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Edited by Dawn Berkelaar and Tim Motis

ECHO is a global Christian organization that equips people with agricultural resources and skills to reduce hunger and improve the lives of the poor.

Issue Highlights

NOTE: Link to extra material from the web version of *EDN* 110.

ECHO
17391 Durrance Rd
North Ft. Myers, FL 33917
USA
Phone: (239) 543-3246
Fax: (239) 543-5317
echo@echonet.org
www.echonet.org

Multiplication and Use of Soil Microorganisms

By Dawn Berkelaar

EDN 96, published in July 2007, featured an article by Danny Blank called "A Fresh Look at Life below the Surface." The article, written after Danny attended a week-long workshop by Dr. Elaine Ingham, discussed composting and the importance of using it to build up the Soil Food Web—the community of microorganisms that live in the soil. The article drew a lot of attention and was adapted as a chapter in the book *No-Till Farming Systems* published by WASWC (World Association of Soil and Water Conservation).

We received an e-mail comment from one reader: "I couldn't agree more! But wouldn't it be simpler to add a pint of condensed microbes to an acre instead of 1 to 10 tons of compost per acre? Wouldn't it also take less time and labor instead of having to mix that much compost and put it out?"

Danny Blank responded that he had intentionally shared about compost, since compost "provides both the microbes and a long-term food resource for the microbes [i.e. the organic matter] that is both inexpensive and low-tech." Compost also provides many other benefits, including a reduction in soil compaction and an increase in water holding capacity.

Since then, ECHO has been experimenting with multiplication and use of soil microbes. This article will outline the process of specifically multiplying and applying microbes in a small farm situation. It will first discuss some of the controversy about use of soil microorganisms in general. Then it will introduce two different approaches that exist when it comes to the multiplication and use of soil microbes (one is commonly referred to as Natural Farming, the other as Effective Microorganisms). Finally it will share experience from the ECHO farm. The online Writers' Supplement to this issue of *EDN* gives practical suggestions for those who would like to experiment with multiplying and using soil microorganisms. Those who lack access to the internet can write ECHO to request a paper copy.

Why Multiply Microbes?

If you have not read "A Fresh Look at Life below the Surface," we encourage you to do so. If you do not have *EDN* 96, you can read it on our website or request a copy. The article explains the importance of the vast but largely unseen web of life that exists in the soil. Multiplying and adding soil microbes to fields or gardens is an attempt to strengthen this Soil Food Web. Within the soil, some microorganisms have 'good' effects, some can cause harm, and others do neither, or may help or hinder depending on whether the helpful or harmful bacteria are in the majority. Adding good microorganisms is an attempt to shift the balance so that more soil microbes are beneficial to crop growth.

Other farming practices can also help strengthen the Soil Food Web. These include reduced tillage, application of organic matter to soil, and use of cover crops. But specifically multiplying microbes and applying them to the soil is sometimes recommended especially for soil that is extremely poor or when a farmer is switching from conventional to organic agriculture.

One Approach: Natural Farming

Natural Farming, abbreviated NF, is a system of farming used in at least six Asian countries as well as a few African countries. It includes some principles from organic farming (i.e. no herbicides or pesticides; emphasis on sustainability; high quality produce), but it has been developed as a complete, integrated system with specific applications and practices. Inputs for farming are made by farmers from locally available materials. Important NF inputs include indigenous microorganisms (abbreviated as IMO) harvested from the soil (e.g. near leaf litter) and fermented plant juice (FPJ). IMO from leaf litter is the main one discussed in this article.

A Brief Background about NF. Originally called Korean Natural Farming, NF was developed by Dr. Cho Han Kyu from Korea. The Janong Natural Farming Institute promotes NF (www.janong.com; English information can be found at www.janong.com/ENGLISH/02.htm). In his book called *Natural Farming*, Cho Han Kyu wrote, "All Natural Farming inputs…can be made with different materials in different places of the world. Natural Farming has one principle, but its application and practice can be infinite."

Because NF is done with locally available materials (and is thus inexpensive), and because of its adaptability to all kinds of situations, it is potentially of use to many *EDN* readers. A Thai language book called *Applied Natural Farming*, written by Dr. Arnat Tancho at Maejo University, is currently being translated into English. We will likely have more to share with *EDN* readers after the translation is complete. This article presents an overview on propagation of microorganisms, and more detail about one of the methods described in NF literature. Although NF is presented by its promoters as a complete system, selected elements can be incorporated individually.

