Direct sowing for reforestation and forest restoration

A pratical and verifiable method

By Pieter Vranckx, OmniVerdi, nov2020
contact: omniverdi@gmail.com

What is direct sowing?
Direct sowing is planting seeds directly into the soil of the zone to be reforested.
It can be used in:

- to colonize areas lacking vegetation with an initial mix of species,
- to enrich secondary forests or
- to restore degraded forests.

Why direct sowing?
Growing trees is more **efficient** when the seeds can germinate and **grow its roots down** already in the place where the trees have to grow tall. In tree nurseries the seeds germinate in small plastic bags where the main tap roots circles around at the bottom of the bag, and when planted later on in the field it will not grow down very well. Without a healthy main root that grows deep down the seedling might die or grow poorly.
Direct sowing can be **very cheap** too, as the weight to be transported is much less, the holes to be dug for planting are smaller and the costs of growing seedlings is avoided.

Why not planting just only the seeds?

- Seeds should be **protected** against predation and desiccation in some way. Using clay to make seedballs gives that protection but make it too hard for most seeds to germinated well. Clay also weight a lot, so for large numbers logistics become expensive.
- When the workers have to **sow a certain pre-defined number of seeds**, lets say 5 seeds of a **mixture** of many species then it will be very difficult to take from a mixed bag that number every time for each planting hole, as seed size and weight differs, so bigger lighter seeds will be on top and thereby planted first and small heavy seeds will be at the bottom of the bag and sown last, meaning that the diversity is not **distributed well** enough over the area to be planted. Even if only 1 species is planted then still it would be time consuming to count every time around 5 seeds.
- It is necessary to **be able to verify the work done** by the planters after they planted the seeds and before paying for the work already done. This **verification** has to be efficient with less then 1% error margin. Also has to be **easy and fast**, it should not take longer then 30min for a technician to verify 1 hectare, by verifying 5 to 10% of the planting holes. The technicians needs to look if the seeds are buried not too deep or too shallow and has to check if there are indeed seeds in the planting hole. For many small seeds and in soils that contain some pieces of twigs and leaves it would be almost impossible to do this verification.

OmniVerdi proposes a solution for this: the **OmniVerdi Arka**. Check out below!

The proposed method: OmniVerdi Arka, compost-seed-cubes

A cube measuring 5 x 5 x 2cm made out of compost and a binder that contains the seeds that needs to be planted per planting hole. For each site a mixture of species can be used. The amount of seeds per species per cube depends on the germination rate, which can be improved by pre-treatment, so less seeds would be needed. In average 5 seeds per cube is enough containing some of the species of the overall mixture.
Example to clarify: a field of 100 Ha will be sown with a mixture of 10 different species. 120 000 cubes are needed, with 5 seeds each, that means 600 000 seeds are needed. Mixing all together and then making the cubes containing aprox 5 seeds each would result in cubes that contain in average 3 to 4 different species (in theory 0 to 10 species per cube if not mixed well but on average 3-4 species if all is mixed well).

To use this technique firstly a conic hole 30cm width and 15cm deep is made. Then the cube is planted at the bottom of the hole at about 2 to 4cm depth. A white stone is placed just West of the planted cube. After planting the technician will dig East of the stone with a finger to search for the cube, which is big enough and different in color then the soil, so easy to find... or not in case the workers cheated or forgot to plant the cube. About 5% of the planting holes needs to be checked, and if in all of these checked holes the cube is present and planted at the correct depth then only will the workers receive their payment and the area is marked Sown and Verified.

The cubes are made very easy at community level by hand. One person can make daily up to 7000 cubes, but on average 3500 cubes per person per day. Daily salary should be over 7500 Ar. Good compost can be produced for a final cost of 100 Ar per liter. Seeds can be obtained at an average of 1 Ar per seed. This results in a production cost per cube of 15 to 25 Ar (0,005 Euro). Using 1200 cubes per hectare and paying 25 Ar to dig the hole and plant the cube would result in a cost per hectare of aprox 55 000 Ar. Adding 2000 Ar for the white stones and 5000 Ar for verification and administration results in aprox 62 000 Ar (15 Euro) per hectare to plant 1200 cubes with 5 seeds each.

Each cube holds on average 5 viable seeds, offering a high probability that at least 1 tree will start to grow per planting hole if adequate species are chosen, if the cube is planted correctly and if rains did not fail too much. Survival until next rainy season and further development of the newly established seedlings will depend on many factors. If a good rainy season occurs after planting the cubes then good success might be obtained the first time. But if rains fail or severe drought occurs that year then a next attempt should be undertaken the year after. In reality some trees will establish already the first time, many will fail and thereby complementary resowing for 2 to 4 times will be needed, enriching each time with the species that still lack in sufficient number or density. About 2500 cubes / hectare would need to be planted to establish the desired amount of trees and shrubs over the first 4 years, resulting in about 130 000 Ar (30 euro) cost/ha in total for direct sowing.

