ECHO® Development Notes

Edited by Dawn Berkelaar and Tim Motis

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Farmer Field School Trials of 2:4:2 Maize/Legume Intercropping

Tim Motis, Biriori Dieudonne, and Robert Morikawa

INTRODUCTION

Farmers often struggle to maintain the productive capacity of their soils, especially where they lack enough land for a fallow (rest) period between crops. Leguminous green manure/cover crops (GMCCs) can help; in association with rhizobial bacteria, legumes convert nitrogen from the air into a form that plants can use. Many tropical legumes have deep, extensive root systems that can take up nutrients which leach past the root zones of other crops. Thus, even on poor soil, they can produce an abundance of nutrient-rich, plant-based mulch. When left on the field, this mulch builds soil organic matter and fertility. Legumes also help suppress weeds and, depending on the species, produce beans and foliage for human and/or animal consumption. While these benefits are well-recognized, the benefit of GMCCs to small-scale farmers depends on how well they are integrated into smallholder cropping systems (see *BPN 7* for information on legume selection and planting strategies).

In *EDN* 133 we described a cereal/legume intercropping strategy in which two rows of a cereal crop are alternated with four rows of a legume. This "2:4:2" planting sequence is an outcome of research done by the International Institute of Tropical Agriculture (IITA) and national partners, with cowpea as the legume and maize or sorghum as the cereal crop (Ajeigbe *et al.* 2010). The planting configuration minimizes competition for light. It is best suited to areas where the return from the legume justifies devoting less land area to a cereal crop. Research at ECHO in Florida showed that the system has potential for integrating other legumes besides cowpea into maize, including those with taller canopies than cowpea, such as jack bean (*Canavalia ensiformis*).

After reading about the 2:4:2 strategy in *EDN* 133, and visiting the Florida research plots, Plant With Purpose (plantwithpurpose.org) expressed interest in working with ECHO on a protocol that farmers in Democratic Republic of Congo (DRC) could use to test the 2:4:2 system. Tim Motis and Stacy Reader corresponded with Plant With Purpose partners in the DRC, together developing a way for farmers to compare the 2:4:2 approach to traditionally-grown maize using a Farmer Field School (FFS) model. Their experience is shared here, both to provide an update on the performance of 2:4:2 outside Florida, and to present one way in which farmers conduct their own research.

ABOUT THE FARMER FIELD SCHOOL APPROACH

Technologies such as the 2:4:2 planting sequence have been shown to have multiple benefits for farmers. One challenge of community development is to effectively share information about a new practice, and then create a forum where farmers can develop a deep understanding of the practice and adapt it to their local context.

FFS is a participatory approach where everyone involved is simultaneously both a learner and a teacher. Traditional agricultural training models involve experts sharing knowledge with farmers, so that information flows in one direction only. By contrast, FFS seeks to put farmers and instructors on an equal footing, so that everyone can share knowledge and information flows in many directions. FFS also introduces the ideas of simple field trials, formal field observations, and practical innovation. FFS emphasizes local testing on real farms, rather than in a specialized centre with specialized equipment and conditions. This kind of research is relatively low cost, and can be managed by community leaders and facilitators with some basic training.

A typical FFS involves a group of 20 to 30 farmers who meet regularly. Group members decide how often they will meet; usually they meet weekly or monthly depending on the nature of the trial. One farmer volunteers a small plot of land on his or her farm as the trial area. All farmers in the group work together to plan, establish,

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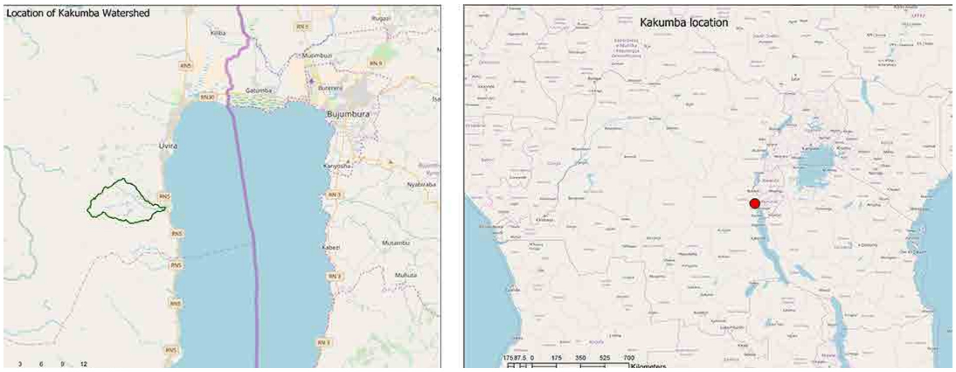

Figure 1. Maps showing the location of the Kakumba watershed in DRC.
*Source: Open Street (*Creative Commons Licence*)*

maintain, and harvest the trial, typically with the guidance and training of a facilitator or technician. The plot is typically divided in two, with one section for the treatment being tested (for example, a green manure crop) and the other section serving as the control. The control should be familiar to all participants, and gives a frame of reference to which results of the new treatment can be compared. A semi-structured observation process, also known as the agroecosystem analysis (AESA) can help guide farmers' regular observations.

