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Issue Highlights

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The Effect of Aluminum in Acidic Soils on Plant Growth

By Edward Berkelaar, Ph.D.

Acid Mineral Soils

Soil acidity, or low pH, limits plant growth in many parts of the world. Although low pH can harm plants in many ways, this article will deal only with one of these factors, aluminum (Al) toxicity.

Al is the third most abundant element on the earth (after oxygen and silicon), and the most abundant metal, making up 8.1 % of the earth's crust. It is especially prevalent in clay. It becomes toxic to plants only under certain conditions.

Types and Distribution of Acid/Aluminum Soils

Acidic soils are widely distributed in the tropics. Over 50%, or 2.6 billion hectares, are considered acidic (pH < 5.5). Almost a third of all tropical soils, 1.5 billion hectares, have soil acidity that is strong enough for Al to become toxic to most crop species. Most of these soils are found in the humid tropics and acid savannas, although some exist in tropical steeplands. Soils in the semiarid tropics and tropical wetlands do not tend to have this problem. Al toxicity is usually found in soils called Oxisols, Ultisols, and Dystropepts, which tend to be highly weathered soils that are low in organic matter and have low nutrient reserves.

Aluminum and Soil Chemistry

Soils have five components: inorganic material, organic matter, soil air, soil water, and living organisms. Elements (including plant nutrients) can be found in various associations with these components. However, plants can take up elements only when they are dissolved in soil water. The water and these dissolved minerals are called the soil solution. As elements loosely associated with solid material are released into soil solution, they can be taken up by the plant.

When the soil pH is 5.5 or higher, Al is strongly bound to insoluble inorganic matter and so cannot be taken up by plant roots. If the pH is below 5.5, and especially below 5.0, an increasingly greater proportion of the total Al present in soils is found either in the soil solution or loosely associated with the inorganic matter (Figure 1). In this ionic form, Al^{3+} is bioavailable (can be absorbed by plant roots) and in this form may be harmful to plant growth. Although acid soils are relatively common in the tropics, Al toxicity is also thought to be one of the causes of forest decline in Europe and North America. In this case the soil pH is lowered by "acid rain" (rain that becomes acidified when certain gaseous pollutants, sulphur dioxide and nitrogen dioxide, dissolve in water droplets in the atmosphere).

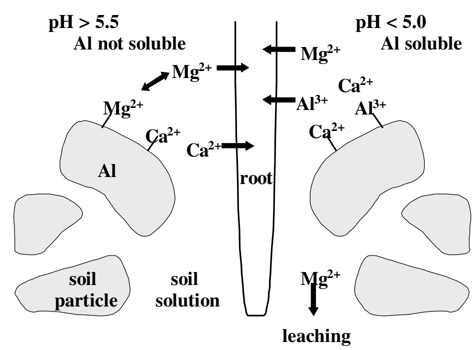

Figure 1: Al bioavailability as affected by pH.

Effect of Aluminum on Plants

There are two major ways in which bioavailable Al (Al^{3+}) can negatively influence plant growth--it can interfere with plant uptake of the essential plant nutrients calcium (Ca) and magnesium (Mg), and it can be directly toxic to plant roots.

Both Ca and Mg are required for plant growth, and plant roots accumulate the ionic forms of these nutrients (Ca^{2+} and Mg^{2+}) through "doors," or ion transporters in root cells. Al^{3+} can compete with these ions for uptake, causing Ca and/or Mg deficiencies in plants. These deficiencies would not occur if Al^{3+} concentrations were lower. Al^{3+} can also cause Ca and/or Mg deficiencies by increasing the amount of Ca^{2+} and Mg^{2+} leached from soils. Normally, a proportion of the Ca^{2+} and Mg^{2+} present in soils is found loosely bound to soil particles, which helps to prevent these ions from leaching away when it rains. Some of the particles to which Ca^{2+} and Mg^{2+} are bound are made up of Al. When Al dissolves at low pH, the soil has a lower capacity to hold Ca^{2+} and Mg^{2+} (i.e. the soil has a lower cation exchange capacity, or CEC), so these nutrient ions have an increased tendency to leach out of the soil. When Al^{3+} concentrations in the soil water increase as a result of low pH conditions, the Al^{3+} will compete with the Ca^{2+} and Mg^{2+} for binding sites resulting in greater leaching of these ions from the soil. The magnitude of the Al problem in soils is often expressed as the ratio of Ca^{2+} to Al^{3+} or Mg^{2+} to Al^{3+} in soil solution, because these ratios seem to do a better job of predicting the risk of Al-induced Ca or Mg deficiency than just the concentration of Al^{3+} alone. Finally, independent of the Al^{3+} concentration, the ability of a plant to accumulate essential ions such as Ca^{2+} and Mg^{2+} is lower when the soil pH is below 5 than it is at a more neutral (6-7) pH.

