EDN ECHO Development Notes

April 2005
Issue 87

Edited by Martin Price
and Dawn Berkelaar

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.

Issue Highlights

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

[From the Editors: This issue of EDN is longer than usual. We did not want to risk leaving out important information by condensing the articles. Information about our annual November conference is also included with this issue. In the future we will continue to aim for eight-page issues.

Please take note of the *Appropriate Technology* magazine offer (for organizations) on pages 11 and 12 of this issue. We reviewed *Appropriate Technology* in *EDN* issue 80 (pages 7 and 8); it is an extremely informative magazine, and this is a generous offer. Note that subscription forms should be returned to the address on page 12, and **not** to ECHO.]

Aflatoxin—A Cause for Concern

By Dawn Berkelaar

Introduction

The term "aflatoxin" refers to several metabolic substances produced by the fungi *Aspergillus flavus* and *A. parasiticus*. These fungi are naturally and normally present in soil and in decaying vegetation. *A. flavus* is found worldwide. *A. parasiticus*, the main *Aspergillus* species found on peanuts (groundnuts), can be found in the Americas but is relatively uncommon in Asia.

The majority of aflatoxin is produced by the fungus in the crop or food in which it grows. This means that even though food may not look moldy, aflatoxin may be present in it. Although the opposite can also be true—that *Aspergillus* mold may grow without producing toxins—this only occurs at temperatures outside their normal growing range. Thus for all intents and purposes, it is safe to say that these toxin-producing *Aspergillus* species always produce toxins at temperatures within their normal growing range.

Aflatoxins were first discovered in 1960, when more than 100,000 young turkeys, ducks and pheasants in England died from a disease that came to be known as "turkey X disease." The birds were lethargic, had poor appetites, and died within a week. Examination of the dead birds revealed enlarged kidneys and necrotic (dead) liver tissue. The cause of the disease was found to be toxins in a moldy shipment of Brazilian peanut meal.

There are four aflatoxins that occur naturally: B1, B2, G1, and G2. When a handheld ultraviolet light shines on grain that contains aflatoxins B1 and B2, the grain will look fluorescent blue. Aflatoxins G1 and G2 will fluoresce green. B1 is the most toxic of the aflatoxins. The incidence and ratios of these four aflatoxins vary. For example, the G aflatoxins do not occur in Asia.

Effects of Aflatoxins

1) Effect on Animal Health

Scientists have intensively studied the effect of aflatoxin on animals. Every species of animal tested was sensitive to aflatoxin poisoning, but to different degrees. Aflatoxin has been found to affect pigs, ducks, chickens, turkeys, calves and trout. In chickens, exposure to aflatoxin B1 results in liver damage, decreased egg production, decreased eggshell quality, and an increased susceptibility to disease. Other symptoms in animals include hemorrhaging (bleeding), jaundice (yellow skin) and weight loss. Some general symptoms of animals that eat aflatoxin-contaminated feed on a regular basis include reduced growth rate, a suppressed immune system, and decreased feed efficiency. Aflatoxin is known to cause cancer in animals. It

can also prove fatal if eaten by livestock.

2) Effect on Human Health

Aflatoxin is also dangerous to humans. Aflatoxin damages DNA and is among the most potent carcinogens (cancer-causing substances) known. It was labeled as a class I human carcinogen by the International Agency for Research on Cancer (IARC) in 1993 (IARC Monograph 56), and primarily targets the liver. This is because the enzymes that convert aflatoxin to its carcinogenic form are present in the liver in high concentrations. The carcinogenic form causes irreversible genetic damage. Other enzymes convert aflatoxin to less dangerous forms that are excreted from the body in urine and feces. Liver cancer is the most common cancer found in Africa; rates of liver cancer in some countries of Africa and Southeast Asia are 100 times higher than in some northern European countries! However, the lack of data from many countries affected by this problem on the occurrence of aflatoxin contamination makes it difficult to know how widespread is the incidence of liver cancer related to aflatoxin ingestion.

