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Edited by Dawn Berkelaar and Tim Motis

ECHO is a Christian non-profit organization whose vision is to bring glory to God and a blessing to mankind by using science and technology to help the poor.

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NOTE: Link to extra material, full references and websites from the web version of *EDN* 105.

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A Low Resource Method to Raise Fish in Haiti

By William Mebane, Marine Biological Laboratory, Woods Hole, Massachusetts

Editors: We at ECHO have followed this project for the past few years as Bill Mebane often stops by ECHO on his way to or from visits to the project in Haiti. We recognized that he had made a breakthrough when he brought reports of success with a technique developed in Israel for growing "organically certified" tilapia by adding (1) submerged bamboo poles or palm fronds and (2) a submerged "compost pile" to fertilize the pond. Microscopic organisms collectively called "periphyton" grow on the surface of the submerged poles or fronds. This is the preferred food for tilapia. According to Bill Mebane, "If used properly, the method can produce high quality protein for human consumption using a minimum of precious human and natural resources." We asked Bill to share some of this work with our readers.

According to the Marine Biological Laboratory (MBL) website, MBL in Woods Hole, Massachusetts (USA) is "an international center for research, education, and training in biology. The oldest private marine laboratory in the [USA], the MBL currently supports a year-round staff of more than 275 scientists and support staff working in such fields as cell and developmental biology, ecology, microbiology, molecular evolution, global infectious disease, neurobiology, and sensory physiology."

Background

In 2002, we at the Marine Biological Laboratory were asked to help enhance fish (tilapia) production in more than 50 ponds that had been built in the Cormeir area of Haiti by CODEP missionaries (CODEP, Comprehensive Development Project, has been active in Haiti for more than 15 years, and works primarily in the area of reforestation). The concrete ponds were designed to be filled via rainwater runoff from mountains and roads during the rainy season, and the fish (provided by the CODEP mission in LaCul) were to be fed commercial feed imported from the states. Political turmoil and the difficulty and cost of importing commercial fish food were problems that plagued the productivity of the ponds. The concept was good but these unforeseen obstacles resulted in the ponds being unproductive or unused.

Method

Our initial approach was to formulate fish food using locally available plant material (leaves from cassava and from calliandra, moringa and leucaena trees). These efforts were successful and the formulation was capable of growing fish. However, the method was too burdensome on both human and plant resources. The science behind making fish food is complicated, but as we found out, not nearly as complicated as making the whole process fit with the culture of Haitian life. Life in rural Haiti is a day-by-day challenge. Families spend most of their waking hours hauling water, tending crops and gathering food; they simply do not have enough time to devote to growing and making feed for livestock that takes six months to be harvested.

Thanks to advice and collaboration with colleagues who have worked in aquaculture in developing areas around the world, a decision was made to use a fish culture technique better suited for rearing fish in Haiti. The method involves using what has been termed periphyton aquaculture technology

(PAT). Periphyton is the green slimy material that grows on the surface of almost anything submerged in water (Figure 1). Depending on the nutrients available in the water, periphyton can contain 100% of the essential amino acids necessary for fish to grow. Tilapia, the species of fish being grown in Haiti, are especially adapted to feed on periphyton and are extremely efficient at converting periphyton into high quality fish flesh. The quantity of fish produced using the PAT technique is directly proportional to the quality of the fertilizer (compost) added to the pond and to the availability of special surfaces that the periphyton need to grow on. If done properly, the growth rate of fish reared using the PAT technique can equal that of fish being fed expensive commercial fish food.

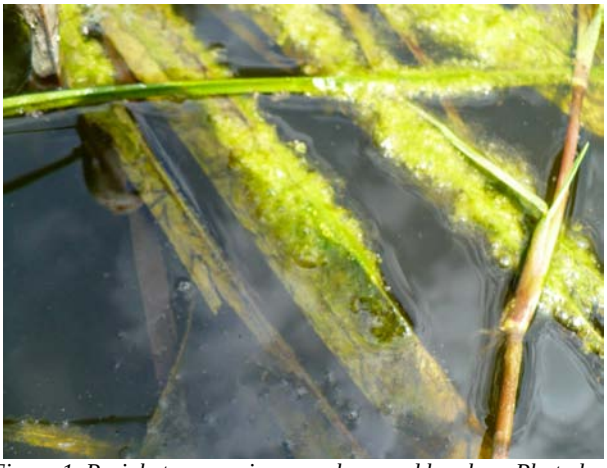

Figure 1. Periphyton growing on submerged bamboo. Photo by William Mebane.