The bioavailable form of Al can also be toxic to plant roots. The mechanism by which this occurs is not well understood, but greater damage seems to occur to root tips. Al^{3+} reduces both root cell division and root elongation, resulting in short, stubby roots. This in turn reduces the ability of roots to supply water and necessary nutrients to the plant. Phosphorus deficiencies can be more pronounced when the growth of a plant's root system is inhibited. This is because phosphorus is not very mobile in soil and so plants benefit from an expanding root system that can "mine" phosphorus from a large volume of soil. Al^{3+} will also react with phosphorus in the soil solution, making it less available to plant roots.

So the effect of aluminum toxicity is primarily caused by nutrient deficiencies (such as a lack of Ca and Mg) or an inhibition of root elongation. Both Ca and Mg are essential macronutrients for all plants. The Ca content of plants typically ranges from 0.1% to >5.0% of dry weight. Ca requirements tend to be lower in monocots (grasses) than dicots (broadleafed species). Symptoms of Ca deficiency include death of young leaf blades and of the growing tips of plants. The Mg content ranges from 0.15 to 0.35% of the dry weight of plant tissue. Deficiency symptoms include chlorosis (yellowing) of older leaves between the veins or chlorosis appearing as blotches. If the deficiency continues, these areas of tissue will eventually die. As mentioned, Al^{3+} inhibits root elongation resulting in short, stubby root systems. Root tips may eventually turn brown.

Aluminum Content of Plant Tissues

When the bioavailability of Al increases, the accumulation of Al in plant tissues also increases. Unlike other metals such as cadmium, Al does not appear to accumulate to high concentrations in plant tissue. Al concentrations in plant tissue are relatively low, with roots tending to contain more Al than stems, leaves, seed or fruit. Al concentrations ranged from 850 to 3500 ppm (mg Al per kg plant tissue) in a study done in tea plantations in China. The amount of Al in tea leaves was found to depend on soil pH, and increased as the leaves aged (Dong *et al.*, 1999, Comm Soil Sci & Pl Anal 30(5&6): 873-883). When native vegetation on acidic high-aluminum soils was sampled in Brazil, the Al content of leaves ranged from 60 to 16400 ppm (Geoghegan and Sprent, 1996, Comm Soil Sci & Pl Anal 27(18-20): 2925-2934). In another study, as little as 13 ppm in maize roots was enough to result in a reduction in root length (Lindon and Barreiro, 1998, J Pl Nutr 21(3): 413-419).

The consumption of Al has been linked to certain human diseases (including possibly Alzheimer's, although this link is controversial). It is very important to realize that different forms of Al are more or less bioavailable (and therefore potentially more or less harmful) to humans. For example, ionic Al (Al^{3+}) that might be released when cooking foods in an aluminum pot is considerably more bioavailable when consumed than is Al incorporated into plant tissue. Little is known about the relative bioavailability of different forms of Al. The diets of Americans and Europeans are thought to contain less than 150 mg of Al per day. As a comparison, people taking prescription antacids in the 1970s and 1980s often consumed 1 to 3 g of Al per day (Greger and Baier, 1983, Am J Pl Nutr 38: 411-419). It is believed that inhalation or ingestion of dust and dirt is a greater source of Al for humans than is the consumption of food containing Al. We are unaware of any complaints of human health problems specific to regions where Al toxicity to plants is a serious problem.

Reducing the Effects of Aluminum on Plants

Very typically, different plant species (or cultivars within a species) differ in their ability to tolerate stresses imposed on them, and this is true for Al^{3+} stress as well. Plants have mechanisms to cope with Al^{3+} when it is present and these mechanisms work more efficiently in some species or cultivars than in others. If you are growing plants in an area where you believe soils are acidic and may contain relatively high amounts of bioavailable Al^{3+}, one thing you can do is ask seed companies if they have Al^{3+} tolerant varieties. You can also conduct your own variety trials to determine if suitable crops that are known to tolerate Al^{3+} can be grown in your area.

Crops such as pineapple (*Ananas comosus*), coffee (*Coffea sp.*), tea (*Camellia sp.*), rubber (*Achras zapota*), and cassava (*Manihot sp.*), as well as pasture species such as guinea grass (*Panicum maximum*), jaragua (*Hypaahanea rufa*), and molasses grass (*Melinis minutiflora*) can grow in soils with bioavailable Al concentrations that would not support corn and soybean.