The milk of cows that have consumed contaminated feed has also been shown to contain metabolites of aflatoxin B1 and G1 (metabolites are chemicals left after aflatoxin has been broken down in the body). These metabolites are called aflatoxins M1 and M2, and are probably not human carcinogens (according to JECFA, the Joint FAO/WHO Expert Committee on Food Additives, 56th meeting, February 2001).

Like aflatoxin, hepatitis B and C are liver carcinogens. A high incidence of hepatitis B occurs in the same hot, humid areas that have high levels of aflatoxin exposure and high rates of liver cancer. Furthermore, aflatoxin is more likely to cause liver cancer when a person has hepatitus B and C. Liver cancer in hepatitis B positive populations [people who test positive for hepatitis B] is 10 to 20 times more likely when they are exposed to aflatoxin.

In addition to cancer, which takes some time to appear, exposure to aflatoxin can cause effects soon after exposure (acute toxicity), including death. In humans, acute exposure to aflatoxin has resulted in jaundice and high blood pressure.

A relationship of some kind seems to exist between aflatoxin and kwashiorkor (a form of malnutrition caused by inadequate protein intake). Children with kwashiorkor have been found to have increased concentrations of aflatoxin in their body fluids than both healthy children and children with other diseases of malnourishment. However, it is not yet known if exposure to aflatoxin actually results in the development of kwashiorkor. The higher levels and more frequent presence of aflatoxin in kwashiorkor patients might mean that they were exposed to more toxins, or it might result from a lack of ability to transport and excrete toxins. If the former is the case, researcher R.G. Hendrickse suggests that aflatoxin may damage the liver, making it unable to manufacture the protein albumin. Low levels of albumin lead to kwashiorkor. Either way, it seems clear that children with kwashiorkor are at greater risk from aflatoxin than normal children. There are also indications that the metabolism of aflatoxin differs depending on the type and incidence of malnutrition. In a study by Hendrickse, a metabolite of aflatoxin B1 was detected in people with kwashiorkor (12%) and with marasmic-kwashiorkor (6%) but only once in a person with marasmus (a form of malnutrition resulting from insufficient energy intake) and not in people with adequate nutrition.

Other factors besides malnutrition can influence a person's response to aflatoxin. According to an article in the August 2001 issue of *Spore*, "For those people who do not manufacture a certain enzyme—in Sudan, half the population—…aflatoxins are even more than fifteen times more likely to lead to liver cancer." Insufficient protein intake also increases susceptibility to aflatoxin.

Spore adds, "The problem is aggravated by the fact that most farmers process lower quality groundnuts [peanuts; lower quality ones are more likely to be contaminated] into groundnut butter for home consumption."

In addition to its carcinogenic properties, exposure to aflatoxin appears to suppress the immune system. In a study of protein energy malnourished children [children who do not get enough protein in their diet], those with higher aflatoxin concentrations in body fluids had a lower hemoglobin level and increased number of infections. They had also been hospitalized for longer periods of time. In another study, children who had been exposed to aflatoxin suffered from more malaria infections.

3) Export Issues

Clearly the less aflatoxin that is present in a crop, the better. While monitoring for aflatoxin may not always seem feasible, it is a necessity for those who wish to export crops. Maximum allowable limits have been set for aflatoxin. These differ from country to country, but are becoming stricter.

In the U.S., the current limit for aflatoxin contamination of agricultural commodities (except milk) intended for human consumption is 20 µg of total aflatoxin/kg of product (20 ppb, or just 20 mg/metric ton). Above certain allowable limits, maize (corn) in the U.S. is not even permitted to be shipped between states. These limits are 20 ppb for maize intended for consumption by humans, immature animals and dairy animals; 100 ppb for maize intended for breeding cattle, breeding pigs, or mature poultry; 200 ppb for maize intended for finishing pigs 100 lbs or greater; and 300 ppb for maize intended for finishing feedlot cattle. One part per billion is like one drop of water in a 21,700-gallon (82,135 liter) swimming pool, or like 1 second in 31.7 years!