In March 2007 we worked with CODEP to conduct training seminars in Haiti, teaching Haitian animators how to rear fish using the PAT methods. (An animator is an agricultural extension agent; each of these animators is in charge of overseeing the work of 30 to 50 fellow Haitians in specific regions of Haiti.) The animators were then responsible for getting their fellow Haitians to implement the PAT techniques in the more than 50 ponds that were currently fallow due to lack of food for fish (Figure 2).

Rearing any form of livestock without the direct use of "food" is difficult to understand, especially for a culture attempting to rear fish for the first time. Initial efforts to develop trust in this odd concept (PAT) were agonizingly slow, but now that people see fish being regularly harvested they are gaining confidence in the methods. Furthermore, we are beginning to see unprompted duplication of the technique by others. A four-hour hike into the Gwo Mon area of Haiti confirmed rumors that over 20 new ponds had been constructed and people were using the PAT technique in this remote area. The families that constructed these ponds were not part of the original group trained by CODEP animators. We speculate that these people learned of the method by talking to others who were having some success.

Figure 2. Animators demonstrating how to install bamboo substrate for periphyton to grow on. Photo by William Mebane.

During our most recent visit to Haiti we witnessed the harvest of a pond that had been managed by two Haitians we had trained earlier. Fish in this pond were raised using the PAT technique. Manure, leaves and minimal human labor were the only inputs. Approximately two pounds of small fish were stocked into the pond and 25 pounds were harvested! A harvest of 25 pounds is only a fraction of what the pond was capable of producing, but it was a great start. The harvested fish were sold, traded, and eaten by many people. It was inspiring to see many people reap the benefits of a nutritious meal and to see the ponds generate some income, but what was most inspiring was the enthusiasm expressed by the farmers to *repeat the process* and try to do it even better!

Basic Guidelines for Successful PAT Fish Rearing

Ponds (rearing units). The ponds can be earthen, concrete, or built using a liner. The depth should be less than a meter, and water exchange rate should not exceed one turnover every two weeks. Every effort should be made to build the ponds in areas where they receive maximum sunlight.

Types of substrate for growing periphyton. Bamboo seems to be the best substrate. [In this context, the word "substrate" means "whatever surface is chosen on which the microscopic plants will grow."] Palm or coconut fronds work well also. It is very important to position the substrate so it remains submerged and gets maximum exposure to sunlight. Many methods can be used to accomplish this goal: bundles of sticks can be stuck in the muddy bottom of a pond; pieces of substrate can be hung from wires strung across the pond; or large branches can simply be placed in the ponds. To facilitate the ease of harvesting fish, the substrate should be installed so that it can be easily removed if a seine is used to harvest. If the substrate begins to rot prior to fish harvest, additional substrate should be added.

Providing nutrients to enhance periphyton production. Construct simple submerged compost bins within each pond. The compost bins can be made of woven sticks, concrete blocks, or other material. There are some key criteria to keep

in mind: the bins need to be permeable to water, strong enough to loosely retain several hundred pounds of organic matter, placed in an area with easy access for filling and mixing, and constructed to occupy approximately 1/20th the surface area of the pond (Figure 3). The compost bin basically serves as a giant "teabag," oozing nutrients while retaining the solid materials. If inorganic fertilizers are available, the compost can be reduced in size or eliminated [though in this case the fish you harvest would no longer be considered "organic"]. Regardless of the source of nutrients for the periphyton, the optimum nitrogen to phosphate ratios appear to be about 6:1. In our experience using submerged compost in Haiti, keeping an equal balance of green (non-woody) plant material, non-meat food scraps and fresh (non-human) manure has worked well. Poultry manure is best for the latter component. The compost bins need to be kept full and stirred or mixed at least three times per week if possible.

