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Standard Operation Procedures for IITA Fieldbank

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Introduction

As one of the frontline objectives of IITA, collections of tropical staple crops diversity are conserved, among other systems, in fieldbank as tools for food security and poverty alleviation. The IITA field bank is majorly composed of vegetatively propagated (clonal) crops, where cassava (*Manihot esculenta*), yam (*Dioscorea sp*.) and Banana/Plantain (*Musa sp*.) are maintained.

For the proper maintenance of the different varieties of each of these staple crops, there are conservation processes which are carefully spelt out in this standard operation procedure (SOP). The proper maintenance of these collections is in line with the objective of making the different varieties accessible to all national and international partners for use (agricultural research, breeding and for food production purposes). From time to time, the procedures in the maintenance of the collections are modified for improved maintenance culture and practice of the germplams in the fieldbank.

Procedures as described in the yam and cassava SOPs include;

- Land preparation for planting
- Planting and harvesting of crops
- Bar coding of the collections for proper inventory
- Proper storage procedures to prevent loss of crops
- Disease and pest prevention techniques in the field and during storage
- Distribution of varieties of the crops after requests
- Recalcitrant accessions backup procedures in the screen house

For the banana/plantain on, the SOP deals with:

- Bar coding of the collections for proper inventory
- Proper storage procedures to prevent loss of crops
- Disease and pest prevention techniques in the field and during storage
- Distribution of varieties of the crops after requests

Standard Operation Procedures (SOP) for cassava field banking at IITA

Folarin Soyode and Dominique Dumet

The international collection of cassava (*Manihot esculenta* Crantz) is maintained in both field bank and *in vitro* genebank conditions. The cassava field bank is located in Ibadan, Nigeria. The collection is regenerated every 2 years. The main field maintenance and regeneration operations are described below.

1. Land preparation

Cassava is a hardy crop that can grow where most other crops would not. However, for the best performance, a well-aerated, loose, and light sandy loam soil is recommended.

- Before planting the selected field is mowed, plowed, harrowed, and ridged. Approximately 0.4 ha is needed for the maintenance of 1000 accessions.

2. Field marking/labeling

- The field is divided into plots separated by 1.5 m wide alleys. Each plot is 2.5 m in width and its length depends on the field dimensions.
- Measuring tape and bamboo or wooden pegs are used to measure, mark, and demarcate the beginning of each plot (Fig. 1).
- There is a distance of 1 m between ridges.

Figure 1. Marking the field with ropes and bamboo pegs.

3. Germplasm selection and preparation

- Healthy stem cuttings are collected from the existing cassava field bank. Selected stems are free from cuts and visible attack by pathogens (viruses, bacteria, and insects).
- Cuttings 20–30 cm long are prepared. Each cutting should show at least five nodes and be heavy enough to allow regrowth.

The middle section of stems is recommended for use when preparing cuttings as it is mature and has enough food reserves for sprouting. The upper parts of the stem are immature and may not allow sprouting; the lower or basal part may be too old and too rich in lignin to assure regrowth. (Fig. 2).

Figure 2. Selection of the best part of the stem for planting.

- For cutting, secateurs rather than cutlasses or any other cutting instruments must be used to ensure neat cuts. This will prevent the broken cutting edges which are the potential entry points for pathogens.
- The sooner new cassava cuttings are planted the better to avoid desiccation of the stems. Depending on various factors (environment, genotype, etc.), cassava stems can remain viable for up to 7–10 days after cutting. Storability of new cuttings can be extended to 2–3 weeks if they are maintained in polythene bags. Alternatively, full-length stems can be stored vertically for up to 1 month under cool shade and with occasional watering. However, when this is done, the stems need to be examined and confirmed viable before planting. This can be done by checking if white sap or latex shows on a stem 3 seconds after it has been cut.

Figure 3a. Stem cuttings tied up in bundles.