Recently established standards for allowable aflatoxin limits for the European Union (EU) are much stricter than internationally agreed upon standards. Cereals, dried fruits and nuts intended for direct human consumption cannot contain more than 4 ppb of aflatoxin. [The standard set by the Codex Alimentarius Commission, in contrast, is 15 ppb. The World Health Organization (WHO) and the FAO (Food and

Agriculture Organization of the United Nations) consult Codex, which sets international food standards.]. These tighter standards set by the EU will undoubtedly reduce exports of many cereals, dried fruit and nuts from Africa to Europe. Authors of one article estimate that the tighter EU standards, which would "reduce health risk by approximately 1.4 deaths per billion a year, will decrease…African exports by 64% or US$670 million, in contrast to regulation set through an international standard." (Otsuki *et al*, 2001. Saving two in a billion. *Food Policy* 26: 495-514)

Highly Susceptible Crops

Crops differ in their likelihood of aflatoxin contamination. Some of the crops most susceptible to aflatoxin contamination include maize, peanuts (groundnuts) and grain sorghum. These crops are mostly used in animal feeds in the U.S., but are staple crops for humans in many tropical countries. Other major products in which aflatoxin is produced include dry beans, cottonseed, wheat and tree seeds. Rice can also be a significant source of aflatoxin when stored in poor conditions in tropical and subtropical areas.

Copra (the dried white flesh of coconut) often has high levels of aflatoxin contamination. To a large extent it has been replaced by crude coconut oil imports as a source of edible oil. Aflatoxin in the oil is removed during the refining process.

How Much Aflatoxin is Too Much? How Big is the Problem?

Aflatoxin contamination in stored grains is often a huge problem. According to an article in *International Agricultural Development* (March/April 1996), more than one-third of stored maize in Benin had high levels of aflatoxins during a 1993-1994 sampling period. Contamination levels dramatically increased during storage. Six months after harvest, maize in more than half of the stores was contaminated with very high levels of toxin.

According to an article in *Spore* issue 94, "In April 2001, high levels of aflatoxins were found in the peanut butter which a South African nutrition programme provided to schoolchildren. A recent study by Ragaa El Hadi Omer in Sudan has shown that poorly stored groundnuts in the country contain twenty times more aflatoxins than the levels permitted by the World Health Organization (WHO)."

In a study of 480 children (aged 9 months to 5 years) across Benin and Togo, 98% had aflatoxin in their blood, with levels highest in weaned children. Children who had stunted growth or who were underweight had 30-40% higher mean concentrations of aflatoxin in their blood than other children.

Some members of our network also shared information about the problem of aflatoxin. Axel Bosselman from Australia shared, "Many years ago I used to work…in the Gambia where aflatoxin has been a real or potential problem ever since groundnuts were planted there and throughout West Africa. [The problem is] usually coped with there by [using] good well-aerated storage to prevent *Aspergillus flavus* from spreading. (Some years ago, almost all peanut butter in Australia had to go off the shelves because of aflatoxin found in some brands.)"

Growth of *A. flavus* and Production of Aflatoxin

The molds that produce aflatoxin can occur both before and after harvest.

1) Preharvest

In some crops, plants are infested with *Aspergillus* fungi while plants are still growing in the field. Before harvest, one of the most serious causes of contamination is late season **drought stress** when the soil temperature is between 76 and 90ºF (25 and 32ºC). In peanuts, moisture during the last thirty days is particularly important because it causes contaminated pods to rot and to remain in the soil at harvest. Irrigation, if available, can effectively reduce aflatoxin contamination of peanuts and corn.

Insect damage to pods and kernels can also lead to increased aflatoxin contamination, by providing points of entry for the fungus. This is another reason that management strategies must begin when the plants are still in the field.

