ECHO® Asia Notes

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Edited by Abram Bicksler and Rebecca Garofano **October 2014 | Issue 22**

Options for Small-scale Aquaponics: Letter from the Editor

by Abram Bicksler, Ph.D., Director of the ECHO Asia Impact Center

Over the course of recent years, we have received much interest from practitioners in our network looking for small-scale, inexpensive, appropriate aquaponics systems that can be used in a variety of situations throughout Asia. This ECHO Asia Note is dedicated to the background, creation, and use of small aquaponics systems with the intention of helping others to set up their own systems. As with all ECHO Asia ideas for use in agriculture, we encourage you, our members, to remember that agriculture is very environmentally and culturally specific. What works well in one location may not work in another location or may need to be adjusted and adapted. We invite you to share your experiences and lessons learned with us so that we may better be able to help others in our network. We hope you enjoy this issue!

A Low-Cost Concrete Ring Aquaponics System

by Preston Coursey

[Editor's Note: Preston Coursey is originally from Atlanta, Georgia. He graduated with a degree in geology with an emphasis in hydrogeology from the University of Georgia Southern. He currently lives in Chiang Mai and helps local Thais find resourceful and creative ways to enhance their own farming capabilities. He is currently researching aquaponics and green water technology, hoping to find appropriate and viable technologies for Thais to use in order to help them work toward self-sustainability.]

What is Aquaponics?

In aquaponic systems, both fish and plants are grown. The fish are typically in a fish tank, and the plants are separated from the fish in a trough or grow-bed. The fish in the system provide nutrients to the plants, while the plants in the system filter byproducts from fish excrement out of the water, which can otherwise accumulate to toxic levels (Figure 1).

After telling people this explanation, I am often asked, "So, do the plants eat fish poo?" The answer is no! Fish excrement is largely made of ammonia. A group of bacteria called *Nitrosomonas* spp. transforms the ammonia into nitrite (Figure 1). Another group of bacteria, called *Nitrobacter* spp., turns nitrite into nitrate (For more information about the roles of these bacteria, see: http://dev.brightagrotech.com/?p=1826). The plants in the system consume the nitrate, one of the most plant-available forms of nitrogen. In this way, the water is cleaned and can be reused without becoming toxic to the

Featured in this AN

The ECHO Asia Impact Center operates under ECHO, a non-profit Christian organization that helps you help the poor to produce food in the developing world.

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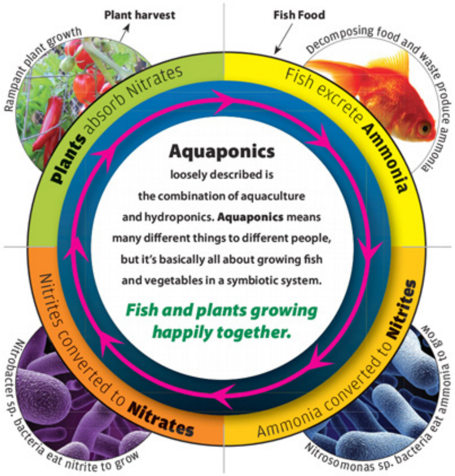
Figure 1. *Diagram of aquaponics systems. Used with permission from backyardaquaponics.com.*



fish. Both *Nitrosomonas* and *Nitrobacter* bacteria occur in water naturally. They are extremely important and make an aquaponics system possible; without them, levels of ammonia would escalate until fish in the system would be harmed and eventually killed.

Even with the presence of *Nitrosomonas* and *Nitrobacter*, too much fish excrement in an aquaponics system will cause problems. In our larger raft system and rock bed system, we use filters to remove the larger, solid pieces of fish excrement. Too many solids can get caught in and start to cover the root structure of the plants, rendering the plants unable to absorb as many nutrients as they need. After some time, fish excrement solids can even start to clog drains and piping, creating flow issues. Using filters in a larger system will dramatically reduce these issues. For more information about some of these filtration systems, see www.backyardaquaponics.com.

The beauty of aquaponics is that you can build a system any way you want. In my experience, there are three common types of aquaponics systems. Elements of each type of system, described below, can be mixed and matched to create a hybrid aquaponics system.

1. Floating Raft System – This system has an open trough of water in which plants float on a raft (usually made of Styrofoam). The plants are typically in 1- or 2-inch cups that sit in holes drilled into the raft. Plants grow above the raft, while the roots are submerged in the water underneath the raft; the latter remove nitrate and filter the water, which is recycled to the fish.
2. Rock Bed System – This system is a trough system just like the floating raft system, but instead of open water, the trough is full of rock (typically river rock). With this system, seeds are planted directly in the rock and do not have to rely on cups. Typically this system works in conjunction with a bell siphon (which will be discussed further).
3. PVC System – This type of system goes by many names. We call it NRT, which stands for nutrient-rich technology. In this system, we use PVC pipes as the "grow beds." The system looks a lot like the hydroponics systems that grow lettuce in pipes, which can often be found in greenhouses throughout the world. While both hydroponics and aquaponics systems produce plants, the nutrients to feed the plants in a hydroponics system come from organic or synthetic fertilizers dissolved in the water. In an aquaponics system, the nutrients to feed the plants come from the fish excrement. This PVC system requires the use of filters! If no filters are used, the big pieces of solid fish excrement will clog up the roots, reducing nutrient uptake and causing water flow issues throughout the system. In my opinion, the PVC aquaponics system is good for shallow-rooted plants such as lettuce, but not for long-rooted plants like tomatoes. If the roots are really long, they will travel throughout the system, clogging it and causing issues for other plants.

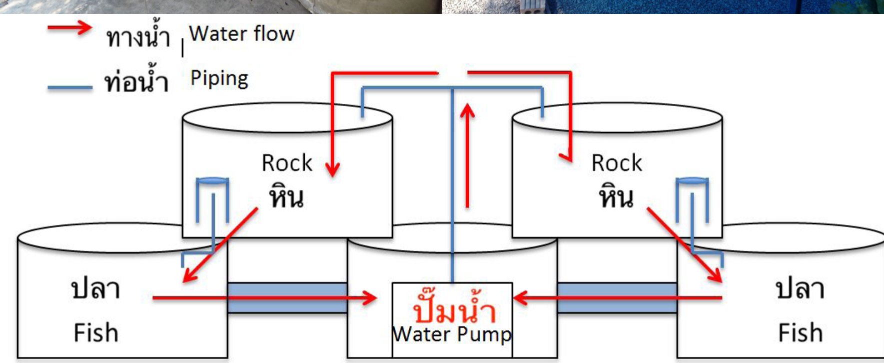
Our Farm

Currently, we have two 16 x 1 meter floating raft troughs, and one 16 x 1 meter rock bed that are connected to six 1 cubic meter fish tanks by PVC piping (elements 1 and 2 above). We also have three smaller stand-alone aquaponics units that we use as example starter units. One of our major goals is to help others understand how aquaponics works. We accomplish this by presenting aquaponics in a way that is easy to understand and replicate. Our Concrete Ring System, a rock bed system developed by Scott Breaden at his home and at the ECHO Asia Impact Center, accomplishes this goal. It has helped us cut down on building costs, simplified the system, and allowed us to use locally available materials.