- Cuttings of each accession are firmly tied up into separate bundles. (Fig. 3a) and the cuttings are planted at an equidistance of 0.5 m at 450 to the horizontal; up to two-thirds of each stem cutting is buried. (Fig. 3b).
- At least one cutting of each bundle is clearly labeled with the accession number. Labeling is performed on a biodegradable ribbon tied securely around at least one cutting or by tying one or several bar codes to at least one cutting of each accession.

Figure 3b. Stem cuttings planted at an angle to the horizontal.

- Bundles are then arranged serially and bagged for onward transportation to the new planting field.
- A map used to navigate the field for the cutting exercise. The accessions that are cut are noted on a daily basis and the information gathered this way is used to update the inventory.

4. Planting

- Planting is done preferably in the rainy season but can also take place during the dry season as long as irrigation is available
- As described above, the field is marked with the aid of a taut rope to ensure straight planting.
- Five cuttings are planted per accession.
- Serial numbers are given to each accession on subplots as they are planted in the field. Each number is written on a plastic peg and/or bar code tag.
- The original ribbons/bar codes used to label the cuttings during their preparation remain attached to at least one stem cutting and will allow accessions to be identified at the earlier stage of the planting.

Important: As ribbons will get degraded over time it is important to update the field map and inventory (location of the accession) within a few days after planting.

- Three to five extra cuttings are planted behind the pegs of each accession to serve as a backup for the main plot in case there is low sprouting rate. (Fig. 4.)
- Cutlasses are used for digging holes in the ridges and hoes for heaping up the soil.
- Cassava plants begin to sprout from 7 to 14 days after planting. Where necessary (if there is no sprouting 3 weeks after planting), planting is repeated with the extra cassava stems planted behind the pegs.

Figure 4. Stem cuttings planted behind the pegs as backup.

- Where sprouting is poor, new materials will be sought in the old field to replace poorly sprouted accessions.

Data capture: Date and location of plantation for each accession

5. Field Bank Monitoring

- The field bank is monitored at least once a week.
- The following indicators are informative of the cassava's health status: termites' presence, changes in leaf color, insect incidence, signs of wilting (plant drooping) or severe chlorosis (plants turning yellow due to disease or lack of necessary nutrients). Any of these signs must be reported to the manager for immediate action. (Fig. 5).
- Once an issue has been reported, daily observation may be needed until the situation is back to normal to prevent the loss of the material.
- The branches of neighboring plants are trimmed regularly (pruning) to allow better lighting and/or aeration of the plantation.
- Dead plants may be replaced with the backup stems as described above.
- If one accession repeatedly fails to show normal growth, it is transferred to a screen house for intensive care (regular irrigation, production of new cuttings for new field transfer).
- Regular watering and mulching are done for accessions showing poor drought tolerance. Watering or irrigating the field should take place in the morning. It is also advisable to keep duplicates of sensitive accessions in a screen house.

Figure 5. cassava plant affected by termites.

Figure 6a. Field sprayer properly kitted before spraying.

Figure 6b. Field sprayer with nose guard when handling chemicals.

Figure 6c. Field sprayer when spraying the field with herbicide.

6. Treatment

- Cassava plants are exposed to frequent invasion of pests (white flies, green mites, mealybugs, termites, and grasshoppers), and diseases. As a result, constant monitoring and regular chemical treatments are needed.
- Treatments may be repeated up to three times in a year if there are neighboring fields where the insects find host plants. If this is not the case and attack is mild, one or two treatments may be enough.
- The quantity required for each treatment is 3.5 to 4 L per treatment. The brand name of the chemical used at IITA is DimeForce. Its active Ingredients are Dimethoate 40% EC, Family: Organophosphate. An alternative which may be used is Cyper-Diforce; its active ingredients are Cypermethrin 30g/l + Dimethoate 250g/l EC, Family: Organophosphate + synthetic pyrethoid.
- The concentration of the insecticide used will depend on the severity of the attack of the insects: 50 ml/20 L of water is used when attack is mild; 100 ml/ 20 L water is used for a severe attack in one knapsack load. About 1.5 L/ha of the insecticide would be used.
- For maximal efficiency, treatments are applied at an early stage of insect development (visible eggs or larvae).
- Insecticide is sprayed from the tip of the shoot to the base of the plant as well as on the soil surrounding the plant.
- Sprayers are fully protected with gloves, nose cover, safety goggles, and rain boots. (Fig. 6a–6c).