Recommended is to remove the savanna grasses with the roots before planting, about 1m around each desired planting hole. This is best done cleaning strips of 1,5m width every 6m, and then planting inside the strips at each 1,5m. So final distances between planting holes will be aprox 1,5m x 6m, resulting in aprox 1100 to 1200 holes/hectare. Not all seeds of all species in each cube will germinate and grow out into an adult tree or shrub. Planting 1200 holes with 5 seeds each will result after a few years in 350 to 800 adult trees per hectare with random distances between them.
Cleaning savanna grasses by removing them with the roots costs 100 000 Ar / Ha, but if only 1,5m width strips are cleaned every 6m would result in a cleaning cost of 25 000 Ar / Ha the first time and 15 000 Ar / Ha / year for maintenance during the next 4 years. Total 85 000 Ar / Ha (20 Euro).

Protection of the area is crucial, against fire, cattle, too early or too much exploitation, etc. A participatory process involving the local communities to secure their interests are being taken into account will already result in some protection, but not enough. To ensure the efficient enough protection during the first 5 years some financial costs will need to be covered: compensation payments, salaries for guards, material purchases, fire break maintenance, etc, which is about 25 000 to 50 000 Ar per hectare per year. On average ensuring protection for first 5 year will cost aprox 175 000 Ar / Ha (40 Euro).

What kind of trees, forests or crops?
Direct sowing imitates nature, and we should look how the seed of each species is spread naturally to understand what conditions or pre-treatments are required for the seed to germinate well in the field. For most species it will be quite problematic to germinate and grow out on degraded soils in a changing climate because that is not the natural way. So when soil compaction is too much we should decompact the soil on the spot below the seeds. If the soil is too poor we should add some compost or fertilizer. If the species we want to plant can not stand full sunlight when young then we should start planting first other species that can provide shade. You can plant any species by direct sowing if you improve just enough the conditions needed for that species to able to establish itself by seed.

Why not using seedballs spread by planes or drones?
Using planes to deposit seedballs over large areas is strongly not recommended for many reasons. First of all is that most seeds are wasted as the hard balls fall on compacted soils and will thereby not result in establishing trees or shrubs. Second is the risk of hitting people or animals. Third is the high cost and lack of enough planes. Using drones on low altitude with accuracy dropping could improve things a lot, but still remains the fact that seedballs fall on compacted soil. But drone use is very expensive and very high skilled people are required for maintenance, programming and flying.
Manually digging holes, and thereby decompacting the top layer, to plant seeds carefully buried at the bottom of the hole is much more efficient, cheaper and would employ local people.

How to make the *Arka*?

Compost

This technique uses compost, but black forest soil can be used too. It absorbs fast the rainwater. Compost greatly improves the germination of the seed and growth of the seedling in the field.

To use the compost it has to be sieved to take out the pieces bigger then a bean. You can just pick out the big pieces by hand or use a sieve with holes the size of a bean.

Compost can be made cheap by mixing Raketa(Opuntia) leaves with dry savanna grasses: chop all in small pieces with a machete and mix 1 volume of each, dig a deep hole, fill the hole with the mixture of chopped raketa leaves and grasses. Do not stamp to compress. Cover with one hand thick layer of soil. Put some spiny branches on top to avoid stepping or children playing on top. Leave the mixture for a few months, then open the hole. Take the mixture out of the hole, loosen up well and throw back into the hole. Repeat this 1 or 2 times more until the compost is ready to use.

Messurements used: *Kapoaky*, aprox 300ml volume (left) and *Daba*, aprox 2 lt volume (right)

Cassava, water and other ingredients

To bind the compost with the seeds together into cubes you need to use a binder. Cassava can be used, both wet or dry. Cut the wet cassava into small pieces or grind the dry cassava into flour and cook until it forms a thick soup. Let the soup cool down a bit before using to avoid burning your hands and killing the micro-organisms in the compost.

You need around 2 *kapoaky* of dry cassava flour, 4 or 5 *daba* water and 20 *daba* compost to make 500 cubes of 5x5x2cm. You could also use corn flour or rice flour as a binder. The amounts will variate according to the quality and humidity of the compost. Experiment a few times, register the amounts used, analyze the Arka when dry. If too soft add more cassava flour to bind better or add more water to be able to compact better. Too much water will result in the pre-mature germination of the seeds inside the Arka, which must be avoided.

It is possible to add some voluminous materials in the mix like rice husks or crushed pea-nut shells. This can be interesting if you want to save up compost or wish to make the cubes even lighter. Do this before you mix the seeds by substituting a certain number of *daba* compost by the same number of *daba* of rice husks or crushed pea-nut shells.
Example: 2 *kapoaky* of dry cassava flour, 4 or 5 *daba* water, 15 *daba* compost and 5 *daba* crushed pea-nut shells to make 500 cubes of 5x5x2cm.