How does a Concrete Ring System work?

The Concrete Ring System at our site is a small aquaponics unit that uses concrete rings with bottoms to hold water, instead of fish tanks or plant troughs.

The system at our site uses three concrete rings for the bottom (as the fish taks), and two concrete rings (as the rick beds) elevated on top of the bottom three. In the bottom of the system, the outer concrete rings are used as fish tanks. We are currently raising catfish in these tanks (see the fish section, below, for details and reasons). A PVC pipe connects all three concrete rings at the base of the unit, allowing water to flow between the three rings at the bottom and creating an equilibrium level among



(top left and right) Photos of ECHO Asia's aquaponics system (a hybrid rock bed and PVC system) and Preston's aquaponics system (a rock bed system), respectively. (below) ***Figure 2.*** *A diagram of the Concrete Ring System.*

the three rings. We use a plastic fencing material at the opening of the pipes, to keep fish from swimming through them. In the middle bottom ring, a water pump transfers water from the bottom of the unit to the top. We use a 50-watt pump with a maximum head (height of water) of 3.0 meters and a maximum flow of 2500 Liters per hour.

The top of the unit consists of two concrete rings. We have filled these two rings with rock (see descriptions below); this is where we grow our plants. We have also installed a bell siphon in each of the top concrete rings. As the bell siphon starts to work, the water is sent from the top of the system back down to the bottom rings. A continuous water cycle is created as water flows from the top of the system to the bottom using gravity, then is pumped back to the top.

Why We Built this Unit

Aquaponics can be a great alternative to farming or traditional gardening where land is limited, but starting an aquaponics unit can seem extremely complicated at first glance. We want to simplify aquaponics and enable individuals to successfully begin experimenting with it. In our quest for simplicity, we have focused on four areas: cost, material availability, size and relevance.

Cost is a major factor in sharing any type of technology; if the cost is too high, no one will be interested. Aquaponics often requires a high initial investment because of construction costs. However, one type of material that is very cheap in Thailand is concrete. It is locally available and Thais have a lot of experience working with concrete. In Thailand, you can buy concrete rings of all different sizes. Thais use these for planting trees, filtering water, and storing water. Thais even sell concrete rings with bottoms already on them, so they can hold water. By using these concrete rings, we have cut the cost of a small home-sized unit down significantly. The size of the unit is based on the size of the concrete rings, so this unit can be adjusted in size by using larger or smaller rings. The number of rings can also be customized. Our current concrete ring system only uses five rings, but the system can be expanded to use more. By keeping the system at the smaller size of five rings, we are keeping the system simple and easier to understand, while still showing how the system has the potential to be expanded.

Specifics of the System

Concrete Rings

For our specific system, we used concrete rings that are 80 cm (31.5 inches) wide and 40 cm (15.7 inches) deep. In Thailand you can buy them with bottoms, so they will hold water. They are usually waterproof, but we use a coal tar epoxy paint to help seal the ring. The coal tar epoxy also helps to prevent changes in pH caused by concrete (discussed later). This is the same type of material that is used to help protect boats from leaking. The coal tar epoxy we use needs to sit for at least two days before filling the rings with water or rocks.

Grow beds

We use the top two concrete rings of the system as grow beds. They are filled with river rock up to approximately 2 inches from the top of the ring. The water in the grow bed should only be allowed to fill to approximately 3 inches from the top of the ring, allowing the top layer of the rocks to stay dry. By doing so, you will cut down on the amount of algae that grows in your system. In our system, the height of the water column inside the grow bed is controlled by the height of the standpipe in the bell siphon (see below). In these grow beds, you can grow a variety of different vegetables, either planting seeds directly by hand, or growing seedlings on a tray and transplanting them into the system. We have had good success with tomatoes, lettuce, Chinese cabbage, cucumbers, peppers and Chinese kale.

Rocks

We use river rocks, which are locally available in Thailand. I would recommend buying some type of river rock because they tend to be durable. For the most part, river rock is made up of quartz, which has a very stable molecular structure and does not erode easily. Other types of rock may break down and cause issues with your pump or fish. I would suggest buying rocks that are as big as your thumb, but smaller than your fist. These should be large enough to avoid any water channeling effects in your system, but small enough for seeds to successfully grow into your beds.

Fish

Many different types of fish can be used in an aquaponics system. We use catfish in our concrete ring system. They are easy to find in Thailand, and relatively inexpensive (five baht / $0.15 USD per fish). They are easy to take care of—they do not require an (expensive, energy-intensive) air pump, because they require little dissolved oxygen in water in to survive. Our bell siphon alone creates enough dissolved oxygen in our system for the fish to live.

Photos: Top view of the Concrete Ring System.

Although catfish are easy to take care of, in other ways they can be difficult. I recommend buying younger, smaller catfish, because bigger ones will fight and kill each other for dominance when introduced to a new tank. Also, you will need to match your fish stocking density with the stage and capacity of your grow bed. *[Ed: see EAN #20 for helpful information on stocking densities]*. Finally, catfish like to jump out of their containers, so you will need to create a simple cover for your concrete rings. The cover can be anything from a plastic trash can lid to a fabricated cap, to plastic or metal netting, but just be sure it can be taken off and put on easily so that you can feed and harvest fish.

We feed the catfish store-bought fish feed that costs 550 baht ($17 USD) per 20 kg bag. It contains 32% protein, and we also use it with tilapia in a larger aquaponics system. Fish feeds contain different percentages of protein; you will need to find the appropriate amount for your fish. As the percent protein increases, the price of feed will increase as well. However, the lower the protein percentage, the less growth you will see in your fish, and the fish excrement will produce less nitrogen. In other words, fish growth and the amount of nitrogen in a system are proportional to the amount of protein in the fish food you are using. Take note that fish can only absorb up to a certain percentage of protein in their feed. Tilapia, for example, cannot absorb all the protein in a feed that is higher than 32% protein. Pick the correct type of fish feed for the species of fish you want to raise. *[Editors' Note: See ECHO Asia Note #20 for more information and ideas about creating your own on-farm fish feeds.]*

Ours is a small system used only to educate others about aquaponics, so we are not interested in harvesting fish. Because of this, we give the fish only 50 grams of food per day for the entire system. As a rule of thumb, if the fish have not eaten all of the food in five minutes, you are giving them too much feed. The more you feed the fish, the more excrement they will produce, and you will need either a more intense filtration system or plants that can deal with more nitrogen (larger plants require more nitrogen).

Here is a great video for understanding which fish to use and what type of food to use: http://www.youtube.com/watch?v=7S-d6MPvkaU&src_vid=oLwTdpTIXd8&feature=iv&annotation_id=annotation_254067

Bell Siphon

Our concrete ring aquaponics system has some technical parts. For example, we use a bell siphon, both to provide adequate moisture for the growing medium and plants in the medium, and to ensure there is oxygen in the root zone. Also, by allowing air to reach the lower parts of the concrete ring, we discourage anaerobic bacteria from growing and causing issues in our system. Here is a great blog to help you understand bell siphons and their benefits over a flood and drain design (http://freshfarmct.org/tag/siphons/). Here is a link to a great video that will help you understand how bell siphons work (http://www.youtube.com/watch?v=lyrvcCqv5V0).

