Growing bananas from "seeds"

Jim Lorenzen

Bananas are an important crop for global trade and nutrition where they are intensively cultivated, but few efforts exist to breed superior bananas. One of the reasons for this is that humans have intensively "selected" against seeded bananas and it is difficult or impossible to pollinate many banana varieties and successfully produce seeds.

Many of the most important banana varieties are triploid, which means that they carry an extra copy of each chromosome compared to the normal diploid. Being a triploid means that it is difficult for normal chromosome pairing and segregation to make fertile eggs or pollen, which results in most triploids being nearly sterile. Sterile bananas are great for people who don't like to crack their teeth on banana seeds, but mean that bananas have to be multiplied via vegetative propagation, similar to propagation of potatoes, sweet potatoes, cassava, and selected varieties of other fruit trees or ornamental species.

Gardeners are familiar with "seed potatoes," small potato tubers that are planted to produce a potato crop. Bananas do not form tubers; new plants derive from "suckers" that emerge from the lower banana stem (corm). These suckers can be uprooted and used to plant new banana plants. Similar to potato tubers, these suckers were a part of the original mother plant, which means that they potentially carry whatever disease pathogens or pests had infested the mother plant. Therefore, banana suckers are one of the main means of transport and spread of certain disease-causing agents, including important fungi, bacteria, and viruses.

Nematodes and pests can also hitchhike on banana suckers to infest the new crop. Not only does such hitchhiking result in early infection/infestation of new banana plants in a farmer's field, but transporting long distances may help introduce a new disease or pest problem in a new location. This dual hazard of reduced yield potential of already infected planting material that may introduce new pests and diseases emphasizes the need for superior disease-free

Finding seeds in breeding plots in Namulonge, Uganda. Photo by IITA

Macropropagated plants in chamber. Photo by IITA

planting material produced through a “seed system” designed to minimize the risks of spreading pathogens and pests.

The traditional means of obtaining banana planting material (“seed”) is to acquire suckers from one’s own banana garden, from a neighbor, or from a more distant source. This method served to spread common varieties around the world and to multiply them in their new locations. This system can be modified to produce more banana suckers or shoots by manipulating banana corms to allow more buds to sprout. One such method that is described here is called macropropagation. A higher tech procedure to rapidly produce many plants in just a few generations of propagation is called tissue culture. In tissue culture, plants are first surface sterilized and then grown in aseptic culture in test tubes using an artificial growth medium based on a gelling agent like agar. The tender tissue-cultured plants can then be planted in the field after rooting and hardening under protected conditions.

Seed systems for producing clean planting material can be operated at various levels of technology and efficiency. In some cases, plant health could be improved by merely raising the awareness of the negative impact of planting “sick” suckers. Where infected plants look visibly different from healthy plants, either because of reduced vigor or visual disease symptoms in infected plants, the propagator could practice negative selection against “sick” plants or positive selection for “healthy” plants (or both). Such plants could be multiplied faster by applying a rapid propagation method such as macropropagation. However, while low-tech and affordable for farmers, such a system does not eliminate problems that cannot be detected by visual observation. Unfortunately, many diseases and pests fall into this category for at least part of their infection cycle.

For crops such as cereals, seed certification systems were developed to assure varietal purity, and later expanded to include freedom from weed seeds and seed-transmitted pathogens. Since most pathogens are seed-transmissible for vegetatively-propagated crops like potato or banana, disease management is the major focus of most seed potato certification programs and banana multiplication

programs. Modern technology has provided diagnostic tests to detect significant pathogens. These tests are similar to those used in modern laboratories to diagnose human diseases, and can be expensive. For this reason, it is more efficient to test a small number of plants and multiply those that were negative for all pathogens tested in the battery of diagnostic tests.

