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ECHO Development Notes

CONTOUR CULTIVATION AND LIVE BARRIERS FOR SMALL-SCALE FARMERS

Many smallholder farmers live in areas with hilly or mountainous terrain. Soil erosion is a major issue in growing crops on steep slopes.

TARO

Taro is a major aroid that contains a starchy, edible corm high in carbohydrates. Corms are enlarged stem tissue that stores plant reserves underground. This article overviews the benefits, cultivation, pests and diseases, and nutrition of taro.

DRIED RICE AS A DESICCANT FOR SEEDS

We have known for centuries that rice absorbs water at high temperatures. In fact, we all use this principle when we cook rice. However there has been a growing interest in using rice as a desiccant.

 Selected material from *EDN* 1-100 is featured in the book *Agricultural Options for Small-Scale Farmers*, available from our bookstore (www.echobooks.net) at a cost of US$19.95 plus postage. Individual issues of *EDN* may be downloaded from our website (www.ECHOcommunity.org) as pdf documents in English (51-162), French (91-161) and Spanish (47-161). Earlier issues (1-51, in English) are compiled in the book *Amaranth to Zai Holes*, also available on our website.

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Contour Cultivation and Live Barriers for Small-Scale Farmers

by Robert Walle

Many smallholder farmers live in areas with hilly or mountainous terrain. Soil erosion is a major issue in growing crops on steep slopes. When we see contoured plantings across slopes, we know that someone cares about erosion and is doing something about it. The curves are aesthetic, but what do they really do?

To understand what those curves do, we need to know something about contours. Contour lines, drawn on a map or marked on the ground, show lines of consistent elevation (Figure 1). They guide the farmer in tilling and planting across instead of up and down the slope. Farming across the slope is one of the easiest ways for small-scale farmers to conserve soil and water. Below are several ways to mark contour lines along slopes and plant simple conservation practices like live barriers.

A-frame Level and Variations

An A-frame level is perhaps the cheapest and easiest instrument to use when tracing contour lines in the field. Learning to mark contours is a great first step in overall farm design for live barriers and surface drainage. Yarger and Doer (2006) describe how to make a simple and fixed A-frame (Figure 2).

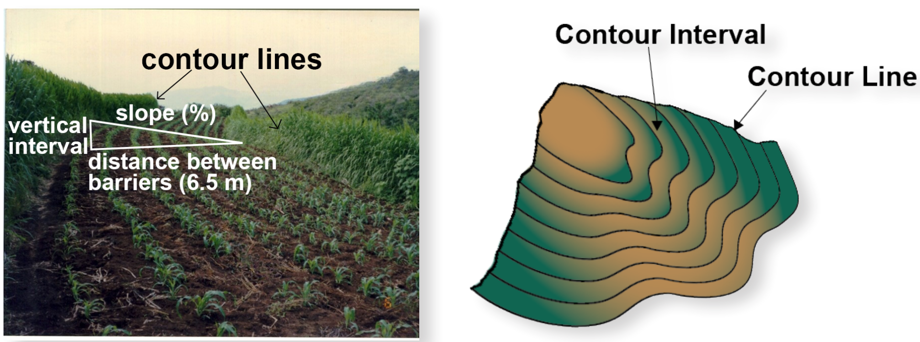

Figure 1. Example of annual crops planted between hedge rows established along contours, which may also be marked in a topographical map. *Source:* Robert Walle (left) and Stacy Swartz (right)

Extensionists improved the basic design to make it easier to transport by bus or motorcycle.

A collapsible A-frame folds up, making it easier to transport than a fixed A-frame (Figure 3). Follow these steps for the construction and use of the collapsible A-frame level.

Figure 2. Basic A-frame level with a weighted string made with bamboo. *Source:* Tim Motis

Figure 3. Collapsible A-frame. *Source:* Robert Walle

- Get two narrow boards (3.81 cm [wide] x 2.54 cm [thick]), each of them about 2.1 m long. These will be the "legs and feet" of the A-frame. One other board, at least 1.5 m long, will be the cross-section of the A-frame level.
- Join the legs a few centimeters from the end, with a single nail through both boards (you can also use a bolt with a wing nut). Make sure that the "A-frame" can collapse or fold using the one nail or bolt as a pivot or hinge.
- Nail or bolt the cross-section about 1 m from the bottom or top of each of the legs. This should form an "A" shape. Leave one of the nails "loose" so that it is removable and so the crossbar can fold or rotate to be alongside the legs when they fold.
- You can use bolts with wing nuts or easily removable nails for re-assembling the level quickly in the field.
- On the nail or bolt at the top of the A-frame level that holds both legs together, hang a weight bound on a cord to serve as a plumb line (often called a plumb bob). Make sure that the weighted string is long enough to pass perpendicular to the crossbar.
- Each time you use an A-frame, you need to calibrate it.

Videos showing how to build and use an A-frame:

Making and Using an A-Frame Level: http://edn.link/wzncnx

How to Build and Use A-Frame Level: http://edn.link/mgtt47

Figure 4. A-frame level with bubble level attached.
Source: Robert Walle

A-frame with bubble Level (Figure 4)

The A-frame level, in its most basic form, has a string with a weight (e.g., a rock) on the end, that forms a plumb-line. Alternatively, you can mount a small bubble level on the crossbar of the A-frame. Using a bubble level speeds up the taking of individual measurements in the field when marking the contours, as you do not have to wait for the plumb-line to stabilize. The bubble level A-frame will be accurate as long as the lengths of the two legs are the same and the distance from the bottom of a leg to the horizontal crossbeam is same for each leg.

Remember, before using collapsible and all A-frames, users should calibrate them. Instructions are given in table 1.

Table 1. Steps to calibrate an A-frame level with a plumb line and bubble level.