Herbicide

- In the cassava field bank weeds are controlled by both herbicides and manual weeding. An average of four herbicide treatments per year is required in the Ibadan field bank if this approach is chosen. (Fig. 7a and & 7b).
- Herbicides are applied both pre-emergence, immediately after planting, and f post- emergence, 3, 6, and 9 months after planting.

Figure 7a. Manual weeding in the cassava fieldbank.

Figure 7b. Care being taken by manual weeder to maintain the ridges around the cassava plants while weeding.

- Premextra or Fitsextra, Paraforce, Roundup, Gramoxone: For pre-emergence weed control, a mixture is used of Premextra (dilution = 100, active ingredients of 290 g/L S-metolachlor and 370 g/L Atrazine) and Gramoxone (dilution 130–200) depending on how vigorous the weeds are.
- For pre-emergence weed control, it is advisable to spray on a moist soil (after rainfall) to facilitate chemical diffusion into the soil.
- Weed control at 3, 6, and 9 months: Gramoxone alone (dilution 130–200) is adequate.
- At the earliest development stage (3 months), plants are short and tender. Extreme care should be taken during spraying to avoid chemical contact with the young plants. To do this, a guard is fitted to the nozzle of the spraying equipment.
- Efforts should always be made to spray only on weeds.
- Gloves, nose cover, safety goggles, and rain boots are used by staff when spraying
- This operation takes 10–15 days for the IITA field bank (as in Figs. 5a-5c above)

7. Regeneration

After 2 years of maintenance in the field, the cassava collection needs regeneration, i.e., new plantings. The field map is used to locate all accessions and the operations described above are repeated.

Standard Operation Procedures for Yam Field Banking at IITA

Folarin Soyode and Dominique Dumet

The international collection of yam (*Dioscorea* spp.) is maintained in field bank conditions at IITA. Only part of the collection is presently duplicated and stored *in vitro*.During its life cycle yam progresses from propagules (true seeds or tubers), emerging seedlings or plantlets, mature plants, to senescing plantsand dormant tubers. As a consequence, over a one-year period yam is alternately maintained first as a tuber, then as growing plant, and again as a dormant tuber. Non-tuber bearing wild yam species are kept as perennial plants in the nursery section. Yam i*s* generally a short-day plant and its flowering intensity varies from nil to profuse in the commonly cultivated accessions.

Germplasm from the following yam species are maintained in GRC field bank; *D. alata*, *D. rotundata*, *D. cayenensis, D. bulbifera, D. esculenta, D. dumetorum, D. praehensilis, D. manganotiana* ,and *D. bulkiliana*.

The main operations requested for field bank maintenance are described below.

1. Field Selection

The yam field bank is maintained on IITA campus in Ibadan (Nigeria). A new field is selected every year. Yam growth is enhanced at low altitudes with annual precipitation of about 1000-1400 mm and a mean annual temperature that ranges from 22 to 30 °C.

- Planting starts only at the beginning of the rainy season.
- Planting season is usually between mid-March and the end of May.

Important: Make sure the rains are well established and steady before planting.

Comment: Ideally, the location selected for field maintenance should provide conditions similar to the place from where the germplasm was collected. However, as the diversity of a collection increases, it is obvious that the field selected for maintenance will provide suboptimal conservation conditions for some accessions.

2. Field Preparation

- Deep, loose, and free-draining fertile soil with a pH close to neutral is required for the establishment of yam plants.
- A field with little or no incidence of pests and diseases (viruses, insects, fungi, and nematodes) is preferred.
- Irrigation facilities are often required during the dry season-even in areas that are rain-fed.

- The selected field should be as flat as possible, with a low risk of erosion and no tree stumps (roots and remnants of old trees) in the soil.
- 100 kg/ha of urea is applied to the field before planting.
- Whenever signs of soil nutrients deficiencies are observed when the yam are sprouting, another 50 kg/ha of urea is applied. Note that fertilizer is best applied when the rainfall is steady.
- Fertilizer is applied in a circular or ring form around 10 cm of the yam seed planted.

