TRAINING MANUAL

MACRO-PROPAGATION OF BANANA AND PLANTAIN

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1. INTRODUCTION

Plantain and banana are important staples and source of income for the smallholders that grow them in the humid forest and mid-altitude agro-ecologies of sub-Saharan Africa. However, the productivity and lifespan of banana and plantain fields have drastically reduced due to pest and disease pressure. This problem is escalating because farmers usually depend on natural regeneration of plants for the supply of planting materials, which are contaminated by pests and diseases. Major pests are the banana weevil (*Cosmopolites sordidus*) and a complex of plant-parasitic nematodes (*Radopholus similis*, *Pratylenchus* spp., *Helicotylenchus multicinctus*, and *Meloidogyne* spp.). Major diseases are fusarium wilt, caused by *Fusarium oxysporum* f.sp. *cubense*, and bacterial wilt, caused by *Xanthomonas campestris* pv. *musacearum*.

Banana and plantain can now be propagated aseptically in the laboratory through tissue culture techniques. *In vitro* micro-propagation eliminates all sucker-transmitted pests and diseases, with the exception viruses. However, tissue culture plants are relatively expensive and not readily accessed by resource poor farmers, who constitute the biggest percentage of farmers in the region.

The international Institute of Tropical Agriculture (IITA) has been investigating alternative means for producing clean planting material. Macro-propagation is a relatively easy technique that is carried out in a shed or even in the field. It consists of generating suckers from clean planting material by removing the apical dominance. Macro-propagation can be classified into two categories: field-based techniques, based on complete or partial decapitation, and detached corm techniques, practiced in a shed.

This training manual aims to provide a step-by-step explanation of macro-propagation. A first edition of this training manual was compiled by Emmanuel Njukwe, Abdou Tenkouano and Delphine Amah for use among farmers in Cameroon. The current version of this training manual was used for training farmer stakeholders from East and Central Africa during a week long training session at IITA-Uganda.

2. MACRO-PROPAGATION: AN OVERVIEW

STARTING MATERIAL

> ☝ ***Of critical importance: start 'clean' !***

It is very important that the starting material for macro-propagation is clean. Clean starting material can be obtained in a variety of ways:

- through paring of suckers;
- through hot or boiling water treatment of suckers;
- through using tissue culture plants;
- through chemical treatment of the suckers.

FIELD TECHNIQUES

Two decapitation techniques exist. The two decapitation techniques involve stimulating lateral bud production by destroying the active growing point (meristem) in the pseudostem. Both techniques increase sprouting and sucker multiplication in the field. Using false decapitation, a small hole is made in the pseudostem through which the meristem is destroyed. The foliage remains physiologically active for about three months thereafter. Using complete decapitation, the pseudostem is cut down, destroying the meristem.

DETACHED CORM TECHNIQUES

Detached corm techniques are currently promoted by IITA because of higher numbers of resulting seedlings and growth uniformity of the seedlings. Seedlings obtained using detached corm techniques are also less prone to stress once established in the field. Detached corm techniques include:

- whole corm;
- split corm;
- excised buds;
- meristem-drilling;
- PIF (plantes issues de fragments de tiges) / plants resulting from stem fragments.

These techniques are simple and therefore easy-to-grasp, and cheap to establish with minimum investment in construction of propagators and weaning facilities.

3. FIELD TECHNIQUES

Both false decapitation and complete decapitation consist of the following steps:

- removal of apical dominance;
- sucker detachment.

FALSE DECAPITATION

Step 1. Removal of apical dominance

A small hole (~ 5 cm in diameter) is cut in the pseudostem of six-month-old plants to destroy the actively growing point (meristem). The hole is made at about 20 cm above the ground by removing the central part of the plant. The hole should slightly slope downwards, so water and plant sap collect in the hole, further killing the meristem. The plant is left to stand for at least one month to allow sprouting.

Fig. 1. A hole made in the pseudostem of banana plant.

Step 2. Sucker detachment

About four to seven suckers, depending on banana or plantain cultivar, will sprout three weeks after removal of the apical dominance. Sprouted suckers are detached immediately once they attain three to four leaves (usually when they measure 20-30 cm in height). Detached suckers are transferred directly to the field.