Take the time to understand how a bell siphon works. At our site, we use a bell siphon with a 1-inch standpipe and a funnel at the top, to help with small changes in flow rates. The height of the standpipe will determine the height of the water column inside the concrete ring. The standpipe should be at least 2/3 the height of the concrete ring. The bell, or outside pipe, is made from 2 ½-inch PVC pipe with a cap. The standard rule for bell siphons is to always have a 1:2 ratio, so if the standpipe is 1 inch, the bell must be 2 inches. However, we use a 2 ½-inch bell to accommodate the funnel on the standpipe. Also note that the bell must be at least 2 inches taller (measured from the inside of the bell) than the standpipe and funnel inside the bell. If it is not 2 inches higher, the bell siphon will not work. Finally, for a successful bell siphon, the outflow pipe (the piping underneath) needs to have an elbow, or trap. The elbow helps restrict the outflow flow rate, which will help the siphon activate. If you do not want to use an elbow, you can use a straight pipe restrictor to achieve the same effect. See http://www.instructables.com/id/How-To-Build-A-Bell-Siphon/ for information on how to build a type of bell siphon.

We installed a guard around our bell siphon. The guard is a 6-inch PVC pipe, cut to fit around the bell siphon. We drilled holes into the pipe in order to allow water flow, but keep rocks out. The guard helps protect our bell siphon from being clogged by plant roots. We use a 6-inch PVC pipe because it is easy to stick a hand inside and pull away roots that may be clogging the bell siphon.

Bell siphons are very useful, but can also be frustrating. I have had several issues with bell siphons in the past, and I created a list of what to consider when troubleshooting a bell siphon:

Problem 1:
The bell siphon will not start siphoning

- Is your flow rate high enough? If it is not high enough, the water will just drain and not start the suction process.
- Are the bell and standpipe level? Generally the more level your standpipe and bell are, the fewer issues you will have. If the bell does not stand up straight, use a string or other mechanism to help secure it.
- If your bell siphon has been working for a couple of months and suddenly stops working, you probably have some flow restriction issues. After a system runs for a while, fish solids can stick to the sides of the pipe, restricting flow. Typically in this case you will need to clean out your pipes or replace the pipes coming from your water pump with bigger pipes.
- Take out the bell and see if there are any roots growing into the bell siphon, which will restrict water flow into the siphon.

(Top) Photos of the bell siphon. (Middle) Photo of the pump pipe. (Bottom) Overview photo of the Concrete Ring System.

Problem 2:
The bell siphon will not shut off

- Typically this means that there is too much water flow. You should always have a valve installed on the pipes coming from your water pump, to control water flow through the system.
- I have known some rock systems to have water-channeling issues. This results in the bell siphon turning on and off rapidly. If you use gravel that is too small, fish excrement will stick to the rock and create localized channeling. One solution is to clean your rocks. A better solution is to replace your rocks with bigger rocks.

Water Pump

For a five-ring concrete ring system like ours, you can use a water pump that is between 35 and 50 watts. A 35-watt pump can provide enough flow for the bell siphon (1 inch stand pipe) in the system to work, but if there is anything restricting water flow, you will start to have issues with the siphon. I would recommend using a 50-watt pump for a five-ring system. When you connect your pump to the system, make sure you use PVC pipes bigger than ½ inch in diameter. The ½-inch pipe will have issues with fish excrement sticking to the sides of the pipes, restricting flow over time. I would also advise against gluing the PVC that connects the pump to the top of the unit. If you use glue and then have any issues or want to reorganize your setup, you will not be able to change anything without rebuilding the system. Currently, our pump runs 24 hours a day, seven days a week, but you can use a timer if you are working with catfish (because they don't need dissolved oxygen).

Sun Protection

Some type of shade is important for this concrete ring system. If the unit is in direct sunlight all day, the water will get too hot and cause the plants to wither. During the hot season here in Thailand, most days easily reach over 95°F (35°C), which is challenging for plants and fish in an aquaponics system. We constructed a frame from bamboo and hung a shade cloth above the plants to protect them from the sun, but most days during our hot season in Thailand, it was still too hot and they wilted during the day. However, they usually perked back up at night when it started to cool a bit. If you live in a country with similar very hot temperatures, I suggest building the unit in an area that is shaded during part of the afternoon.

In an aquaponics system, sun protection also benefits the *Nitrosomonas* and *Nitrobacter* bacteria, which are extremely sensitive to sunlight. In addition to a shade cloth over the entire system, we also use shade cloth to cover the bottom rings of the unit.

Bottom Flow

We raise catfish in the two bottom outer rings of our system. These two rings are connected to the center ring, where the pump is located, by 2-inch PVC pipes that have been cemented into the walls of the concrete rings. 2-inch PVC pipes allow the water to flow through the system unrestricted. We also have a porous cover over the 2-inch pipe opening, to keep our catfish segregated to the outside tanks. Because the center ring is open to the air, it is important to have some type of mosquito control; in our case, we use guppies that eat mosquito larvae. We allow the guppies to swim from ring to ring. *[Editors' note: in the system at the ECHO Asia Impact Center, our "sump" ring, i.e. where our pump is located, contains a healthy population of guppies for mosquito control, as well as a covering of water ferns. The latter provide food for the guppies to eat, help clarify our water, and are an excellent protein source, if you are interested in making your own fish food (See EAN #20 for more information about the use of water fern).]*

(Top) Photos of the water pump and piping from the pump to the grow beds. (Bottom) Photos of the drain system.

Drains

We installed drains in all our concrete rings. These are necessary when we have to do any type of "deep cleaning." We use 1-inch PVC pipes with valves that drain into a nearby area. If you install similar drains, I suggest that you have them drain into an area where you can collect the water. This water is high in nitrate and can be used on a garden as a natural liquid fertilizer.

Filters

Since our system is a rock bed system, filters are not totally necessary. However, for our system we do use a very small filter. We cut off the bottom of a 4-inch planting cup, then placed an easily-removable sponge-like filter material inside. We placed the filter under the water inlet in the grow bed, where it catches excrement solids and reduces splashing from incoming water, thus reducing algae growth. We wash the filter daily, to take some of the excess excrement away from the system. Too much excrement may cause your rock to fill up with solids, which will block water from flowing to all parts of the grow bed, thus creating channeling issues. (Author's note: most water pumps bought at fish shops will come with a filter inside of them. In my opinion, the filter should be taken out. If left in, it can easily fill up with excrement and the pump will not work as well, thus causing your bell siphon not to work. The filter can be taken out and even used in the small filter mentioned above.)