Mix well together the compost and the cassava soup.

Seeds

(to be included here lateron: info on how to collect, clean, label, store seeds / seed pre-treatments / germination tests)

How may seeds of each species do I need fr the mixture? Follow the steps bellow

1. Define the limits of your planting site (or the budget available)
2. Measure or choose how much hectares you wish to plant
3. Calculate how many planting holes you need to plant
4. Analyze well the soil conditions
5. Choose the species that might grow under the current site conditions (to be included lateron a chapter on how to choose/select with-in the local flora the appropriated species for each situation)
6. Define the desired density of each species (some species needs to be much more abundant then others within the area)
7. Do a germination test for each species to know how many seeds germinate within each 10 seeds. For some species a pre-treatment of the seeds will be needed if they do not germinate quickly. Check the germination rate after pre-treatment.
8. You need to obtain for each planting hole 2 to 3 seeds that will germinate, so if about half of the seeds you have will germinate then you need to have 5 to 6 seeds within each cube, and multiply the number of planting holes by 5 or 6 to know the total amount of seeds needed. Then divide that total number among the species you wish to plant according to their germination rate and desired density. A bit complicated the first times....
9. Count and separate the required amount of seeds for each species (see next page)

Easy seed-counting

To avoid having to count large numbers 1-by-1 every time again you can use a standard size of container like bottle caps, Kapoaky or others. Choose a size that contains at least 100 seeds of the species you wish to count seeds for. Fill it with seeds in the way you will always fill it lateron too. Then count the seeds that are in that size and write it down.
When you need a certain number of that species lateron you just divide that number by the amount of seeds in the container you choose for that species, and then you know how many filled containers you need of that species.
You can repeat the process in case you need to count very large numbers of seeds, for example count the seeds in 1 bottle cap, then count how many caps you need to fill one Kapoaky. Now you know how many seeds there are in 1 Kapoaky.

It is not recommended to count seeds by weighing them, as scales are not everywhere available, scales can be easily dis-calibrated and the weight per seeds can variate according to provenance, ripeness, dryness, etc.

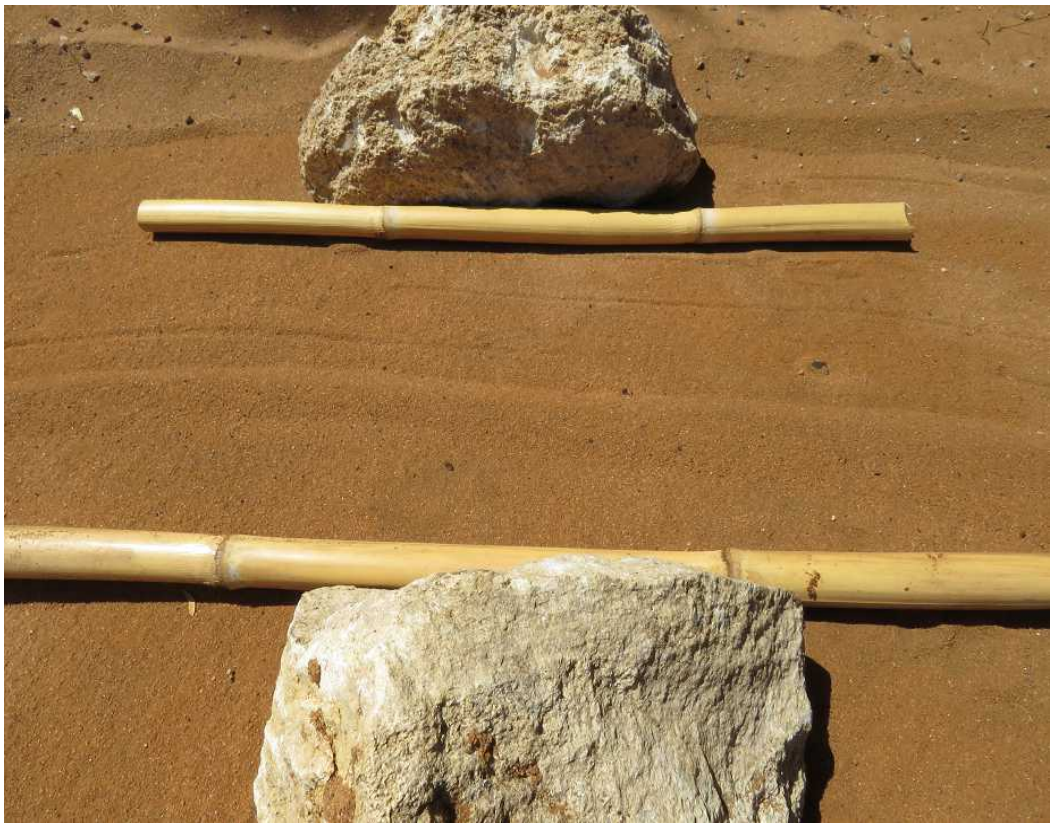
In picture: Kapokay filled with Anakaraky (Pongamiopsis pervilleana),
blue cap with Kasi (Acacia magnum) and red cap with Manary (Dalbergia sps)

Mixing

Throw all the needed seeds on top of the compost-cassava mixture. Mix it all well together by kneading, ensuring that the seeds are spread well throughout the mixture.