METHODOLOGY

The Kakumba watershed is located in South Kivu, eastern Congo, in Uvira territory (Figure 1). It is part of the larger Congo River watershed and empties into Lake Tanganyika. Approximately 20,000 people live in the area, most of them depending on agriculture as their principle source of income.

2:4:2 maize/legume intercropping was new to the community, so prior to meeting with farmers, Plant With Purpose and ECHO developed a step-by-step process that FFS facilitators could easily communicate to farmers, and that farmers could then replicate. To minimize communication barriers, the research plan contained hand-drawn illustrations (Figure 2) with instructions translated into Swahili. The protocol called for locally-available seeds (of the cereal and GMCC crops) and fertility inputs, to minimize cost to farmers. A known, appropriately-sized (had to be small considering the small plot size) volume-based unit of measurement called the kigoz (Figure 3) was identified, to be used for quantifying grain production. One kigoz of maize or cowpea grain weighs approximately 0.67 kg. This meant that participating farmers did not need to purchase and calibrate scales or transport their harvest to a central location to be weighed. A questionnaire was developed to guide and record farmers' observations. We minimized labor requirements by limiting data collection to farmer observations and grain yield.

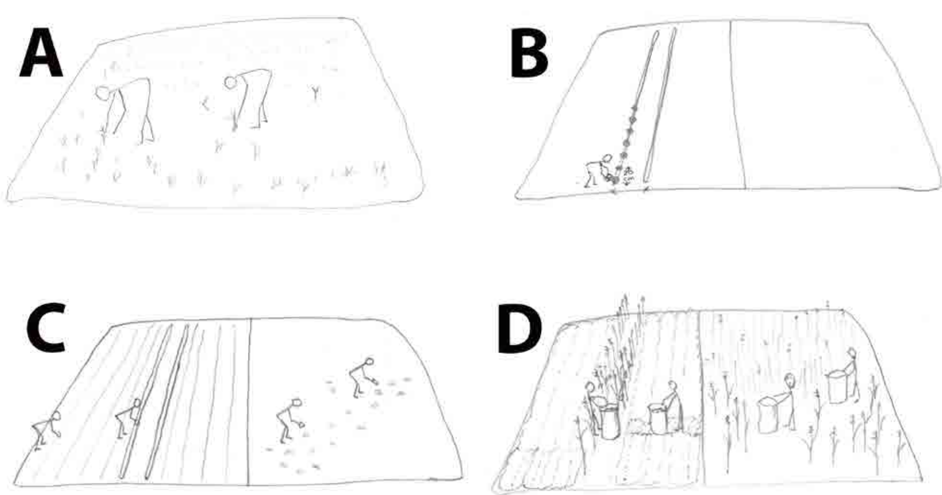

Figure 2. Hand-drawn illustrations of ground preparation (weeding [A] and compost application [B]), seeding (C), and harvesting (D). *Source: Robert Morikawa*

In FFS trials, farmers normally meet with a Plant With Purpose facilitator or technician, together discussing various options and deciding what they want to test. Farmers groups in Kakumba are regularly running FFS on a variety of topics such as soil conservation, improved crop varieties, and soil fertility practices. Because the 2:4:2 trial design was already well-defined, discussion this time focused more on which groups were interested, who would volunteer a plot of land, and what the control planting of maize would look like. The farmers decided that the legume would be cowpea, commonly known as *ngore* in the Uvira region. They chose cowpea even though it appears to be subject to some pest damage, is not widely planted, and seed is currently expensive. However, since the experimental plots were small, seeds for the trial did not cost a lot. In the future, farmers could multiply their own seed if they want to try the system themselves; also, if cowpea becomes more popular and is planted more widely, the cost of seed will decrease. Farmer groups, facilitators and technicians worked together to set up the trials.

Figure 3. A typical kigoz measuring can.
Source: Biriori Dieudonne

Six separate FFS groups each established a trial (Figure 4). Each trial site measured 12.6 m x 7.5 m, with each site divided into two 6.3 X 7.5 m plots. One plot was randomly assigned to the control treatment and the other to the 2:4:2 treatment. The control treatment consisted of traditionally grown maize, with seeds sown at an approximate spacing of 50 cm X 80 cm, and with no fertility input applied; only in recent years have farmers in the Kakumba watershed begun to use compost to grow maize. The 2:4:2 plot contained a mixture of maize and cowpea--four rows of cowpea alternated with two rows of maize, with rows spaced 70 cm apart. In-row spacing was 40 cm for cowpea and 30 cm for maize. Maize seeds were sown into shallow furrows (dug

Figure 4. Measuring (left) and hoeing (right) activities to establish a 2:4:2 trial.
Source: Biriori Dieudonne

with hoes), to a depth of about 15 cm. Prior to seeding the maize, a handful of compost was placed every 20 cm within furrows and lightly covered.*

> *NOTE: The 2:4:2 approach, as outlined by IITA, makes use of fertility inputs, especially for the maize. DRC farmers did not have NPK fertilizers, so they used compost instead; a high rate was used to compensate for no NPK fertilizer being used, but farmers could certainly experiment with lower rates. The purpose of the trial was to simply compare two cropping systems; a more rigorous design could have included treatments to determine the contribution of manure and cowpea to the maize.