A-frame with a plumb line[1]	A-frame with a bubble level
1. Place the A-frame on a relatively flat surface (does not have to be perfectly level).	1. Place one leg of the A-frame on a relatively flat surface (does not have to be perfectly level).
2. Mark the spot on the ground or other surface where each leg of the A-frame was placed in step 1.	2. Keeping the first leg of the A-frame at the same spot as in step 1, rotate the A-frame to find a spot where the bubble is centered.
3. Wait for the plumb line (string) to stop swinging and then mark where it intersects the crossbar.	3.Mark the two spots where the legs touch the ground or other surface.
4. Turn the A-frame 180° and place the legs on the same two spots (marked in step 2) and again mark where the plumb line intersects the crossbar.	4. Turn the A-frame level 180° and place the legs on the same two spots.
5. Halfway between the two marks will be level. Mark this point prominently.	5. Check to see if the bubble is still centered. If not, adjust the placement of the crossbar or adjust the bubble level with shims under it.

[1]See Yarger and Doerr (2006) for similar instructions.

Figure 5. Using a basic water ring in East Africa. *Source:* ECHO East Africa Staff

Alternatives to the A-frame level

Water level

Make a simple, accurate, U-shaped water level using zip ties, string, or clamps to attach each end of a length of transparent tubing to a 1.5-m long stake marked every 1 to 2 cm with the 0-cm mark at the top of each stake (see Lancaster, 2019 [http://edn.link/wjy2ha] for instructions). The length of the tubing will correspond to the desired distance between markings used to determine the contour lines. With the tubing filled with water and bubbles removed, points of constant elevation are those where the water level is the same on both ends (as indicated by the markings on each stake). These points are marked along the contour in a manner like that with the A-frame.

The longer the distance between the two ends, the more water you will need to fill the tubes. Add food coloring or any colored fluid available to increase visibility. Another water-based technique called the ***Water Ring*** (Figure 5) is described by Kinsey (2013) in Issue 2 of *ECHO East Africa Notes*.

Basic hand-held sight level

Extensionists increasingly use basic hand-held sight levels because they are very simple to use over longer distances. The hand level is also simple to transport, a definite advantage for extensionists on the go.

An aperture allows sighting along a straight line. A prism reflects a small, attached bubble level on the top of the level, so you can see the bubble as you look through the aperture. You will need two people to take measurements. One person will use the level to sight along a level line and guide the other person holding a stick with a marked level point. Section 6.4 of an FAO training manual (Brouwer *et al.*, 1985), entitled "Elements of Topographic Surveying" explains and diagrams steps for marking the level point and points of constant elevation along a contour.

Lasers and total station

Various laser levels (including total stations) are increasingly available. The total station is a survey instrument that measures the X, Y, and Z coordinates of any point. They are unnecessary for contouring on the small farm but are useful for designing ponds and managing drainage over long distances (e.g., for furrow irrigation). A total station may not be feasible for small farmers, but some extension agents will have access to one.

Measuring the slope

The slope of a parcel of land is the vertical "fall" of the land's surface, divided by the distance between the same points from which this "fall" is measured.

An A-Frame easily measures the slope in the field. Put one leg of the A-frame on a point on the soil surface and the second leg in the air above the downslope surface. When the A-frame is level, measure the distance above the soil surface, divided by 2 meters (or the length of the base of the A-frame [distance between the bottom of each leg of the A-frame]). This is the slope of that section of land. Take and record several measurements over similar areas.

Do this for each section where the slope is relatively equal. Where the slope differs, the distance recommended between conservation practices (e.g., rock or vegetative barriers) will be different. Remember to consider aspects of the natural formations and "lay of the land".

Limits to effective contour cultivation

The Natural Resources Conservation Service (2017) found contouring alone is most effective on slope lengths 30.5 to 122 m long. This corresponds to slopes of about 0.5 to 4.5 percent. Societal and economic realities relegate many small-scale farmers to slopes much greater than these. Contour planting/tillage are not sufficient alone but are the first steps in controlling erosion. Large intense storms on hillsides can generate enough runoff and rill erosion to overtop or "melt" the ridges left by tillage.[1]

Therefore, on sloping lands, it becomes necessary to augment contour cultivation with soil conservation barriers to shorten the slope length[2] and reduce the erosive forces of water. Conservation structures like live barriers physically detain eroded soil and prevent erosion further downslope. Contouring with related soil conservation techniques can slow down runoff water and allow the soil to absorb more water. They enhance water management by channeling excess water and encouraging rainwater to seep into the ground in dry regions. By reducing runoff, along with pesticides and nutrients that the runoff may contain, contamination of surface water is also reduced. These structures are most effective when established along marked contours. They can be live barriers, hillside ditches, swales, or agroforestry plantings. Below we focus on live barriers.

[1] Rills are areas of concentrated runoff or overland flow and are one of the major forms of erosion from cultivated lands. Rills get larger with increasing rain and over time. When normal farm operations no longer remove them or when machinery cannot pass over them, they are called "gulleys".

[2] The USDA (2001) defines slope length as the distance from where overland flow starts to where it either gets deposited or becomes concentrated in a channel. Extensionists can use this deposition to show the erosion process. Conservation methods like stonewalls, swales, hillside ditches, live barriers, and agroforestry, are all aimed at reducing erosion.

Live Barriers for Erosion Control

Live barriers are simply plantings along the contour to break up the formation of rills and eventually gullies when possible (Garrity, 2000). They also function to retain eroded sediments (Walle and Sims, 1998) and form natural terraces. Live barriers across the gully can effectively treat small gullies in the field (World Bank, 1987).