COMPLETE DECAPITATION

Step 1. Removal of apical dominance

The pseudostem of a 6 month old plant is completely cut down at ground level. Emerging suckers should not be cut. The meristem is destroyed by using a clean knife or machete and removing the 5 cm diameter growing part in the middle of the pseudostem. Usually, the meristem is soft and when hitting harder tissue (the corm), one can be sure the meristem is destroyed. The corm is left to sprout for a month.

Fig. 2. After cutting down the entire pseudostem, the meristem is removed and the corm is left to sprout.

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Fig. 3. Suckers sprouting after a complete decapitation.

4. DETACHED CORM TECHNIQUES

Using detached corm techniques, activities are carried out in propagators and weaning facilities. Detached corms or buds are prepared for primary bud sprouting. Plantlets resulting from these primary buds are subsequently prepared for secondary bud sprouting. Plantlets resulting from these secondary buds are rooted. Finally, after an acclimatization period, they are ready for field planting. After 12-18 weeks, using this technology, planting material can be multiplied ten-fold.

Using detached corm techniques, the following steps can be identified:

- construction of propagators;
- filling of propagators;
- selection of suckers;
- preparation of suckers and planting;
- propagator management;
- potting mixture preparation;
- rooting;
- acclimatization.

STEP 1. CONSTRUCTION OF PROPAGATORS

Propagators are used for sprouting of new seedlings and hardening of the subsequent sprouts. Simple propagators can be constructed using fairly cheap materials, such as bamboo and polythene sheets. Enterprising banana seedling producers could use iron rods and cast a concrete floor. It is important that at least 50% shade is provided and that the fragile seedlings are well-protected, by constructing a shade above the propagators. A convenient size for a propagator is 1.5 (width) x 5.0 (length) x 1 (height) meter. Propagators should be kept clean and completely covered with transparent polyethylene sheets. Humidity and temperature should be high. The propagator compartments can be made using wood or bricks and should measure not more than 0.5 m in height.

Fig. 4. Examples of propagators, with and without shades.

Fig. 5. Close-up of propagators.

STEP 2. FILLING OF CHAMBERS

Propagators are filled three quarter-full with steam-sterilized fine sawdust. Steam sterilization of sawdust can be performed as follows using an oil drum. Iron bars are welded 20 cm above the bottom of the drum on which an iron net is placed. The modified oil drum is then placed on stands welded on the outside, usually about 20 cm above ground. An old potato bag can be placed on top of the iron net to prevent sawdust from falling through the iron net. Water is poured into the drum up to the height of the iron bars. After applying the sawdust into the drum, the sawdust can be covered with old potato bags again. Heat is applied under the drum using firewood and steam from the water sterilizes the sawdust. Steam is passed through this construction for one hour.

Fig. 6. A propagator filled with steam-sterlized sawdust.

STEP 3. SELECTION OF SUCKERS

Healthy sword or maiden suckers detached from plants that are in between flowering and harvest can be used as source material, as well as corms of plants that are about to flower or that are already harvested. Of critical importance is that the source material is pest- and disease free. A maiden sucker is the most mature sucker on a stool and will give rise to the next crop cycle. A sword sucker is a young sucker whose leaves are pointed like a sword. The decision whether to use a sword sucker, a maiden sucker or corms depends on the type of detached corm technique explained below. Prior to use, the pseudostem is cut off from the suckers.

Roots are removed from a harvested sucker or corm, followed by a thorough wash to remove plant and soil debris. The outer leaf sheaths are removed, one by one, 2 mm above the corm and from the leaf base with a sharp knife. This will expose all the buds and/or the meristem. The prepared material can be surface-sterilized for 20 min in a fungicide mixture. The buds are scarified and the planting material is air dried for 24 hours.

Fig. 7. Sword suckers before paring (right) and after paring (left).

Fig. 8. A whole corm.

Fig. 9. Suckers ready for cleaning.

Fig. 10. Cleaning, paring and antifungal treatment of corms.

STEP 4. PREPARATION OF SUCKERS AND PLANTING

Detached corm techniques include:

- whole corm;
- split corm;
- excised buds;
- meristem-drilling;
- PIF (plantes issues de fragments de tiges) / plants resulting from stem fragments.

