Cassava rapid stem multiplication tunnel

OPERATIONS MANUAL

Alliance Bioversity & CIAT

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Contents

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Introduction

This manual explains how to manage a cassava rapid stem multiplication tunnel system. A previous manual in this series described the construction of tunnels using common, locally available materials. That manual is available here:

https://cgspace.cgiar.org/handle/10568/129793

In this manual, based on experiences from tunnel managers in Cambodia, Colombia, Lao PDR, and Vietnam, we describe the major stages and operations for rapid multiplication of cassava planting stems using the tunnel system.

What are the advantages of the tunnel system?

The tunnel system has multiple advantages when compared to traditional stem multiplication.

Clean planting material

Diseases like cassava witches' broom, cassava mosaic disease, cassava brown streak disease, and others are spread through infected planting materials. Stem multiplication and distribution projects can spread diseases widely if proper measures are not taken. Insect pests like mealybugs, scale insects, and spider mite species can also move on stems and leaves. The tunnel system allows us to produce clean material that does not spread these pests and diseases.

Make it clean, keep it clean!

Above: mature stems ready for planting season in Vientiane Province, Lao PDR. Previous page: a six-tunnel rapid stem multiplication system with screenhouse at NAFRI (Lao PDR).

Rapid multiplication

The introduction of a new variety, the spread of a disease, or the loss of planting stems due to an emergency produce a need to multiply stems very fast - much faster than the traditional system. When a new variety becomes available, growers can usually only access a small amount of stems, but planting one hectare of cassava at normal density requires over 10,000 cuttings. Traditional woody stem cuttings from improved Asian varieties typically achieve a multiplication ratio around 1:10, meaning that each cutting planted will produce about 10 more after one full cycle of growth, which takes almost a full year. A faster option is needed.

The tunnel system can greatly increase the multiplication rate, up to 1:100 or even 1:200 depending on the exact techniques used. Because the tunnels can be used year-round in most cassava-growing environments, the cycle time is much shorter. And because the method does not rely on rainfall, multiplication can continue during the dry season.

Ease of use

The tunnel system is designed to be simple to use. The system has requires low investment and can be managed by non-specialists. However, there are a few techniques that tunnel managers need to learn. This manual will cover all the steps in stem production.

What can a properly managed tunnel system provide?

A properly managed tunnel system allows for quick multiplication of cassava varieties while maintaining pest and disease-free conditions. It does this by taking advantage of cassava biology. Starting with a source of 35-45 clean mature stems, a single tunnel can produce 1100 (in some cases up to 2000) seedlings every 2 months, compared to only about 2000 per year for traditional cassava field multiplication. Because tunnels are modular, it is easy and cost effective to increase the number of tunnels in one location. Our basic recommendation is a four-tunnel installation to take advantage of efficiencies of scale.

Personnel and resources needed

Typically 2 staff can manage a typical four tunnel system, depending on the arrangements for starting materials, irrigation, outplanting and field management. In addition to personnel and the tunnels themselves, in some cases a screenhouse or greenhouse may be desirable, depending on the needs in a given context (see section I). Access to an isolated multiplication field is necessary to care for the rooted seedlings (described in detail in section II, stage 3).

The rest of the manual will show the overall system for tunnel use, and explain how to manage the stages of cassava seedling production. After that we discuss some modifications and troubleshooting (section III).