Live barriers are the easiest conservation practice to install (Garrity, 2000). For best effect, it is essential to establish them as close to the contour as possible. Once marked, farmers can plant live barriers along the contour lines. Deposition of sediments behind the barriers smooths out contour line imperfections. The distance between barriers varies with the slope. Table 2 gives the recommended distances based on slope for simple live barriers. Note in the table that the distance between barriers decreases with increasing slope and that distance figures are based on a vertical difference in elevation of

Table 2. Slope and the suggested distances between live barriers (2 m vertical interval).

Slope (degrees)	Slope (%)	Distance between barriers (for a 2 m vertical interval)
1	1.7	114.6
2	3.5	57.4
5	8.8	23.0
10	17.6	11.6
15	27.0	8.0
20	36.4	6.0
25	46.6	4.8
30	57.7	4.0
35	70.0	3.4
40	84.0	3.2
45	100.0	2.8

Source: Vetiver Network International (2021)

2 m (recommended by the Vetiver Network International as optimal for erosion control).

Distance between barriers should also accommodate farmers' needs. Account for factors such as turning space needed for animal traction or other tillage equipment. Most importantly, she/he will factor in the cultivated area they need to live and generate income on the hillside farm. If the barrier does not produce a commodity that is useful to the farmer, they will usually extend the distance between the barriers to take up less cropland.

Adjusting the distance between the barriers

Many of the distances recommended between barriers are too narrow for the small-scale farmer. This highlights the necessity of the barriers to produce something of value to the farmer. Farmers must consider agroforestry and fodder crops to provide for animals. Trees will take up more space than most annual crops. Extending these distances so that they are more favorable to the farmer is a common modification.

When increasing distances, important things to consider are the barrier species; their effectiveness in soil and water conservation; and the crop space needed. For example, agroforestry trees alone are usually less effective barriers than grasses. In combination, however, they can provide leguminous fodder while conserving soil and water.

Types of live barriers

Live barriers should be dense at the soil surface so that overland flow does not form rills. The barriers should also be dense enough to catch, or deposit eroded sediment from above.

This is a problem with many agroforestry species; the tree roots stabilize the soil, but rills find their way around tree trunks and laminar erosion still occurs and continues downslope. To trap eroded soil, farmers often combine live barriers with agroforestry. Table 3 lists some options and uses for various tropical species used for live barriers.

Table 3. Some species of interest for live barriers.

Common Name	Scientific Name	Legume	Fodder	Soil and Water Conservation
Gliricidia	*Gliricidia sepium*	yes	yes	yes
Leucaena	*Leucaena leucocephala*	yes	yes	yes, caution- can become weedy
Pigeon pea	*Cajanus cajan*	yes	yes	bi-annual, needs replacing
Napier/King grass	*Pennisetum purpureum*	no	yes	fair, maintain high density
Sugar cane	*Saccharum officinarum*	no	yes	fair, maintain high density
Lemon grass	*Cymbopogon citratus*	no	no	yes
Pineapple	*Ananas comosus*	no	no	poor
Vetiver	*Vetivaria zizanoides*	no	yes	yes, high
Sisal	*Agave sisalana*	no	no	poor
Setaria	*Setaria* spp.	no	yes	yes
Guatemala grass	*Tripsacum laxum*	no	yes	yes
Guinea grass	*Panicum maximum*	no	yes	yes, caution- can become weedy
Albizia	*Albizia* spp.	yes	yes	fair, maintain high density

Table 3. Some species of interest for live barriers.

Calliandra	*Calliandra spp.*	yes	yes (10-30% diet)	fair, maintain high density
Flemingia	*Flemingia*	yes	yes	fair, maintain high density
Mulberry	*Morus alba*	no	yes	fair, maintain high density
Orchid tree	*Bauhinia* spp.	yes	yes	fair, maintain high density
	Grevillea spp.	no	no	fair, maintain high density

Grasses such as such as napier/king grass will eventually form a dense barrier, but the plant crowns dry and leave spaces in the barrier. Some grasses can provide fodder for animals. Many grasses are invasive, but animal traction or digging hoes (with more effort) can be used to control rhizomes. Experience has proven vetiver grass to be effective and a good option for farmers. It does not provide any additional benefits, such as food or fodder. There are a lot of effective options.

While establishing live barriers, manage weeds and irrigate as needed. If there are gullies in the field, it is best to treat them with appropriate erosion control measures before they become larger.

Farmers can use the rocks in their fields to build stonewalls aligning with the contours (Figure 6). Larger constructed stonewalls should have the correct anchoring as needed. They require an excavated anchor as erosion can undercut the base. Sometimes smaller stones are just arranged on the contour. Making use of the present rocks while improving your cultivation environment is very important. Rocks can also be important in the building of dikes and other structures.

Figure 6. Making a soil conservation barrier with available rocks in East Africa. *Source:* ECHO East Africa Staff

Closing note on extension

Contouring is a simple way to conserve soil and water on mild slopes and is the foundation for soil and water conservation on hillsides.

It's important for extension agents to be aware of labor costs for soil and water conservation. Many times when extensionists introduce soil and water conservation concepts, the farmers will say "what you brought here is more work! " Many times, in reference to increasing erosion, farmers will comment on how the rocks "grow." Even though the process of sheet erosion may not be visible, the deposition of eroded material downslope is. Examination of the soil surface for rill erosion is another example of low-cost extension methodology. These are useful for highlighting the importance of erosion control in extension/demonstration efforts conducted in settings like farmers' fields and farmer field schools (Walle and Sims, 1998). Low-cost techniques like live barriers and agroforestry can provide solutions and promoting them with examples is an effective extension methodology.

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Taro (*Colocasia esculenta*)

by Stacy Swartz and Josh Jamison

Description

Taro is a major aroid that contains a starchy, edible corm high in carbohydrates. Corms are enlarged stem tissue that stores plant reserves underground. Corm size and shape vary based on variety, agronomic practices, and ecological factors. Cormels are corms that form on the sides of the main corm.