Cleaning

The amount of cleaning an aquaponics system will need depends on the type of system. If you are using filters in your system, you typically won't have to clean your system for a couple years. Our concrete system has to be cleaned about four times a year. In our system, we currently have about 20 adult catfish that we feed 50 grams of food every day; if you are giving more than that, you may need to clean your system more often, depending on the amount of solid fish excrement in the system. Cleaning the system is not difficult, if you have drains installed. Be sure to move your fish to a temporary tank or bucket before cleaning your system. When it is time to clean, just open the drains. After running the unit for some time, the bottom rings will fill up with fish waste. When cleaning your system, make sure you stir up the fish waste so it is suspended in the water that is drained out of the system.

pH Control

Typical aquaponics systems usually have a pH range between 6 and 8. Using any type of concrete will cause the pH in your system to change drastically, potentially creating issues that could be detrimental to the health of your fish and plants. This problem can be solved in a couple of ways. We use coal tar epoxy to paint the inside of our concrete rings (discussed above). This is expensive to use, but you only need it for one application. If you prefer not to use coal tar epoxy, local Thais instead will cut up the trunk of a banana tree, put it in the concrete ring with water and let it sit for two weeks, which will neutralize the pH. This is a very successful method of neutralizing pH, but we used coal tar epoxy instead because we did not want to wait two weeks.

Getting Your System up and Running

When you first start your system I would suggest using only about 10 fish. As discussed earlier, the bacteria groups that convert ammonia to nitrite and nitrite to nitrate are extremely important for a successful aquaponics system. These bacteria groups occur naturally in water, but develop slowly. The older your system is, the better it will begin to work, because there will be more bacteria to create the nitrate you need. Your system may not be able to handle more than 10 fish in the beginning. After a month or so, you can start raising more fish.

As far as what to grow, I suggest starting with a vegetable that is easy to grow and does not demand a lot of nutrients. Remember, younger systems will not contain as much good bacteria as an older system, and thus will have fewer available nutrients. For systems that are started in Thailand, I always suggest to grow morning glories, since this vegetable seems to be able to grow anywhere. After about a month, you should be able to grow more nutrient-demanding vegetables, such as tomatoes.

As we learned earlier, in an aquaponics system, plants help fish and fish help plants. There should be an equilibrium between the number of fish you have and the number of plants you have. Aquaponics is all about balance, so if you have a lot of fish, then you should have a lot of vegetables (or more filters). That said, in my experience, the real issue is not how many fish you have, but how much you feed them. When you first start your system, I would recommend testing your system for ammonia, nitrite, and nitrate. Test kits for ammonia, nitrite, and nitrate can usually be found at most fish shops. If you see that your ammonia or nitrite has spiked to over 1ppm, then simply stop feeding your fish for a couple days (fish can live for several days without food).

The amount of feed you use will depend on the purpose of your system. For example, if you are more interested in harvesting plants than harvesting fish, you won't have to feed your fish very much everyday. You will just need to feed the fish enough to have a healthy amount of nitrate in the system. Here is a great article if you want to learn more about feeding ratios and general guidelines of aquaponics: http://aquaponics.com/media/docs/articles/Ten-Guidelines-for-Aquaponics.pdf

Safe Ways to Test Additives

An aquaponics system does not use soil. While there are some benefits to this, including a cleaner harvest and no need to till land, there are also some disadvantages. One major disadvantage of aquaponics is that some minerals that are naturally present in soil will not be in the water of the system. For example, iron is needed by most plants. It is not naturally found in an aquaponics unit, because the fish do not provide iron to the system. You will have to buy the appropriate type (usually chelated iron) and add it to the unit.

Any type of additive or pest control used in an aquaponics system must be totally organic, or your fish and/or plants may die. So, how do we know what we can put into the system? There is a way to test if what you hope to add is safe. Place a few of your fish in a container separate from your system, and connect it with an air pump. Then add half the concentration of the additive you wish to have in your system. Leave the fish in the tank for five or more days. If they survive, add double the amount of the additive. If the fish are still alive a week later, the additive is safe to use. Do not add anything that will change the pH of your system drastically, because aquaponics systems are very susceptible to swings in pH.

Costs

The cost of creating an aquaponics system will depend on the design of your system, the cost of materials, and the cost and usage of electricity, fish, and fish feed in your area. To give an idea of some of the affiliated costs, here is a table showing construction costs for two different cement ring systems created in Northern Thailand.

Double-Sided Unit	
Materials	Cost (THB)
Concrete rings (x5)	1000
6 inch PVC (for bell siphon guard)	400
2 inch PVC	200
2 inch PVC caps (x2)	60
1/2 inch PVC	200
1 inch PVC	200
Rock media* (per 80 cm3 side) (x2)	400
Water pump (35 watt)	250
Concrete	300
Plastic chicken wire	100
1 inch PVC elbows (x4)	100
1/2 inch PVC tee, 2 valves, hose adapter and elbow	100
Zipties	60
Paint**	400
Catfish	weighed
TOTAL COST	3770 = $115 USD

*Can use brick instead at 3 baht a piece
**May use banana stalks instead of paint to balance pH, but takes 2 weeks

All prices are dependent on how and where you buy materials. All PVC is estimated based on a 4 meter length price. Does not include false bottom.

Lessons Learned from Cement Ring Aquaponics Systems in Northern Thailand

by Scott Breaden

[Editor's Note: Scott Breaden has lived in Northern Thailand for eight years. He came here with a rich background in cross-cultural ministry, project management, and development in Australasia and Africa. For the past six years, he has enjoyed experimenting with backyard gardening and aquaponics in Chiang Mai, where he lives with his wife and son.]

The Beginning

Around five years ago, after reading online about aquaponics, a friend wanted to try a small-scale system in his urban backyard (a rental property) in Chiang Mai. I had some experience working with a larger system and was interested in trying a small-scale, low-cost system that would be portable and that could be used as a demonstration/training model. Unlike today, in which a great deal of information can be found online (especially in the form of YouTube videos), very little free information was available on the design, setup, and maintenance of small-scale systems. So everything we did during that first build-out was experimental.

Materials

Here in Northern Thailand, many backyard cement industries make cement rings (either 80 cm or 1 meter in diameter, and 40 cm high). These hollow rings are stacked on top of each either to form in-ground septic tanks, or stacked on top of each other to make above-ground water storage and water filters. The bottom rings have a cement base and are commonly used for raised garden beds, ornamental ponds, and raising frogs and/or catfish. In addition to the cement rings, blue PVC pipes and fittings of many sizes are common and cheap. Small 220-volt aquarium pumps are also easily available (in the city at least) and are commonly used for fountains and in small water features for homes, restaurants and gardens. Ideal medium (such as uniform round rocks around 1-2 cm in diameter) is harder to find, but normal crushed rock for use in concrete is cheap and easily available.