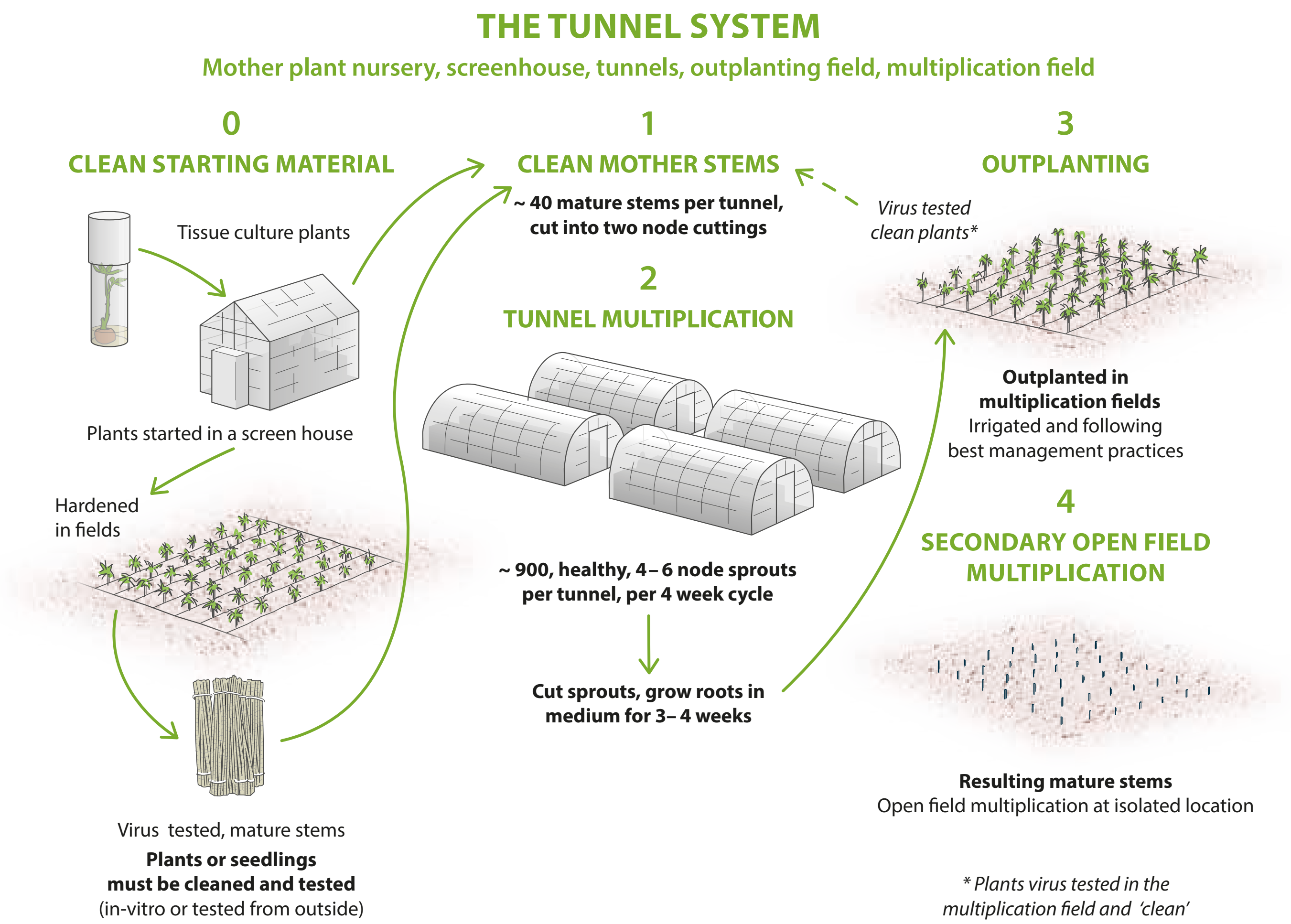
I. Overview of the tunnel system

What it is

The tunnel system is composed of several parts. Besides the tunnels themselves, there are supporting facilities to prepare the mature stems going into the tunnels, and to manage the seedlings coming out of the tunnels.

The Illustration below, shows an overview of the system, beginning with a source of clean starting material, multiplying it quickly using the tunnel system, and taking care of the seedlings in multiplication fields. Depending on the context and circumstances, tunnel managers may only choose to do some of the stages shown, with partners or other institutions taking responsibility for the other stages.

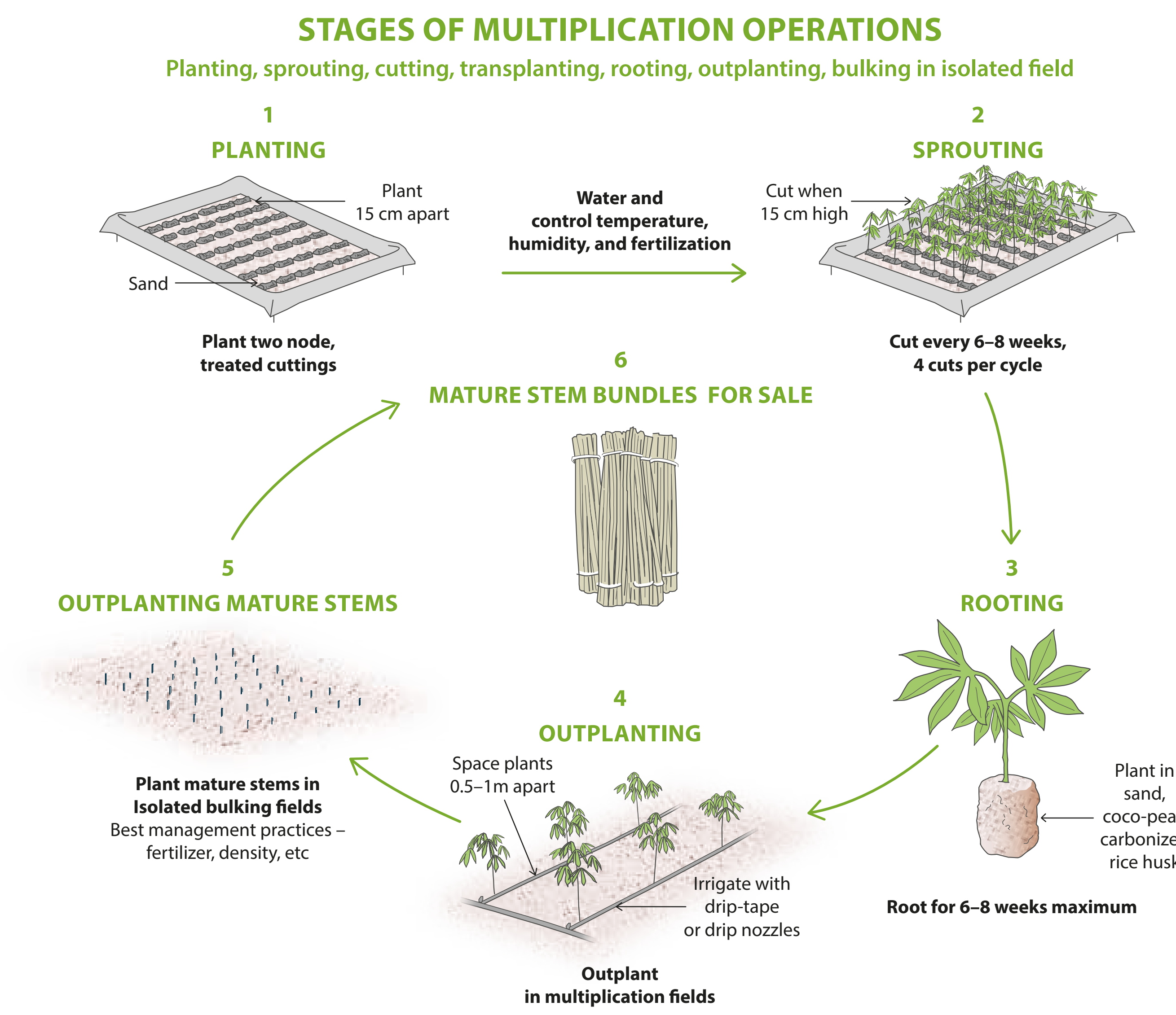
Most tunnel users will not receive in vitro plants, or go through the stages of outgrowing and hardening themselves (0 below). Instead, most users will start by getting clean, tested starting materials from a government, university, NGO, or private sector organization.



Think carefully about who will take care of each stage in the process before starting multiplication. If the material being used to plant the tunnels is not clean, the tunnel manager will only be multiplying their problems. If there is no one taking care of the rooted seedlings coming out of the tunnels, the results will be wasted.

How it works

The tunnel system increases seed multiplication rates by taking advantage of the vegetative biology of cassava. This means there is no need to wait for cassava plants to become fully mature before replanting. Instead, we can sprout all the nodes on our cuttings simultaneously, up to four times in one tunnel cycle. The result is the ability to produce far more plants, far more quickly and less expensively. The next section of this manual will show you how.