Cowpea rows received no fertility inputs. Seeding was done at the beginning of the rainy season, during the months of November-December 2017. Crops were rainfed; no irrigation was used.

Farmers in the FFS groups met twice a week to record planting and harvesting dates, as well as observations related to pests, disease, soil, crop growth, grain yield, and the overall performance of each treatment (Figure 5). At the end of the season, each group recorded the volume (number of kigozes) of maize and cowpea grain that were harvested. The number of kigozes per plot were converted to kilograms (kg), and final yields were expressed as kg per hectare (ha) of a 2:4:2 or traditional growing system. At the end of the trial, farmers held focus group discussions (summarized below), to share their reactions to the 2:4:2 system.

Figure 5. Farmers observing maize and cowpea plants at a 2:4:2 trial site.
Source: Biriori Dieudonne

GRAIN YIELDS

Cowpea grain yield

Grain yields for each FFS group are summarized in Table 1. Cowpea grain production ranged from 213 to 638 kg/ha. Yields at one Kalonge site (managed by the Umoja Wetu group) and at one Gomba site (managed by the Uamusho group) exceeded the 100 to 500 kg/ha average for tropical parts of Africa (Madamba *et al.* 2006); the average for all six sites, 406 kg/ha, was on the high side of that range. A 2:4:2 cowpea crop is capable of producing 800 or more kg/ha of grain (Ajeigbe *et al.* 2010) when fertilized and protected from insects, so these trial results seem promising considering that there was no additional fertility or pest-control management.

In many parts of Africa, cowpea is grown under cereal or cassava crops. With the 2:4:2 approach, farmers can still grow these crops at the same time, but without competition for light. Within a 2:4:2 system, 67% of the crop rows are occupied by legume plants. With their low nutrient requirements, farmers are able to use most (if not all) of their fertility inputs to benefit the maize crop. That said, if a field is low in nutrients and organic matter to begin with, legume growth may be optimized with modest amounts of organic or inorganic fertilizer. Legumes do need some phosphorus in order for biological nitrogen fixation to occur (Ssali and Keya 1983; Zahran 1999). They also need sufficient levels of other plant-essential nutrients. Fortunately, as mentioned earlier, many tropical legumes have deep root systems able to take up nutrients from soil layers that may not be accessible to roots of the cereal crop. Leaving legume biomass on the soil returns those nutrients to the soil surface, thus helping to maintain crop-accessible nutrient levels.

Using seed of improved varieties is another way to optimize legume productivity. Depending on your location, seeds may be available through research centers like the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). Depending on the length of the rainy season, use of early-maturing varieties may allow for two cowpea crops in a single growing season (Ajeigbe *et al.* 2010).

Maize yield

Maize production at four of the six sites was higher with 2:4:2 than when maize alone was planted. Ajeigbe *et al*. (2010) also reported higher first-year grain yield in

Table 1. Grain yield produced by maize alone or maize and cowpea in a 2:4:2 (two rows of maize alternating with 4 rows of cowpea) planting sequence.

Farmer Field School		Cowpea and maize grain with the 2:4:2 system			
Group name	**Site**	**Cowpea (kg/ha)**	**Maize (kg/ha)**	**Cowpea + Maize (kg/ha)**	**Sole Maize (kg/ha)**
Muungano	Gomba	319	851*	1170	425
Umoja Wetu	Kalonge	638	851*	1489	709
Ushirika	Kalonge	425	851*	1276	425
Maarifa	Katongo	319	425	744	709
Mupango wa Mungu	Kigongo	213	425	638	709
Uamusho	Gomba	532	1276	1808	709
	Average	408	780	1188	614

*Similarity of these numbers is due to the same number of kigoz (local unit of volume) reported for each site; farmers were not asked to report fractions of a kigoz.

Nigeria with 2:4:2 maize (978 to 2533 kg/ha) than with traditionally-grown cereals (489 to 1611 kg/ha in multi-crop systems such as maize + sorghum, with or without cowpea). That study used more inputs than ours did (for details, a link to their online report is available here and in the references section).

The Nigeria and DRC trials show that it is possible to produce as much or more maize with the 2:4:2 system as with traditional practices. This is important in light of how much less land there is for maize in a 2:4:2 system than in a traditional cropping system. With spacings used in the DRC trial, a farmer would plant 11,111 maize plants per ha of 2:4:2, compared with 25,000 plants per ha of traditionally cropped maize. Maize in the 2:4:2 plots received more fertility inputs than maize in traditional plots; traditionally grown maize production would likely have been higher if those maize plants had received the same level of inputs as the 2:4:2 plants. However, in low-resource settings, farmers are unlikely to generate enough manure or compost, or to afford enough NPK fertilizer, to treat an entire field.