Varieties are categorized into upland and lowland groups based on irrigation requirements. Lowland varieties are typically grown in permanently flooded paddies while upland varieties are grown in regular planting beds, in agroforestry systems, and even on hillsides. Varieties are also characterized by corm and cormel formation. *C. esculenta* var. *esculenta*, also called dasheen, has larger main corms and smaller cormels while *C. esculenta* var. *antiquorum*, also called eddoe, has smaller central corms and larger cormels (Labot, 2009). Corm cores can be white, yellow, orange, pink, red, and even purple. Planting to harvest is anywhere from 5 to 12 months depending on variety. Taro's geographical origin is from Asia, Southeast Asia, and Melanesia.

Benefits

Taro can fill several agroecological niches not filled by many crops, particularly in water-logged soils which host very few crop species. Taro is well adapted to understory cultivation in agroforestry schemes and is more tolerant of rainforest climate than most cultivated starch crops. Taro has multiple edible parts, including nutritious leaves and starchy corms. It is not susceptible to the diseases and pests that affect sweet potato (*Ipomea batatas*) and can fit into rotation schemes. Taro has a longer shelf life than sweet potato (in the presence of weevils) as well as cassava (*Manihot esculenta*), which can make it a valuable crop for storage purposes. It has a shorter shelf life than *Dioscorea* yams. Cultivation can be very simple/primitive. There is speculation that taro is one of the oldest crops under human domestication, where people were semi-farming with very crude tools like digging sticks.

Figure 7. Mature taro plants (upland variety). *Source:* Josh Jamison

Cultivation

Replant taro annually. Plant whole corms 15 to 45 cm below the soil surface, making sure that the top of the corm is upward in the planting hole. The depth of planting depends on your soil type and health as well as the taro variety. Plant varieties that produce large central corms a little deeper than those that produce cormels. Corms form up the plant shoot system as the plant grows. If propagation pieces are planted too shallow, corms will be smaller at harvest and plants will have more leafy material. Use pieces from the previous season that are a bit larger than the size of an egg (200-400 g). Using pieces smaller than this will lead to weak plants. In drought-prone areas, use larger pieces to ensure success. Plant in triangulated rows, 50-80 cm between rows and 60-100 cm between plants. Larger-leafed varieties (Figure 7) need wider spacing than more narrow-leafed varieties.

Temperatures under 15°C lead to dormancy for most cultivars (Labot, 2009). If your area gets frost, make sure to plant after the last possible chance of frost to prevent shoot damage. Freezing temperatures will kill plants.

In most contexts, taro is not fertilized. Plants respond well to amendments between 3 to 4 months after planting when rapid root growth is occurring (Labot, 2009). Potassium is essential for cormel initiation but can cause an overproduction of cormels in soils high in potassium. Researchers Hartemink and Johnston (1998) found that fertilization[3] increased yields when harvesting taro mid-season at 126 days (~4 months) after planting but did not significantly increase yield when harvested at 231 days (~7.5 months) after planting.

[3] They applied 100 kg/ha of nitrogen and potassium and 50 kg/ha of phosphorus.

Watering requirements vary by variety. Water supply is most important during the first 20 weeks after planting, when most of the shoot system develops. Upland varieties are more drought-resistant with some varieties not able to handle flooding. Lowland varieties are either cultivated where water is constantly moving or in paddies that are permanently flooded.

Some farmers in Nigeria cultivate taro and rice together with two rows of taro at 60 x 60 cm spacing alternating with four rows of rice (Labot, 2009). Possible upland taro intercrops include beans, sweet potatoes, sweet corn, and groundnut (Peña and Melchor, 1993).

Weed management is important in the first four months of growth or until the canopy closes and taro naturally shades out weeds.

Harvest (Figure 8)

Figure 8. Harvested taro corms.
Source: Josh Jamison

If your area receives frosts, harvest before the first frost. Taro is mature when older leaves begin naturally to die back and individual leaf stems become shorter. You may also notice corms above the soil surface starting to form a bottleneck shape. If soil fertility and irrigation requirements are met, you can expect upland taro corm yields of between 30 and 60 t/ha though yields of up to 110 t/ha have been recorded (Spriggs, 1981). Without intensive management, expect yields of 8 to 16.5 t/ha (Lebot, 2009).

Pests and diseases

There typically aren't many pests that affect taro. Taro beetles (*Papuana* spp. and *Eucopidocaulus* spp.), taro leafhoppers (*Tarophagus proserpina*), aphids (Aphididae), taro hawkmoth (*Hippotion celerio*), and apple snails (Ampullariidae) are a few pests that have economic importance for taro (Lebot, 2009). Control methods for taro beetles include wood ash, flooding, trap cropping (e.g. with wild sugarcane [*Saccharum spontaneum*] or bananas [Musacaeae]), mulching, intercropping, adjusting planting time, and biological control. Taro leafhoppers and aphids vector viruses that impact crop growth and also cause leaf damage by sap-sucking. Taro root aphid (*Patchiella reaumuri*) is only an upland taro pest while apple snails are typically only pests on lowland taro crops. Nematodes can also impact taro yields in both lowland and upland contexts. Bacterial soft rot and taro leaf blight are the major microbial diseases of taro. Some of the best ways to mitigate both insect and microbial diseases for taro are to use crop rotations, using uninfected planting material, and growing in polycultures (intercropping).

Nutrition and cooking

Corms of several aroids are edible but must be processed before consumption due to high levels of oxalic acid. The crystals of calcium oxalate feel uncomfortable when ingested, similar to the poke of a needle, and can cause severe stomach aches. Varieties contain different concentrations of oxalates. One variety, "Lampung hitam" which is cultivated in Bogor, Indonesia, has levels that are so low that corms only need to be cooked a short time (Lebot, 2009). Among 20 varieties, crude protein and total oxalate content of corms were 1 to 2% and 8 to 130 mg/100 g respectively (Sen *et al.*, 2005).