There are also large differences between cultivars within the same species. It is possible that if you are in an area with acidic soils, locally selected varieties may have been chosen partially for their ability to tolerate Al^{3+}. In a study of the variation in response of various sorghum varieties to Al^{3+}, it was found that genotype SC0283, which originated in Tanzania, was the most tolerant of all the cultivars tested. The genotypes CS3541 (India), SC0112 (Ethiopia), and SC0056 (Sudan) were somewhat tolerant, while SC0170 (Ethiopia), P721, and NB9040 (both from the US) had little or no tolerance (Duncan *et al.*, 1983, Agron J 75(6): 1023-1026). Another study on amaranth found a very wide range in the ability of different species to tolerate Al^{3+}. In that study it was discovered that different strains of *Amaranth tricolor* L. (S-30, S-99, S-133, and S-69) grew best on Al-toxic soils, while 6 strains of *A. cruentis* L. (S-1011, S-53, S-1, S-27, S-31, and S-40) and a *A. hypochondriacus – A. dubius* L. (strain S-94 Type A) mixture fared the worst. Three strains of *A. hypochondriacus* L. (S-224 Type A, S-180, and S-122) and a strain of *A. caudatus* L. (S-122) grew moderately well in the Al-toxic soil (Foy and Campbell, 1984, J Pl Nutr 7(9): 1365-1388).

Tolerant species or varieties seem to be able to do one or a combination of the following: suffer less injury to roots, raise soil pH near the root surface (so that Al^{3+} precipitates and becomes less bioavailable), secrete organic acids to form complexes with the Al^{3+} (so that Al becomes less bioavailable), translocate less Al to plant tops, and have a strong ability to accumulate Ca^{2+} and/or Mg^{2+} despite the presence of Al^{3+}.

Adding lime to the soil can reduce Al toxicity, since Al is toxic to plants only when it is soluble and Al solubility is strongly dependent on soil pH. As the pH increases from below 5.0 to between 5.5 and 6.0, Al^{3+} will precipitate out of the soil solution and will no longer be bioavailable to plant roots. It is important not to raise the pH too much, however, since many tropical plants are adapted to growing in slightly acidic soils (pH of 5.5-6.0) and will not grow well if the pH is neutral (7.0). While adding lime may improve the conditions of the surface soil, the subsoil will remain quite acidic.

Adding organic matter to soil is another good way to reduce Al bioavailability. Organic matter has the ability to bind Al^{3+}, reducing its bioavailability and its ability to harm plant roots or to compete with Ca^{2+} or Mg^{2+} for uptake.

As already mentioned, plants growing in acidic soils high in Al may also suffer from a deficiency in phosphorus (P), because P is not very mobile in soil, and because Al^{3+} reacts with P, reducing its bioavailability. Al^{3+} also inhibits root elongation and the ability of root systems to "mine" large volumes of soil for P. When plants have a healthy relationship with mycorrhizas, the accumulation of P may be improved. Mycorrhizas are fungi that associate with plant roots enabling greater accumulation of plant nutrients, especially P. It has been shown that as much as 80% of the P found in plant shoots has been removed from soil by mycorrhiza associated with plant roots. Plant-mycorrhizal associations are lower when soils are particularly saline, waterlogged, or disturbed (from tillage), or when soil has extremely high or low fertility. Associations arise from a preexisting network of fungi in the soil.

As mentioned, one of the mechanisms of Al^{3+} toxicity is its ability to induce Ca and Mg deficiency. Adding Ca and Mg fertilizer to the soil will help offset Al-induced Ca and Mg deficiencies. Dolomitic lime contains both Ca ($CaCO_3$) and Mg ($MgCO_3$), and in tropical soils the fertilizing effect of the lime can be of equal importance to the pH effect.

Conclusion

Acidic soils are quite widespread in the tropics. Although Al is present and not harmful to plants in many soil types, in acidic soils the Al can dissolve into the soil solution and become bioavailable to plants. Al^{3+} can harm plants by inducing Ca and Mg deficiency, and/or by damaging plant roots directly. The damage can be lessened by choosing crops or cultivars tolerant of Al^{3+} stress, and by using management strategies aimed at reducing the bioavailability of Al^{3+}, such as raising soil pH and increasing soil organic matter. Increasing the amounts of Ca and Mg in soil may help as well.

Full references available upon request.

AMC 2000 Conference Summaries

By Dawn Berkelaar

ECHO's seventh annual Agricultural Missions Conference this past November was a huge success! 230 people working in 30 countries met in North Fort Myers for several days of talks, workshops and informal networking.

Here are a few highlights from the conference.

A Ceramic Water Filter: Jeff Rogers, Potters for Peace and Beyond Borders, Haiti

Jeff Rogers from Potters for Peace (PFP) made a clay water filter and explained its use during a workshop. A similar clay filter was first designed by Fernando Mazariegos of the Central American Research Institute of Industrial Technology (ICAITI). Now Potters for Peace is working to refine the filters, partnering with NGOs for their distribution. One of PFPs main goals is to see filter-making become a sustainable micro-enterprise.

To make the filters, equal parts (by volume) of dry, powdered clay and dry sawdust (or comparable material such as rice hulls, millet husks or coffee husks) are mixed. Sawdust is first put through a 30-mesh window screen. Everything that stays in the screen is discarded, removing particles that are too big. The finer sawdust is then put through an 80-mesh screen. This time everything that falls through is discarded, removing particles that are too small. The sawdust that is left should be about 50-mesh in size. Water is added slowly to make the mixture workable. The resulting material will be more plastic and workable if it is left to sit overnight.