Figure 3. A drained pond showing the compost bin in the top left corner. Photo by William Mebane.

Stocking ponds. Obtaining fingerlings for stocking can be done either of two ways:

a) Collecting fry from existing ponds. Tilapia as small as 50 grams are sexually mature and will spawn every 30 to 40 days if they are healthy. Eggs are fertilized externally and are incubated and hatched in the mouths of adults. Young fry can be collected from almost any pond containing mature fish using a fine mesh net (window screen mesh size works well) on a long handle. Adults carrying eggs or young fry will not eat often and their lower jaw will appear distended. When agitated, or during brief times of feeding, these adults will discharge or spit out their cargo, which can be collected. One of the easiest ways to collect young fry is to walk quietly along the edge of a pond and look for plumes of young fry that hover near the surface while their parents forage nearby. A quick net and stealthy movements by the collector are key to successful fry capture (if the fry are startled they will quickly swim back into their parents' mouths). This method should also be used to cull young fry from production ponds, to keep the fish from overpopulating the pond.

b) Producing fry from selected brood stock. Stocking adult fish in well-maintained smaller tanks at a ratio of 3:1 (female:male), is probably one of the easiest methods to produce fry. Careful observation of these brood stock fish will reveal when an adult is caring for eggs (distended lower jaw) and the harvesting of fry can be a bit more controlled. It is important to collect the fry as soon as they are able to swim, and to use large fish for brood stock. The quantity of eggs produced is directly proportional to the size of the adults.

If the fry were placed into the production pond, there would be equal numbers of male and female fish. Because they reach sexual maturity at such a young age, soon the pond would be filled with a harvest of thousands of small stunted fish. None would reach a good size. [It is quite possible that even very small fish might be fried until crisp and eaten whole, but large fish would be more profitable.]

Because of this, the most productive fish farmers use a process called "sex reversal." It is easy to do even in remote settings without electricity. The collected young fry are placed into 40-liter plastic containers in the shade, where they are fed (for approximately three weeks) a commercial fish diet that has been treated with methyltestosterone. Methyltestosterone is a hormone that can be purchased in a powder form, which must be dissolved in isopropyl alcohol prior to mixing with the feed. Once the feed is mixed with the alcohol/hormone mixture, it is spread out to dry in the shade. The alcohol evaporates and the hormone remains. When fed to the fish, the hormone remains in the fish's tissue for a very short period of time (days) but it "persuades" the sexual traits of the fish to be male.

Though used worldwide for sex reversing fish, methyltestosterone is not approved for such use in the USA. To locate the hormone for sex reversal of fish, check with the nearest fishery in your country or try asking a veterinarian. If you are unable to obtain the hormone, you can still avoid ending up with large numbers of very small fish by removing baby fish from the ponds as frequently as possible (using the method described in part (a) of "Stocking ponds"). For more information about sex reversal of tilapia, see the following pdf or (if that does not work) request a copy from ECHO: http://aquanic.org/species/tilapia/documents/sex_reversal.pdf

(6 Mb) a copy of this article in a smaller file (1.3Mb) is available on the ECHO Website.

During this period when fish are being treated with methyltestosterone, the water in the containers is exchanged twice a day. The surface area to depth ratio of the water should be maximized (it is better to have a shallow container with a lot of exposed surface area than a deep narrow container). 400 young fry per square meter of surface area can be safely stocked in a container of static water (i.e. without a system to mechanically add air to the water). The container should be kept partially shaded in a quiet area and fish should be fed using the "5 minute rule" (feed only what the fish will consume in a 5 minute time period) at least 3 times per day.

Debris and any dead fish must be removed several times per day if possible.

Stocking the grow-out pond. Stocking rates for the grow-out pond should not exceed two fish per square meter if periphyton is the only source of food. Three to five fish per square meter can be stocked if periphyton is supplemented with papaya leaves or moringa cast upon the pond surface. If possible, sex reversed fingerlings should be used to prevent stunted fish due to uncontrolled breeding. *This is very important!* (See description of sex reversing in previous paragraphs).