A big advantage of the NF system is that costs can be kept low by making the inputs used for the system right on the farm or buying from a local producer. The NF system requires a lot of thought and coordination from farmers. NF farmers are managers, not just laborers.

Indigenous Microorganisms (IMOs). NF promotes the widespread use of indigenous microorganisms (IMOs) that can be produced by farmers. Use of purchased and/or imported microorganisms is discouraged by NF proponents, who claim that they are often found to be ineffective. IMOs are collected near the farm from an open field [or forest] and are cultivated at ambient temperature, ensuring that the microorganisms are locally adapted and will grow at normal temperatures. IMOs carry out two major functions: they decompose organic matter, releasing inorganic nutrients that can then be absorbed by plants; and they create other compounds, such as enzymes, lactic acid, and fixed nitrogen (plants take nitrogen from the air and convert it to a form available to plants). IMOs contain a mixture of known and unknown microorganisms, including *Azotobacter* (that fix nitrogen), *Actinomyces* (that suppress diseases), yeast fungi (that break down complex sugars) and lactic acid bacteria (that break down organic matter under anaerobic conditions). IMO is considered the basis for making fertile land, because with good conditions and available food, use of IMO greatly increases the population of the beneficial microorganisms in the soil. Fungi will grow first. Other microorganisms and larger organisms like earthworms will be attracted to the healthy soil culture.

Bamboo forests and leaf molds abound in IMO. IMOs are also found and collected in deciduous forests and rice paddy fields. IMOs should be collected and used continuously, even after fields have improved. Diversity is essential. It is difficult to classify microorganisms as beneficial or harmful, but according to Cho Han Kyu, "lively and diverse microorganisms will check and balance each other." See the Supplement for details on how to collect and propagate IMOs.

Fermented Plant Juice (FPJ). Another NF category of soil microbes is Fermented Plant Juice. Dr. Arnat describes FPJ as follows (translation by Rick Burnette): "Fermented plant juice from green plants is derived from cell sap and chlorophyll using brown sugar or molasses to increase osmotic pressure which causes the cell walls to rupture as well as the degradation of the cell walls by enzymes that are produced by various microorganisms. This contributes to fermented green plant juices that are rich in plant nutrients and hormones which stimulate the growth of various types of plants, animals and microbes."

Koreans eat kimchi (a fermented vegetable dish) for nutrition and as an aid to digestion. Cho Han Kyu used leftover kimchi juice to soak seeds, and found that they grew extremely well. FPJ and kimchi are made similarly, except that FPJ is made using brown sugar instead of the salt that is used for making traditional kimchi.

Some basic FPJs are made from water spinach (*Ipomoea aquatica*), banana stalk, vegetable amaranth, leucaena tree leaves, bamboo shoots and waste vegetables from the market and garden. But ingredients for FPJ are everywhere; you can use weeds, crop residue, or native plants. According to Cho Han Kyu, "It is particularly effective to use green plants that start to grow first in spring or those that remain green longest in late fall. Fast growing bamboo shoots and arrowroots are also good. In the southern tropical areas, banana, papaya [and] mango [are good].. Lateral buds of all plants contain high growth hormones; excellent for FPJ." Again, see the Supplement for instructions on making FPJ. It is a relatively easy process.

Another Approach: Effective Microorganisms (EM Technology)

On Wikipedia, Effective Microorganisms are described as follows. "EM is a trademarked term now commonly used to describe a proprietary blend of three or more types of predominantly anaerobic organisms that was originally marketed as EM-1 Microbial Inoculant but is now marketed by [many] companies under various names, each with their own proprietary blend. 'EM Technology' uses a laboratory cultured mixture of microorganisms consisting mainly of lactic acid bacteria, purple bacteria, and yeast which co-exist for the benefit of whichever environment they are introduced…"

"The concept of 'Effective Microorganisms' was developed by Japanese horticulturist Teruo Higa, from the University of the Ryukyus in Okinawa, Japan. He reported in the 1970s that a combination of approximately 80 different microorganisms is capable of positively influencing decomposing organic matter….Higa invokes a 'dominance principle' to explain the effects of his 'Effective Microorganisms'. He claims that three groups of microorganisms exist: 'positive microorganisms'…, 'negative microorganisms'…, and 'opportunist microorganisms'. In every medium (soil, water, air, the human intestine), the ratio of 'positive' and 'negative' microorganisms is critical, since the opportunist microorganisms follow the trend to [positive or negative]. Therefore, Higa believes that it is possible to positively influence the given media by supplementing with *positive* microorganisms."