Figure 2: Jeff Rogers making a clay filter at ECHO's AMC 2000. Jeff is using the first method described below, packing the clay into a bucket with a plastic liner. Photo by Adrienne Rogers.

The clay and sawdust mixture is formed into a shape like a flowerpot (Figure 2). Filters can be formed with varying levels of sophistication. The easiest method is to shape the clay by molding it into a bucket with a plastic liner. More efficient (but more difficult to set up) is production using a potter's wheel. A special press can also be made to form the filters. Using the most primitive method of packing the clay into a bucket, an experienced potter can make a filter every 20 minutes. Filters are fired at the same temperature as traditional pottery. In the process, the sawdust in the filter is burned out and pores are left behind. The result is a matrix of clay through which the water filters. During firing, the filter will lose about 30% of its weight due to water loss. The filter will also decrease in size by up to 10%.

Once fired, the inside of each filter is brushed with a colloidal silver solution (7 cc of 0.32% colloidal silver, added to 250 cc of distilled water). The silver solution acts as a disinfectant. Water needs to pass through the filter at a rather specific rate. If the rate is more than one or two liters of water per hour, the water may not have filtered long enough to be disinfected. If water is filtered much slower, the device will be impractical for use. Flow rate is adjusted by making adjustments to the clay/sawdust ratio; more sawdust is added to create a faster rate, and more clay is used to slow the rate down. A series of tests must be carried out for each new clay deposit, because clay from different deposits will have differing properties. Jeff stressed that clay water filters are medical instruments; if they do not have the proper flow rate, they are destroyed.

Once completed and treated with silver, filters are placed inside a receptacle tank with a spigot and a lid. The receptacle can range from a 5-gallon plastic bucket to a locally produced traditional ceramic container.

Clay water filters can be produced quite economically if the main materials, clay and sawdust, are readily available. Colloidal silver and plastic spigots are the only items that may need to be imported. The filter and receptacle should be cleaned every eight days. This can be done by scrubbing with a toothbrush and rinsing it with water. If the water you add to the filter is very dirty, drape a piece of fine clean fabric inside the clay filter before you pour water into it. When the device is used to filter dirty water, it lasts about one year. If the water is initially less turbid, the filter may last even longer.

The filters have been introduced in Nicaragua through NGOs, where 7000 filters are sold each year by direct marketing. Both filters and receptacles are being produced in several pottery communities. Jeff says demand for the filters increased after Hurricane Mitch. Jeff and his wife, Beth, recently moved to Haiti to begin filter production there near the city of Hinche. Training has also been carried out in other countries including Kenya, Peru, Guatemala and Mexico.

Potters for Peace has a Spanish educational brochure which is used to introduce the filter into a community. For more information about clay water filters, contact Potters for Peace at 2216 Race Street; Denver CO 80205; potpaz@igc.org

Jeff and Beth Rogers can be reached in Haiti at claywork83@hotmail.com

The Role of Native Trees: Dan Turk, Madagascar

Dan Turk, working with the Presbyterian Church (USA) as a mission specialist in Madagascar, gave a talk about potentials and realities for native trees of that country. In some areas of Madagascar, native forests are rapidly disappearing due to slash-and-burn agriculture and harvesting for firewood. At the same time, non-native trees (which grow much more quickly than native trees) are springing up all over. What can be done?

Dan made several excellent points in his presentation. When we plant trees, he said, we need to have a goal in mind. In a seemingly paradoxical way, sometimes encouraging the use of exotic trees can help to save the native trees! For example, eucalyptus trees are better than native trees for firewood and construction, and could be grown expressly for that purpose. In the same way, exotic fruit trees are most often better-producing than native fruit trees.

So what roles are there for indigenous trees? Dan listed several:

1) Some products from native trees are not available from faster-growing exotics. In Madagascar, these products include spade handles, medicines and ornamentals.

2) Native trees are also important for honey production, because the variety of trees in a native forest means that nectar and pollen will be available during times when plantation crops are not in flower.

3) Re-establishment of native forests is one place where indigenous trees can play a huge role.

Where a population of native trees is critically endangered, programs of off-site conservation are extremely important. These programs could be at the level of a national collection.

Finally, Dan stressed the importance of environmental education. If people cannot name a tree or know nothing about it, they will have less desire to conserve that tree. Dan showed slides from tree projects that are being done at schools in Madagascar. When it comes to education, emphasis should be placed on learning from people who have traditional knowledge about particular trees.

Marketing Niche Crops: Marlin Huffman, Plantation Botanicals

Marlin Huffman, founder of Plantation Botanicals, gave a talk about opportunities and pitfalls in growing and marketing niche crops. "Niche crops" are specialized crops for which there is a very particular but limited market. Huffman is well established in growing and supplying products for niche markets. However, based on his experiences, he has some very important cautions for people looking to grow and market specialized crops.