After peanuts have been dug, they can fairly safely be placed in inverted windrows for drying. However, they should not be stacked because the peanuts will dry too slowly. Slow field-drying methods allow *A. flavus* to grow, and peanuts are most likely to become infected during this time of harvesting. Adequate **air flow** is essential during the initial field-drying period.

2) Storage

After harvest, *A. flavus* is often found in stored grains, especially in maize and peanuts. A combination of **high kernel moisture content** (16 to 30 percent), **warm temperatures** (77 to 90ºF or), and **high humidity** (80 to 100 percent) create ideal conditions for *Aspergillus* to grow and for aflatoxin to form. Improved storage conditions are one of the best long-term approaches to prevent aflatoxin contamination.

The optimal temperature for aflatoxin production by *A. flavus* is 27ºC (80ºF), though it can occur in a temperature range of 12 to 42ºC (54 to 108ºF). *A. flavus* requires a relative humidity of 85% in order to grow. This corresponds to different moisture contents in different crops: in starchy cereals, 17.5 to 18.5%; in high oil crops like peanuts, 8 to 9%; and in copra, 5 to 6%.

Localized patches of high moisture and humidity can form in storage (e.g. due to the presence of insects), creating suitable conditions for *A. flavus* to grow. Under optimal conditions, aflatoxin can be produced within 24 hours and a maximum amount is reached in about 10 days.

Usually when *A. flavus* is growing in grain, other types of fungi will also be present. However, the maximum amount of aflatoxin is produced when *A. flavus* occurs alone, as a practically pure culture. If other fungi, yeasts and bacteria are

present and growing, little or no aflatoxin is formed or else it is metabolized as it is formed.

Prevention of Aflatoxin Production

Prevention is by far the most practical control strategy to minimize the dangers of aflatoxin.

1) In the field. To reduce mold contamination in the field, you can improve plant vigor by rotating crops; planting at proper densities; and generally controlling pests, especially soil-inhabiting insects.

2) Dry crops quickly. Grain should be properly dried after harvest, as soon as possible and as quickly as possible. Keeping stored crops at the right moisture level can be difficult in high humidity areas, but it may work to dry the seeds carefully and then store in moisture-proof plastic sheeting.

3) Avoid grain damage. A second prevention strategy is to avoid grain damage before and during drying, and also in storage. Insects cause damage to grain, which makes it more prone to fungal invasion. Foreign material and damaged kernels and pods should be removed.

4) Proper storage conditions. A third strategy to prevent the growth of *A. flavus* is to ensure proper storage conditions. In the tropics, temperatures are generally warm enough for the fungus to grow. Moisture is often slightly easier to control. Ideally, you should use well-designed structures with floors and walls that are impermeable to moisture. In very humid areas, ventilation during the driest part of the day can help reduce moisture. Stored grain requires adequate ventilation, especially if metal containers are used. If available, an instrument for measuring humidity can be helpful to monitor relative humidity in storage.

Sealed storage can be an effective prevention method, as long as temperature fluctuations are minimized and grain is dried properly before storage. Crops generally should be stored or transported in cotton, burlap or paper bags, and not kept in plastic bags.

The form in which crops are stored can also affect the presence and growth of *A. flavus* and aflatoxin. In one study in Benin, aflatoxin levels were lower in maize that was stored on the cob than in maize stored as kernels.

5) Other prevention measures. There are a few other basic ways to prevent and control aflatoxin in stored crops. Clean grain bins before using them for storage. Monitor bins every few weeks to detect spots of high temperature and high moisture. If you find moldy grain, have it tested for toxins if possible in your area. Separate contaminated kernels, nuts or seeds, and remove foreign matter.

6) Handling of prepared food. Aflatoxin can form on prepared foods, but a few practices can help reduce this kind of aflatoxin contamination. Refrigerate leftovers (if possible), since aflatoxin does not develop under refrigeration. The exclusion of air from foods (e.g. by vacuum-packaging) is another way to minimize fungus growth. Precautions regarding prepared food are important. However, the fungus that produces aflatoxin cannot grow in peanut butter, so levels of aflatoxin in peanut butter would not increase even without refrigeration.