A paper written by Higa and soil microbiologist James F. Parr can be read at www.agriton.nl/higa.html. Read a summary of highlights in the online issue Supplement.

Controversy over Propagation of Soil Microbes. Does it Work?

Controversy exists over whether or not propagation of soil microbes is an effective way to improve the Soil Food Web. Different people have strong views regarding whether or not propagation of beneficial microorganisms is possible or helpful in a non-laboratory setting. Let's take a look at some of the arguments for and against such practices.

Those Opposed

In general, it seems that scientists tend to be skeptical of the widespread claims regarding propagation and use of soil microorganisms. Little peer-reviewed scientific research has been done to substantiate claims. A blanket of secrecy shrouds various EM formulations, and the contents of IMO are largely unknown.

The Wikipedia article on EM shared the following: "The Effective Microorganisms concept [is] considered controversial in some quarters and there may not be scientific evidence to support all of its proponents' claims. This is acknowledged by Higa in a 1994 paper co-authored by Higa and soil microbiologist James F Parr, a USDA [U. S. Department of Agriculture] Researcher [the link for the paper is above, in the section on EM]. They concluded that, '*the main limitation...is the problem of reproducibility and lack of consistent results*.' They went on to state, '...it is difficult to demonstrate conclusively which microorganisms are responsible for the observed effects, how the introduced microorganisms interact with the indigenous species, and how these new associations affect the soil plant environment. Thus, the use of mixed cultures of beneficial micro-organisms as soil inoculants to enhance the growth, health, yield, and quality of crops has not gained widespread acceptance by the agricultural research establishment because conclusive scientific proof is often lacking.'"

My brother, Matthew Bakker, is a microbial ecologist who studies how plant-microbe interactions impact plant health and bacterial antibiotic production. When I asked his thoughts on 'effective microorganisms,' he shared with me a paper he had written for a class, based on the Wikipedia article above. Among his comments, he shared these: "The premise of the [EM] technology is that the introduction of a mixture of beneficial microorganisms can improve everything from agriculture to human health. I do not find much to dispute in this general statement, but the specific claims of the technology are difficult to evaluate on a case-by-case basis because a range of products may be marketed under the same name, and a great deal of relevant information is not made publicly available. . . .Claims abound with little supporting information provided. A critical audience would demand that more detailed explanations and supporting data accompany research results and product claims. The most glaring omission in the literature on Effective Microorganisms is that mechanisms of action [i.e. an explanation of how they work] are almost never discussed. The consumer is basically asked to accept on faith that the product will work for all of the stated purposes. Without any understanding of the mechanisms of action [nor research demonstrating effectiveness], the consumer has no option for making independent judgments about the suitability of the product to any given situation or application."

Another skeptical viewpoint comes from Dr. Ken Giller, professor of Plant Production Systems at the University of Wageningen, the Netherlands. Dr. Giller researches soil microbiology and microbial inoculants. The magazine *LEISA* (*Low External Input Sustainable Agriculture*; now called *Farming Matters*) published two different views on Effective Microorganisms in their June 2008 issue (Volume 24, Number 2).

In the *LEISA* article, Dr. Giller made strongly negative comments about EM (you can read them by clicking on the link below; they are also summarized here).

Dr. Giller pointed out the lack of scientific support for the supposed positive effects of EM, and strongly recommended against their use. He commented that even if a good microorganism (that could stimulate plant growth) was present in the mixture, it would be difficult to multiply it, since producing quality inoculants is not easy. "The target organisms need to be grown on suitable media in a laboratory. If this is not done under stringently-clean conditions, by trained microbiologists, then it is likely that the cultures become contaminated."

Dr. Giller also questioned the quality of EM preparations available on the market, because the latter are not subject to any standard quality control. "By contrast, inoculants of the root-nodulating bacteria *Rhizobium* for use with legumes are subject to stringent quality control. This quality control is conducted by an independent regulatory body in most countries, and products that do not meet the requirements have to be withdrawn from the market. Rhizobial inoculants are tried and tested and their producers, nearly always, adhere to strict quality standards."