3. Germplasm Sorting

Yam planting can start when tubers break their dormancy. That generally takes place shortly after the rainy season starts. For the tubers conserved in the cool store (18 to 20 °C, see below), tuber dormancy breaks from April to June, depending on the accession.

- A list of selected yam accessions and their respective shelf numbers is printed to locate each accession in the store.
- Only tubers that look viable and free of bugs and physical damage are selected for planting.
- Large enough tubers are cut into minisetts on a clean table. Note that only one accession is handled at a time to avoid mixing the accessions.
- Healthy tubers are planted either as small tubers or mini-setts with an average weight of 50 g. Entire tuber or ± 30 g pieces of minisetts of each accession are transferred into a net bag.
- Each net bag is carefully labeled with 2 bar codes. One of the bar codes is included in the bag while the other is attached to the bag with string to avoid exposure to chemical treatment and prevent possible alteration.

Data capture: The inventory is updated with the number of tubers from the store room sorted for planting.

4. Germplasm Chemical Treatment before Planting

- Minisetts are treated with the following mixture diluted in 10 l of water: Perfekthion (insecticide) 40 ml, Dithane M 45 (fungicide) 50 g, Basamid fumigant (nematcide) 10 g, and Wood ash 200 g.
- Net bags containing yam tubers or mini-setts are soaked in the chemical for 2 to 3 minutes.
- The treated tubers or minisetts are then allowed to dry in a cool and shaded place for 18 to 24 hours (Fig. 8a-8d).

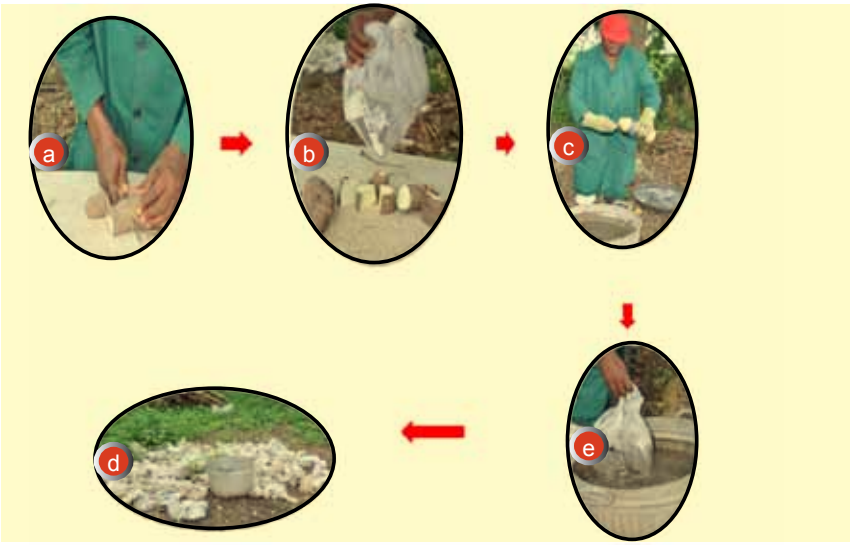

Figure 8. (a). Cut yam mini sets of (50gm). *(b).* Pack mini sets into net bags. (c). Prepare Treatment solution. (d). Spread out to dry (e). Dip the yam into solution.

Figure 9. Yam fieldbank with pathway for walking through field.

5. Planting

- The field is marked and clearly divided up into plots and sub-plots for each accession.with tape, rope, and bamboo pegs of about 1 m length or any other appropriate material.
- For regeneration, a spacing of 2.5 m per row is allocated for each accession with a pathway of 0.5 m between lines.
- For characterization or evaluation, a spacing of 6 m is allocated for each accession with a pathway of 1 m. (Fig. 9).

Figure 10. Yam miniset planted face-up.