Detection of aflatoxins

Many methods exist to detect aflatoxins. Below is a brief description of some of them.

1) Ultraviolet or "black" light test

A. flavus fluoresces (seems to glow) bright blue or green under ultraviolet (UV) light (365 nm). However, screening by ultraviolet light is not a conclusive test for aflatoxin. While fluorescence **may** indicate that aflatoxin is present, it does not necessarily mean that it is. The test uses a long wave UV light in a dark area to detect bright greenish-yellow fluorescence (BGYF) that can indicate aflatoxin contamination. The test actually detects a product of fungal metabolism called kojic acid, rather than the aflatoxin molecule itself. It is called a "presumptive test" and should be used only as a preliminary test followed by more accurate testing to detect aflatoxin. If you use a UV light to test for aflatoxin, you should be aware that both "false positives" and "false negatives" can occur. [For example, rat urine supposedly also fluoresces under ultraviolet light—not that you would want to eat it, either!]

Another shortcoming of the black light method is that fluorescence does not indicate quantities of aflatoxin present. Besides, the fluorescent color may diminish during corn storage although the aflatoxin remains. For best accuracy, the "black" light test should be done on a representative sample, all kernels should be cracked, and the person viewing the sample should be experienced and have perfect color vision.

2) Thin Layer Chromatography (TLC)

There is a TLC method that is accepted internationally (IARC Monograph 56). This is possible to undertake even in rural conditions. Isha with the Auroville Farm Group, a member of our network in Tamil Nadu, India, told us that one of their food processing units for peanut butter relies on TLC to test for aflatoxin. One test sample costs rs 500 (rupees) commercially. For members of the organization a sample costs rs 250 (~US$5.50). We can send more information about this method to those who wish to know more about it.

3) Other Detection Methods

Another detection method includes minicolumn detection. ELISA (enzyme-linked immunosorbent assays) are also used. The latter tests involve a simple extraction procedure, with the extract then being used to react with a treated surface to cause a color change. ELISA tests are relatively inexpensive, easy to use and accurate. Most are "qualitative," giving a positive or negative reaction.

4) Sampling techniques

When testing for aflatoxin, it is important to use a representative sample. Probe sampling or stream sampling are

two good methods. Probe sampling involves the use of a compartmented probe that is inserted into the container to take samples in at least five different locations. Stream sampling is done when grain is poured in a stream during harvesting. A cup is passed under the stream of falling grain at periodic intervals. Whatever method is used, samples should amount to 300 grams or 10 ounces.

Removal of aflatoxins

Much work has been done on the subject of removing aflatoxin from a contaminated crop. David Miller, a toxicologist at Carleton University in Ottawa, Canada, says, "The most important method by far is the physical separation of the infected kernels. That is what is done in the US and this is what is done where there is sufficient crop in developing countries."

Work has been done to find ways to remove aflatoxin from contaminated products. Blanching and color sorting is possible for peanuts. In the book *Peanut Health Management*, David Wilson writes, "Blanching to remove aflatoxin contamination is a specialized process during which the peanuts undergo a white roast and the skins are removed. The blanched peanuts are then color sorted. Almost always, the peanut lots that are formed after the final color sort contain very small amounts of aflatoxin because peanuts containing any mold or damage darken during the roasting process, making the final colour sort very efficient. Blanching for aflatoxin removal sometimes results in as much as 25% shrinkage [of kernels], but the residual peanuts are usually free of aflatoxin."