Dr. Giller commented on the questionable purity of EM inoculants. "Before sale the cultures are often added to a 'carrier' medium, such as sterilized peat in which the microorganisms can survive until added to crops in the field. Again, if non-sterilized carrier media are used, or if the inoculation of the carrier is not done under sterile conditions, the packets of inoculum become contaminated and the inoculant organism can often be undetectable by the time the product is sold to a farmer." [Matthew Bakker commented, "This is a real concern, and particularly in developing countries. At a conference I was at…a scientist from Africa reported results showing that many inoculants available commercially in his country did not even contain the organism(s) that the label claimed were present and active."]

Dr. Giller concluded, "Uninformed (and perhaps unscrupulous) businessmen profit from selling ineffective microbial inoculant products to farmers in developing countries who can ill-afford the money or the wastage of their time. The burden of proof of efficacy should lie with the producer and seller of the product. If you know of people selling microbial inoculants in your area where they do not name the micro-organisms and have good evidence of their efficacy, maybe it is time to challenge them to produce it!"

Those in Favor

On the other hand, many farmers who use EM and IMO on their farms report good results, and the number of people using such preparations continues to increase.

For example, Dr. Narayana Reddy commented in favor of EM in the *LEISA* issue. Dr. Reddy is a "prize-winning organic farmer (who made the transition from conventional agriculture in 1980), writer and trainer from Bangalore, India."

Dr. Reddy had known about EM for 25 years. He shared, "In my vast experience on my family's five mixed (bio-intensive) farms, I can recommend the use of EM to increase soil fertility and to help suppress harmful organisms from developing there. In particular, I suggest that farmers use EM during their transition from chemical to organic farming. In the first two to three years, we used EM as a 5% spray on our crop residues such as maize, rice paddy stubble and sunflower, to make them decompose more quickly. We noticed that by using EM spray, composting is quicker and better. Similarly, when we applied bokashi [a microbe-rich soil amendment; see Supplement] together with farmyard manure, we noticed no fungal attacks and viral diseases on our rice, tomato, bottle gourd, soybean, gladiolus, banana and papaya."

Dr. Reddy also commented, "Farmers in Erode District, Tamil Nadu, south India, are regularly using EM preparations for soil treatment to [control] root-rots. Farmers in Raichur District, Karnataka State are using EM to help quicken the breakdown of paddy stubble, as do sugarcane growers in Sivaganga District, Tamil Nadu. The EPPL thermal power company, with 700 acres of hill neem trees (also in Tamil Nadu), found that the germination capacity of their seeds increased from 5 percent at the beginning to 85 percent after soaking their dry fruits in 5 percent EM solution for 24 hours before planting. I myself and over 500 farmers in the area also use EM solution to soak all our seeds before sowing." [Editors: This would be a more helpful comparison if the germination rate was compared to the germination rate of seeds soaked in plain water for 24 hours.]

To view the full discussion in the *LEISA* article, see http://ileia.leisa.info/index.php?url=show-blob-html.tpl&p[o_id]=209100&p[a_id]=211&p[a_seq]=1

(The November 2008 *LEISA* issue summarized input from nine people who joined a discussion based on the two views that were shared in relation to EM. The summary is available at http://ileia.leisa.info/index.php?url=show-blob-html.tpl&p%5Bo_id%5D=211332&p%5Ba_id%5D=237&p%5Ba_seq%5D=0)

What are we to conclude? Not much exists in the way of peer-reviewed research (with results that are available to the public) when it comes to EM and IMO. Dr. Arnat at Maejo University in Thailand has been conducting research on the practical application of Natural Farming methods (the Thai NF book has been produced based on this, and is being continually revised). With the support of Thailand's National Science and Technology Development Agency, Dr. Arnat has been conducting field tests to fine tune the various NF techniques, ingredients, etc. with regard to crop/livestock response and overall farm productivity. So it seems that preliminary scientific testing is taking place in some quarters with some finding/results beginning to emerge, especially with regard to applied research.