Total grain yield

Total 2:4:2 grain yield (maize + cowpea) exceeded that of traditionally-grown maize in five of the six sites (Table 1). Averaged over all six sites, the 2:4:2 system produced nearly twice as much grain as the traditional method, clearly showing the benefit of cowpea as a second source of grain in the 2:4:2 system. However, the quantity of grain produced by a legume is only one piece of the picture; the suitability of a 2:4:2 system in any given area also depends on the economic value of the grain. In the Kakumba Watershed, a kigoz of cowpea was more valuable (1500 FC) than maize (1000 FC), making 2:4:2 with cowpea an attractive option. Economic returns from cowpea grain would probably decline if a large number of farmers start growing cowpea at the same time, which could be a reason for future FFS trials to evaluate other legumes such as pigeon pea.

FARMERS' REACTION

Farmers' reactions to the FFS trials were positive. When the 165 participating farmers were asked about the 2:4:2 system, 88% said they were interested in trying it on their own farms. Farmers were primarily interested in the 2:4:2 system for increased yields, and for improved soil quality. One disadvantage noted by farmers was the extra labor required to prepare fields at pre-planned spacing. Farmers also observed some pest damage to leaves during their early development. Despite these challenges, all 6 FFS groups are starting a second season of the 2:4:2 trials on the same plots of land, and 4 new groups are starting first season trials.

The farmers' discussion, analysis, and action demonstrate the way FFS allows farmers to research and learn within the local context. In fact, 40% percent of farmers involved in the FFS groups would like to experiment with other legumes besides cowpea, indicating that the FFS model is helping to stimulate farmer-led research within the community.

CONCLUSION

Research that benefits small-scale farmers can be done in a variety of ways. Rigorous studies with multiple replicated/randomized treatments can best be done at project sites or research stations; these are also good locations for pilot studies. In this case, an initial ECHO trial in Florida helped us craft a 2:4:2 protocol that could then be tested by farmers. Research that benefits farmers is much more likely to occur when farmers are able to participate in the process. Plant With Purpose staff shared the following when asked about starting a FFS:

> In our experience, FFS has worked best where there is already a well organized and motivated group within the community. It works well when integrated into a teaching curriculum which offers ideas and technologies that are well suited to the local context, and that meet recognized needs of farmers. FFS and trial design principles should be clearly explained and principles kept as simple as possible. Catalyzing farmer-led research is challenging, and requires a process that creates as few barriers as possible for farmer participation. This includes using training materials and strategies that work with people who typically cannot read or write, or who have limited education. It is also important that trainers be able to use a participatory style of instruction rather than a top-down style. As much as possible, farmers should be encouraged to participate, and they should be viewed as experts as well as learners.

We hope this article inspires you to find ways to involve farmers in conducting research that improves their livelihoods.

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Madamba, R., G.J.H. Grubben, I.K. Asante & R. Akromah. 2006. *Vigna unguiculata* (L.) Walp. In: Brink, M. & Belay, G. (Editors). *PROTA 1: Cereals and pulses/Céréales et légumes secs*. [CD-Rom]. PROTA, Wageningen, Netherlands.

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Further Reading

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> This document explains with pictures how to establish a 2:4:2 planting. It can be found in the IITA Bibliography website; type "improved cowpea cereal cropping systems" into the search bar, click the "search" button, and click on the PDF button to the right of the publication title that comes up.

Davis, K., E. Nkonya, E. Kato, D.A. Mekonnen, M. Odendo, R. Miiro, and J. Nkuba. 2012. Impact of farmer field schools on agricultural productivity and poverty in East Africa. *World Development.* 40(2):402-413.

> A review of the literature on FFS. Studies reviewed show that FFS participants have higher crop value per hectare, greater livestock gains per capita and greater agricultural income per capita. More vulnerable households tend to benefit more from FFS participation. A full-text 2010 IFPRI (International Food and Policy Research Institute) version is available here.

ECHO/MEAS Summaries

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A series of ECHO Summaries publications, written to distill MEAS (Modernizing Extension and Advisory Services) resources for the benefit of our network, contains information on farmer extension and training.

Khatam, A.M., S.H. Muhammad, K.M. Chaudhry, and M.U. Khan. 2014. Impact of farmer field schools on skill development of farming community in Khyber Pakhtunkhwa Province, Pakistan. *Sarhad Journal of Agriculture* 1:30(2).

This study identified improved learning, decision-making capacity, and community organization as benefits of FFS; FFS groups also showed increased knowledge of pest identification and pest control methods.

Ortega, D.L., K.B. Waldman, R.B. Richardson, D.C. Clay, and S. Snapp. 2016. Sustainable intensification and farmer preferences for crop system attributes: Evidence from Malawi's central and southern regions. *World Development* 87:139-51.

This article describes a study in Malawi, which showed that farmers had varying preferences for maize only, maize plus legumes or legumes only. Preferences depended on local conditions and availability of labor.

Pretty, J., C. Toulmin, and S. Williams. 2011. Sustainable intensification in African agriculture. *International Journal of Agricultural Sustainability* 9(1):5-24.