The 'nodes' are the bumps found on cassava stems. They are actually made up of two parts. The first is the leaf petiole, or, when the leaf has already fallen off, the leaf scar. The second, the small round areas above each leaf scar, are called 'axillary buds'. These parts of the plant have a unique ability: they can grow and generate new sprouts.

Cassava nodes with visible axillary bud above the leaf scar on mature stem (left) and sprouts (right).

In a typical cassava field, the bottom end of each ~20 cm cutting is placed in the soil, and only 1–2 of the top nodes will produce a sprout. Using the tunnel approach described below allows all of the nodes to continuously sprout several times each. This is what makes the tunnel system so much more efficient at producing new plants.

Traditional vertical cassava cutting planting method, and a cutting sprouting with leaf symptoms of cassava mosaic disease (left Lao PDR, right Cambodia).

II. Step by step instructions

Stage 0: Obtaining clean starting material

The most important thing to consider, before even starting to use the tunnel system, is the source of the starting material. The tunnels use traditional mature stems, but there are several ways to obtain clean stems depending on your context. Only a small number of mature stems is required: 35-45 per tunnel. However it is critical that these be clean and of the highest possible quality. Example sources of starting material:

(a) ***Tissue culture.*** Users with capacity to handle in vitro materials can receive vials or bottles of plantlets in gel media. This is the preferred method to send plant materials internationally, since it can be guaranteed that the plants are disease free and have not been in contact with soil or exposed to vectors of disease.

(b) ***Healthy mature stems*** from known multiplication partner. In many cases, the work of handling in vitro plants from tissue culture will be done by a specialized institute like a government organization, university, NGO, or private company. In this case, tunnel managers will be able to receive hardened plantlets or mature stems from these actors.

(c) ***Tested stems from disease-free area.*** Another possibility is to use mature stems coming from a disease-free area. Mother plants that the stems for the tunnel come from should be tested to guarantee quality. Contact your local agricultural extension office for advice on testing. As shown in illustration 1, an established tunnel can also use stems from the multiplication field to re-supply the tunnels, if tested.

Being confident about the quality of the starting material is the best way to guarantee production of high-quality plants. Think carefully about the varieties desired, timing of sprout production, number of plants needed, and quality assurances for starter material before beginning.

Key questions to ask yourself

What is the source of stems for my tunnel system? Where will the starting material come from?

How do I know that the stems I am using are clean?

Is the source I am using reliable?

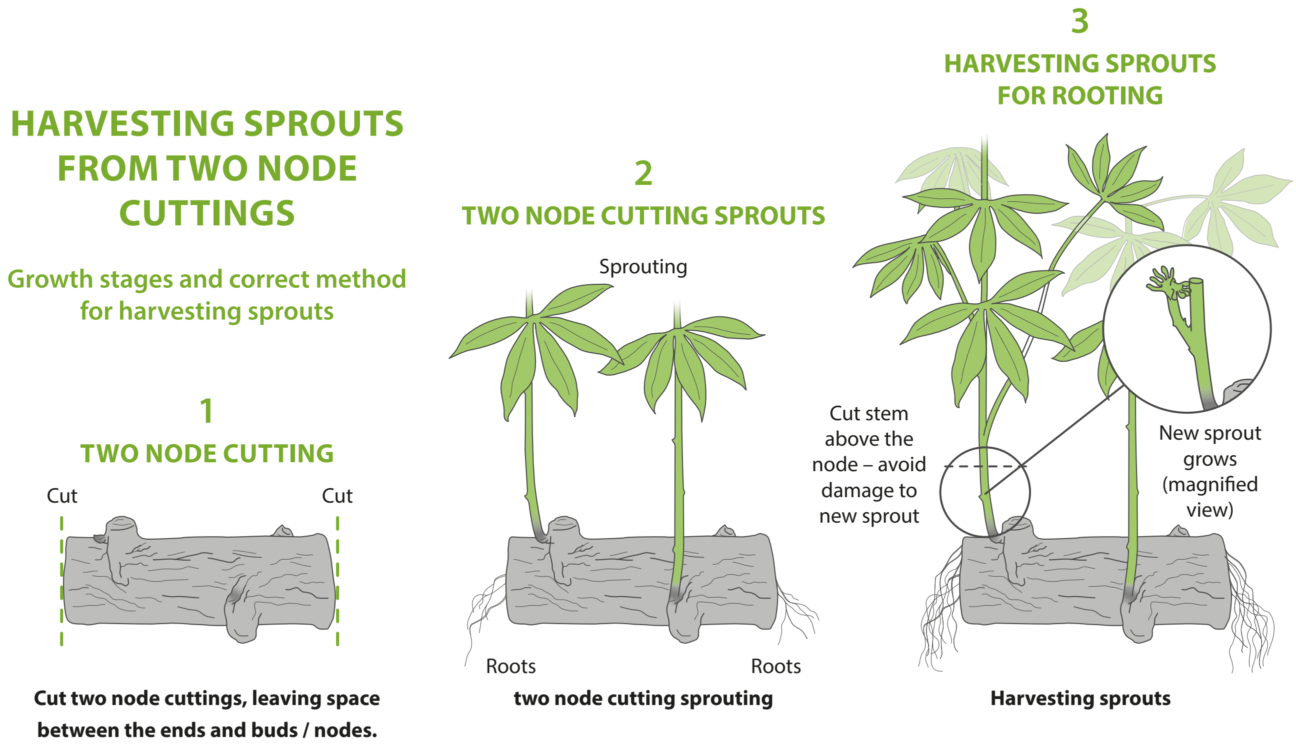
From left: in vitro cassava materials at NAFRI (Lao PDR). Mature stem bundles for testing, harvested from a field at CARDI (Cambodia), and clean, tested stems arriving in a sealed styrofoam container to GDA (Cambodia).

Stage 1: Preparing clean mother plants for tunnel planting

a) Preparing quality stems and making two node cuttings

After securing 35-45 mature stems for each tunnel in the system, it is time to prepare them for planting in the tunnel. Instead of using the 15–25 cm cuttings and vertical planting in a normal cassava production field, the tunnel system uses 'two node cuttings'. These will be planted in the tunnel sprouting benches horizontally instead of vertically, and closely spaced together. They are called 'two node cuttings' because they are only long enough to contain two nodes facing the same side.