- Hoes are the preferred tools used for planting. A quick strike with the tip of a hoe on the spot designated for planting by rope and a sideways movement creates a hole into which a minisett is placed, face up (Fig. 10).

6. Field mapping

It is very important to map the field very carefully to avoid germplasm mixing during the field bank and harvesting processes.

- Plastic pegs labeled with accession number, plot number, and/or bar codes are placed in front of each set of minisetts planted.

Important: Use only weather-resistant labels to prevent information loss.

Data capture: The inventory is updated on a daily basis with the new planting.

7. Field and Germplasm Management

- Staking is carried out when yam vines start sprouting and crawling. The stakes are placed at a distance of about 50 cm from the plant (Fig. 11).
- Weeds are controlled by regular hand weeding (at least twice in a month for a period of 5 months) and the use of herbicides for effective weeds control (Fig.12a and12b).

Figure 11. Staking of sprouting yam.

- During the dry season an irrigation system is set. Yam plants are sprinkled with water twice weekly for 6 hours in the morning .The irrigation takes place for 2 to 3 months.
- Characterization data is captured using the bar code mobile according to the plan (Fig.13a and 13b). Any newly collected data are downloaded to the system daily.

Figure 12a. Manual weeding of the yam field.

Figure 12b. The use of herbicide in yam fieldbank for weed control.

Figure 13a. Bar coding the newly planted yam field.

Figure 13b. Monitoring the yam fieldbank for status update with the use of mobile device.

8. Field Monitoring

- The field needs constant monitoring to prevent the irreversible loss of germplasm. Field bank members of staff visually check the entire collection at least once a week (for disease incidence, possible theft, etc.). Any sign of stress observed on accessions is reported to the supervisor and action is taken when possible.

Data capture: In case of loss, the inventory system is updated (with accession number and date of loss).

9. Harvesting Procedures for yam

At the point of senescence (drying of leaves and stems), yam tubers are ready for harvest.

- The yam tubers are excavated from the soil with the aid of 2-m long iron rods, cutlasses, and hoes.
- All relevant information for the process of harvesting, such as the number of tubers harvested per accession and the date harvested, is recorded and the inventory is updated with it.

10. Post-harvest treatment

- The chemical treatment applied before planting (see above 4) is given to the newly harvested yam tubers.

11. Management

- After drying, yam tubers in net bags are transferred to the yam barns and placed on the shelves for 4 to 6 weeks (Fig.14).
- The new location in the yam barns for each accession is recorded.

Important: Compact storage should be avoided at this point to allow the flow of air around the tubers.

- The net bags are transferred to the yam store (dry storage temperature of 18–20 °C) where they are maintained for 3 to 4 months. (Fig.15). The inventory is updated with the location in the yam store.
- During storage, it is necessary to carefully monitor the germplasm weekly for signs of rotting or deterioration from rodents or insects.
- Any deterioration is reported to the manager for action.
- Monitoring also involves pbservations about a break in dormancy.
- Other information that may be recorded includes any occurrence of a natural disaster that may have led to the loss of part of the germplasm. This must be reported in the inventory and will include the date of the occurrence and the number of units that were lost.

Figure 14. Storing yam tubers in net bags at the yam barn.

12. Phytosanitary monitoring

In the field, growing yam plants and tubers are affected by a number of different pests and diseases that need proper management and control. These include yam beetles (*Heteroligus meles*), yam nematodes (mainly *Scutellonema bradys* and *Meloidogne* spp.), yam viruses (*Yam mosaic virus*). There are also some postharvest diseases that affect yam during storage, such as fungi (*Penicillium* spp., *Fusarium oxysporum, Botrydiplodia theobromae, Rosselina,* and *Sphaerostilbe)*. Below are some recommendations to limit the incidence of pests and diseases during field banking:

Figure 15. Harvested yam tubers being stored in the yam store under a controlled environment.