Whole corm

Whole corm technique is applied to corms that are about to flower or that are already harvested. The meristem is absent while buds are present. Propagation is by means of bud manipulation. Roots are removed and the leaf sheets are cut away one by one, exposing the buds. A fungicide can be applied. The corm is scarified at the top (by cutting an X) after which every other observable bud is scarified. The entire corm is planted in the propagator. Corms are planted at 30 cm intervals and covered fully with sawdust, and have to be well watered immediately after planting.

Fig. 11. Harvest of entire corm from the field and preparation for whole corm technique.

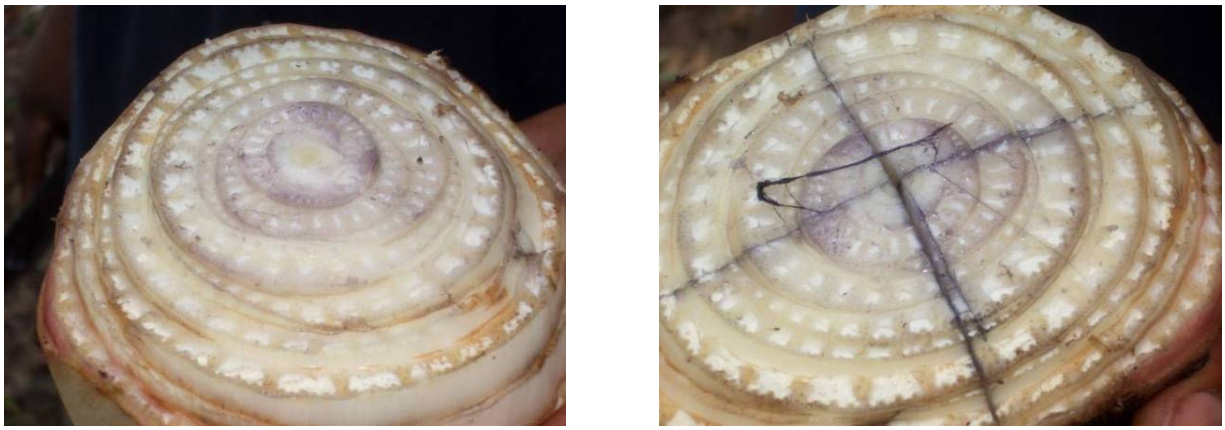

Fig. 12. A corm with removed leaf sheets (left) and after scarification (right).

Split corm

Split corm technique is applied to corms that are about to flower or that are already harvested. The meristem is absent while buds are present. Propagation is by means of bud manipulation. The whole corm is harvested and pared. Exposed buds on top are scarified. Leaf sheets do not need to be removed. The corm is fragmented into two or more bits, depending on its size, and planted in the chamber for buds to sprout. Prepared corm pieces are planted at 10 cm intervals and covered with 2 cm of sawdust. The chamber is well watered immediately after planting.

Fig. 13. The corm is fragmented into two or more bits depending on its size.

Fig. 14. Sprouting suckers.

Excised buds

Excised bud technique is applied to corms that are about to flower or that are already harvested. The meristem is absent while buds are present. Propagation is by means of bud manipulation. Buds are cut out from the corm in pieces of 50-100 g and planted in the propagator to sprout. Buds are planted at 10 cm intervals and covered with 2 cm of sawdust. The chamber is well watered immediately after planting.

Fig. 15. Buds are cut out from the corm in pieces of 50-100 g. Buds can be planted directly in plastic bags.

Meristem drilling

Meristem drilling is applied to a maiden sucker. The meristem and buds are present, but the meristem is drilled. Propagation is by means of bud manipulation. The meristem is destroyed by using a clean knife or machete and removing the 5 cm diameter growing part in the middle of the pseudostem. Usually, the meristem is soft and when hitting harder tissue (the corm), one can be sure the meristem is destroyed. The chamber is well watered immediately after planting.

PIF

PIF is applied to a sword sucker. The meristem is present while buds are absent. Propagation is by means of meristem manipulation. The corm is pared and sterilized. The apical meristem is scarified or fragmented longitudinally into 2 or 4 bits before planting. Fragments are planted with the cut portion, which includes the meristem, facing up. The chamber is well watered immediately after planting.