One recent scientific paper evaluating EM (Mayer, Jochen, *et al*., 2010, in *Applied Soil Ecology*) had discouraging results. The paper reported on research that evaluated "the effects of EM on crop yields and soil microbial parameters in a 4-year field experiment under organic management" in Switzerland. The authors stated, "We conclude from our results that 'Effective microorganisms' did not improve yields and soil quality during four years of application in this field experiment under the temperate climatic conditions of central Europe." [Would results differ in the tropics? After reading this paragraph, Dr. Tim Motis commented, "Baseline microbial populations in the soil samples taken at a research site in South Africa were low. The person in charge of the lab at the University of Limpopo where the samples were analyzed commented that this was typical of many soils in the tropics. One of the reasons he stated was that there is no time of the year when the soil is covered by ice. He didn't elaborate, but I would imagine that the fact that soils never freeze in the tropics means that any organic content (which microbes would feed on) is more rapidly decomposed and depleted unless soils are purposely covered using cover crops, mulching or additions of compost."]

Despite the very limited scientific results demonstrating the effectiveness of adding soil microorganisms, I think of SRI

(System of Rice Intensification; see *EDN* 70), a methodology for growing rice that also seemed too good to be true. Adoption of SRI also started with very little (if any) scientific validation of the technology. Yet SRI has now been demonstrated to be effective in at least 42 countries. So the spread of a technique or approach is not necessarily dependent on scientific confirmation. And the many positive observations made by hundreds of farmers are an indication that something helpful is (sometimes) happening, in some situations and with some preparations. It is unlikely that farmers with limited time and money would invest effort in something that did not work. The propagation and use of soil microorganisms seems worth a try, though on a small scale initially.

EM or IMOs?

For those who believe it is worthwhile to propagate soil microorganisms, matters are complicated further by disagreement over which approach to take—the one advocated by Natural Farming proponents (to harvest and use the local microbes) or the one advocated by EM (purchase a [presumably] carefully prepared blend of microbes). Again, both sides have reasons for favoring one or the other approach.

IMOs. According to the Natural Farming school of thought, indigenous (local) microorganisms tend to be stronger and more effective than purchased inputs. They also have the advantage that they can be 'made' at home. NF proponents consider commercialization of microorganisms to be misleading, claiming that foreign microorganisms can be effective for the short term, but often die quickly in local soil. Cho Han Kyu's manual comments, "What you need is what is around." IMOs, being locally adapted, will be able to survive varying climatic conditions.

Table 1. Effect of a non-treated control, effective microorganisms (EM), and two fermented plant juice (FPJ) treatments on early- (sum of first two harvests), late- (sum of last three harvests) and total-season zucchini fruit weight averaged over four replications.

	Marketable fruit yield (grams/10-plant plot)		
Treatment	Early	Late	Total
Control	1330	2085	3416
EM	2764	4162	6926
FPJ-leaf tips	1200	3512	4712
FPJ-banana stalks	445	3166	3611
P value[Z]	0.015	0.357	0.078
LSD value[Y]	1068	2012	2381

[Z]Within each column, yield values are statistically similar unless the corresponding P value is ≤ 0.10 (10% level of significance)

[Y]Within each column, any two yield values are statistically similar unless the difference between them exceeds the corresponding least significant difference (LSD) value.

EM. Using a prepared mix of microbes such as EM is clearly much less work. Dr. Reddy (who was in favor of EM in the *LEISA* discussion) weighed in on purchased EM vs IMOs. He commented, "Although some farmers produce their own microorganism mixtures, for example keeping rice gruel near humus-rich wet soil for 4 to 5 days, my fear is that farmers cannot identify any harmful organisms getting into the preparations as they do not have suitable laboratory equipment to segregate them. [Editors: A similar objection could be made about a compost pile.] Therefore I think it is better to get EM stock solution from an authentic laboratory. It is very cheap to use it: in India, the use of EM on one acre costs less than a cup of coffee. Farmers use it three to four times a year on all their crops. Nevertheless, it is enough to use EM preparations only in the first two to three years during the transition from chemical to organic farming."

The initial expense of EM can be minimized by extending it (this is sometimes referred to as EME, or EM Extended). To make EME, put one liter of water into a plastic bottle with 45 ml of EM and another 45 ml of molasses. (Note that dilution rates vary; EM, molasses and water are used at ratios of 1:1:8 to 1:1:22) Shake the mixture well to dissolve the molasses. Allow it to ferment for one week, occasionally shaking the bottle to agitate the suspension. Also, once a day, quickly open and close the cap to relieve the pressure of the gas that may build up. Do not try to keep 'extending' EM past one round. Keith Mikkelson of Aloha House in the Philippines cautioned about this in his book *A Natural Farming System for Sustainable Agriculture in the Tropics*: "Remember: don't extend the EME; it will not remain true to the mother culture." The shelf life of EME varies, but it is best to use it up within a matter of months.