Using a sharp, clean tool, cut the stems into two node cuttings as shown in the Illustration below. In Colombia, cutting is done efficiently using a power saw mounted on a table. In other contexts, hand tools like hacksaws, machetes, and sharp knives have been used.*



When making cuts, take special care not to damage the nodes. Damaged nodes will not sprout. Do not make cut too close to the node; leave space by making each cut in the center of the internode space.

Keep in mind that different varieties, grown under different conditions, can have different amounts of space between the nodes (called internodes). Always use healthy plants when collecting stems. Sick or stressed plants often have shorter internodes, and the sprouts will be weaker.

Before going into the tunnel, sterilize the cuttings with an insecticide and fungicide soak. This will ensure that you do not contaminate the sprouting bench with pests or microorganisms that can damage plant quality. Follow advice in your country from extension agents or agriculture officers for recommended pesticides.**

* when using cutting tools make sure to use appropriate personal protective equipment like safety gloves, eye protection, and if using power tools, ear protection. Your health and safety is the most important consideration.

** Pesticides are dangerous to human health. Always follow all precautions listed on the product labels, including proper use of personal protective equipment like gloves, eye protection, and breathing masks. Never mix pesticides or allow them to come into contact with your skin. Breathing the fumes of pesticides without a mask is hazardous to human health.

Tunnel hygiene

Your tunnels are special, controlled environments, and you must take care to ensure that the environment inside them does not get contaminated. Never leave the door open to prevent insects from entering from outside. Change clothing before entering the tunnel if you have been walking through cassava fields as insects can crawl on your clothing. Infestations are hard to eliminate, so it is worth extra effort to avoid them. See the contamination section in the Annex of this manual for more advice on avoiding and dealing with contamination.

b) Planting two node cuttings in the tunnels

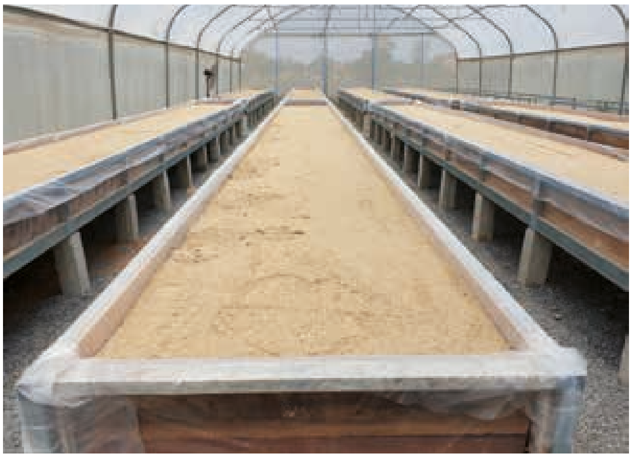
Plant the cuttings together in close rows, with about 5 cm between cutting edges, and about 10–15 cm between rows. The cuttings do not need to be planted deeply, only about 2–3 cm depth in the sand is enough. This lets shoots easily emerge, but prevents cuttings from drying out in the sun, especially if they get uncovered by frequent watering. Take care when planting to orient as many nodes as possible upwards, not facing down into the soil. Sprouts should be able to emerge upwards easily and avoid growing downwards into the sand.


An example of cutting too close to the node. The sprout is significantly stunted, and root development is hampered.


The result of planting with a downward pointed node. The sprout on the right has grown downward into the sand and did not produce a viable sprout. The wasted energy has caused the other sprout to also become stunted.

Planting and covering two node cuttings. Note the shallow planting depth and close spacing, use of gloves to avoid touching cuttings that have been treated with pesticide, and total coverage of cuttings with sand.

Two node cuttings before being buried (Dak Lak, Vietnam). Note that all nodes are facing upward, and the extra length of the cuttings to account for longer internodes.

Cuttings covered by a thin layer of sand in Cambodia (Left at GDA, right at CARDI).

Stage 2: Tunnel multiplication

Managing tunnels and sprouting conditions

Now that the cuttings are in the tunnels, they need to be watered and taken care of as they grow roots and shoots.

Watering or irrigation

Making sure that the plants are receiving enough water is the most urgent requirement. The sand should remain moist throughout, but fully drained and not flooded. The layers of substrate used in the benches provides good drainage, and the slight angle caused by making one end higher than the other allows excess water to flow out of the bench.

Water can be delivered manually using watering cans or a hose, but to reduce labor the best solution is to have a watering system with microsprinklers or misters. This also makes controlling the tunnel humidity much simpler. In Vientiane, Lao PDR, tunnel managers watered the benches manually three times per day. When the system was switched to an overhead misting system, they were set to come on once per hour for 3 minutes each time from 8 am to 7 pm. Testing different methods is the best way to determine what works in your context.


Sprout growth 1 week after planting (left) and 4 weeks after planting (right) at NAFRI, Lao PDR.


Manual watering and heavy automatic misting (Lao PDR).


Left: Sprinklers in Daklak, Vietnam. Right: Sprinkler system at General Directorate of Agriculture farm, Cambodia.

The automated misting system at NAFRI, Lao PDR.


Water droplets on cassava sprouts of varieties Rayong 11 and KU50, NAFRI, Lao PDR.

Heat and humidity

The tunnel environment needs careful managing to maintain high humidity and reasonable temperature. Cassava likes heat and humidity, but even this tropical crop has limits. The strategies for maintaining tunnel climate conditions depend on your local environment. In general, it is always at least 10° C hotter inside the tunnel than outside. For more discussion on temperature and humidity, see the dedicated section in part III – Annexes.

The use of shade cloths and enlarging or reducing screen panels are ways to modify the temperature in the tunnel. Misting irrigation helps to lower temperature. However, care should be taken that the water being applied is not also hot (for example if it comes from a cistern exposed to full sun), which can stress the plants. Increasing the size of the mesh/screen panels can reduce the temperature in the tunnel, but also allows humidity to escape faster.