This review of 40 projects in 20 African countries examines the factors that contribute to successful adoption of technology by farmers. Key factors include: farmers and scientists collaborating on research; creation of social structures to generate trust between farmers and agencies; and sharing of information through use of farmer field schools.

Sileshi, G., F. Akinnifesi, O. Ajayi, and F. Place. 2008. Meta-analysis of maize yield response to woody and herbaceous legumes in sub-Saharan Africa. *Plant and Soil* 307(1):1–19.

Sileshi G., F.K. Akinnifesi, O.C. Ajayi, and F. Place. 2009. Evidence for impact of green fertilizers on maize production in sub-Saharan Africa: a meta-analysis *ICRAF Occasional Paper* No. 10. Nairobi: World Agroforestry Centre.

These extensive meta-analyses of 94 studies in sub-Saharan Africa demonstrates that herbaceous green manures increase maize yields by 0.8 t/ha on average compared to unfertilized plots.

Waddington, H., B. Snilstveit, J. Hombrados, M. Vojtkova, D. Phillips, P. Davies, and H. White. 2014. Farmer Field Schools for Improving Farming Practices and Farmer Outcomes: A Systematic Review. *Campbell Systematic Reviews* 2014: 6. Campbell Collaboration.

A systematic review of the FFS literature, covering both the benefits and constraints of FFS.

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Laurel Wilt Disease

by Gene Fifer

Figure 6. Ambrosia beetle. *Source: Tim Motis*

Introduction

"Save the Guacamole!" is the battle cry of a Florida campaign to fight the fungal disease killing avocado (*Persea americana*) trees throughout Florida. Laurel wilt disease is caused by the fungus *Raffaelea lauricola* and spread by the redbay ambrosia beetle (*Xyleborus glabratus*) (Figure 6). The redbay ambrosia beetle (a member of the insect order Coleoptera for the entomologists among you) was first identified in Georgia in 2002. It is thought that this beetle, native to Southeast Asia, was introduced through untreated cargo pallet wood and spread quickly to native redbay (*Persea borbonia*) and sassafras (*Sassafras albidum*) trees.

Other common trees and shrubs of the Lauraceae family are also susceptible, including Asian spicebush (*Lindera latifolia*), yellow litsea (*Litsea elongate*), camphor (*Cinnamomum camphora*), silkbay (*Persea borbonia humilis*), California bay laurel (*Umbellularia californica*), and the endangered native species pondspice (*Litsea aestivalis*) and pondberry (*Lindera melissifolia*) (GISD 2015). Plant death is not caused by the feeding of the beetles but from the laurel wilt fungus, which is now carried by the exotic redbay and native species of ambrosia beetle. The fungus grows in a tree's vascular system (the xylem and phloem), leaving it unable to transport food and water. The adult and larval stages of the beetle feed on the fungus in a symbiotic relationship. The beetles "farm" the tree, harvest their crop, and the spreading fungus chokes the tree.

Figure 7. Redbay die-off in The Everglades. *Source: JaxStrong, Creative Commons Attribution License*

The spread of the disease has been rapid due to the abundance of wild and ornamental host plants, and the transportation of firewood and other untreated wood products across state lines (Figure 7). Laurel wilt has spread throughout coastal regions of southeastern US, and infected redbay trees were identified in Texas in 2015.

Signs of attack by the ambrosia beetle and laurel wilt infection are toothpick-like accretions of sawdust (i.e., frass created while tunneling; Figure 8) protruding from trunk or branches, drooping leaves that

Figure 8. Frass tunnels (top) and sawdust frass at base of tree (bottom). *Source: Tim Watkins*

turn reddish or purple (Figure 9), and black streaks in the sapwood. The sapwood of dead and dying branches should be examined with a knife or ax to detect black or bluish streaks caused by fungal staining. Lack of black streaks indicates stress from phytophthora root rot, drought stress, freeze damage, lightning strike, and other causes. The University of Florida Plant Diagnostic Center is a good resource for pest and disease questions and lab services.

Figure 9. Dead leaves on infected branches. *Source: Tim Watkins*

Past and Future Impact

Avocado consumption in America increased sevenfold in the past twenty-four years, eclipsing bananas as America's highest value fruit import. Ninety percent of US production is in California, and 90% of US consumption is grown in Mexico. Avocados are high in vitamins, minerals, and unsaturated fats, which is part of the reason for their extraordinary growth in popularity. The emergence of avocados as a lucrative international commodity led to the nickname "green gold." The impact of laurel wilt on Florida's agriculture sector, the second largest avocado producing state, has included more than 40,000 culled trees, millions of dollars of lost revenue, and job losses.

If redbay ambrosia beetle makes its way to the US west coast, its spread will be hastened by the native California bay laurel (*Umbellularia californica*) and will quickly infect avocado orchards. The disease could also spread rapidly through avocado's native range of central Mexico, the highlands of Guatemala, Costa Rica, and Panama, as well as several commercial production regions elsewhere in Latin America. This epidemic potential has led faculty from the University of Florida Tropical Research and Education Center in Homestead, Florida, to collaborate with California researchers on best practices to detect infected trees, implementing swift sanitation procedures, and trapping ambrosia beetle populations (Crane *et al.* 2011).