Taro is traditionally processed into a paste called "poi" in Hawaii or "achu" in Ghana. Corms or cormels are boiled, peeled, then pounded in a mortar and pestle until smooth. Sometimes, the paste is fermented. Another traditional processing method from Nigeria is to boil (for about three hours) then peel and cut into 1 cm slices that are dried in the sun until they break apart between your fingers (Nwana and Onochi, 1979). Taro flour and chips can also be made by air-drying and then grinding or frying, but you must select varieties with low levels of oxalates for these purposes.

Taro leaves of some varieties are edible. Leaves are 4.2% protein and contain 426 mg total oxalate/100 g of leaf material, with most of the oxalates in the form of calcium oxalate (Bradbury and Holloway, 1988).

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From ECHO's Seed Bank: Oven-Dried Rice as a Desiccant for Seed Drying

by Guinevere Perry, PhD

Introduction

Seed preservation is an effective tool to promote agrobiodiversity. Seed preservation also increases the cultivation of local plant species better adapted to specific areas, enhances genetic variability in pollinated species, and preserves food security. Seed preservation saves farmers money and improves their chances of increasing crop yields (Montúfar and Ayala, 2019).

How to dry seeds

Seed drying is the most vital step in the seed preservation process. How quickly and effectively seeds are dried affects germination rates and seed viability (Harrington, 1959; Saipari *et al.*, 1998). Most seed preservation practices are not new (Weisdorf, 2005; Blakemore, 2019). Seed preservation options evolved over centuries of trial and error, indigenous knowledge, and advances in agricultural technologies (Matsa and Mukoni, 2013; Shaila and Begum, 2021).

Methods to dry seeds include hanging seeds from trees, solar drying, desiccant drying, simple local driers, drying seeds on tarps, curing tables, and using wood ash (Chua and Chou, 2003). These practices vary based on culture, climate, and crop. For example, in Ghana, maize (*Zea mays*) seeds are picked at the first of harvest by the color and size and then dried on the cob near stoves in woven bags to reduce pest problems. In Malawi, women pick the seeds from the cob throughout the harvest season based on the maize size. Seeds are placed near the stove but may also be hung from the trees (Wright and Tyler, 1994).

Figure 9. Meter used to determine the moisture of rice kernels and cowpea seeds.
Source: Guinevere Perry

Rice as a desiccant

We have known for centuries that rice absorbs water at high temperatures. In fact, we all use this principle when we cook rice. However there has been a growing interest in using rice as a desiccant. One study focused on using rice to dry out hearing aid devices (Nelson *et al.*, 2017).

Sadik and White (1982) experimented with rice as a desiccant to dry seeds for long-term storage. They found that 30 to 40 g of toasted rice (with < 1% moisture) dried 20 g of true potato seed from 11.5% moisture down to 4 to 5% moisture. They also found that toasted rice had more drying capacity than toasted kernels of wheat, maize, or soybean.

There is, therefore, support in the literature for using rice to dry seeds. We wanted to determine if rice serves as a suitable desiccant to dry freshly harvested cowpea (*Vigna unguiculata*) seeds, as well as to find out if it is feasible to dry cowpea seeds with reheated rice that has already been used as a desiccant.

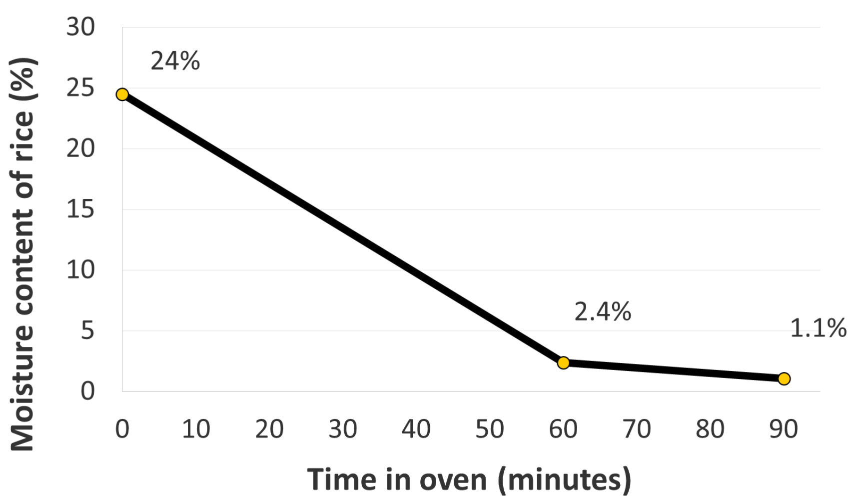

Figure 10. Moisture content of rice kernels after 0, 60, and 90 minutes of oven-drying at 135°C.

ECHO trials using oven-dried rice

Can you remove moisture from rice in an oven?

We used store-purchased, long-grained white rice. The rice was not washed. Prior experience at ECHO and work by Sadik and White (1982) indicates that the drying capacity of rice is enhanced by pre-heating, to remove existing moisture out of the grain before using it as a desiccant. In our study, we heated the rice in a drying oven for 1 and 1.5 hours at 135°C. The rice displayed a visible change in appearance, becoming a light golden color in appearance that was most noticeable after 1.5 hours.

We tested rice moisture content before and after heating using the device pictured in figure 9. Initial rice moisture content was over 24% (Figure 10). The heating process removed a significant amount of moisture from the rice, drying it to 2.4% moisture after 1 hour of heating.

Can oven-dried rice remove moisture from freshly harvested cowpeas?