1) Niche crops have a limited market, so it would not be good for your business if absolutely anybody had the ability to enter the same market. So a really good niche crop will have a barrier to entry--something that makes it difficult for others to enter the same market. For example, the barrier might be that a certain crop takes many years to reach harvesting age, so that someone who wants to grow that same crop can't immediately start up and take over the market.

2) You shouldn't try to enter a market that is dominated by a larger and better-financed group, because that group can and probably will undersell you and drive you out of business.

3) Do the marketing yourself whenever possible. Brokers and dealers absorb a very large percentage of the profits.

4) Niche crops often are profitable only for a short time. As more people enter the market, the profits will be reduced. Don't try to grow a niche crop that must produce a living for your family year after year.

All of these precautions might make it seem too difficult to find a niche market, but here are some tips for finding a successful market.

1) Try and sell to **local** markets, since developing export markets can be extremely difficult for small organizations and is filled with dangers. For example, grow nicer-looking vegetables than are currently being sold or find an ethnic market for a particular vegetable, perhaps a vegetable or herb for Chinese restaurants in South America. Start by asking what people are currently eating and buying. Then ask what you could produce that will be cheaper or of better quality.

2) Once you have developed a special product, keep your secret for production.

Cover Crop Seed and Information Resources Available through TropSCORE Member Organizations

By Daniel Sonke

TropSCORE, the Consortium for Tropical Soil Cover and Organic Resources Exchange, is a consortium of nongovernmental development organizations and research/educational institutions with a common interest in cover crops, green manures and other organic means of managing tropical soils relevant to resource-limited farmers in Africa, Asia and Latin America.

Core TropSCORE members currently are:

CIDICCO: The International Cover Crops Clearinghouse, an NGO located in Honduras, is concerned with information exchange on green manure and cover crops in the tropics. It operates in Spanish and English. ECHO has utilized CIDICCO on numerous occasions to help our readers find further information on specific cover crops and sources of cover crop seed. We encourage our readers to visit their website (http://rds.org.hn/miembros/cidicco/) or write to them (Apdo. Postal 4443, Tegucigalpa MDC, Honduras; phone: 504-239-5851, 504-232-3850 or fax: 504-239-5859; e-mail cidicco@gbm.hn or cidicco@sdnhon.org.hn) for their excellent publications in Spanish or English.

CIEPCA: The Cover Crops Information and Seed Exchange Center for Africa (or Centre d'Information et d'Echanges sur les Plantes de Couverture en Afrique) is a group hosted by IITA in Cotonou, Benin. It contributes to the sustainable management of tropical soils by assisting researchers and development specialists to develop, target and test appropriate cover cropping systems in Africa. CIEPCA operates in French and English. It has recently begun to sell seed of several of the major cover crops species, and ECHO readers may wish to use them as a resource for seed or for French or English information about cover crops in Africa. Please visit their website (http://ppathw3.cals.cornell.edu/mba_project/CIEPCA/home.html) or contact them for their useful resources (08 B.P. Tri Postal, IITA, Cotonou, République du Bénin; phone: (220) 350188, fax: (229) 350556, e-mail: ciepca@cgiar.org).

CIIFAD / MOIST: The Cornell International Institute for Food, Agriculture and Development's working group on Management of Organic Inputs in Soils of the Tropics investigates and exchanges information on cover crops, green manures, other organic inputs and fallow management in tropical farming systems. CIIFAD/MOIST maintains, in conjunction with other TropSCORE member organizations, some excellent website and Internet resources described below. See also their own website at http://ppathw3.cals.cornell.edu/mba_project/moist/home2.html. (Address: CIIFAD/MOIST Group, 618 Bradfield Hall, Cornell University, Ithaca, New York 14853, USA; e-mail: lhf2@cornell.edu, phone: 607-255-2920).

ECHO, as our readers know, is a non-profit interdenominational Christian organization that provides international agriculture development resources including publications and free seed of underexploited food, agroforestry and soil-improving crops to a network of over 4,000 individuals and organizations in 140 countries. Our website and other contact information are on the cover of this newsletter.

There are several Internet-based TropSCORE projects that ECHO has often found to be useful resources:

The TropSCORE Information Gateway Website is an international clearinghouse and search engine for TropSCORE Internet resources on soil cover, organic inputs and tropical soil management. Using next-generation technology, the Gateway is being developed in conjunction with Cornell University's Mann Agricultural Library and designed to link into the Agricultural Network Information Center (AgNIC), a national alliance of U.S. land-grant university libraries. See http://arneson.cornell.edu/Tropscore/index.html for this useful resource.

MULCH-L is an open, unmoderated electronic mailing list for the interdisciplinary exchange of information on cover crops, green manures, managed fallows and other woody/non-woody mulch-based agricultural systems in tropical and sub-tropical areas. Members are encouraged to post questions or share information that may be relevant for others involved in research or extension of sustainable agriculture practices that include mulch, cover crops, green manure or other organic inputs as a component.