"Control of Aflatoxin in Raw Peanuts through Proper Manual Sorting" is a document by Galvez and coworkers, published by the United States Agency for International Development Peanut Collaborative Research Support Program (http://168.29.148.65/images/pdfs/reports/ monograph3.PDF). It describes a method of dry-blanching peanuts that was developed in the Philippines to facilitate sorting of damaged peanuts that are likely to be contaminated with aflatoxin. The method is considered labor intensive for large-scale operations such as those in the United States, where it can be used as a final sort, but is very effective for smaller-scale operations. Machinery including a roaster and deskinner are required for this method. 50 kg of shelled peanuts were dry-blanched at 140ºC (284ºF) for 45 minutes (or up to 55 minutes if the skins still did not come off easily; roasting for too long will cause color change that will make it difficult to see the damaged and discolored kernels). Roasting time depends on the weight of the peanuts to be roasted. Peanuts were then cooled, deskinned and manually sorted for defective, discolored kernels. Dry blanching caused damaged peanuts to appear dark, shriveled and discolored, so that they were easier to pick out.

In experiments, typically no aflatoxin was detected in deskinned unsorted peanuts. In contrast, deskinned sorted discolored peanuts from these batches contained aflatoxin ranging from very low levels to very high levels (as high as 16,000 ppb!). This is because often aflatoxin is found in only a small percentage of kernels, but the concentration in a single kernel may be extremely high. The remaining deskinned sorted peanuts had no detectable aflatoxin.

Dry blanching and sorting added another whole step to peanut processing, but the collaborating company that adopted the technology saw added benefits from it. For example, peanuts no longer had an unpleasant aroma during roasting (perhaps due to early onset of rancidity in unblanched peanuts); the shelf life of products containing peanuts went from six months to 2 years; and demand for the company's products went up. The company that was unable to export peanut products is now able to successfully export their products containing peanuts.

Aflatoxin is heat-stable, meaning that it is not broken down when food is cooked. Heat will not remove aflatoxin.

An ammoniation process has been developed to inactivate aflatoxin in feed ingredients. However, it is not approved by the FDA for use in food in the U.S., and the process is not always successful in detoxifying aflatoxin-containing seeds.

Treating maize with lye (as is common in Central America) reduces exposure to aflatoxin. However, treating maize with lye is not feasible in areas where water is scarce. Procedures used to process corn help to reduce contamination. Although aflatoxins are generally stable when processing foods, they are unstable in processes such as those used in making tortillas that employ alkaline conditions or oxidation steps. (www.Ansci.cornell.edu/plants/toxicagents/aflatoxin/aflatoxin.html).

Oils refined from seeds such as peanuts contain little, if any, aflatoxin. Apparently aflatoxin is separated with the solid fraction when peanuts are pressed for oil. The FDA has agreed that aflatoxin contaminated peanuts may be processed into oil, but the residual meal cannot be used for domestic food or feed unless first tested for contamination. (www.cfsan.fda.gov/~comm/cp07001.html). However, according to ICRISAT, peanut oil refined in a solvent-extraction process is free from aflatoxin, but oil processed by village-level technologies may require additional treatment to render it safe for human consumption. (1988. Summary and recommendations of the International Workshop on Aflatoxin Contamination of Groundnut, 6-9 October 1987) [Details were not given regarding what additional treatment is recommended.]

Tough questions

When thinking about this article, we wondered what kind of advice to give regarding aflatoxin. In particular, we wondered, "Should people overseas ever eat local peanut butter? What advice would you give someone faced with the choice of eating possibly contaminated peanuts or eating nothing at all?"

We heard from some of our network members in this regard, in response to a request in *EDN* 72 for information about aflatoxins. Jared Barker, Sr., wrote to us from South Cotabato, Philippines. "Aflatoxin is very prevalent here in the Philippines. As you mentioned, it is often found on corn and peanuts plus copra (coconut flesh). [This is] probably an increased problem due to our high rainfall and humidity and

our methods of solar drying. It is well known that aflatoxin is a cause of liver cancer. We remember that many years ago, the USAID/US Embassy sent an information letter on this, warning Americans to beware of foods containing the risk of aflatoxin molds. This was not highly publicized, because corn, peanuts and copra are major products in this country.