We placed the oven-dried rice in the bottom of glass jars (500 ml volume). We moistened cowpea seeds in Ziplock® bags with water to achieve an initial moisture content of 12%, simulating a level of moisture that may be present at harvest. Then, we placed the rehydrated cowpea seeds in mesh cloth directly above the rice (at a 2:1 ratio [60 g oven-dried rice:30 g cowpea seeds]) as shown in figure 11. We collected samples of cowpea seeds at each of two sampling times, 5 and 24 hours, to measure cowpea seed moisture. This was done for rice that had been oven-dried at 135°C for 1 and 1.5 hours. Results were comparable for the two drying times. Figures 12 and 13 show data obtained with rice that was oven-dried for 1 hour.

After 5 hours, the oven-dried rice (for 1 hour at 135°C) reduced the moisture content of cowpea seeds from 12% to 10.68%, a 1.32% drop in moisture (Figure 12). After 24 hours, cowpea moisture declined to 9.46%. Thus, the rice reduced cowpea seed moisture content by over 2.5% within 24 hours.

Can oven-dried rice be reused as a desiccant?

We collected the rice from each of the glass jars, and reheated the rice in the oven at 135°C for 30 min. We watched closely to make sure the rice did not burn. The reheating process reduced the moisture content of rice to around 0.55%. We placed the reheated rice back into glass jars with a fresh set of cowpea seeds for 24 hours. Initial moisture content of the fresh cowpea seeds was 11.8%. Upon removal from the jars, results shown in figure 13 suggest that rice can be reheated and still act as a desiccant to dry out seeds.

We observed something interesting from rice initially dried for 1.5 hours (data not shown). The amount of moisture removed from cowpea seeds was 0.54% less with the reuse of rice initially heated (at 135°C) for 1.5 hours than for 1 hour. Perhaps the additional heating time made the rice more brittle and less able to absorb moisture. The finding suggests that heating should be done in such a way as to minimize darkening (indicative of potential burning) of the rice while heating. This could be confirmed with additional research.

Conclusion

The study suggests 1 hour of heating suffices to make rice an effective seed-drying desiccant.

Pre-heated rice, both new and used, proved capable of drying cowpea seeds to a moisture content of less than 10% (a good value for long-term seed storage); this happened within 24 hours in this study with an initial cowpea moisture content around 12%. Longer drying times may be needed for newly harvested seeds that have higher moisture content. More research is needed to find out if rice can be re-used more than once. See an *ECHO Development Note* article entitled "Are my seeds dry enough [http://edn.link/salttest]?" (Reader and Motis, 2017) for information on ways to determine seed moisture even if you do not have a moisture meter. Let us know of your experience using rice as a desiccant.

Figure 11. Cowpea seeds being dried with oven-dried rice. *Source:* Guinevere Perry

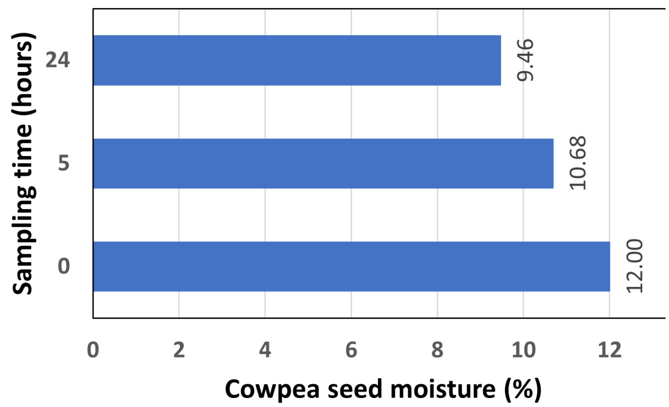

Figure 12. Cowpea seed moisture (%) with 0, 5, and 24 hours of drying in a sealed jar with rice that had been heated for 1 hour. Data shows the average of two replicates.

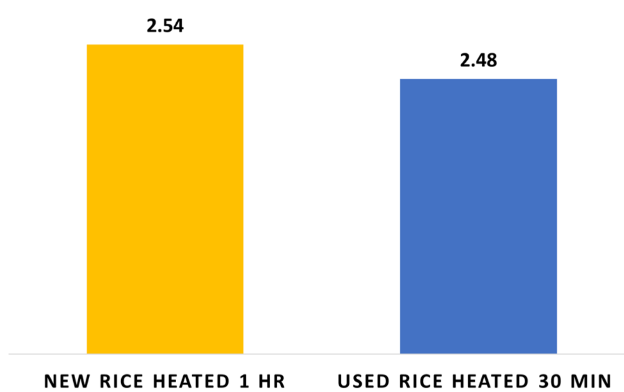

Figure 13. Moisture (%) removed from cowpea seeds dried with new rice (heated at 135°C for 1 hour) and used rice (re-heated at 135°C for 30 minutes). Data shows the average of two replicates.

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Additional recommended resources:

Bicksler, A. 2014. The importance and biology of seed saving. [A presentation at the 2014 ECHO Asia Seed Banking Workshop] http://edn.link/d24w4p

ECHO Staff. 2016. Seed storage in the tropics. *ECHO Best Practice Note* no. 5. http://edn.link/bpn5

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ECHOcommunity Mobile App – Resource Management

Most ECHOcommunity resources, whether from ECHO or from ECHO's network, are available in downloadable PDF or video formats.

The ECHOcommunity Mobile App makes content available to you to select, download, store, and share. Please note that some resources on ECHOcommunity.org are not downloadable and must be accessed online.

When accessing a PDF or video in **My Library** on a cellphone, try turning your phone to landscape view for the best experience.

To browse resources, go to the **Resources** (Figure 14) tab from the menu. You'll see multiple categories (Figure 15) including ECHO publications, Network publications, Agricultural Practices, Appropriate Technologies, Development, and Animal Options.