Mikkelson shared a number of ways that EME can be used. It is sprayed in livestock pens to help control odors (dilution of 1 part EME to 100 parts water). It can also be mixed with molasses and water at a dilution rate of of 1:1:500 (EME:molasses:water) and sprayed on plants. In this case it is sometimes referred to as EMAS (EM Activated Solution) or AEM (Activated EM), because the molasses provides extra nutrients for the microorganisms [and plants. The molasses may have many effects of its own. If you want to do a proper experiment to test EM in your situation, it would be good to include a control that contains molasses and preferably even killed or inactivated EM product, in order to account for effects due to something other than the microorganisms.]

Beneficial Microorganisms at ECHO

At ECHO, we are trying out many different approaches for multiplying and using soil microorganisms. Though we are not at a point where we can draw many conclusions, in the Supplement to this issue of *EDN* you can read some comments from ECHO Farm Manager Andy Cotarelo.

ECHO interns Brandon Lingbeek and Brian Dant have been experimenting with EM for several months. They used four treatments on their target plant of *Cucurbita pepo* (zucchini squash, variety 'Spineless Beauty'). Treatments included 1) control (plants that received water but no additional applications); 2) EM-1 (Dr. Higa's blend; Effective Microorganisms applied to the entire plot at regular intervals); 3) FPJ made with (mostly leguminous) plant leaf tips and molasses; and 4) FPJ made with banana stalks and molasses.

Brandon shared some observations from the trial: "All of the zucchini plants have been experiencing the same amount of pest pressure (caterpillars and squash bugs) no matter what spray was being applied, and all of our plants have a fungus or virus that is destroying older leaves. The differences lie in the amount of fruit production we are getting from the zucchini plants."

Table 1 shows data for marketable fruit yields harvested during the trial. Use of effective microorganisms (EM) influenced early and total yields, but not late-season marketable zucchini fruit yield. Early-season fruit yields were highest with EM. The FPJ treatments failed to improve yields, at any time, beyond that with the non-treated control; however, FPJ from leaf tips performed better than FPJ from banana stalks in the sense that total-season yield with leaf tips was statistically similar to (as opposed to less than) yield with EM.

Fruit yields with the control treatment would have been higher than those shown in Table 1 if not for the fact that plants in one of the four plots failed to produce fruit. This trial would need to be replicated further (e.g. other locations, seasons, and crops) before coming to any strong conclusions as to the performance of EM and FPJ. Nevertheless, these results suggest that, at least under our conditions in southwest Florida, EM favorably impacted zucchini production and would be worthy of future research efforts. We would love to hear of your observations with the use of EM, FPJ or IMO treatments.

Conclusion

The propagation and use of soil microorganisms is a practice that is growing among many small scale farmers, especially in Asia. Arguments exist both for and against their use. If, after reading this article, you decide to experiment with EM or IMO, check the Supplement to this issue of *EDN* for some recipes and tips.

References and Resources

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ZZ2 Laboratories. Address: Private Bag 1106, Aquaculture Research Unit Room 0004, University of Limpopo, Sovenga, 0727. Tel: (+27) 15 268 2912 / Fax: (+27) 86 586 5674 / E-mail: lab@zz2online.com / Web: www.zz2.biz (click on the 'Laboratories' tag along the top). This laboratory offers several helpful tests, including a EM quality test; a complete Soil Health test ("for those who want to establish a baseline for their land(s)") and Soil Foodweb Institute (SFI) tests that describe "key features of microbial food webs in soils, composts and compost teas."

FROM ECHO'S SEED BANK

Chia (*Salvia hispanica* L.): An Ancient Food Crop with Rediscovered Potential for Providing Nutrition

By Tim Motis

What is chia? When the word 'chia' is mentioned, it may bring to mind—especially among North Americans—the "chia pets" that are sold as a novelty item. These clay-based figurines come in a variety of animal shapes with chia seedlings grown on the tops to resemble animal fur. But chia (*Salvia hispanica* L) has a long history as a food crop, both for humans and animals, and is being "rediscovered" for its nutritional value and health benefits.

Chia originated in southern Mexico and Guatemala. The Aztecs used chia for food, medicine and oil; the crop was so valuable that 21 of 38 Aztec states gave chia in annual tribute. Some historians suggest that chia was as important as (or more important than) maize as a staple food. An article in the journal *Economic Botany* by Joseph Cahill (volume 57 number 4, "Ethnobotany of Chia, *Salvia hispanica* L. (Lamiaceae)), shared information about chia based on written accounts and conversations.