Harvesting. In our experience, a 10-gram fingerling will usually reach a size of 150 to 200 grams in six months. This growth rate is improving with each harvest, as improvements are made in substrate and compost management. According to the literature, a six-month growing period using the PAT technique can yield fish weighing 400 to 500 grams each. (Milstein *et al*, 2003).

All of the ponds we have been working with in Haiti are harvested by draining and collecting the fish. This process is not ideal, as it requires considerable time and is dependent upon rain to refill the ponds. A seine is the most efficient way to harvest. However, some of our Haitian fish farmers have been successfully experimenting with fish traps.

Problems and Pitfalls

We have run into some problems. We hope that sharing our experiences will help prevent similar problems for those who experiment with PAT.

a.) Overpopulation of the ponds. Uncontrolled reproduction continues to be a problem if sex-reversed fish are not used. It is possible to solve this problem by introducing a predator species that selectively feeds on very small tilapia, but we have yet to find a good predator species in the areas where we work. As mentioned earlier, regular removal of small fish is another way to keep down the population if using sex-reversed fish is not an option.

b.) Proliferation of single cell algae may keep sunlight from reaching deeply enough into the pond. PAT is 100% dependent upon sunlight reaching the substrate. Introducing a filter feeder (perhaps silver carp?) to the ponds would help. Alternatively, using a flocculant (such as moringa seed powder) might help clear the water.

c.) Ownership of the ponds. The PAT method will grow fish at a rate similar to fish fed a commercial diet, but the total yield per pond is less. (This is because the poundage of periphyton produced—and consequently the poundage of fish that can be harvested—is limited by the size of the pond. In contrast, with a commercial feed, almost unlimited amounts can be used.) A problem we have encountered in Haiti (in many cases) is that too many people are involved in the ownership of a pond. The return per person at the end is too small to warrant even the little bit of work needed**.**

d.) Keeping compost bins full can be challenging. People who do not own fish ponds now see value in their food scraps, manure etc., and are reluctant to give them away for use in composts.

e.) Failure to recognize the value of consuming fish. Fresh fish contains high-quality protein. It is also a valuable marketable product. Many farmers sell their harvest to purchase large quantities of less nutritious food, rather than consuming the fish themselves.

Conclusion

Periphyton aquaculture technology is a very low-cost, low-input technique for raising fish. We hope the information in this article is helpful for those readers who wish to try it. If you experiment with the technique, please let ECHO know the results!

Editors: If you are interested in learning more about low-input options for raising fish, consider attending the four-hour post-conference workshop at ECHO on Friday, December 11, 2009. The conference this year (held in Fort Myers from December 8-10) will also feature a 45-minutes plenary talk on raising fish.

References

Milstein, A., M.E. Azim, M.A. Wahab, and M.C.J. Verdegem. 2003. The effects of periphyton, fish and fertilizer dose on biological processes affecting water quality in earthen fish ponds. *Environmental Biology of Fishes* 68: 247-260.

Further information about the PAT method can be found in the following article:

Milstein, A. and O. Lev. 2004. Organic Tilapia Culture in Israel. Proceedings of ISTA 6 (Sixth International Symposium on Tilapia in Aquaculture) Manila, the Philippines, Sept 12-16. Vol. 2, 657-660. http://ag.arizona.edu/azaqua/ista/ista6/ista6web/pdf/657.pdf

The reference for the paper about sex reversal in tilapia that was referred to in the article is:

Phelps, R.P. and T.J. Popma. 2000. Sex reversal of tilapia. Vol. 2, *Tilapia Aquaculture in the Americas*, edited by B.A. Costa-Pierce and J.E. Rakocy (The World Aquaculture Society, Baton Rouge, Louisiana, United States), 34-59.

Contributing Articles for *EDN*

As a member of our network, you have an opportunity to be eyes and ears for ECHO! One of ECHO's unique strengths is the ability to learn from individuals in our network and then in turn share with our broader network. We often ask for permission to quote from an e-mail or letter, either in the section of *EDN* called "From ECHO's Network" or as part of a larger article. Feedback from our network members adds to the relevance and credibility of the articles we publish.