Putting it together (Figure 1)

After materials had been collected (we used 1 m cement rings with floors, a small pump, gravel of 0.5-0.75 cm diameter, and PVC fittings), our system was assembled in less than three hours and was test run without fish the next day, after the cement had dried. Then we stocked the system with 30 cheap and readily-available catfish fry (people growing catfish alone in cement rings in Northern Thailand sometimes stock up to 50 per ring). Locally, catfish are usually raised in cement rings in low quality

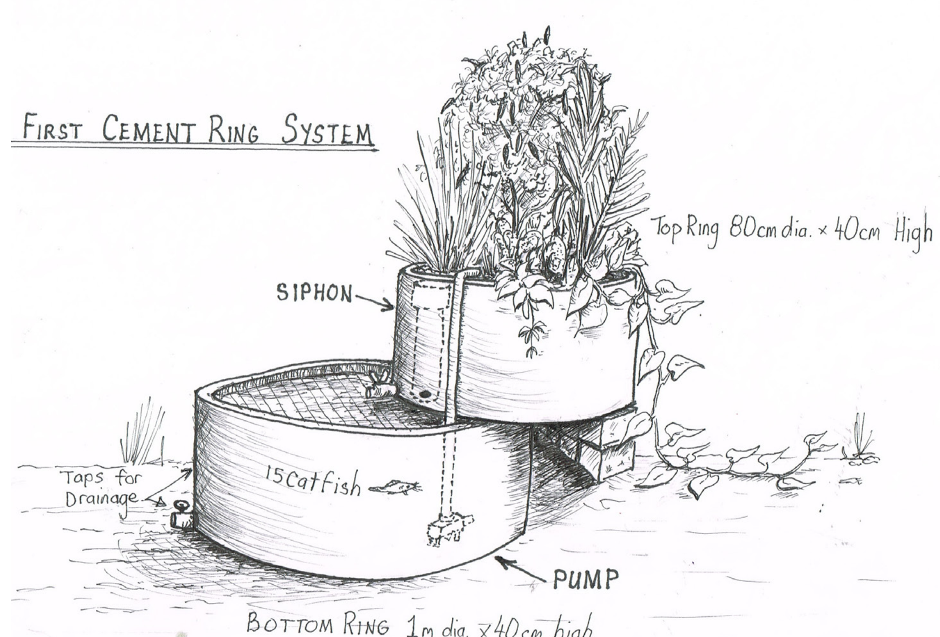


Figure 1. *Scott's first cement ring system. Illustrated by Scott.*

Single Unit	
Materials	Cost (THB)
Concrete rings (x3)	600
6 inch PVC (for bell siphon guard)	400
2 inch PVC	200
2 inch PVC cap	30
1/2 inch PVC	200
1 inch PVC	200
Rock media* (per 80 cm^3 side)	200
Water pump (35 watt)	250
Concrete	300
Plastic chicken wire	100
1 inch PVC elbows (x2)	50
Black or green hose	50
Zipties	60
Paint**	200
Catfish	weighed
TOTAL COST	2840 = $87 USD

*Can use brick instead at 3 baht a piece
**May use banana stalks instead of paint to balance pH, but takes 2 weeks

All prices are dependent on how and where you buy materials. All PVC is estimated based on a 4 meter length price. Does not include false bottom.

Conclusion

Aquaponics is a wonderful new technology that can be customized in many different ways. However, a successful aquaponics system will require daily management and basic knowledge of water chemistry. It will also involve a good deal of trial and error. As you experiment with aquaponics, you will tailor your system to fit your specific needs.

The world of aquaponics is new, but growing fast. Setting up a smaller unit is a great first step into learning about aquaponics. Our concrete ring system design provides an excellent and cheap opportunity for someone to try their hand at aquaponics!

water, so there was a low risk of having fish die if we made mistakes.

It took more than a month to get the plants growing well. While the fish were still fingerlings, our system was easy to manage, but as the fish grew bigger, the small aquarium pump struggled with too many fish waste solids and needed daily cleaning. *[Editors' Note: as mentioned in the previous article, the build-up of fish excrement and solids can reduce the water flow and cause problems in aquaponics systems].* We tried many things to keep the flow rate high and the pump clean (homemade filters, for example), but the cheap pump remained the weak link in the system. The small system worked well, although it would be a stretch to say that it was easy to operate. But it met our goals at the time of: 1) being cheap (under $ 40 USD) and 2) demonstrating that the principles of aquaponics could work on a small-scale.

Lessons Learned (Figure 2)

With the cement rings, pipes are easy to add and changes in design are straightforward. However, the rings are very heavy and difficult to move or rearrange, as I found when my friend moved countries and I moved the system to my own backyard. I did not like the idea of checking/cleaning the pump daily, so I changed the design and added an extra ring to act as a sump tank, which helped to collect the solids and keep the pump clean. As a result, I only needed to check and clean the pump once a month (Figure 2). I also stocked it with 15 catfish instead of the 30 that I started with initially, and I planted many perennials and water-loving plants to help in the water filtration process. The final system made a very good Thai herb garden, with perennial plantings of lemongrass (*Cymbopogon citratus*), birds eye chilies (*Capsicum frutescens*), basil (*Ocimum basilicum*), pandanas (*Pandanus amaryllifolius*), ginger (*Zingiber officinale*), galangal (*Alpinia galanga*), edible ferns (*Diplazium esculentum*), and morning glory (*Impomoea aquatica*). During the cool season, I also grew tomatoes, lettuce, bok choi, strawberries, and other leafy greens. Overall, the system didn't really produce large quantities of fish or food, but for me there was benefit even in producing a small amount of fresh, chemical-free food. I found this aspect was also the greatest point of interest to neighbors and visitors.

Looking Back

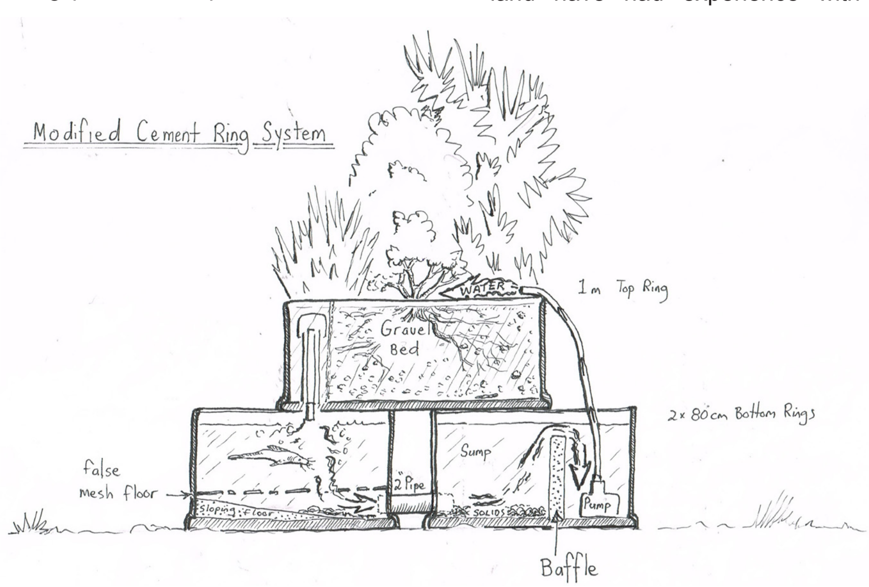
Today, if someone were to ask me to help build a small system on their urban rental property, would I use cement rings? The easy answer is yes, but I would not use the large 1 m rings. Today more options exist in terms of materials and designs (see Figure 3 for a prototype that I would like to try sometime). Something lighter and more easily moveable (than the 1 m rings) is generally more appropriate for an urban setting. I think a larger cement ring design could be appropriate for rural areas, since many people in rural areas (at least in Northern Thailand) know how to join the cement rings together and add PVC pipes. Four or five people could drop in and give a hand to lift or shift the rings without any trouble. Also, the issue of weight and permanence would not be as much of a problem in a rural setting as in an urban area. And finally, many rural people in Northern Thailand have had experience with raising catfish in cement rings, so adding the pump and gravel bed would just be adding to an already existing system.