STEP 5. PROPAGATOR MANAGEMENT

During propagator management, it is important that a clean environment is maintained. Plants should only be watered when necessary. If the plastic sheets are moist, no watering needs to be done.

Depending on the cultivar, three to seven shoots arise from one piece of planting material. Large shoots (usually obtained after three weeks) should be manipulated (scarified) to obtain secondary plantlets as follows. Apical dominance is destroyed by cutting of the shoots and making an X in the middle of the remaining corm. After another three weeks, each of these shoots will give rise to three to seven shoots again.

Fig. 16. Primary shoots growing in a propagator.

Fig. 17. Young plants (primary shoots) emerging from axillary buds on the corms.

STEP 6. POTTING MIXTURE PREPARATION

Potting substrate can come from a wide variety of sources: top soil, sawdust, coffee husk, cocoa husk, rice husk or oilpalm fiber. These substrates can be mixed in different proportions and should be prepared in advance. Topsoil mixed with sawdust and composted organic matter at a 6: 3: 1 ratio is preferred. The potting substrate is steam-sterilized for 12 hours in a drum. An old oil drum, modified by welding iron cross bars at about 20 cm from the bottom can be used for steaming. Steam is prevented from escaping from the mixture when heating. After sterilization, the potting substrate should be allowed to cool for 24 hours.

Fig. 18. Steam-sterilized potting substrate.

STEP 7. ROOTING AND ACCLIMATIZATION

After about 10 weeks, 10 to 50 secondary shoots will have emerged, each with two to three small leaves. These plantlets are detached. Those that have roots go straight into the potting mixture, using one plant per bag or cup. Those without roots are replanted in sawdust for 10 days prior to their movement to the potting mixture. It is important that a little portion of corm remains attached to provide the plants with a nutrient reserve.

Fig. 19. Secondary shoots emerging from axillary buds on the corms (left). After they attain two to three leaves (right), they are ready for rooting.

Fig. 20. Secondary shoots without (right) and with roots (left).

Fig. 21. Sorting of secondary shoots without and with roots.

Fig. 22. Secondary shoots without roots are placed back in sawdust for 10 days.

Plantlets with roots are transferred in their plastic bags or cups to weaning facilities for acclimatization. If plantlets are moved to distant nurseries for acclimatization, they should be transported in humid transparent polythene bags. Acclimatization is ideal at 25-27^{o}C and is accomplished in shades 2 m in height for proper lighting and management. Plantlets being acclimatized should be watered four times a week.

Fig. 23. Young plants placed in rooting substrate.

Fig. 24. Plantlets being acclimatized.

After three to six weeks in the weaning facility, plants are ready for the field.

Fig. 25. Plantlets ready for field planting.

