should be done in such a way that rain or irrigation water does not collect at points in the field; such points of collection tend to harbor higher concentrations of nematodes if they are present. . Many yam pests, such as nematodes, mealybugs, scale insects, and crickets, (see Annex) are carried from the field into store where they continue to cause damage in stored tubers, and then are returned to the field at planting if not

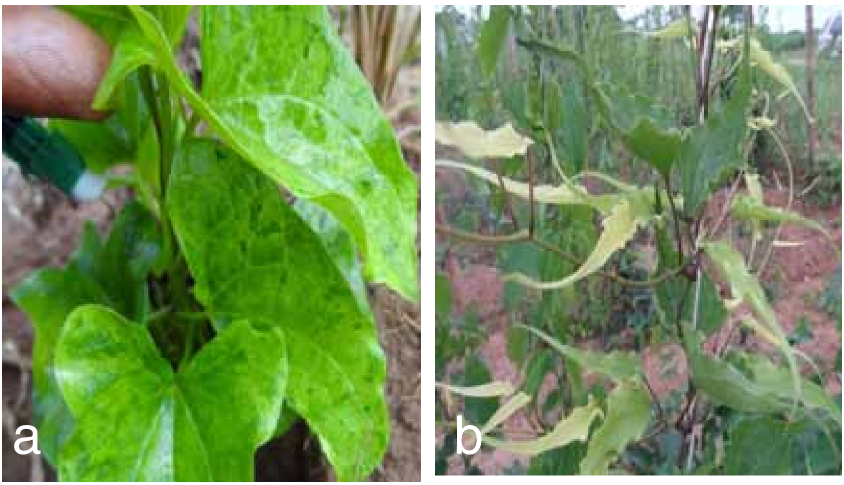

Figure 15. Symptoms of viral disease in yam plants.

well managed. In summary, adequate precaution should be taken to keep pests out of the field and store.

Harvesting and sorting seed yam

Seed yam mature in 5 to 6 months after planting or transplanting. At maturity the leaves turn yellow and dry off; this is followed by the drying of the vine. The tubers should be dug carefully to avoid cuts and bruises which serve as entry points for pathogens and increase respiration during the healing process. Harvesting when the soil is wet may increase the chances of wounded tubers developing rots in storage. Immediately after harvest, seed yam should be removed from direct sunlight to a shaded place to prevent sun scorch. Tubers do not store well that are left in the sun for too long or have cuts. Seriously damaged tubers should be sorted out for immediate use. Seed yam of each variety should be stored separately and graded according to size.

Curing seed yam before storage

Curing after harvest helps to heal wounds and bruises on tubers. Immediately after harvest, the tubers should be taken to the store and placed in a condition in which the heat and water generated are trapped within the pile of tubers to accelerate the process of wound healing. Curing can be achieved by piling tubers in a heap and covering them with materials such as grass, mats, sacks, and/or canvas tarpaulin for 2-3 days (Wilson 1989). After proper curing, tubers store longer.

Storage of seed yam

A good storage facility for seed yam must have good ventilation, adequate shade, and good security against pilfering, rodents, and other pests. As living organisms, seed yam require oxygen, so adequate air circulation through the stored tubers is essential. Too little air will delay wound healing and promote tuber decay; too much air circulation will promote dehydration and reduce the weight of seed tubers.

Good sanitation for stored tubers is essential; diseased tubers should be appropriately discarded. Before and after storage, the store and all materials used should be cleaned and disinfected. Seed yam can be stored in barns where they are tied to poles with live plants to provide shade or in barns where they are placed on racks. Adequate attention should also be provided to control storage pests. Regular inspection should be carried out to dispose of rotting tubers and to remove sprouts that come up earlier than planting time.

Improving the Quality of Seed Yam Produced by Minisetts

Quality Standards for Seed Yam

Yam farmers should desire to use good quality seed yam to plant their crop. To increase production and productivity, it is essential to have farmers with the capacity to provide quality seed yam to the market. Several criteria are used to determine the quality of seed yam, the most important being varietal purity, viability, weight, and cleanliness in terms of freedom from pests and diseases. Tied to production systems and quality, there are three major categories of seeds that could be available to farmers for the production of ware yam: farmer-saved seeds, quality declared seeds, and certified seeds.

Farmer-saved seeds are what farmers reserve from their farms to plant the next crop. Seeds of this type are most readily available and their quality is determined by the farmers' own standards and experience.

Quality declared seeds are those produced in a system in which about 10 percent of the seeds produced and distributed are checked for quality by an autonomous seed control agency and the rest are assessed by the seed producer. Realistic minimum standards are set by local quality control officials to enhance quality of the seeds. This category of seeds is very important in a situation where there is no formal seed system or where it exists but cannot meet demands. The control of standards of quality declared seeds is not as stringent as with certified seeds, but the quality is better than that of traditional farmer-saved seeds. The FAO protocols and standards for vegetatively propagated crops have provided the standards for quality declared seed yam tubers (FAO 2010).