An "Archives by topic" of recent discussions on MULCH-L is now available on the web at: "http://ppathw3.cals.cornell.edu/mba_project/moist/mulchmail.html".

To subscribe to MULCH-L, send the following message to listproc@cornell.edu:
SUBSCRIBE MULCH-L Firstname Lastname

COBERAGRI-L is a Spanish language cover crops mailing list maintained by CIDICCO with assistance from MOIST.

COBERAGRI-L es una lista de discusion electronica, en espanol, sobre el uso de cultivos de cobertura. El proposito de esta lista es el de servir como foro de discusion e intercambio de experiencias sobre la tematica de cultivos de cobertura y abonos verdes.

To subscribe to COBERAGRI-L, send the following message to listproc@cornell.edu:
SUBSCRIBE COBERAGRI-L Firstname Lastname

EVECS-L is a French language cover crops mailing list maintained by CIEPCA with assistance from MOIST.

EVECS-L est un forum de discussion électronique axé sur les plantes de couvertures et les engrais verts. Il s'agit d'échanges d'information interdisciplinaires: agronomie, sciences animales, économie, géographie, sciences environnementales, phytopatologie, etc.

To subscribe to EVECS-L, send the following message to listproc@cornell.edu:
SUBSCRIBE EVECS-L Firstname Lastname

Questions for ECHO? Read This First!

By Dawn Berkelaar

Every Wednesday, six to eight ECHO staff meet to discuss the letters and e-mails we have received with requests for information or advice. “Technical Requests” is the term we use for the questions those of you in our "network" encounter as you work with small-scale farmers and urban gardeners. Responding to these requests is an important part of our ministry, and some of our staff spend a great deal of time researching answers. We thought it might be helpful and interesting for you if we shared the way we process technical requests.

Usually we get several dozen requests per week, about 60% of them arriving via e-mail. When first processed, a Technical Request Form, or TRF, is attached to the letter. The sender’s name and address is written on the form. The TRF helps us in the process of answering questions, writing down seed orders, or listing publications that need to be gathered. It also helps us to keep track of your request as it passes through different people's hands.

After the TRF is attached, the request is sent to the technical staff. We read through each request, authorizing shipment of requested Technical Notes and seeds and making note of questions that we need to answer. To help us answer questions, we use our library of over 2500 books and numerous files and publications; we check the Internet; and we talk to people at ECHO or in our network who have experience and expertise in particular areas. Over the years, ECHO staff have written dozens of Technical Notes (TNs) on a variety of topics to help us answer frequently asked questions. We also have a bookstore with many useful titles that we sometimes recommend. [Note: All of our TNs and past issues of EDN are on our web site and can be accessed from there. They are also on the CD-Rom that we reviewed in the last issue of EDN. Our bookstore is on the web, too.]

For the past year and a half, ECHO interns have been included in the technical request answer process. Each month, one intern is assigned to help answer technical requests three mornings a week, with careful guidance by more senior staff. This enables the intern to learn about a variety of topics and makes more time available than we would otherwise have for searching through the library for information.

After answers have been written and proofread and the appropriate seeds or publications have been authorized, the technical staff send the TRF to the central office where volunteers gather the publications (Technical Notes, ECHO documents, books, etc.) that have been authorized. If seed needs to be gathered, an intern is assigned the task of going to ECHO's climate-controlled seedbank to collect the packets.

Plant information sheets are often included with seed orders. These sheets tell how to plant and cultivate the particular species. A harvest report is sent along with seed, to be filled out by the recipient after the harvest and returned to ECHO. This data is entered into a computer so that we can track how seeds that we send have performed around the world.

The next step is to calculate payment, if any. For people working in agricultural development, their first ten trial packets of seed are free (but only one free packet of any particular variety is sent for free, so ten different varieties of seed need to be selected). Once we have received a completed seed harvest report from a development worker, s/he may request up to ten more free trial packets of seed. The first $8.00 worth of ECHO TNs are also sent for free to those working in agricultural development. More seeds or publications can be purchased. We do not send books or seeds before payment has been received.

Finally a volunteer gathers the seeds, letters and publications and mails them to you. Then the TRF, which contains information about the request and the responses given, is coded into the computer. The next time you write, we can quickly bring up the history of our correspondence with you. The TRF and your original letter are stored in our files.

Usually numerous people handle a technical request before the process is completed. We can be most efficient with our time when different people are responsible for different parts of the process, and our many volunteers bless us greatly by handling some of these steps. However, having many people involved also means that not everyone who handles a request will recognize your name, even if you are a part of our network. Please do not be offended if you are not recognized; your requests are important to us.

A typical technical request takes at least a week to go through the whole process described above. If you have a time-sensitive order, please let us know several weeks in advance!