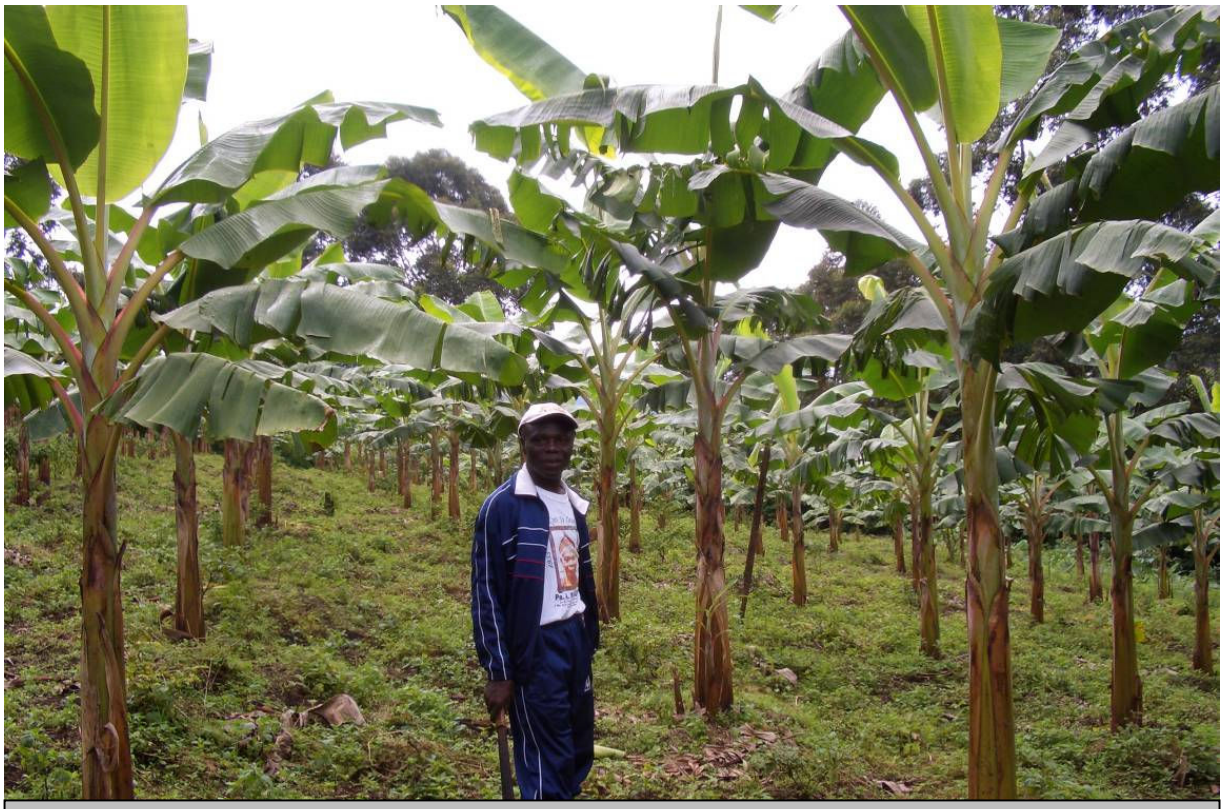

Fig. 26. Macropropagated plants in the field.

5. TIMELINE FOR DETACHED CORM MACRO-PROPAGATION

Plants can be achieved ready for planting after 12-18 weeks.

Propagation stage	Time period
Primary bud sprouting	3-5 weeks (depending on the climatic condition and variety)
Secondary bud sprouting	2-3 weeks
Rooting of detached plantlets	2 weeks
Acclimatization	3-6 weeks

6. BUDGET FOR DETACHED CORM MACRO-PROPAGATION

This is a budget estimate for constructing a propagator comprised of four chambers with a total capacity of 800 corms. These 800 corms can yield at least 8,000 plants in four months. The propagator can last for more than five years

Item	Unit cost (USD)	Quantity	Unit	Total cost (USD)
Propagator (1.2 x 2 x1 m)				
Transparent plastic sheets	6	8	sheet	48
Wood/scandle	6	50	scandle	300
Nails/zink nails	8	3	packet	24
Pins	4	2	packet	8
Roofing sheets	6	22	sheet	132
Transparent roofing sheets	5	18	sheet	90
Old roofing sheets	3	16	sheet	48
Subtotal propoagator				**650**
Materials				
Old oil drums (200 L)	16	2	drum	32
Tags for identification	0.2	100	tag	20
Sawdust	2	100	bag	200
Plantain or banana corms	0.2	800	corm	160
Top soil	15	3	tipper	45
Poultry manure	2	50	bag	100
Polybags	0.04	8000	bag	320
Subtotal materials				**877**
Tools				
Wheel barrow	12	1	barrow	12
Cutlass	7	1	cutlass	7
Digger	7	1	digger	7
Spade	7	1	spade	7
Big knives	1	2	knive	2
Small knives	0.5	2	knive	1
Large bowl	4	1	bowl	4
Watering cans	7	7	can	7
Fungicide	7	1	can	7
Protective clothes	20	1	suit	20
Subtotal tools				**74**
Labour (1 month)				
Technician for construction	300	1	person	300
Skilled labour for preparation	100	2	person	200
Labour for Maintenance	50	4	person	200
Subtotal labour				**700**
Grand total				**2301**

MORE INFORMATION

For further information please contact IITA-Cameroon or IITA-Uganda.

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