The certified seeds are produced in formal seed systems where management of quality is most important and different agencies are responsible to ensure that only quality seeds reach the market. Inspections are done by the appropriate agencies at different growth stages in the field and later in storage and, at the end, a certificate is issued certifying the quality of the seeds.

There are definite rules to be followed in growing, storing, and marketing the produce, and these must be strictly observed. The ECOWAS rules governing quality control, certification, and marketing of seeds have set standards for certified seed yam (ECOWAS 2008).

The traditional seed yam farmers may not be capable of producing certified seed yam but can improve the quality of their farm-saved seeds or upgrade to quality declared seeds by understanding the attributes of good quality seed yam and following the practices, such as those given below.

Practicing Positive Selection to Maintain a Healthy Crop

Positive selection is done while the crop is growing and the most desirable plants in the field (those without disease symptoms) are selected to maintain the seed lot. The selected plants remain in situ, are marked or tagged, and may be inspected more frequently than the rest of the field.

Steps to follow in positive selection:

1. Study the yam crop to recognize the normal characteristics of the variety, diseased and healthy plants. (If you are not sure, get an extension agent or someone conversant with the variety to assist.)

2. Mark healthy looking plants so that at harvest they will be recognized for use as a source of seeds. It is better to use a cane to mark the plant stand because at senescence the yam vine becomes brittle and easily detached from the tuber, making identification of selected stands impossible.

3. Check throughout the season to eliminate plants that eventually develop disease symptoms or show-off type characteristics.
4. At harvest, collect tubers from the pegged plants first before harvesting the rest of the field.
5. Store selected seeds separately from the rest of the harvest and monitor regularly to remove diseased tubers.
6. Plant seed tubers from the positive selection and repeat the process until only clean plants are maintained in the field.

A properly managed positive selection process will provide the farmer with better quality seed tubers to use for ware yam production and seeds for the following season. Any excess of better quality seed yam can be sold to other farmers.

Using Small Plots for Seed Production

A small area of land can be selected on a farmer's field to maximize seed yam production by planting at a high density. The small seed plot is recommended for ware yam farmers who wish to improve the quality and increase the quantity of their seeds. With a small plot, it is easy to maintain the proper hygiene which is necessary for a high quality crop. It is essential to select land that is fertile and does not harbor any of the pests and pathogens that affect yam. Choose a plot with a good rotation history, ensuring that yam does not follow yam, and that it is located in full sunshine. Avoid fields where runoff water flows into low-lying or waterlogged areas, especially during the cropping season. Such areas are prone to harboring nematodes that will affect the tubers. If the soil is not sufficiently fertile, a good supply of farmyard manure should be applied before planting. The selected seed plot should be made into ridges 1.0 m apart and planted using a spacing of 25 cm between plants. With this spacing, a plot of 100 m2 can provide enough material to plant 400 stands of ware yam.

Certified seeds are the best planting material with which to start yam production but where these are not available, positive selection from an available yam crop will provide a low-cost alternative. After planting, the seed plot should be inspected regularly to monitor crop performance and the occurrence of pests (particularly aphids and leaf beetles). Spot application of insecticide can control insects which spread diseases before they multiply in the seed plot. An agricultural extension officer should be contacted for advice on the control of detected insects. Any diseased plant must be removed as soon as it is noticed. Pictures included in this manual will help in identifying plants diseased by virus infection and pests of tubers.

Hand weeding is recommended for the seed plot and should be done from the first appearance of weeds. Timely weeding is necessary as some weeds harbor disease pathogens and pests. Harvesting, handling, and storage should be carried out as already explained in other sections of this document, with special attention being paid to hygiene.

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Annex. Major pests that affect the quality of seed yam

1. Scale insects are found on tubers both in the field and in store. They feed on the sap of tubers, reducing their nutrient content and viability.

2. Adult mealybugs are generally ash-colored and covered with whitish cotton wool-like material. Infestation leads to poor sprouting and establishment.

3. Yam beetles (inset below) eat tubers in the field, leaving holes that could lead to secondary attack by rot-causing organisms. The market value of damaged tubers is reduced.

Three important nematodes that affect the quality of seed yam are as follows:

4. Root-knot nematodes (*Meloidogyne* spp.) – The presence of the nematodes produces galls on roots and tubers, giving a warty, bumpy and/or hairy appearance.

5. Yam nematodes (*Scutellonema bradys*) – During early infection small yellow necrotic lesions develop under the skin of tubers. These later turn dark brown and coalesce to form a continuous layer beneath the surface (dry rot). Infected tubers have the characteristic longitudinal cracks.

6. Lesion nematodes (*Pratylenchus* spp.) – These cause necrosis beneath the skin of yam leading to dry rots. Cracks may also appear on the tubers.

Infection by nematodes could be a source of secondary infection by rot-causing organisms resulting in storage losses. Infected tubers exhibit suppressed sprouting and are a source of inoculum for the spread of nematodes. They should not be used as planting material.