Lately, more and more of the technical requests are coming over e-mail. Often people do not list their full name and address, and we might not even know what country they are in! Also people in distant parts of the world learn about us from the web and ask questions even though they are not part of our network. For example, a question about raising rabbits by John Doe might be from a high school student in Argentina. We ask that people who write to us over e-mail include their name, postal address, e-mail address and the organization with which they are working. If you are a member of our network, please identify yourself as such. This will keep the request process from slowing down and will help us be the best stewards possible of the resources we have been given. If your information is not complete, your request will be returned to you and you will need to submit it again with the required information. Please also tell us to what your request relates, so that we have as much information to work with as possible. Information about the climate where you work is helpful, too. A good way to give us insight into the climate is to tell us the four most commonly grown crops in your area, as well as what time of year they are grown.

ECHOES FROM OUR NETWORK

Enthusiasm for SRI (System of Rice Intensification)

Roland Bunch, Honduras

Congratulations on doing an EDN on SRI. I have a feeling that this technology will become the basis for a veritable revolution in rice growing in Asia. I also suspect that you will look back someday on this issue of EDN as having been one of the ones that had the most impact among all those you've written.

Once again, hats off.

J.B. Hoover, Asian Rural Institute, Japan

Congratulations on a most interesting issue (#70)! I was fascinated by SRI and especially pleased that you decided to devote most of the issue to this topic. In our training institute we grow all the rice we consume, and we use our own labor for transplanting, weeding, etc. Also we use only organic methods of fertilization and protecting against insects. However, growing enough rice has become more and more difficult as "development" in our area has led to the paddy land we once leased from other farmers being turned into apartment buildings. I certainly plan to dedicate part of our on-campus paddy to this method this year.

Thank you again for your excellent work. From our perspective here at ARI, this is the kind of scientific research that we feel really makes a positive difference in the lives of the people our participants (trainees) serve.

SRI Questions

Mr. J. B. Hoover of the Asian Rural Institute in Japan wrote to us with a few questions about SRI. To answer his questions, we contacted Norman Uphoff from Cornell University. His colleague Erick Fernandez (who has done a lot of work in Madagascar where SRI was developed) also responded. Here are the questions and their responses:

1) Has SRI been tried in temperate monsoon climates like Japan? If so, is there any documentation?

NORMAN UPHOFF: I don't know of any application of the SRI set of practices in temperate monsoon climates, but since SRI is not a technology but a set of principles to be adapted to local conditions, there is no reason why it should not work under those circumstances. We do know from Madagascar that yields are higher in the higher elevations with cooler climates. The problem with a monsoon climate may be that it is hard to keep the soil well-drained during the height of the monsoon, though this may be done by growing the rice on raised beds, as is now being done increasingly with wheat, to reduce irrigation requirements (furrow rather than flood irrigation) and raise yields. For best SRI results, indeed for ANY SRI results when there is continuous flooding under monsoon conditions, the soil needs to be kept at least intermittently well drained.

ERICK FERNANDEZ: As Dr. Uphoff points out, SRI should apply across the range of rice-growing sites (tropical to sub-tropical/temperate). We should not, however, be too surprised to find that SRI is better for some climates versus others. There are still many unknowns about the interactions and synergies.

2) As to the weeding "problem" raised in the article, we at ARI, like many organic Japanese farmers, use Aigamo ducks in the field. Using Aigamo has virtually eliminated the need to weed the paddy, and they rid the paddy of most harmful insects. However, we have used Aigamo in conjunction with typical flooded fields. Do you have access to any documentation about using Aigamo or other flightless ducks as part of the SRI system?

DR. UPHOFF: No experience or documentation. We have found, however, that pests (and diseases) are less with SRI compared to other cultural practices, so maybe the ducks would not be as well-fed with SRI? That is a nice thought.

DR. FERNANDEZ: Ducks are common in the rice systems in Madagascar. Although SRI seems to reduce rice pests, nothing is known about the impact on other beneficial insects and aquatic fauna/flora that make up a large part of the 'a la carte' duck menu! Another point to consider: by paddling around and 'dibbling' around the rhizosphere, ducks help aerate the root zone.

(Mr. Hoover wrote to us with more information about Aigamo ducks. Aigamos are a crossbreed of wild and domestic ducks. Mr. Hoover says the ducks do not touch the rice leaves but must be removed from fields just before rice plants head. Fences or nets are kept around the fields to prevent wild animals from reaching the ducks and to keep the ducks within the rice fields. Ducks are given a small amount of crushed rice in the morning to supplement their diet of weeds, weed seeds and insects. 15 –30 ducks are used per 10 acres. We do not know of any studies that have been done using Aigamo ducks along with the SRI methodology.)