Prevention and Treatment

No cost-effective fungicides or insecticides have yet been found. A complicating factor is that the pathogen can spread through root grafts (i.e. roots from adjacent trees that contact each other and join together). Infected trees should be removed immediately and neighboring trees should be treated with antibiotics (Ploetz *et al.* 2017). Preferred integrated pest management (IPM) options include:

- constant scouting with tree inspections
- removal and burning of affected trees (Ploetz *et al.* 2017)
- spraying chemical pheromone repellents to disorient and disrupt ambrosia beetles, combined with pheromone traps (Figure 10)

Figure 10. Pheromone trap. *Source: USDA, Creative Commons Attribution License*

- use of a parasitic biocontrol containing the fungus *Beauveria bassiana* that infects beetles (Zhou *et al.* 2018)

Long-term control will probably only come through breeding and identifying resistant varieties and rootstocks, which may take decades of research.

Though avocados have generally been a low maintenance, nutritious, and high yielding crop, increased vigilance and management are now required. ECHO community members in the Western Hemisphere should start inspecting their trees for signs of beetle attack and fungal disease on a regular basis. Since avocados are an important food and income source for smallholder farmers, it is important to have a cooperative community effort to identify the ambrosia beetle and affected trees, and to respond with whatever measures are available and affordable in your area.

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ECHOES FROM OUR NETWORK

Metal silos for grain storage

Recently, ECHO Community member Brad Ward asked on our online forum about metal silo construction. "I'm going to be building a 3.5 cubic meter metal silo. I have come across a couple of good resources online that cover the topic pretty well, but I would love to hear from those of you who have built and/or implemented silos at the household or community level. Are there some construction tips you could share? What has your experience been with using the silos? If they were used by more than one household, do you have some recommendations for helping to avoid future conflict? Thanks!!"

Brad received feedback from several network members.

Dr. Joel Matthews encouraged a community-first approach. "First, you will want to investigate traditional grain storage techniques. Do local farmers build their own silos? If so, does their traditional design utilize clay or other locally available building materials? Do local farmers believe that their traditional design fails? Are they interested in phasing in a new design? If so, what are the limitations of their technology that have been voiced by the farmers, and how can your design address those concerns? What is the cost/benefit ratio of traditional design vs. your proposed design?"

[Brad responded that these considerations have been taken into account in the community to which he referred.]

Nate Gray from Agri-Plus in Ghana responded, "I've been working on a similar project in Northern Ghana for the last couple years. We made and tested several prototypes inspired by the model that was at ECHO Florida. Our challenge was to adapt it in a way that could easily be reproduced here in Ghana using locally available materials, tools, and skills, while still being affordable to a smallholder farmer. So here is a brief explanation of what we have found...

"Currently we have some confidence in a model that measures about 46 inch tall by 46 inch in diameter using a 0.8mm to 1mm thick galvanized sheet metal. The joints are made simply by folding the seams in the same fashion as a tin can, a method that is already used by tinsmiths here in constructing water drums and other locally made sheet metal products. The seams are then sealed with some sort of sealant. One sealant that we've tried is a putty made from shea butter (very common here), cement and oil paint. This type of sealant can last a couple years if mixed properly and if the bin is not moved around much after sealing. More recently, though, we have been using a polyurethane caulk that has become available here. It is a bit more costly, but is much more reliable and longer lasting. For the inlet and lid, they made it wide enough for somebody to fit through to clean out the bin, and they fashioned it from sheet metal and then lined it with PVC. This is done by cutting a length of 1 inch PVC pipe lengthwise, then slightly heating it to press it out flat till it cools. It is then used to line the metal inlet and lid. The outlet spout and cap is made from a piece of 6 inch PVC riveted onto the opening of the bin. We've also added a fumigation chamber at the top using a 2 inch piece of PVC attached to the bin in the same way as the outlet pipe, with the exception that there is a perforated piece of sheet metal over the bin opening that allows air to flow but nothing more. This way when using fumigation tablets that are common here (such as aluminum phosphate tablets), there is very little risk of direct contact with the grain held inside, in case the tablets are not properly wrapped. We used PVC for all the openings because it makes it much easier to get a nice tight fit than with metal on metal.

Figure 11. Grain outlet spout and outlet locking lid. *Source: Edward Martin*

Figure 12. Finished metal silos roofed to protect them from the elements. *Source: Edward Martin*

"Concerning the question of use even by more than one household.... We have started to help organize the forming of what we have called Food Management Groups here. These groups are made up of about 10 people per silo that agree to contribute an equal amount of corn and store it in a locked bin until 'hunger season,' the last couple months of the growing season before new harvests come in (Figure 13). One silo can adequately serve 10 people, each representing an average size family, for about two months. Each year every member pays a small fee to use the silo. That money is saved and used to pay for the silo, purchase additional silos so the group can grow to include more of their community members, and possibly build some capital so that eventually they can use the extra funds to invest in grain to store and resell at a higher price. Each group is formed with a chairman/woman, secretary, and technician who is trained in proper fumigation and silo handling/maintenance. The fee is enough for a group of 10 to be able to buy a silo in two years, and low enough that it is less than half the value increase of their grain, so it still makes financial sense to use a bin. While we are still in the infant stages of forming these groups, so far we have seen them work together very well. Some members have testified that they have never experienced being able to feed their families debt-free through the hunger season with quality grain that is free of insect infestation. As a group, they are learning to better manage their food resources so that they still have food in the highest time of need, rather than selling their grains early in the year and needing to buy back at a higher price (often on credit), to be able to feed their families till the new harvest comes in.