As an example, experiences in subtropical Vietnam led to a model of raising a shade cloth around noon during the hottest 3 hours of the day. After the first 2–3 weeks of growth, plants were strong enough to withstand the temperature in full sun.


Shade cloths giving partial cover to tunnels at GDA, Cambodia.

You will need to experiment with your tunnels to find temperature regulation practices that work in your environment. If your environment has cold temperatures shoot growth will slow, so maintaining higher nighttime temperatures in the tunnels will become an issue.

Fertilizer and pesticide

If you plan to apply fertilizer during shooting, only do so once roots have already formed to absorb the nutrients. Slow-release fertilizers are better suited for this purpose. In Hung Loc Vietnam, diammonium phosphate (DAP) is applied in low doses. In Dak Lak Vietnam, partners are achieving good results without applying any fertilizer at this stage.

Cutting sprouts

After approximately 6 weeks, sprouts from each node will reach 15 – 20 cm tall. It is important to avoid letting the sprouts become too tall. Cutting slightly early is better than cutting too late. The amount of time required can vary according to cutting size, quality, and variety, so make sure to watch closely the first time to determine the proper timing in your case. Experience in the summer in Northern Vietnam showed that 5 weeks was the optimal time between cuts, while in Lao PDR 6 weeks was preferable. Keep in mind that sprouts are very sensitive, so before starting to cut them prepare your rooting setup (see next section).

When cutting the sprouts, it is important to make the cut above the first or second node on the sprout. This is because, like with the two node cutting, the node is where the new sprout will emerge. Use a sharp and clean cutting tool, like pruning shears or scissors, and avoid damaging the node. See illustration on page 8. This will allow new sprouts to grow back.

Starting with a single set of two node cuttings, 4-6 cycles of sprout regrowth and harvest can be completed. Monitor the quality of the sprouts to decide when it is time to replace the two node cuttings with a fresh batch.

New sprouts emerging from the sand (NAFRI, Lao PDR).

Regrowth after first sprout harvest, and cuttings planted too shallow and exposed by irrigation (NAFRI, Lao PDR).

Cuttings sprouting for the second time 3 weeks after a sprout harvest (left, CARDI, Cambodia), and a healthy 2 month old two node cutting ready for sprout harvest (right, NAFRI, Lao PDR).

One or 2 plants per sprout?

Advanced users can consider the possibility of cutting each sprout into two 10 cm pieces. As long as these each contain healthy nodes, they have the ability to grow into a full plant. This technique allows users to double the number of plants they can generate from a single cycle of cutting, but because the resulting plants are only half the size, and the bottom piece does not contain an apical shoot leaf, they are very delicate. For this reason, only experienced tunnel managers should attempt this practice, and at first with only a small number of sprouts, to test the method.

Preparing sprouts for rooting

To prepare for the rooting process, soak the ends of the cut shoots in water. You can transport the shoots to the planting area while still immersed in water.

To prepare the sprouts for rooting, remove all of the expanded leaves on the lower part of the sprout, leaving only the small, topmost shoot leaf intact. This can be done with any good sharp implement like snippers, garden shears, scissors, or even a sharp knife. It is important that the tool be as sharp as possible so that it cuts cleanly rather than 'tearing'. A dull blade can lead to ragged edges which can block the xylem and inhibit rooting. As usual, make sure not to cut too closely to avoid damaging the nodes. Use ethanol to sanitize your cutting tool to avoid contamination.

When damaged, cassava produces a rubbery latex, which can make a scab that blocks root formation. To remove this, trim off the bottom 0.5 cm from the sprout stem immediately before planting. Make your cut slightly diagonally to increase the cut surface area. This will promote rooting as well as creating a sharp tip that makes it easier to poke the sprout into the rooting substrate.




Cutting sprouts (Banteay Meanchey, Cambodia).

Cut sprouts with the tips soaking in water before leaf trimming (NAFRI, Lao PDR).

Top left: trimming leaves from cut sprouts (Banteay Meanchey, Cambodia). Top right: soaking cut sprouts in water before planting in a wheelbarrow (Daklak, Vietnam). Bottom: Cutting and trimming leaves from sprouts (Daklak, Vietnam).

Rooting sprouts

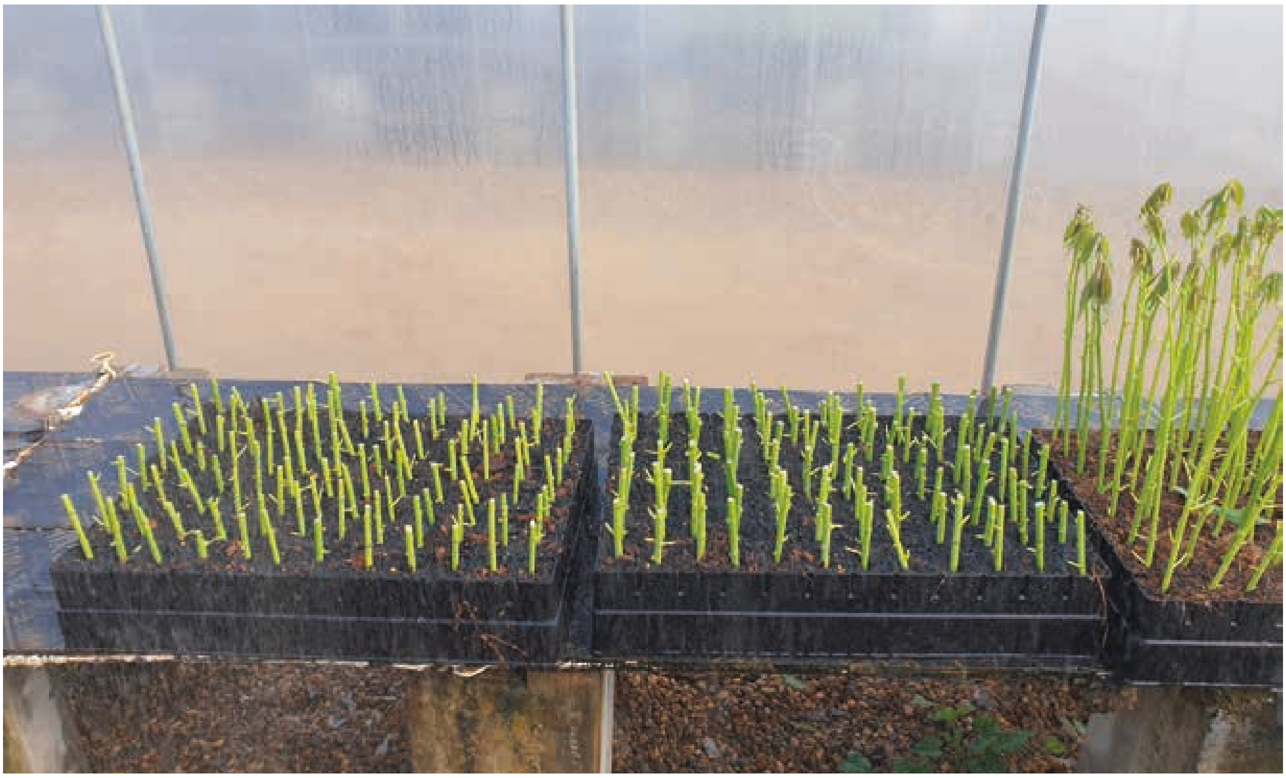
To grow into full seedlings ready for the field, the sprout cuttings must be planted in substrate to grow a root system. This can be done inside the tunnels on side benches, or if desired in a separate screenhouse. The rooting process can take place in several different types of containers. Polybags, the type that are frequently used for tree seedling production, are one option. Other possibilities include vegetable germination trays, plastic pots, or paper-wrapped cells as used by the forestry industry. Another possibility, used in both Colombia and Cambodia, is to purchase 'Jiffy pots' made of condensed peat moss. These must be soaked in water to expand before use. In Daklak, Vietnam, tunnel managers have also experimented with rooting large numbers of sprouts directly in plastic tubs filled with substrate. When the sprouts have rooted enough, the root balls hold some substrate when they are carefully removed from the tub.