BOOKS, WEB SITES & OTHER RESOURCES

New From ECHO: Appropriate Technology Technical Notes

By Dawn Berkelaar

In January, ECHO published several new technical notes describing some of the appropriate technology designs that are displayed here at ECHO. The new technical notes are authored by Jason Dahlman (a former intern) and Charlie Forst (head of ECHO's appropriate technology department). The technical notes appear on our publication list under the heading "Technologies Demonstrated at ECHO". Prices are as follows:

Sand Water Filter	$1.00
Sawdust Cookstove	$1.00
Haybaler	$1.00
Floating Drum Biogas Digester	$1.00
Solar Dehydrator	$3.00
Briquette Presses for Alternate Fuel Use	$2.00

These technical notes are also located along with other ECHO publications on our website (www.echonet.org).

Those working in development overseas may request copies of any of these technical notes that are of particular interest. For all other individuals, charges for the technical notes are as listed. Shipping is included in the price. Payment we accept includes US checks, US money orders, and credit cards (Visa, Mastercard and Discover).

FROM ECHO'S SEEDBANK

Moringa stenopetala and *Cajanus cajan*

By Daniel Sonke

ECHO now has a fairly steady supply of *Moringa stenopetala* seed. As reported in previous issues of *EDN*, this is an African relative to the more commonly known *Moringa oleifera*. *Moringa stenopetala* seems to be much more drought-tolerant, and has larger leaflets which many people say are better tasting.

We have seed of three types of pigeon pea (*Cajanus cajan*, or congo pea) in good supply. Why grow pigeon peas? This is what is written in our Technical Note on the plant, "I think of three principal reasons. (1) They grow under poor soil conditions. (2) They are tolerant of dry weather. (3) They are a nutritious, high-protein pulse crop. Other reasons include: (1) Leaves can be used for animal feed. (2) The fast-growing plants make good shade for other crops, e.g. vegetables, herbs, vanilla. (3) Plants are perennial for up to 5 years. (4) Woody parts can be used for firewood. (5) Water and nutrients from deep in the soil can be caught by its deep taproot."

ECHO now has '2-B Bushy' seed available. It is a determinant variety developed in Puerto Rico and is a bushier type than most pigeon peas. 'Caqui' is a selection from South America that was developed primarily for use as a fodder or green manure, though it is still acceptable for human food. 'Agroforestry Select' is a "folk" selection of an upright pigeon pea from Thailand further selected in Hawaii. As the name implies, the selection has been made with agroforestry (firewood, green manure, woody stakes) in mind, though the peas produced are useful for human consumption as well. Pigeon peas are commonly requested from ECHO's seedbank. These varieties may facilitate more diverse uses of pigeon pea in your area of the world.

Also available:
'Kahala' soybean, a nematode-resistant cultivar from the University of Hawaii.
'African' okra. Previously mentioned in *EDN*, this variety continues to impress us with its ability to continue producing in short days after other okra have ceased flowering. The pods are edible even at a fairly large size. This variety was much sought after by Haitians when they saw it in full leaf and producing in the Central Plateau in August, when their other okras had died. If okra is already grown in your area, this one may well be worth a trial for comparison.
Broom corn – this species of sorghum is grown not for food, but primarily for the long, thin stalks which support the seed in the seed panicle. After the seed is threshed out, these dried stalks traditionally are used to make high quality brooms

and could also be used for making marketable craft items.

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One free trial packet of each of the above varieties may be requested from ECHO by anyone working not-for-profit with farmers in developing countries. Others may purchase them for $4.00 each (includes shipping)

UPCOMING EVENTS

Konferans Agrikol 2001

Global Outreach, TiTyen, Haiti (Rue National #1, Km 25 across from La Minoterie d'Haiti)
May 21-25, 2001.

This is the fifth Conference for Christian Agricultural Workers sponsored by ECHO and a dedicated committee of Haitian and expatriate staff from organizations working in Haiti. The conference will feature speakers highlighting successful projects from around the country, field trips to informative projects in the area, and spiritual encouragement for those working in development. Both small "gwoupmas" and large organizations are encouraged to send up to 2 delegates. All activities are conducted in the Creole language.

The Konferans Agrikol begins the evening of May 21 and ends the morning of May 25. For more information or to register (US$35), contact:

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ECHO IS NOT INVOLVED IN REGISTRATION.

Amaranth as a Promising New Crop Alternative

Columbia, Missouri, USA
August 16-17, 2001

This conference will include presentations on topics related to production and utilization of amaranth. The conference is intended for farmers, extension specialists and agricultural consultants, in addition to researchers and food industry representatives.

For more information, contact: Amaranth Conference, c/o Jefferson Institute, 601 West Nifong Blvd, Suite 1D, Columbia MO 65203, USA. Phone: (573) 449-3518. E-mail: rmyers@tranquility.net

Please Note: Some of the EDN 70 issues that we mailed in January were destroyed in transit. Those issues included important renewal notices for EDN. If you have not yet received a copy of EDN Issue 70, please let us know and we will make sure a copy gets sent to you as soon as possible. Please also check your address label. If the year listed after your name is 1998 to 2000, please send us the label and a note saying that you want to renew your subscription for the next three years.