Figure 13. Food management group depositing grain into metal silo. *Source: Edward Martin*

"I was concerned that the improvements we made after our original prototypes added too much cost to make them affordable to individual families, but so far we have still sold some to individual families that are using them."

Edward Martin from Agri-Plus added, "Last fall when I was in Ghana, I interviewed Peter Namba, the man on the left in Figure 14. I asked him what he likes about the Agri-Plus program and the metal storage silos. He replied, "I had grain left over at the end of the 'hunger' season. This has never happened before." Mr. Namba shares these two silos with several other families."

Figure 14. Peter Namba (left) in front of his silo. *Source: Edward Martin*

Brad was also encouraged by members to reach out to specific individuals who have experience in grain storage or who work in his region.

Join the conversation and get connected at http://edn.link/metalsilo.

For more resources about metal silos, visit ECHO's Grain Storage page at http://edn.link/grainstorage.

FROM ECHO'S SEED BANK

Culantro

by Gene Fifer

Culantro (*Eryngium foetidum*) is often confused with, or substituted for, cilantro (C*oriandrum sativum L.;* also called coriander). To add to the confusion, culantro has as many common names as countries of use:

Common name	Language or Country
longleaf or spiny coriander, sawtooth herb	English
shado beni or bhandhania	Trinidad and Tobago
chadron benee	Dominica
coulante	Haiti
recao	Puerto Rico
culantro de pata	Honduras
culantro coyote	Costa Rica
alcanate	El Salvador
coentro do pará	Brazil
fit weed	Guyana
ketumbar java	Malaysia
pak chi farang	Thailand
ngo gai	Vietnam
bhandhanya	India

Figure 15. Culantro leaves. *Source: The Rican Chef, Creative Commons Attribution License*

Culantro is in the Apiaceae family, which includes carrot, parsley, celery, and parsnip. Like many of the plants in this family, culantro has a biennial life cycle. Its natural habitat is the moist, shaded floors of tropical forests. When cultivated, it does best in fertile soil, planted in the shade and watered abundantly. Full sun, high temperatures, and long day length will end foliage production and initiate flowering and seed production, known as bolting. Preventing bolting is the key to longer production of the leafy cooking ingredient. Culantro is planted from seed and takes three weeks or more to germinate. The leaves form a basal rosette and should be picked when 30 cm long and 4 cm wide (Figure 15). As the season progresses and flowering begins, the emerging flower stalks should be plucked off to promote vegetative growth. Culantro is relatively pest and disease free.

Culantro is commonly used in chutneys, curries, soups, and meat and noodle dishes in Asia. Sofrito, a common spice mixture added to many recipes throughout Latin America, consists of culantro, garlic, onion, sweet peppers, tomatoes, salt, and pepper. Culantro's nutritional benefits include high levels of vitamins A, B2, B1, and C; it is also a rich source of calcium and iron. Culantro is used medicinally to reduce fevers (including from malaria), to relieve pneumonia symptoms, to reduce inflammation, and to relieve pain. The leaves and roots are boiled in water and used as a tea.

Go to ECHO's Global Seed Bank or Asia Seed Bank to order culantro seeds and learn about other herbs we offer.

References

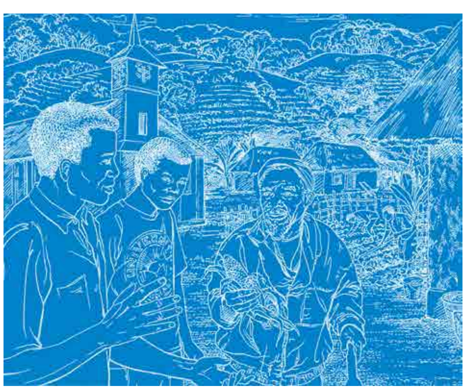
Ramcharan, C. 1999. Culantro: A Much Utilized, Little Understood Herb. *Perspectives on New Crops and New Uses* 506–509.

WorldCrops. 2018. Culantro. WorldCrops. 2018.

BOOKS, WEB SITES AND OTHER RESOURCES

Practical Creation Care: lessons on congregation-based restoration

Let's Restore Our Land by Dan Fountain has been republished by ECHO and is now available as an eBook and print book from Amazon in French and English. Print copies of these, and of a Creole translation, are also available at ECHO's Bookstore.