Forming

To make the cubes you must make a frame or use reeds or sticks of about one thumb thickness. *Bararata* is excellent for this, choose one that is the same thickness as your thumb. Place the pieces 20cm apart (width of a office paper). Put some stones to keep the pieces in place.



Then start filling up between the pieces.

Press well to compact and make it flat to the level of the pieces.

Cut the borders if needed to make it straight. The rest can be put back with the mixture to use for the next cubes.

Divide in 4 strips.

Divide in 5cm width strips

Cut the cubes

When finished cutting it should look like this

Place 1 piece 20cm apart from the other add put a stone, to make the next cubes.

Fill up again

Press well to compact and make flat to the level of the pieces

Divide into 4 strips and cut the cubes

Remove the stones and the pieces. Let it now dry in the sun for 1 to 2 days.

For speeding up production you can also make permanent frames from wood or iron. Best use ¾ iron corner profiles and make the frame 25 x 25 cm internally.

When filled well, cut the cubes and also cut alongside the frame to release the cubes from the frame. Then lift the frame one side at a time.

Packing and storage

In most cases you need to make the cubes a few days before planting because the species that germinate easily and the seeds pre-treated will already start to germinate inside the wet cubes while drying. In these cases you should make the cubes only after the first rains has fallen and the soil is already a little bit humid, then plant the cubes still a bit wet. Place them in a box or bucket to take them to the field.

In case you have seeds that will not germinate inside the wet cube before drying and they will germinate only after planting and some good rains then you can dry well the cubes and store them in bags. These can also be planted before the rains started to fall and will wait inside the soil for the rains to come.

For natural forest restoration seeds should be sourced locally, from forest fragments that are identical or very similar to the forest that once stood in the area you wish to restore. The few trees in the landscape that where not cut down yet can testify of what kind of forest once stood there.
Many local tree names are used in different regions but in each region it are often different botanical tree species which look very similar, so it is important to source the seeds as closeby as possible to restore a natural forest and don't source seeds from other regions even is the local name is the same. Even more, within a same botanical species you have different phenotypes for each different region. A certain phenotype from a Northern region might not grow as well in a Southern region or might not deliver the same ecoservices. That is why it is very important that each ecoregion has its own local seedbank. Exchange of seeds between such seedbanks is not recommended.

Outsourcing the production of the cubes can be an option, or buying available ones on the market. Be very clear about the botanical species and/or seed source.

How to plant

site preparation

If you plant in savanna then you should clean strips of at least 1,5m width. Ideal is to take out the grasses with the roots and remove the root clumps to outside the clean strip. But also an option is to cut the grasses very short and to remove all dry biomass to outside the strip.
You can organize easily this work by placing a bag or bucket at about 150 to 200m further up, but still in good sight, and clean the strip of 1,5m width towards that visible point. Then put another visible point just 6m beside from the center of the last strip you cleaned, and repeat the process.

Use white stones to mark the planting spot for inspection and followup. Construction gravel painted with lime is a easy and cheap option. Separate in bags or buckets the amount more or less you need for 1 line.

Place a stone and cube each 1,5m apart within the cleaned strip.

Dig the holes to plant just beside each stone+cube. About 30cm width and 20cm deep is enough. The hole can be conic, so it collects and concentrates the rainwater towards the cube.

Place the cube at the bottom of the hole

Place the stone West from the cube

Cover the cube with 2 to 3 fingers thick of soil, about 3 to 4cm layer of soil on top of the cube.

When finished planting the hole should look like this.

Inspection of the work can now be done by a supervisor or independent inspector. Just dig East of the stone with a finger to check the planting depth and presence of the cube.

To be included still in this guide:

cleaning grasses, why, how, tools
organization field work (logistics, teams, leader, ...)
strip size, distances, orientation (wind direction, solar radiation, shade, contour, ..)
additional wider firebreaks

planting: density, distances, planting depth
holes: tools, size, depth (halfmoon)

Admin: control, verification, payments, registers, ...

protection: ...

maintenance:
grass pressing, cutting, mulching outside strips
grass removal and compost making

Followup: analysis, re-sowing, resprout management

Possible costs overview.

Please contribute to: omniverdi@gmail.com