Occasionally, we ask someone from ECHO's network to write an article on a particular topic for us. In these cases, when we have been able to do so, we have offered some financial compensation. We currently have some funds available to pay members of what we refer to as our "Global Office." Payment is on a per page basis, and varies depending on several factors, including the topic's relevance to our network, the author's level of personal experience with the topic, the amount of library or other research needed to gather required information, and the perspective that is communicated. Clarity and completeness of writing is also considered.

If you have an idea for an article for *EDN*, we strongly encourage you to submit an outline of your idea first. Some guidelines about how we choose material for *EDN* may be helpful as you consider whether or not you could contribute in this way. *EDN* is written for the purpose of sharing ideas, techniques, case studies, and new plants with our readers, **with the aim of helping them have a greater impact in their work with small farmers**. Keep your eyes alert to something you have done or observed that might be of considerable interest to readers in several countries other than your own. Have local farmers responded and perhaps begun adapting it? If so, why?

We assume that our readers have a basic knowledge of gardening and farming, so we do not publish articles on elementary topics that are covered in many book and magazines (e.g. how to make compost). We also do not tend to publish articles that detail the "big picture, global problems" that are so big and broad that network members are not usually involved in solving, e.g. the cause of hunger, or rampant corruption in the world. Ideally, *EDN* should feature several very pithy, to-the-point "notes" or articles that would help members of our network with a broad selection of ideas for projects, or would bring a perspective based on experience. That is why we call our publication *ECHO Development NOTES*, not *FEATURES*. If we consider that something is especially important, we occasionally print articles that are several pages long. If an article is too long for *EDN* or is of interest to only a small percent of our readers, we sometimes publish it as a Technical Note that is available on our website or (by request) as a paper copy.

Perspective is a very important word to us. The best articles go beyond just giving information on a subject; they also provide perspective as to how important the subject is, confirmation that its claims are valid, and information about where/when to consider it. For example, it would not necessarily be very helpful to just know that people use a certain plant to treat a particular disease or kill an insect pest, but it would be helpful if personal experience and observation could demonstrate that it worked. (Just because people do something does not mean it works.) If in doubt about whether or not an article about a plant or technique would be of interest, please send us a note about it!

If a relevant subject has been written about well by another author/organization, we likely would not write about it ourselves. Instead, we would try to get permission to put a link to the other organization's article on our web or possibly place it on a CD or compile an abbreviated article for *EDN*. Please be looking for this kind of helpful material, and let us know about it.

As you investigate a topic that could be of benefit to our network, try to anticipate what questions might arise in the mind of a reader who is contemplating trying what you have written. Then try to answer the questions while you have opportunity to do so. In *EDN*, we try to share enough information that a reader would be able to try any technique after reading about it.

It is very important that writers keep track of sources of information (whether an interview, book, etc), and include proper credits for ideas and wording taken from others. Include quoted material in quotes with formal reference citing. ECHO works hard to avoid plagiarism. A person can be accused of plagiarism even without intending to do so, due to carelessness in making notes and referencing information while researching material for an article.

Send outlines or drafts of proposed articles to echo@echonet.org, Attn: *EDN* Editor. Acceptance of an article is entirely at the discretion of *EDN* editors, as are all other editorial decisions, including cutting out or adding material and editing for clarification or to match *EDN* style. If substantial changes are made to an article, we will run it by the author for final approval.

Thinking of Exporting a Plant Product to Europe?

The March issue of *Haramata* (54: March 2009) mentioned that "In July 2008, Phototrade Africa was [authorized] to market baobab dried fruit pulp in Europe. . . . [it will be] used in a range of products such as smoothies (mixed juice drinks), cereal bars . . . etc." What struck us was the reason they had to be authorized. "Under EU [European Union] legislation, any food that has not been commonly eaten in Europe prior to 1997 is classified as a 'novel food' and must gain special approval before it can be used in products for the European market."

The article does not discuss what is involved in getting such approval. This requirement is something to keep in mind if you are thinking of a possible plant product to export to the EU.