If you already know what topic you want to look up, you can search for the keyword directly in the search bar at the top of the screen (Figure 16).

Downloadable resources currently available will appear in a list. At the top of the search results, you'll see filters to help you find exactly what you're looking for (Figure 16). **Key resources** are resources that ECHO staff considers authoritative on the subject. You can filter the search results by supported **languages**, or by a specific **type of resource** (article, publication, presentation, book, video, or collection).

Once you find the resource you want, select it, and you'll be taken to that resource's page (Figure 17).

The page contains more information about the resource itself, so you can decide if it is what you're looking for. At the top of the screen, you'll see a back arrow in the top left corner, so you can go **back** to the list of resources, or a **home** icon to be taken directly back to the resource

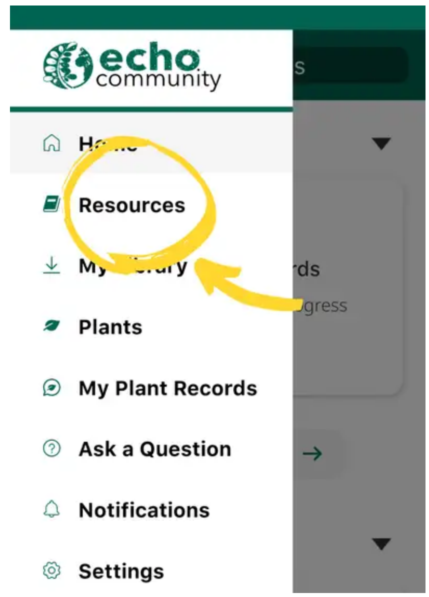

Figure 14. *Source:* ECHOcommunity mobile app

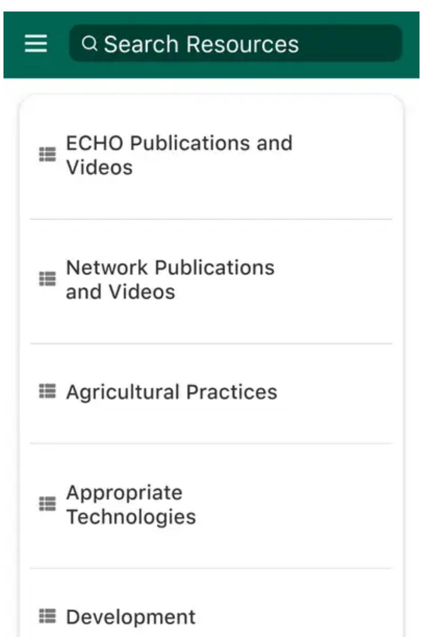

Figure 15. *Source:* ECHOcommunity mobile app

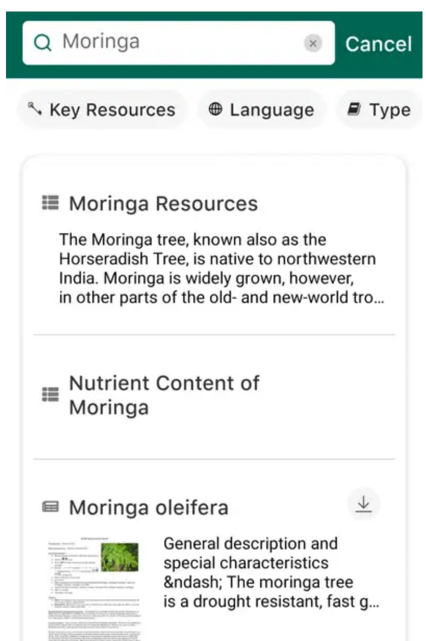

Figure 16. *Source:* ECHOcommunity mobile app

Figure 17. *Source:* ECHOcommunity mobile app

Books, Websites, and Other Resources

by Abigail Jackson

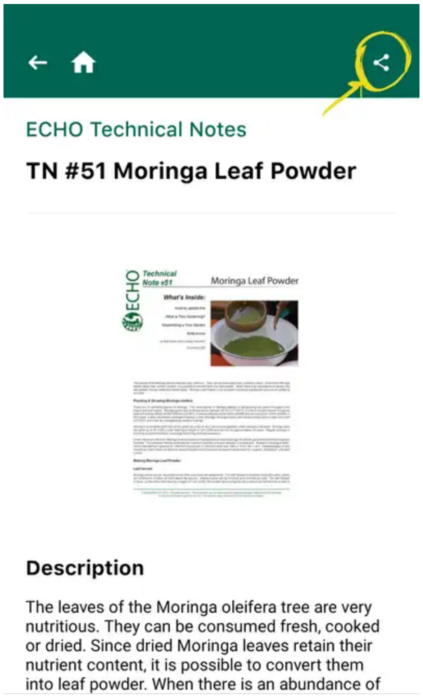

Figure 18. *Source:* ECHOcommunity mobile app

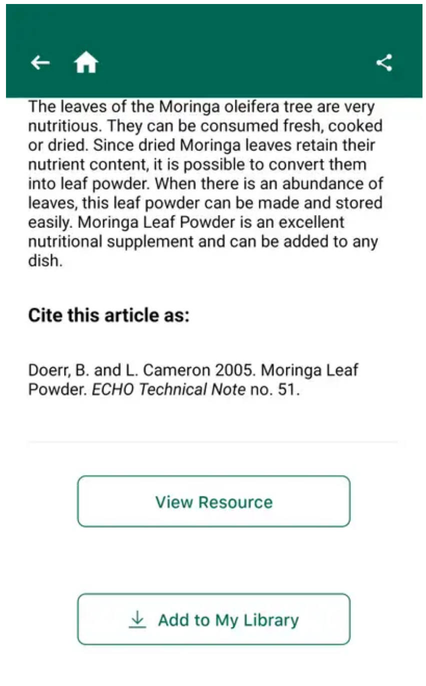

Figure 19. *Source:* ECHOcommunity mobile app

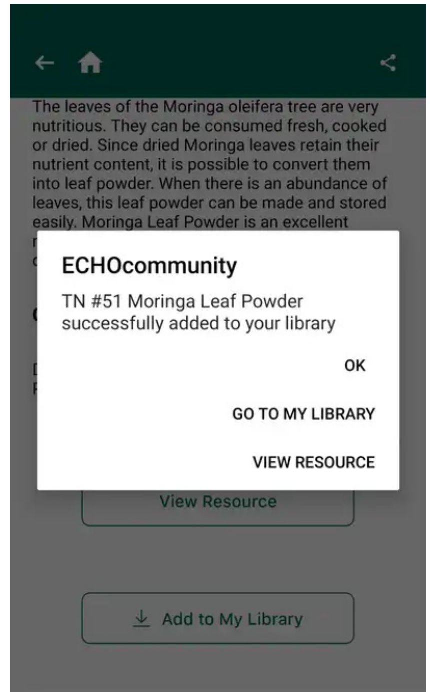

Figure 20. *Source:* ECHOcommunity mobile app

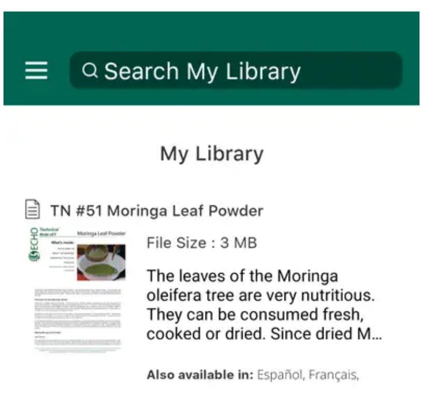

Figure 21. *Source:* ECHOcommunity mobile app

home page. In the top right corner, you also have an option to **share** the resource.

To share, tap the share icon in the top right corner (Figure 18). You'll be prompted to ensure that you have the correct sharing option already downloaded for your device and area. Choose whether to share the file itself, or a link to the resource on ECHOcommunity.org. Share via your device's native share option (Nearby Share for Android, or Airdrop for Apple), or a 3rd party app such as Xender, ShareIt, or WhatsApp.