Rooting substrates

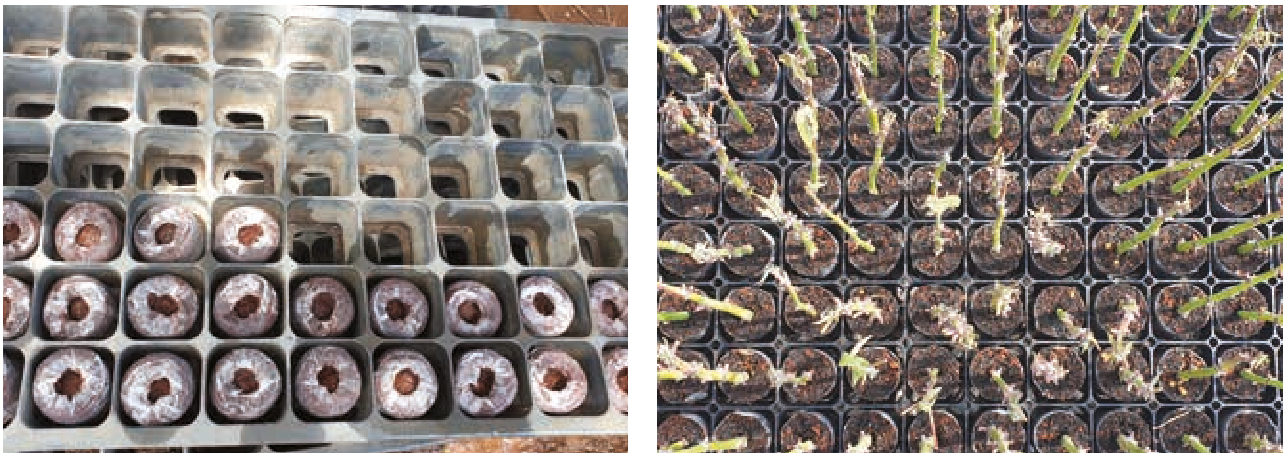
Different substrate mixtures have been used depending on local availability of ingredients. In Lao PDR, tunnel managers have had success with a 1:1:1 mixture of sand, cocopeat, and carbonized rice husk. This mixture creates a porous substrate, promoting good water balance and encouraging root penetration. Whatever the mixture, the texture should not be compacted, but light and fluffy. You should experiment with different recipes in your area to find out what works. In areas where soil-borne disease is an issue, consider the use of sterilized planting medium, or transporting sprouts to be rooted on the site of planting to avoid moving soil between fields.

Rooting management

During the rooting period, carefully monitor the plants, especially in the first weeks when they are particularly sensitive. It takes 4-5 weeks to develop well-rooted seedlings. In Hung Loc, Southern Vietnam, 5 weeks was more appropriate. Check the plants and use visual cues. If the leaves are wilting, the plants need water. However, be careful not to over-water as this can promote tissue rot. Fertilizer can be used for seedlings once roots have begun to develop, in this case slow-release fertilizer is also preferable.



Full and half size sprout cuttings in rooting trays (GDA, Cambodia).



Hydrated Jiffy pellets (left) and trimmed sprouts in cells (right) (CARDI, Cambodia).

Sprouts in polybags (left) and paper cells (right) (CARDI, Cambodia).

Left: sprout cuttings rooting in trays (NAFRI, Lao PDR). Right: fully developed root system in a 5 week old seedling (NAFRI, Lao PDR).

Stage 3: Outplanting rooted seedlings

Field area selection

Once the seedlings are rooted, they are ready to be planted in the multiplication field. The choice of field location is important. If possible, it should be isolated from other cassava by at least several hundred meters to reduce the possibility of pests moving from nearby cassava fields into the multiplication block. Select an area with good quality soil, as the plants are still sensitive. Since root yield is a secondary objective in the seed plot, it is possible to increase the planting density. Outgrowers in Banteay Meanchey, Cambodia have found that planting on ridges at density of 1.1 m x 0.5 m allowed them to nearly double stem production in the multiplication field, while only sacrificing a small percentage of root yields.

Left: outplanting rooted seedlings in paper cells (GDA, Cambodia). Right: rooted seedling in a paper cell (GDA, Cambodia). Below: three month old seedlings from the tunnel system at NAFRI (Lao PDR).