Haramata is published in English and French by the International Institute for Environment and Development in the United Kingdom (email: drylands@iied.org, website: www.iied.org).

GenStat Discovery: Free Statistical Software for Non-Profits

By Tim Motis

EDN 81 included an article by Edward Berkelaar titled, "Formalizing Your Research: How to Carry Out an Agricultural Experiment." The article provides some basic information on experimental design and data analysis, and would be worth revisiting if you are interested in designing experiments and gathering data from which statistically valid conclusions can be drawn.

You might also consider GenStat Discovery if you have a basic knowledge of statistics and are looking for software to analyze your data. While doing variety trials in Haiti, I found GenStat Discovery to be more than adequate for the project's needs. It was very easy to select the experimental design used (e.g. we often follow the "randomized complete block design" in setting up trials at ECHO), to generate analysis of variance tables, and to calculate and separate means/averages.

GenStat Discovery is free of charge to those working for non-profit organizations located in developing countries. See http://www.vsni.co.uk/downloads/genstat-discovery/ for a list of qualifying countries and information on registering for and downloading the software to your computer. Provided you qualify for a free download, you will be given a one-year license code that can be renewed annually.

For Clarification

After publishing the last issue of *EDN*, it was brought to our attention that we neglected to give the dilution rate for Cornell spray. The rates given in the article "Introducing a New Crop: Reasons Why Seeds Fail" (5 Tbsp vegetable oil; 1 Tbsp baking soda; 2 Tbsp dish soap) are for one gallon of solution.

FROM ECHO'S SEED BANK

Peanut (*Arachis hypogaea*): A major and versatile crop

By Tim Motis, PhD

Our seed bank specializes in under-utilized crops, though we do also carry seed of a few varieties of major field crops like sorghum and maize. We do this primarily when we are able to obtain special varieties of these crops. While working for ECHO in Haiti, I had the opportunity to evaluate about 30 lines of peanut (*Arachis hypogaea*) from ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) in Mali, West Africa. The top four of those, in terms of yield, were also evaluated in a variety trial conducted by an intern (Heidi Renkema) here at ECHO in Ft. Myers, Florida. We are now offering one of these lines (ICG 9257) through our seed bank. From our observations, it has a spreading growth habit (Figure 4) with two peanuts per pod. This variety seems to be resistant to foliar diseases, as it did not develop black spots as quickly as other varieties in nearby plots. As an indication of time to harvest, plants of ICG 9257 were harvested 145 days after seeding. While our supplies last, we are also offering trial packets of several other varieties, listed at the end of the article, with which you may wish to experiment.

The main purpose of this article is not to establish ECHO as a major source of peanut seed, but rather to provide introductory information for those who are new to the crop and may be wondering how peanut varieties or subspecies may differ from each other. I hope this information will serve as a starting point to help you relate to and work with the many farmers in developing countries who are growing peanuts as part of their livelihood, and will inform you as you investigate resources from research centers in your part of the world.

Figure 4. Peanuts (ICG 9257) growing at ECHO. Photo by Tim Motis.

There are many reasons why a small-holder farmer might want to grow peanuts.

- **Protein** (21-36%). Peanuts are a less expensive source of protein than meat.
- **Oil** (36-56%). Peanuts are an excellent source of dietary oil—mostly "good" (unsaturated) fats (that do not

Table 1. Common traits and uses for each of four main groups of peanut varieties.

Variety group	Subspecies	Growth habit	Seed size	Seeds/pod (number)	Primary uses
Virginia	*hypogaea*	upright or spreading	large	2	salted and roasted in shells*
Runner	*hypogaea*	spreading	medium	2	peanut butter, salted peanuts **
Spanish	*fastigiata*	upright	small	2-3	oil and peanut butter
Valencia	*fastigiata*	tall, upright	intermediate	3-6	roasted or boiled in shells

*Salted in the shell by soaking in a mixture of water and salt, and then dried by roasting. This leaves a residue of salt on the peanuts inside the shells.