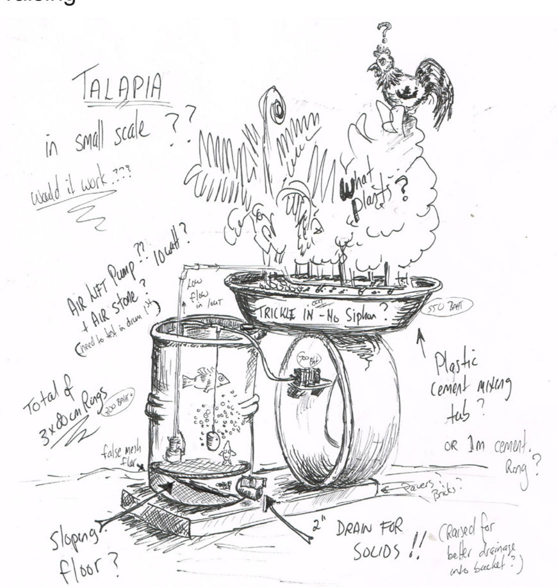
The Bigger Picture

I personally think that small aquaponics systems are more difficult to run than larger systems (larger than 1000 L), and I warn people that things can go wrong quickly in these small systems. But a small system like the one I have outlined is great to show people the principles and parts of an aquaponics system (i.e. it demonstrates how various siphons, pumps, etc. work, and shows the relationship between fish, nitrifying bacteria and healthy plants; it can also make a very nice water feature on a property). But a small system doesn't necessarily model food production, because it isn't big enough to show how to produce larger quantities (or support larger projects such as large childrens' homes) of either vegetables or marketable fish.

A larger scale system has additional challenges. Besides keeping the fish-vegetable system running in equilibrium, someone running a large scale system also needs to source and store seeds; germinate and transplant vegetables; and harvest, process, and market the fish and produce. The complexity of all these parts working together is more easily appreciated when seeing a larger system. However, for home consumers, a small system is a great starting place for learning the principles of food and fish production, and it can easily be ramped up.

When I made my own backyard aquaponics system, I constantly thought about how I





(left) ***Figure 2.*** *Scott's modified cement ring system.* (right) ***Figure 3.*** *Plans for a future prototype aquaponics system. Both ilustrated by Scott.*

could make it simpler and how I could make it work in the cheapest, easiest manner. I came from a background in large-scale extensive agriculture, with no experience or knowledge of highly intensive small-scale systems. Over time, each of my aquaponics systems have become more complex, and this increase in complexity has been rewarded with a better product or more produce. I have also found that the more energy and time I put into improving the design, the more satisfaction I get from managing it.

I now have the capacity to produce food for my own family in a satisfying way. I am no longer afraid of producing food intensively; I enjoy the complexity of the system and see it as a positive attribute, because it opens doors to learning and to new ways of doing things. With aquaponics, you can start simple, and as your knowledge increases (about best practices and how to best maintain the system), you can grow and expand your system in many different ways, being rewarded for your creativity (i.e. thought/design is rewarded with tangible outputs).

As an unforeseen side benefit of creating this system, I have met many people, and have built relationships with people I would not have known otherwise, which has made life so much richer and deeper. My aquaponics system has been a great talking point with my neighbors, all of whom value healthy food and see my system as a source of love/care in the way it provides good, healthy food to the family.

Photos of Scott's backyard aquaponics systems. Photo credit: Scott Breaden.

Selections From the ECHO Asia Seed Bank

Two plants of merit that our seed bank stocks include Chia and Mung bean. As a registered Active Development Worker on ECHOcommunity.org, you can receive up to 10 free packets of seed each year. In exchange for seeds, we ask that you fill out a crop evaluation form, which you can find here. For more information about our seeds, see our current 2014 Seed Bank Catalog, and also be sure to note that we currently have 28 new Seed Fact Sheets as part of our Online Seed Store, which provide more in-depth information about the crop, nutritional and culinary values, the care and culture of the crop, and how to overcome any potential issues (pest, disease, growing period) the crop may have. We hope that you find these fact sheets to be of great use!

Chia/เชีย *Salvia hispanica*

"Chiang Mai" Variety: Multicolored seeds, from white to brown to grey, come from plants naturalized in Northern Thailand.

Description

Chia is an annual, herbaceous plant in the mint family growing to about 1.5 meters (approx. 5 feet) in height. It originates from Central America, where it has been grown primarily for its tiny but highly nutritious seeds, for thousands of years. Chia is best planted towards the end of the rainy season, with the harvest of mature seeds taking place approximately four months later. Too much moisture during seed-setting and maturity can lead to harmful mold and bacteria growth on the seeds.

Chia seeds yield 25-30% extractable oil which is rich in essential fatty acids. It is one of the highest known sources of Omega-3 fatty acids. Seeds can be added to any meal or drink and can be digested without breaking the seed coat. The widely acclaimed health benefits of Chia can be attributed to its overall high nutrient content: high in soluble fiber, 20-23% protein, rich in antioxidants and minerals. Seeds soaked in water will dissolve to create a gel that can be used in other cooking and mixed in juices. Leaves can be steeped to make tea used for a myriad of health problems.

Mung Bean/ถั่วเขียว *Vigna radiata*

"Burmese Green" Variety: Day-neutral, bush variety. New to ECHO Asia. Green seed.

"Lao" Variety: Day-neutral, bush variety; approximately 60 days from flowering to seed. Green seed.

Description:

Mung bean is an early-maturing bush/slightly vining legume, high yielding and widely adaptable. It is used throughout Asia as a food legume, for flour, in desserts and sprouted for use in other dishes. It has a protein content of approximately 25%. Mung bean is cultivated most extensively in the India-Burma-Thailand region of South-east Asia but found in countries such as Iran, Pakistan, Vietnam and China as well.

Mung bean is a short season crop requiring 60 to 90 days from planting to maturity. Grows mainly within 20-40° C (68-104°F) and up to 2000 m (6,562 ft.) in the tropics. Grows well in areas with average rainfall of 600-1000 mm (24-39 in.) but it can survive with less precipitation. Generally grows well on warm, sandy or otherwise loose soils but prefers well-drained loams or sandy loams with a soil pH range of 6.2–7.2.

Book Review: Edible Leaves of the Tropics

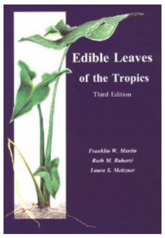
Reviewed by Craig Soderberg

[Editor's Note: Reprinted with permission from Appropriate Technology and Craig Soderberg. Edible Leaves of the Tropics is carried by ECHO Asia, as well as ECHO in Ft. Myers, Florida, and many of the plants highlighted in the book are carried by ECHO Asia or can be sourced from our network partners.]

Edible Leaves of the Tropics, Third Edition, by Franklin W. Martin, Ruth M. Ruberte, and Laura S. Meitzner.