"The Philippine government through the National Food Authority did research on this subject a few years ago. The agency, NAPHIRE, had a major research project on one of our campuses. They also confirmed the presence of these molds on much of the farmers' production during the period. We try to be very careful about our source of peanuts and corn grits. Earlier information claimed that the oils from these crops did not contain the aflatoxin; however we have not been able to verify this. We would be interested in further information on this subject. Malignancies of the liver are very common here."

We also found many cautions in our reading. For example, in a book published in 1975, Clyde M. Christensen commented, "Anyone who travels or sojourns in tropical countries anywhere in the world would do well not to eat peanuts or peanut products in any form, ever." ("Mycotoxins and Mycotoxicoses: Aflatoxin." In Chapter 3 of *Molds, Mushrooms and Mycotoxins*). Aflatoxin is still a huge issue, so that advice would probably be repeated today. [Take note that in the U.S., Canada, and western Europe, there is essentially no risk of aflatoxin exposure from commercial peanut butter.]

However, the advice above obviously wouldn't work if peanuts are a staple food in your area, and if you don't have alternatives. If I knew that the peanuts were sorted using the dry blanch process described above, I would eat them—otherwise I would do my best to avoid them.

Almost every food that you eat contains nutrients that nourish your body as well as toxic factors that have negative effects. Of course you want to minimize the toxins; we hope that this article has given an idea of the seriousness of aflatoxin ingestion, but also some ways to minimize the danger.

Conclusion

Aflatoxin is an extremely harmful toxic metabolite of fungi that grow on different foods. Eating food that contains aflatoxin can lead to health problems, including liver cancer and an increased susceptibility to hepatitis B. Proper storage (as dry and cool as possible) will minimize the growth of the offending fungi. Damaged kernels and seeds are most likely to be infested with aflatoxin, so the best way to ensure that aflatoxin is removed is to mechanically sort the seeds and throw away the damaged ones.

Full references available upon request or from our website (www.echotech.org).

Thank you to Dr. David Miller of Carleton University (Ottawa, Canada) and to Dr. Russell Paterson of CABI Bioscience for comments on drafts of this article.

A Discussion with Jacque Breman

University of Florida County Extension Director

Several years ago, Jacque Breman visited ECHO. He has worked with groups in Haiti that grow peanuts, and mentioned that in one lot of peanuts, 18% of the lot tested positive for aflatoxin under a black light test. Below is a summary of my discussion with Breman.

DRB: You said 18% of a peanut lot glowed, indicating possible aflatoxin contamination. Is that a serious amount?
JB: Yes! In the U.S., if even one peanut from a sample glows, the whole load stops and the sample is sent to a lab. (USDA standards can be found on the Internet). In contrast, peanuts in storage in Haiti were severely contaminated. 18 of 100 glowed under 110 V UV light. On the island of Gonave, 8% glowed. Peanuts that fluoresce under UV light are not necessarily contaminated with aflatoxin, but some undoubtedly are.

DRB: How can you test for aflatoxins?
JB: The easiest way is to use a 110 V UV light. Contaminated peanuts glow like fool's gold.

DRB: Why are aflatoxins such a problem? What can be done to reduce them?
JB: Moisture is a huge problem when storing peanuts in Haiti. The humidity in storage areas is too high. There is no moisture barrier against the cement on the floor, so the moisture wicks up into the peanuts. Part of the problem with moisture results because the peanuts are still living and thus they respire moisture.

[In Haiti there are also major problems with Indian meal moth, which has a 14 to 21 day life cycle. Bt has been suggested for treatment of Indian meal moth because Bt is not toxic to people.]

DRB: What ideas can you share to improve storage conditions and reduce aflatoxin contamination?
JB: 1) Put hardware cloth under eaves to keep rats out and screens to keep bats and insects out.
2) Use a moisture barrier between the floor and stored peanuts.
3) Find a way to vent moisture out through the roof. For example, use a black hot pipe in the roof for passively drawing out the warm moist air.
4) Place a fan in the side of the building with a solar panel to drive it.