**Peanuts can be roasted in or out of the shells, but runner-type peanuts are typically roasted after shelling. Adding a small amount of cooking oil (e.g. peanut oil) or melted butter prior to salting (if this is desired) helps the salt adhere to the peanuts.

contribute to unhealthy cholesterol as do trans fats). Peanut oil is an excellent source of linoleic acid, which is one of several omega-6 fatty acids that are essential for proper nutrition.

- **Energy**. Pound for pound, peanuts provide at least the same amount of energy as beef.
- **Vitamins and minerals.** Peanuts are a good source of many essential vitamins and minerals, especially folic acid.
- **Food.** George Washington Carver, a noted educator and experimenter who lived in the late 1800s and early 1900s (http://www.lib.iastate.edu/spcl/gwc/bio.html), published "How to Grow the Peanut and 105 Ways of Preparing it for Human Consumption." See Table 1 for a few common uses of peanuts.
- **Nitrogen.** Being a legume, peanut can add nitrogen to the soil for subsequent crops.
- **Animal feed**. Peanut crop residue can be used as hay to feed animals. However, note that if the residues are removed from the field, the amount of nitrogen left for subsequent crops is reduced. Considering that the roots are dug up and often moved to another location to dry before the peanuts are removed, the land can be left quite barren if all the plant tops are removed from the field as well.

Where will peanuts grow? A peanut crop needs full sunlight and temperatures between 77 to 86°F (25 to 30ºC). Thus, they are grown in places such as the southern United States, Africa, parts of Asia, Australia, and South America. Peanuts prefer light-textured soils, such as sand or sandy loam, with plenty of calcium (for pod filling) and a pH ranging from 5.3 to 6.5. Soils with pH greater than 7.5 are unsuitable for peanut. Rainfall amounts of 30 to 49 inches (750 to 1250 mm) are needed for best yields.

How are peanut varieties classified? Peanuts are believed to have originated in South America. Common names include groundnut, ground pea, and monkey nut. Varieties are categorized into four groups: Virginia, Runner, Spanish and Valencia. Typical traits of these variety types are outlined in Table 1.

Pods of most peanut varieties contain two seeds each, but Valencia-type pods can contain as many as five seeds. Virginia types produce the largest peanuts, while Spanish types produce the smallest. Varieties with a more upright growth habit produce pods closer to the base of the plant than do spreading varieties. Spanish types generally mature in less time (90 to 140 days) than the longer-season (120 to 190 days) Virginia-type varieties. Consider planting varieties with varying times to maturity to extend the harvest period.

Do peanuts grow on trees? No, they form underground. Plants begin to emerge within about two weeks of planting the seeds. About four to six weeks later, the plants will begin to flower. After self-pollination, the flower then withers and a "stalk" forms at the base of the ovary. This stalk quickly grows downwards to form what is called a "peg." The tip of the peg buries itself two to three inches underground, where the pod then develops and matures (Figure 5). Flowering occurs during much of the growing season, which means that peanuts are in varying stages of development at harvest time. Harvesting occurs 110 to 160 days after planting, depending on the variety. The website http://enchantedlearning.com/subjects/plants/pages/peanutplant.shtml has a diagram showing the anatomy of a peanut plant.

What are some basic steps in growing peanuts?

Planting: Because the pods are formed underground, prepare ridges or a planting bed with deep, loose soil. Choose a planting date that allows the crop to become established during the rains and to mature during the dry season. If the peanuts mature during the rains, they can be infected by molds and become toxic. Individual seeds or unshelled pods can be planted. Spacing recommendations in the literature vary greatly; one source suggested 6 inches (15 cm) of space between seeds in rows 12 to 18 inches (30 to 46 cm) apart. Leave enough space for weeding between rows and for air circulation between plants to minimize the risk of plant diseases. Consistent spacing will encourage uniform pod development.

Weeding: This is especially important prior to flowering of the crop. If the crop is planted in rows, weeding can be done with animal-drawn implements. Otherwise, weeding is done by hand with hoes. In the early stages of crop growth, before the pegs have reached the ground, soil can be pulled towards the stem while weeding. After flowering, weeding needs to cease or be done with care, so as not to damage developing pods.