Published by Educational Concerns for Hunger Organization, Inc. 1998

ISBN: 0-9653360-1-8



To purchase this book or for more information contact: echoasia@echonet.org; http://www.echonet.org

Chapter Overview

This book contains ten chapters: (1) the place of green leaves in the diet, (2) the principal edible green leaf herbs of the tropics, (3) some vegetables, fruits, and ornamental plants with edible leaves, (4) common weeds with edible green leaves, (5) tropical trees with edible green leaves, (6) tropical leaves as spices and teas, (7) temperate zone green leaves in the tropics, (8) lettuce in the tropics, (9) tropical leaves that are poisonous, (10) culture and care of green-leaved vegetables.

Chapter one contains a helpful list of other books with information on edible leaves. Unfortunately many of these books are hard to find because they were not recently published. For example, A Dictionary of the Economic Products of the Malay Peninsula (Burkill 1935) was published in 1935 and therefore difficult to obtain.

Chapter two was helpful in that it lists many edible plants which are perennial (i.e. can grow for several years) (i.e. *Xanthosoma brasiliense*, *Basella alba* a.k.a malabar spinach, *Gynura crepioides* (okinawa spinach), *Ipomoea batatas* (sweet potato), *Ipomoea aquatica* (kangkon, water spinach, *Manihot esculenta* (cassava), S*auropus androgynus* (katuk), sauropus, *Hibiscus sabdariffa* (roselle).

Chapter three mentions which vegetables and fruits have edible leaves. For example, the young developing leaves of corn are edible. Leaves of young onions are edible. The spicy shoots of ginger (consisting of young leaves folded around each other) are edible. Leaves of okra, carrots, radishes, and eggplant are also all edible. Many fruit trees have edible leaves as well. For example, the leaves of mangoes, ambarella, durian, soursop, bignay, gooseberry, papayas, coffee can all be eaten.

Chapter four lists some common weeds with edible green leaves, including moonflower, mustard, butterfly pea, *S.macrocarpon*. But the reader is cautioned that many of these plants, when eaten excessively, can be poisonous.

Chapter five lists tropical trees with edible leaves including coral trees, dwarf bucare, (p.47), *G.gnemon* trees, *Pisonia alba* (nyctaginaceac) (tree lettuce), neem, moringa.

Chapter six lists various tropical leaves used as spices. In fact, 52 tropical spices are listed in table 2 and 20 plant leaves used in tea are listed in table 3 of this chaper. But the chief spices of the tropics are not from the leaves, but from other plant parts, as with pepper, cloves, ginger, cinnamon, allspice, vanilla, chili peppers, cardamon, and nutmeg.

Chapter seven provides some information about temperate zone green leaves in the tropics. The chapter primarily describes different types of cabbages but it also describes chicory, endive, swiss chard, beet greens, celery, and a few miscellaneous species.

Chapter eight discusses different types of lettuce that can be grown in the tropics.

Chapter nine discusses tropical leaves that are poisonous.

Chapter ten discusses the culture and care of green-leafed vegetables such as climate, moisture, soils, fertilization, soil preparation, care and harvest.

The book ends with 56 helpful photos and illustrations of some of the plants mentioned in the book.

Strengths and weaknesses of the book

This book was a helpful resource which is readily available to the public. Many similar books are now out of print because they were published decades ago. The authors provide helpful advice in that they recommend cooking the vegetables because cooking reduces bacterial and fungal contaminants, tends to wash off any pesticides, and changes the nature of some nutrients (p. x).

The book did have a few weaknesses. One weakness was that the book had no glossary. A glossary would have been helpful for those of us who are not experts in agriculture. For example, the word 'crucifers' was used on the first page of the first chapter. But many readers may not know that crucifers are vegetables of the family *Brassicaceae* (also called *Cruciferae*).

The book spoke of drying green leaves and preserving them as powder. But no instructions were given for this practice and no reference was given for those of us who would like to know how to do this (p.1). However, Motis and Berkelaar (2012) did have a short overview of this topic.

Also many of the plants mentioned in the book did not have corresponding photos or sketches or at least did not mention where to find those corresponding photos or sketches.

Most of the readers of this book would probably like to know where to obtain seeds for the plants mentioned in the book. The book did have a section for seed sources but most of the companies listed were not located in the tropics (p. 151). After this current reviewer contacted many of them asking for certain seeds listed in this book, the seed companies said that they did not carry those seeds since there are not selling tropical seeds. But this is not a shortcoming of the book. This is a shortcoming of the seed distribution system in the tropics.

However, overall this book is recommended for farmers, development workers, survivalists, and anyone else wanting to learn how to plant and eat what they plant in the tropics.

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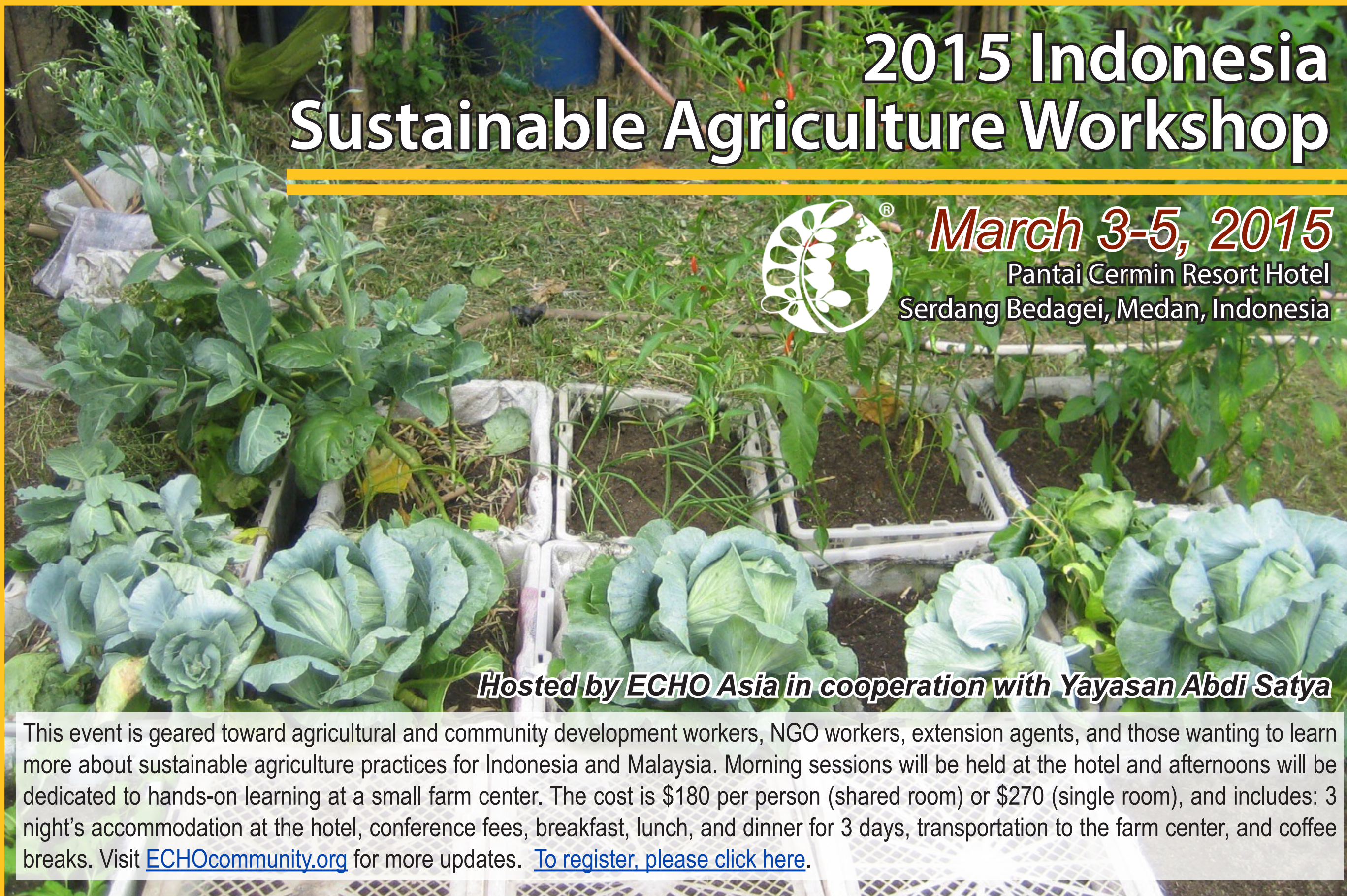
Burkill, H.L. 1935. A Dictionary of the Economic Products of the Malay Peninsula. Crown Agents for the Colonies, London. 2402. Pp.