From the resource page, you can choose to view the resource or add it to your library (Figure 19).

Tap **view resource** to see the information full screen.

When you choose **add to library**, you will be prompted to choose the language (and file size, if applicable). Once you have chosen the language, tap **download** to download the resource to your library. The first time you add something to your library, you will be prompted to allow the app to access files on your device. Select **allow** for the app to function properly.

The resource will be saved, and you can access it from your home page and from the **My Library** tab. Tap **ok** to go back to browsing through the resources, tap **Go to My library** to view the resources you have saved, or tap **view resource** to pull it up again (Figure 20).

Navigate to your library by opening the menu (the three horizontal lines in the top left corner) and selecting **My**

library. Once you have added at least one resource to your library, resources will be visible in this tab (Figure 21). Tap on the resource you'd like to open, then tap **view resource** to open it fully.

Removing resources from your device:

If you are no longer using a resource, you can remove it from your library by tapping on **remove from library** (Figure 22). This only removes the resource from your library. It will not remove the resource from the app itself. You will still be able to access it again if needed.

You can also delete unnecessary resources directly from the library page by swiping left and tapping **delete** (Figure 23).

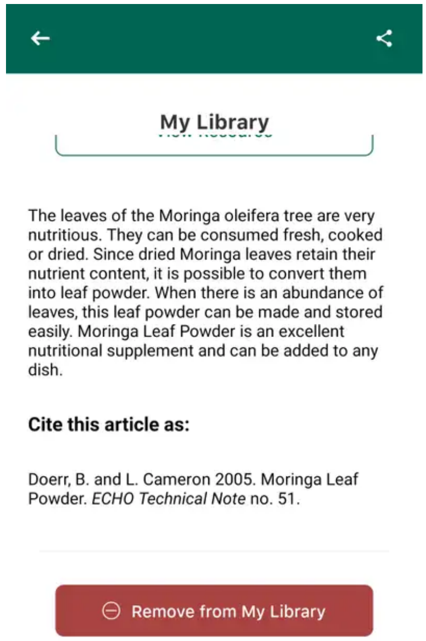

Figure 22. *Source:* ECHOcommunity mobile app

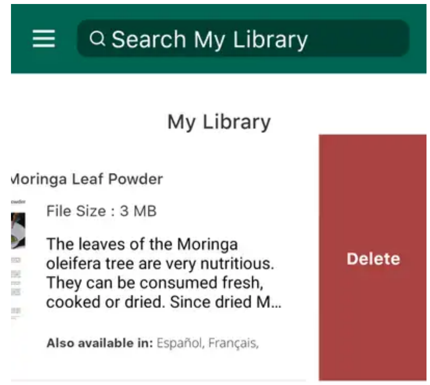

Figure 23. *Source:* ECHOcommunity mobile app

Upcoming Events

ECHO Asia

Faith and Farming: A LEAD Community of Practice Training Event

Chiang Mai, Thailand
February 5-9, 2024

Tropical Agriculture Development

Chiang Mai, Thailand
February 19-24, 2024

ECHO North America

Introduction to Tropical Agriculture Development

North Fort Myers, Florida
April 2-5, 2024

Syntropic Agroforestry (TAD 2)

North Fort Myers, Florida
April 9-12, 2024

ECHO East Africa

Best Practices in Sustainable Agriculture and Appropriate Technologies

Juba, South Sudan
Febrary 20-22, 2024