Harvesting: When is the right time to harvest? If you know the variety you are dealing with, the estimated days to maturity can serve as a guide. Another suggestion is to sample a few pods periodically and examine the seeds. Immature seeds are light-colored with thick, fleshy skin that is easy to rub off. In contrast, the skin of mature seeds is

Figure 5. Photos showing the flower (left), peg (middle) and pod (right; developing on the end of a peg) of a peanut plant. Photos by Tim Motis.

thin and papery and is not easily rubbed off the kernel. Harvesting should not begin before 50% of the pods contain mature seed. Harvesting should be completed by the time 70 to 80% of the pods have mature seeds. A third suggestion is to examine the leaves. If the plants have lost most of their leaves to foliar diseases, they should be harvested. Finally, if seeds in the underground pods begin sprouting, the plants should be harvested.

To harvest peanuts, loosen the soil if needed and then "lift" (term often used for harvesting) the entire plant (leaves, roots and pods). Take steps immediately to promote drying of the peanuts to proper moisture content (10%) for storage. For instance, shake the soil off the pods and place the plants in the rows with the foliage instead of the pods contacting the soil. In warm, dry weather, the harvested plants can be left in the field for a few days to cure. Otherwise, hang the plants to dry somewhere out of the rain, or remove the pods and dry them on screens.

What are some problems to be aware of? Diseases of peanut include early leaf spot (*Cercospora arachidicola*), web blotch (*Phoma arachidicola*), yellow mold (*Aspergillus flavus*), groundnut rosette virus and aphids. Aphids feed on plant tissues, but the primary concern is that they transmit groundnut rosette virus, which in periodic epidemics can cause massive yield losses.

Mold caused by *Aspergillus flavus* produces aflatoxin (see *EDN* 87). A few basic principles for minimizing contamination by aflatoxin are: 1) Avoid damage to pods by insects or during harvesting, because cracked pods allow entrance of moisture and mold. 2) Allow pods to dry immediately after harvesting. 3) Harvest when pods are mature (but not rotted) and, if possible, during dry weather. 4) Moisture content of stored peanuts should not exceed 10.5%. Storing seeds under low humidity helps keep seed moisture content low (see *EDN* 86).

Roughly 1 in 100 people is allergic to peanuts. Such an allergy often appears in the first years of life. Symptoms vary from minor irritation to more severe or even life-threatening reactions. Those allergic to peanuts need to avoid not only the peanuts themselves but also foods made from peanut products such as peanut oil.

Requesting seed from ECHO: Members of our overseas network may request (email: echo@echonet.org) a complimentary packet of ICG 9257. While our supply lasts, we will also supply ICG 6161 (another ICRISAT line similar to ICG 9257), 'Virginia Jumbo' (135 days to maturity; large seeds), and 'Carolina Black' (110 days to maturity; black-skinned seeds slightly larger than Spanish types). We encourage you to also evaluate local varieties in your region, as well as other varieties you may be able to obtain from universities or research centers.

In Memory of Keith Hess

We were saddened to learn that Keith Hess, a long-time member of the ECHO "family" and overseas network, passed away at the age of 59 in Monrovia, Liberia, at the end of August (2009). He died from complications associated with malaria.

Over the years, Keith had become a familiar face at ECHO, as he often volunteered for weeks or months at a time while between overseas assignments. He attended and helped out regularly with our annual conference. He was especially instrumental in maintaining and improving the agroforestry demonstration at ECHO. Many of the tree specimens in our agroforestry collection were planted by Keith. It was a rare privilege to have a hard-working volunteer with so much international experience.

Notes from the Hess family: After graduating from Miami University of Ohio, Keith served in the Peace Corps and continued his humanitarian and environmental work with the Mennonite Central Committee (as a history writer in Haiti) and with ECHO. Keith's dedication to spreading God's grace took him to Haiti, Costa Rica, El Salvador, Nigeria, Chad, Burkina Faso, Benin, Ghana and the Ivory Coast. Keith devoted himself to the Mennonite vision of healing and hope, living a life of peace, love, and joy. He had a generous heart, kind words for everyone he met, and a determination to live his utmost for God's Highest.

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!