Management

Outside of the rainy season the seedlings need irrigation for the first several weeks. Drip irrigation is a convenient and efficient way to do this, and also conserves water compared to overhead sprinklers. For those with experience outplanting field vegetable seedlings or tree seedlings, the procedure is very similar.

Once the seedlings are established in the field, they will grow into plants that are nearly indistinguishable from plants planted from stems. Early experiments with improved Asian varieties also show that root yields were similar to those from traditional cuttings.

Stage 4: Open field multiplication

The mature stems produced from the multiplication field are indistinguishable from traditional planting stems. But to lower the overall production cost of clean stem production, it is important to continue multiplying stems under open field conditions. This may be done by the tunnel manager, or by other actors like farmers' groups, commercial plantations, farmer entrepreneurs, or others.

In addition to the precautions taken above, farmers can employ practices including positive selection (choosing only the best, healthiest plants to collect stems from) and negative selection (removing infected or weak plants from the field during the growing season). There is evidence that these practices can preserve yields under disease pressure and significantly improve stem quality over several seasons of production.

Outplanted mature stem cuttings in an irrigated open field (Bachieng district, Champassak, Lao PDR).

III. Annex: Troubleshooting and technical details

Tunnel modifications

There are many possible ways to build tunnel structures. We have provided step by step instructions for a simple, inexpensive, and effective tunnel construction in a separate manual that is available for free. You can find it by scanning the QR code below with your smartphone, or by going to www.cassavadiseasesolutionsasia.net.
This system allows for efficient use of resources, and easy control of temperature and humidity. However, you should always consider what works in your own situation.

In Asia, tunnel managers have experimented with different type of tunnels. At GDA experimental farm in Cambodia, steel frame structure greenhouses designed for vegetable seedling production have been adapted with sprouting benches made of concrete blocks holding up steel frames with chain link fence. Similarly, at CARDI in Phnom Penh large screenhouses have been repurposed to hold three sprouting benches inside a single structure. This allows tunnel managers to raise many sprouts under one roof, and shade cloth can easily be hung inside to control

Steel frame tunnel structures at GDA experimental farm (Cambodia).

Three sprouting benches inside a single structure at CARDI (Phnom Penh, Cambodia).

temperature. However, this approach should be used with caution: if the structure gets contaminated with pests or disease, all three benches will be lost, instead of just one with the traditional system. In Dak Lak, Vietnam, steel frames were also used to hold up the benches. But instead of the traditional wooden bench, the tunnel managers have used free-draining plastic boxes to hold coarse sand for sprouting.

Use of free-draining plastic crates for sprout production in tunnels in Dak Lak (Vietnam).

Temperature and humidity

Managing tunnel conditions

One of the biggest challenges of the tunnel system is managing temperature and humidity levels. Research is still ongoing to determine the optimum temperature and humidity combinations that maximize sprout growth without stressing them. This will vary depending on local conditions and varieties used. At NAFRI in Lao PDR, the tunnel system showed good performance with average temperatures of approximately 35°C and relative humidity of approximately 60%. This humidity level allowed the tunnels to retain manageable heat into the evening. When the humidity level is much higher, the tunnels run the risk of allowing mold to grow on the tunnel plastic if there is not sufficient ventilation.

Monitoring temperature and humidity levels

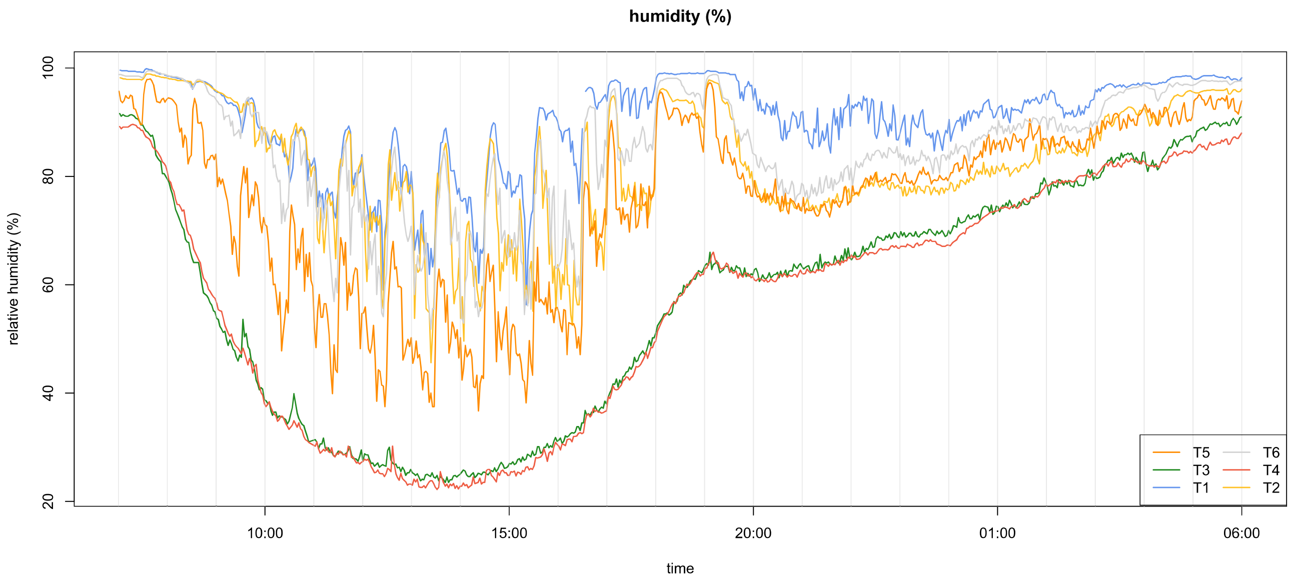
To monitor the temperature in the tunnels, users can place thermometers and humidity meters near the sprouting bench. It is a good strategy to take readings throughout the day, including early in the morning (to find the coolest conditions), and in the early afternoon (to find the hottest conditions). Keep in mind that