It is possible to use tissue culture to efficiently and rapidly multiply plants that tested "clean" in the pathogen testing. Most potatoes eaten in the Western world are just a few field generations removed from tissue-cultured plants used to produce "seed potatoes" in screened glasshouses to start the seed production cycle. Similarly, most dessert bananas in the global export trade are from plants originally propagated in tissue culture from plants that tested clean for known banana diseases. A modified form of tissue culture can also be used to eliminate pathogens from plants that did not test clean, after which they can be propagated to produce "seed" planting material. There is great potential to improve the health of banana plantations in the developing world through increased use of this technology.

Tissue culture is the process of growing plants that have been surface sterilized and planted in test tubes or similar containers in sterile medium that contains all the nutrients they need to grow. This is almost always done in indoor laboratory facilities and the medium also contains the sugars needed to grow, since there isn't enough light for photosynthesis.

Sanitation is extremely important, since a single mold spore is enough to contaminate a test tube. Tissue-cultured plants are generally tested for pathogens before commencing the multiplication cycle so that infected plants are not multiplied. The small banana plantlets produce small suckers that can be detached and planted as new plants, or an experienced technician can cut sections that contain buds that will grow. Extra shoots can sometimes be induced by cutting through the growing points so that multiple plants develop from single buds. This process can be repeated every 5-8 weeks so that a single plant can produce many new plantlets in a relatively short period of time.

Bananas are sometimes unstable in tissue culture and mutant versions can develop. For this reason, most multiplication labs try to limit the number of multiplication cycles before renewing their cultures from field plants observed to have all the correct traits for that variety.

When tissue-cultured plants are rooted in soil, hardened, and then planted back in the field, they can be more susceptible to some pests and diseases than the original plant was. To restore natural levels of resistance, these plants can be reinfected with the endophyte microorganisms that normally coexist with

Bicycle transport to Bujumbura, Burundi.
Photo by IITA

"A combination of new and old seed systems can improve the overall health of new plantings by providing healthy plants of preferred older varieties and resistant new varieties." - Jim Lorenzen

bananas, similar to the gut bacteria that are important for human intestinal health (see article on endophytes on page 19).

Macropropagation falls somewhere between tissue culture and traditional systems of distributing suckers. In macropropagation, large suckers from healthy banana plants are removed and the roots and soft stem portion (pseudostem) of the sucker are cut away to expose the buds of the corm (the hard stem portion at the base of the sucker). The bare corms are briefly dipped in boiling water to kill any nematodes (micro-worms) that were not removed when cutting off roots. Small cuts are made through the buds to encourage development of multiple sprouts from each bud. The apical (top) bud is often removed because it can suppress development of lower buds. The corm is then covered with moist wood shavings and incubated in a small plastic-covered chamber for a few weeks to encourage shoot development.

Primary shoots can be rooted and used as planting material, or cut off and the growing point again cut to promote additional shooting. Shoots that develop are broken off with a bit of hard stem and roots attached, placed in small nursery bags in a similar high humidity chamber for a few days to allow root development, and finally moved to a nursery for hardening.ww Hardened plants can be planted in the field, similar to suckers or hardened plants from tissue culture.

A major drawback of macropropagation is that rustic or low-tech methods of detecting pathogens have not been developed, so this method can propagate infected plants if they were chosen as mother plants. Both macropropagated plants and tissue-cultured plants have less food reserves than suckers and require more care (compost/ manure, watering) after planting than suckers. Careful siting of "mother gardens" established from tissue-cultured plants in clean areas may be the best way to produce suckers for macropropagation.

Traditional seed systems have produced most of the nearly 6 billion banana and plantain plants in Africa currently spread over nearly 4 million hectares of farm and gardens. Many of these are in excellent condition; others have become infected with one or more banana diseases and need to be replaced. Since new banana diseases have been introduced to Africa in the last century, and many diseases have increased in distribution and prevalence, greater care needs to be practiced to multiply "healthy seed".

Breeding programs are nearly ready to release new varieties with resistance to some of the disease problems.

A combination of new and old seed systems can improve the overall health of new plantings by providing healthy plants of both preferred older varieties and resistant new varieties.

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Banana roadside market in rural southwest Uganda. Photo by IITA