Let's Restore Our Land explains important aspects of community-based development by following the story of the Katindi people in Zambia. Led by Pastor Simon, they analyze, plan, and implement practical solutions to the challenges they face. Diverse subjects include soil improvement, tree nurseries, erosion control, conflict resolution, water conservation, and livelihoods, all from the perspective of consensus building, cooperation, and stewardship. The well-illustrated chapters can be used in a variety of group settings to teach and stimulate discussion on how to meet physical and spiritual needs.

Farming for Change: A Participatory Integrated Curriculum Project

Last November, at ECHO's International Agriculture Conference in Florida, Dr. Rachel Bezner Kerr shared results from over a decade of farmer-led research in Malawi, working to improve food security and nutrition. The research is unique because of its multifaceted nature. Dr. Bezner Kerr and her colleagues developed and released a curriculum that introduces agroecology, climate change, nutrition and social equity. The curriculum was designed for Malawi and Tanzania, and tested with 500 households and 400 households, respectively.

The curriculum is meant to equip community development workers or 'mentors.' It can be used by people with limited education, and includes people-centered learning; participatory methods encourage all who attend to teach and to learn from each other. Lessons incorporate stories, acting, and other participatory activities.

Lessons alternate between topics in the curriculum. In each of the categories, topics are covered sequentially. Categories and topics include the following:

- **Learning and Teaching Approaches**
- **Nutrition**: Basics; Dietary Diversity; Healthy Cooking; Special Nutritional Needs and Family Planning; Nutrition during Pregnancy; Breastfeeding; Complementary Feeding; Nutrition and Children's Health; Recipes for Children's Food.
- **Inequality**: Learning about Inequalities; Gender Inequality in Homes and Communities; Gender Roles; Work at the Home and Other Places; Relationships; Family Budgets and Food; Gender Inequality and Violence; What We Can Do about Gender-based Violence; Alcohol and Drug Abuse.
- **Farming with Nature**: Mixed Farming; Crop and Animal Diversity; Soil Health; Weed and Insect Management; Planning your Farm.
- **Weather and Climate Change**: Local Weather and Climate Change; Extreme Weather and Climate Change; Climate Change's Causes and Our Future Climate; Farming to Reduce the Threat of Climate Change.

The Farming for Change curriculum is available in Swahili, Tumbuka, Chewa, and English. It can be downloaded from this page; in order to access a download link, you will need to answer a few questions about your interest in the curriculum. The curriculum may be adapted and copied without requesting permission, if it is presented to users at no cost—but the curriculum's authors would love to know where and how it is being used! Contact information is available on their website.

UPCOMING EVENTS

ECHO Florida Events:

Location: ECHO Global Farm, USA
Presented by: ECHO

Introduction to Underutilized and Tropical Crops: Growing, harvesting, preparation
September 10 -14, 2018

Underutilized crops are those with "underexploited potential for contributing to food security, nutrition, health, income generation and environmental services." With severe weather extremes and other risks to global food security, many agricultural experts agree that global cropping systems should be as diversified as possible. As small-scale farms are particularly vulnerable to climatic and economic instability, underutilized crops may be key to their resilience.

In our Introduction to Tropical and Underutilized Crops class, participants can expect to receive an overview of appropriate crop options for challenging climates and environments. This course will cover a wealth of lesser-known crops, and review propagation, care and practical uses including cooking and tasting many of these plants.

ECHO's 25th Annual International Agriculture Conference
November 13 - 15, 2018

***Celebration** is the theme for this year's ECHO International Conference! We want to celebrate YOU, our network! One way we would like to celebrate and highlight you is with a video. We want to hear about your work, what ideas or techniques kick-started your project? What lessons did you discover along the way?*

We are asking for 1-2 minute cell-phone videos of network members sharing their journey in agriculture and community development. Everyone will watch these stories at our conference in November. You can upload your video here: http://edn.link/send-video

Tropical Agriculture Development I: The Basics
January 7 - 11, 2019

Tropical Agriculture Development 101
February 18 - 22, 2019
Gain practical experience! This introductory course will cover key topics to allow our participants even more hands-on practical experience!

Agroforestry
July 22 - 26, 2019

Seed Saving & Banking
September 16 - 20, 2019

More information and registration details can be found on www.ECHOcommunity.org.

ECHO Asia Event:

Sustainable Agriculture & Seed Production Workshop
August 5-6, 2018

Presented by: Department of Agricultural Land Resources Management, CIRAD, Royal University of Agriculture, ECHO Asia and Sustainable Intensification Innovation Lab

Location: Bos Khnor Station, Chamcarleu district, Kampong Cham

ECHO East Africa Events:

Best Practices to Improve Nutrition in Dryland Areas Symposium
August 7 - 9, 2018

Location: Naura Springs Hotel, Arusha, Tanzania

5th ECHO East Africa Symposium on Sustainable Agriculture and Appropriate Technologies
February 12-14, 2019

Location: Naura Springs Hotel, Arusha, Tanzania

ECHO West Africa Events:

Please contact Noemi Kara (knoemi@echonet.org) for information on trainings.

PLEASE NOTE: At ECHO we are always striving to be more effective. Do you have ideas that could help others, or have you experimented with an idea you read about in *EDN*? What did or did not work for you? Please let us know the results!