- Only healthy tubers are maintained. Where possible (i.e., there are enough good tubers in stock) rotten tubers are eliminated as well as those with mealy bugs or showing signs of fungal infection or damage by rodents.
- Insecticides, such as Tricel, Indocel ,or Perfecktion, are used at a rate of 80 ml/20 L of water as soon as staking has been done to protect the leaves of the plants. This is done at least once in two weeks.
- Bait traps or rodent poison are used to eliminate rodents during storage.
- Fungicides, such as Dithane M45 (50 g into 20 L of water), are used to protect the leaves and the tubers of the plants after staking. This is done at least twice in a month.
- Mulching is done to protect exposed yam from rodent attack and scorching by the sun

Important: Note that Germplasm Health Unit experts need to be contacted to identify the symptoms of pests and diseases for appropriate action.

13. Documentation of information during regeneration

Data are collected during the entire conservation process, for each accession, as follows.

- Accession number
- Regeneration site name and map/GPS reference
- Environmental conditions (altitude, precipitation, soil type, others)
- Name of collaborator (only if NARS are involved)
- Field layout used: field/plot/nursery/greenhouse reference
- Flower type (male/female)
- Number of tubers sorted
- Number of tubers planted
- Planting date (± more than 7 days)
- Number of plants germinated
- Field management details (watering, fertilizer, weeding, pest and disease control, stresses recorded, others)
- Date of first harvest and method

Figure 16a. Collection of important data on agronomic traits from yam plants.

Figure 16b. A training session for trainees to the yam fieldbank.

- Date of final harvest
- Number of tubers harvested
- Total weight (kg)
- Location in yam store
- Date of first sprouting (during storage)
- Agronomic evaluation; agromorphological traits recorded (Fig.16a and 16b)
- Postharvest

Standard Operation Procedures for Musa field banking at IITA

Folarin Soyode and Dominique Dumet

At IITA the international collection of *Musa* (banana and plantain) is maintained in a field bank. Part of the collection is duplicated and stored in *in vitro* conditions. The collection maintained by GRC presently holds 337 distinct accessions.

1. Field selection

Musa plants grow best in regions where there is an even distribution of rainfall throughout the year. Young plants generally performbetter under shade. All accessions presently maintained in the GRC fields were planted many years ago.

2. Field mapping and land preparation

The germplasm is maintained in 2 main fields divided into 4 collections.

- *Musa* plants are grown in rows with a spacing of 3 m by 2 m. Within the rows, plants are separated by 2 m and the distance between rows is 3 m.
- Holes (about 20-30 cm deep) are dug the day before the suckers are planted..
- A little poultry manure is put is placed in the holes.
- Suckers are pre-treated in hot water (100 ºC) for 20 seconds and planted. in the prepared holes.
- Soil is added around and at the base of the suckers to give them firm standing.
- A bar code is assigned to each accession.

Data captured: For each accession the location is recorded with the mobile device.

Field bank maintenance: The life span of a **Musa** plant is about 1 to 1.5 years. Young suckers naturally replace old plants.

- When necessary (no more suckers on a stand), a new sucker is planted.
- With time, the number of suckers on the same stand increases. The surplus is regularly removed to maintain a maximum of 3 to 4 plants per stand (thinning) (Fig.17).
- Each accessions is replicated 2 to 3 times in the field as a for backup for safety.

Figure 17. Removal of excess suckers to give room for better growth to banana plants.

- Old and dry leaves are regularly removed (de-leafing) and old and dead plants are dug out with a spade.
- Weeding and slashing of weeds is done around and within the field every day.
- The young plants are mulched (to prevent dehydration) by folding dry grass and straw around their bases during the dry season.
- Insecticide is applied occasionally when necessary. Indicators of the need for insecticides include defoliation (gradual loss of leaves), and other signs of infection.

3. Field monitoring

- The field bank is monitored at least once a week. Any sign of accession erosion is reported to the manager and necessary action is taken.
- As the growth of *Musa* can be affected by prolonged drought, careful monitoring should be done during the dry season.

Data capture: Any lost plant is recorded in the inventory via pocket PC direct reading of the bar codes and updated when a new planting is organized (Fig. 18a and 18b).

Figure 18a. Bar coding of the Musa fieldbank.

Figure 18b. Monitoring of the Musa fieldbank with mobile device for status update.