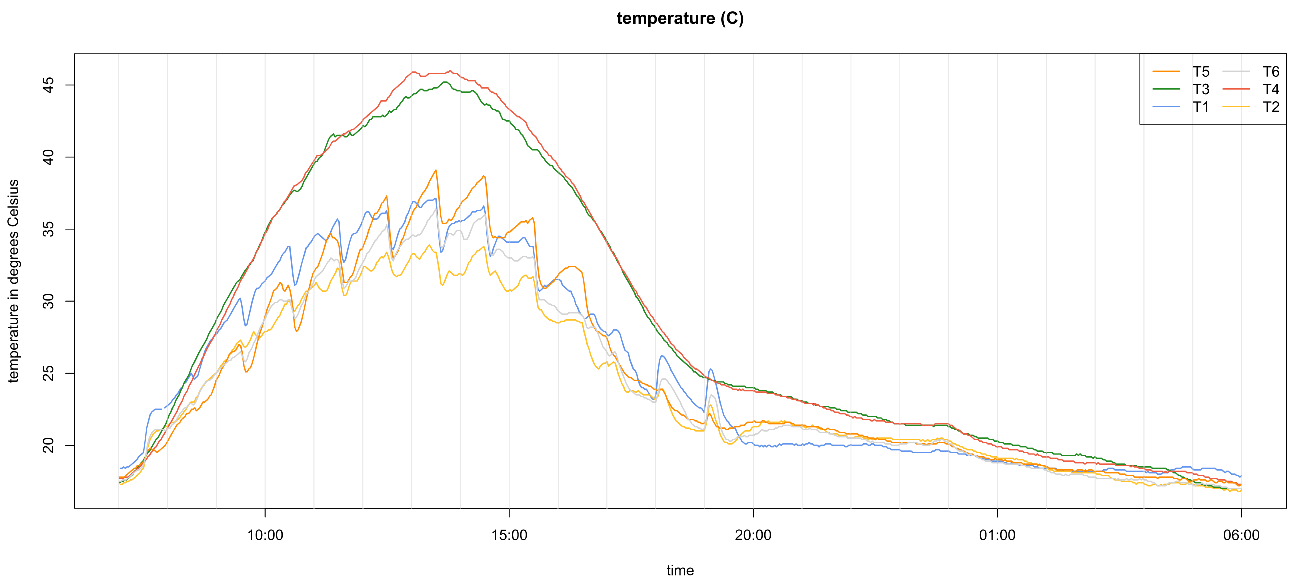

The installation of data logging equipment and electronic timers allow for automation of irrigation timing as well as monitoring and logging of temperature and humidity data. Such systems can also be programmed to send alerts in case conditions fall outside desired ranges.


Temperature and humidity monitoring equipment at CIAT in Cali, Colombia (left), and NAFRI, Vientiane, Lao PDR (right).

conditions can vary throughout the year depending on the seasons. Advanced users wishing to gather data on environmental conditions in the tunnels should consider the use of sensors placed inside the tunnels. Data gathered by the sensors can be collected manually, or using remote download systems. This information allows users to calibrate conditions inside the tunnel, and to do tests to determine optimum conditions for production in a given environment.*

Using a remote temperature and humidity logging system, CIAT researchers at NAFRI in Lao PDR have been monitoring the conditions inside each of their 6 tunnels. See the graphs below. In these graphs, tunnels T3 and T4 were left empty, and the irrigation system not turned on. For the rest of the tunnels, a misting system was being activated every hour between 8 am and 7 pm. The difference between the empty tunnels and the tunnels in use is very clear. The misting system kept the temperature manageable (10 degrees lower than the empty tunnels, peaking around 35° C), and the relative humidity high (20% higher, peaking around 85%). The 'spikes' on both graphs are caused by the irrigation system switching on for five minutes, and the mist rapidly lowering temperature and increasing humidity. After the irrigation system switched off, humidity remained high throughout the night. This clearly shows the impact a misting system can have on maintaining optimal growth conditions for the sprouts.





* Note that the installation and use of this equipment requires a good supply of electricity and some skills with electronics.

Soil and fertilizer

Healthy soil is important for plants to grow well. Always try to use high quality soil for rooting sprouts, and watch for signs of stress. Sprouts germinating from two node cuttings have access to the nutrients in the mature wood to help them to grow. Once the cuttings grow roots, they can also absorb nutrients from fertilizer.

Signs of nutrient problems can include leaves turning yellow, red, or white, slow growth and weak looking sprouts, or failure to germinate. If problems persist, a soil pH or nutrient analysis can help to determine whether the soil is the cause of the problem. Contact your local extension agent, government bureau, or private soil analysis lab for more information about testing.

A good way to control soil-related issues is to use a standard recipe for preparing rooting substrate. It is a good practice to try different recipes on small numbers of seedlings to compare their performance. Once a satisfactory recipe is found, be consistent.


Rooting mix in biodegradable paper cells in Vientiane, Lao PDR. The rooting mix is 1:1:1 sand, cocopeat, and carbonized rice husk. Osmocote, a slow-release fertilizer, has also been added to provide extra nutrition to the developing seedlings.

Contamination (algae in the beds, weed seeds, pests)

Avoiding contamination is one of the biggest challenges of operating tunnels. Remember that pests (and potentially diseases) can spread on your clothing, so avoid entering the tunnel right after walking through cassava fields. Always keep the doors closed to prevent pests from getting inside.

Treating pest or disease contamination is challenging. These problems can often be very persistent and force the manager to remove the plants and leave the tunnel empty until all of the pests have died. The use of pesticides inside a tunnel structure is challenging and hazardous, so it is best to try hard to avoid contamination in the first place. To maintain high quality, the sand in the sprouting bench should be replaced periodically to make sure it is free of algae, salt buildup, or other contamination. Check the sand regularly to make sure it is in good condition before replanting. Excessive use of fertilizer promotes growth of algae, fungi, and undesirable microorganisms, so avoid providing excess nutrition.

When replacing the sand, make sure to access high quality sand free of contaminants. Sand can also be washed with water to remove dust and weed seeds before use.

In case there is a soil-borne pathogen present, soil fumigation or steam sterilization are possible options for decontamination. Check with your local extension agent. Shoes can be decontaminated using a foot bed with lime at the entrance to the tunnel.

Tunnel door with lime for decontamination of shoes on the way into the tunnel (CIAT, Colombia).