Motis, Timothy N. and Dawn R. Berkelaar. 2012. Agricultural options for the poor: A handbook for those who seek to serve them. Fort Meyers, FL: Echo. p. 175.


2015 Indonesia
Sustainable Agriculture Workshop
March 3-5, 2015
Pantai Cermin Resort Hotel
Serdang Bedagei, Medan, Indonesia
Hosted by ECHO Asia in cooperation with Yayasan Abdi Satya
This event is geared toward agricultural and community development workers, NGO workers, extension agents, and those wanting to learn more about sustainable agriculture practices for Indonesia and Malaysia. Morning sessions will be held at the hotel and afternoons will be dedicated to hands-on learning at a small farm center. The cost is $180 per person (shared room) or $270 (single room), and includes: 3 night's accommodation at the hotel, conference fees, breakfast, lunch, and dinner for 3 days, transportation to the farm center, and coffee breaks. Visit ECHOcommunity.org for more updates. To register, please click here.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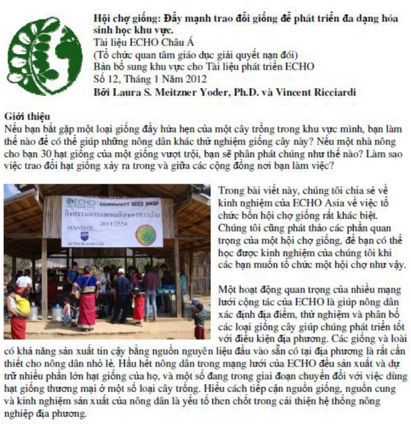
ECHO Asia Notes Now Available in Vietnamese



Hội chợ giống: Đẩy mạnh trao đổi giống để phát triển đa dạng hóa sinh học khu vực.
Tài liệu ECHO Châu Á
(Tổ chức quan tâm giáo dục giải quyết nạn đói)
Bản bổ sung khu vực cho Tài liệu phát triển ECHO
Số 12, Tháng 1 Năm 2012
Bởi Laura S. Meitzner Yoder, Ph.D. và Vincent Ricciardi

Giới thiệu
Nếu bạn bắt gặp một loại giống đầy hứa hẹn của một cây trồng trong khu vực mình, bạn làm thế nào để có thể giúp những nông dân khác thử nghiệm giống cây này? Nếu một nhà nông cho bạn 30 hạt giống của một giống vượt trội, bạn sẽ phân phát chúng như thế nào? Làm sao việc trao đổi hạt giống xảy ra trong và giữa các cộng đồng nơi bạn làm việc?

Trong bài viết này, chúng tôi chia sẻ về kinh nghiệm của ECHO Asia về việc tổ chức bốn hội chợ giống rất khác biệt. Chúng tôi cũng phát thảo các phần quan trọng của một hội chợ giống, để bạn có thể học được kinh nghiệm của chúng tôi khi các bạn muốn tổ chức một hội chợ như vậy.

Một hoạt động quan trọng của nhiều mạng lưới cộng tác của ECHO là giúp nông dân xác định địa điểm, thử nghiệm và phân bổ các loại giống cây giúp chúng phát triển tốt với điều kiện địa phương. Các giống và loài có khả năng sản xuất tin cậy bằng nguồn nguyên liệu đầu vào sẵn có tại địa phương là rất cần thiết cho nông dân nhỏ lẻ. Hầu hết nông dân trong mạng lưới của ECHO đều sản xuất và dự trữ nhiều phần lớn hạt giống của họ, và một số đang trong giai đoạn chuyển đổi với việc dùng hạt giống thương mại ở một số loại cây trồng. Hiểu cách tiếp cận nguồn giống, nguồn cung và kinh nghiệm sản xuất của nông dân là yếu tố then chốt trong cải thiện hệ thống nông nghiệp địa phương.

ECHO Asia Notes are now being made available in Vietnamese! To see the first Vietnamese publication, on Seed Fairs, please visit ECHOcommunity.org.

To subscribe to future Vietnamese publications and other ECHO Asia Notes in regional languages, be sure to change your subscription preferences in your membership profile.

Seeking Applicants: ECHO Asia's National Volunteer Program

ECHO Asia is looking for talented individuals to enroll in our National Volunteer Program. The aim of the program is to give Asian leaders, development workers, farmer-leaders, etc., hands-on training at our ECHO Asia Seed Bank in the basics of sustainable agriculture, appropriate technology, seed banking, and a host of other ECHO Asia techniques and services. This program is open to nationals of Asian countries who are actively engaged in agriculture or community development and wish to further their knowledge base and application of sustainable development techniques. Volunteers should demonstrate: a commitment to agriculture and/or community development by previous work experience; the ability to work independently, yet while part of a team; the possession of critical thinking skills; and the ability to engage with and live in a diverse community of Thai nationals and foreign workers.

Volunteers will be accepted on a rolling-basis and the length of the program can be tailored from 3 months-1 year. Volunteers will stay at the ECHO Asia Seed Bank, on the grounds of the Upland Holistic Development Project, in Mae Ai, Thailand. Volunteers must be able to speak English and/or Thai and be able to work outside at all times of the year. Organizational or church affiliation is desired, but not absolutely necessary. As this is a volunteer program, most of the training will be hands-on, and training will mainly be provided while assisting the seed bank staff with daily operations.

ECHO Asia will provide housing for the volunteer and a small monthly stipend. The individual or affiliated organization/church will be expected to write a letter of recommendation for the individual, cover all visa costs and processing fees to receive a visa for the Kingdom of Thailand, provide transportation to/from the Seed Bank, and cover any other costs the individual may accrue during the program.

To request an application, please e-mail echoasia@echonet.org