Before 1600, "a common practice of roasting and grinding of the seeds into a flour known as *Chianpinolli* mimicked the processing of maize grains and often the two seeds were processed simultaneously. The *Chianpinolli* became incorporated into tortillas, tamales and various Aztec beverages known as *Chianatoles*." Oral accounts confirmed chia's use in this way. "All consultants began by describing a process that involved roasting seeds of maize and *Salvia hispanica*…together. Once roasted, grinding of the seeds proceeded to make a flour or *pinole* that is then mixed with water to make an *atole* beverage." The pinole was also used to make tamales.

Since 1600, a drink often referred to as 'chia fresca' became popular. It is made with whole chia seeds in water, mixed with fruit juice or with lemon and sugar. This is still a popular way to consume chia.

A member of the mint (Lamiacea) family, chia is an annual herb that grows to about 1 m in height (Figure 1). The plants have purple or white, self-pollinating flower spikes resulting in white or dark-colored seeds that are 1 mm wide and 2mm long (Figure 2). Chia is marketed under a number of trademark names (e.g. Anutra, Chia Sage, Mila, and Salba). More than one *Salvia* species is referred to as chia. *Salvia hispanica* and *Salvia columbariae* are said to both have nutritional benefits, but *S. hispanica* is the domesticated type with seeds produced in the flower instead of within sharp-tipped bracts (part of flower structure).

Figure 1: Chia plants at six weeks. Photo by Clayton Phillips.

What are the benefits? In recent years chia has gained significant attention as a dietary supplement. It is even described as a "super food". I found an abundance of information on the internet, much of it posted by companies selling chia products. There are, however, online links to technical data and scientific journal publications, some of which are referred to in this article. According to the Nutritional Science Research Institute (NSRI), a non-profit organization that provides information on nutritional supplements, chia seed is considered a Dietetic Nutritional Supplement by the Food and Drug Administration in the United States, and qualifies as "healthy food" by NSRI's standards (www.nsrinews.com/nsriChia_research.html).

Summarized below are some of the benefits I found highlighted in the literature:

Very nutritious: The nutrient-dense seeds contain roughly 20-30% protein, 30-35% oil and as much as 25% fiber. Chia is promoted as a rich source of omega-3 essential fatty acids, antioxidants, dietary fiber, protein, and vitamins/minerals. See the above NSRI link, as well as a European Safety Commission document (http://nutrimenti.simplicissimus.it/files/2010/11/efsa-chia.pdf) for a comprehensive breakdown of nutrition components. Table 2 (in the online Supplement) shows a summary of nutritional data by NSRI.

Long storage life: Like moringa powder, chia seeds can be stored before consumption. As long as they are kept in a cool (but not freezing), dry location or container, chia seeds can be stored for as long as 3 years without deterioration.

High potential as a food enrichment option: ECHO promotes moringa leaf powder as an extremely nutritious addition to foods. Chia could be another option to consider. Its impressive nutritional profile and long storage life, combined with a mild flavor, means that chia seeds can be used to fortify any number of traditional foods. See more information below on how the seeds are eaten. In light of the information from the journal *Economic Botany* about chia's use in combination with maize, consider the following statement from NSRI (percentages are based on U.S. recommended daily intakes). "Without chia, [a one cup serving of] white rice does not supply the 10% of the daily reference intake (DRI) required to be labeled a 'good source' of protein, fiber, omega-3, and magnesium. It has no omega-3 fatty acids. With [the addition of 6.3g or 0.23oz] chia, the serving supplies 11%, 13%, and 11% of

Figure 2: Salvia hispanica seeds next to a ruler with markings in centimeters. Photo by Tim Motis.

protein, fiber, and magnesium DRIs, respectively, making it a 'good source' of these nutrients. With chia, the serving supplies 84% of the omega-3 DRI, making it eligible to be labeled an 'excellent source' of omega-3 by FDA standards."

Healthy oils with no cholesterol or anti-nutritional factors: Chia is one of the richest sources of omega-3 fatty acids [surpassing flax (*Linum usitatissimum*)].

Easy to save seeds: Chia is a self-pollinated crop, so it is easy for farmers to save seeds and multiply the crop. There may be some benefit to purchasing initial seed stocks from suppliers who can provide certified seed.

Resists insect pests: One source noted that, because of their high oil content, the leaves of chia plants repel insects.

Weed suppressor and pollinator enhancement: This is an interesting one. A USDA-Agricultural Resource Service posting (www.ars.usda.gov/pandp/docs.htm?docid=19317) mentioned that, in the United States (in Beltsville, Maryland), a chia planting in late July/early August attracted bees and performed very well as a weed-suppressing cover crop before the plants were killed by frost in December. To see photos of chia as a cover crop, visit: www.ars.usda.gov/SP2UserFiles/person/30842/Chia-plant-spiel-1.pdf. In Central America, some consider chia weedy because if it is allowed to remain in the field long enough, the crop will reseed itself.

How is it eaten? Chia seeds can be eaten raw or ground into flour and incorporated into bread or cakes. Water can be added to the seeds, which results in a gel that can be consumed as a drink (often combined with other juices to add flavor). A suggested approach is to soak 1/3 cup of seeds in 2 cups of water (or, for smaller quantities, 1 Tbsp of seeds in 1/2 cup of water) and let it sit for 9 minutes, which is enough time for the gel to form; amazingly, the seeds can soak up 10 to 12 times their weight in moisture, whether water or juice is used (www.herbco.com/p-928-chia-seed-whole.aspx). Soaked seeds are gelatinous in texture, and are used in porridges and gruels. Basically, chia seed can be eaten in a variety of ways. The seeds have a mild flavor and can easily be mixed with traditional foods without affecting the taste. Some sources suggest a daily consumption of 4 teaspoons (15 g) per person per day, although most state that there is insufficient data on which to base firm recommendations.

Are there any cautions? The general consensus in the literature seems to be that, although it would be helpful to have more safety data, the evidence to date coupled with the historical consumption of chia shows that the seeds are generally safe to eat. A few sources mention a blood-thinning effect from eating chia. If consumed along with heart-related drugs, the additive effects are unknown—so people taking heart or blood-thinning medications should be careful. According to the *Economic Botany* article mentioned earlier, "There is…a longstanding belief that infusions composed of whole chia seeds help to overcome resistance to uptake of medication."

How is it cultivated? Chia prefers well-drained soils of light to medium texture. It is not particular with respect to soil pH, but it does require a sunny location. A spacing of 4 in (10 cm) between plants was suggested in a USDA-ARS document. For cover-cropping, though, where complete ground coverage is the goal, they suggested a spacing of 2 in (5 cm), which amounts to a seed sowing rate of about 5 lb/acre (5.6 kg/ha). Flowering and seeding occurs 90 to 120 days after planting. Chia is a short-day plant, meaning that it will flower and produce seed in the tropics/subtropics; however, in northern temperate areas it may not flower until fall when the days shorten and the crop can be damaged by freezing temperatures. Harvest the seeds when they are mature and then allow the seed structures to dry, after which they can be threshed (one way would be to beat against the sides of a container or winnowing basket) and then winnowed to remove the chaff. In Argentina, seed yields of up to 1602 kg/ha have been obtained (see www.hort.purdue.edu/newcrop/proceedings1996/v3-045.html; this site also contains a table showing some data on economic returns).

Can I get seeds from ECHO? Yes. Clayton Phillips, working with Seeds for Life (http://seedsforlife.net/) to promote chia in the Philippines, shared a bag of seed with ECHO recently. Network members may request a complementary trial packet. We would like to hear of your observations.

UPCOMING EVENTS

ECHO East Africa Symposium

Arusha, Tanzania
February 8-10, 2011

ECHO is conducting a symposium for East Africa in February 2011. It will bring together key people and organizations directly involved in the fight against hunger in this region. Some of the subjects on the schedule are Conservation Agriculture, Permaculture, Organic Agriculture, Integrated Pest Management, Soil Fertility, Marketing, Value Chain Development and Seed Systems.

Afternoon workshops and discussion groups will be led by regional agricultural development workers and experts. We expect participants to have an opportunity for significant networking with fellow symposium participants and resource persons. We will post presentations and information from the symposium on our website when available.

ECHO sponsored a well attended conference in Kenya in 1998 which encouraged subsequent meetings in Tanzania for several years. We look forward to once again interacting with our contacts in East Africa and hope to establish a Regional Office by 2012. Information is online at www.echonet.org/content/Conferences/1678.

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!

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