DRB: What problems exist with post harvest management?
JB: 1) Currently peanuts are dried on the dirt in full sun. They ought to be dried in the shade and off the ground. 2) The nuts, especially those that are to be eaten, need to be graded and diseased ones need to be removed. Currently the damaged and underdeveloped kernels are fed to chickens. When warned about aflatoxins, women who shelled the peanuts said, "Oh that must be why the chickens die when we feed the kernels to them."!!

*One thing that makes changing production and post harvest practices difficult is that Haitians "live for today because they might not be around tomorrow."

*Interesting note: Jacque said that cows could handle moldy peanuts because a cow's rumen breaks down aflatoxin. The ammonia in the rumen chemically breaks the toxin. This sounds similar to the ammoniation process that has been developed to inactivate aflatoxin in feed ingredients (see section "Removal of Aflatoxins").

DRB: Do you eat peanut butter in Haiti?
JB: Yes.

DRB: Do some peanut varieties tend to result in a higher level of aflatoxin production than others?
JB: 'Georgia Green' is BAD for aflatoxin but produces a high yield. 'Southern Runner' gives an 18% increase over Haitian Runner. It has a clean, hard pod and low insect damage. 'Viragard' aflatoxin levels were 1.5-3%. Peanuts were left in the ground 1 ½ months.

ECHOES FROM OUR NETWORK

Experience with chaya, moringa and katuk in Indonesia

Andy Bell wrote to us in December 2004 about his experience with chaya and a few other leafy crops in Indonesia.

"In 1998(?) I requested chaya sticks to be mailed to Indonesia. They arrived wrapped in paper and still moist. I planted the sticks directly in our yard in West Java. Two of the sticks slowly began to bud and put out leaves. One of the plants was in the front of the house, one in the back. The one in the back that received fuller sun grew tremendously. Over the five years of its life, it would reach heights of three meters with over 30 productive stems and branches. While we did have some curling at times, particularly on new leaves, it never suffered from any ill health that I could observe. About two times each year I trimmed it back, almost to the ground, simply because it had grown so big. In the end, the trunk had reached the diameter equivalent to a coffee can. The one in the front had fewer leaves, I believe because it received extra shade.

"Popularity: The local Sundanese people are famous for eating leaves. It is said that all you need for a Sundanese person is to provide hot sauce on a banana leaf and release them out to the fields and forest, as they enjoy much of what grows naturally. They call this lalab. One of the most common (if not the most common) "vegetables" among the farmers I live with is boiled cassava leaves. These are readily available and easy to prepare. Sometimes they are cooked with coconut milk and lemon grass.

"I believe the Sundanese preference for picking rather than growing food makes cassava leaves, "daun singkong," so popular. They don't have to mess with it, as they just go out and pick it and it is available in all seasons. I believe this is one factor that also makes chaya so popular. It is very similar to cassava leaves, though less bitter. The Sundanese understand you can't eat it raw, as it is similar to cassava in this way. So, culturally, they are already used to this type of plant.

"Distribution: Basically, I have passed out cuttings wherever I have gone or to whomever has visited. We eat the chaya leaves about two or three times per month, and serve it to guests so they will ask for it and we can send it home. I am aware that it is now distributed across Java and to Lombok island and I believe some on Sumatra just through me. I am aware that others are now sharing it as well. I would guess now there are over 1000 plants in the country, maybe three or four times that. I have never met an Indonesian that had seen it before. In about 30 to 40% of the cases of my sharing a bundle of stalks with someone, I will receive an unsolicited response that it has thrived and they eat it regularly. I have found that it seems to grow better and faster in more sandy soil as compared to high clay soil. It definitely seems to be bushier when regularly cut back. Soil fertility doesn't seem to affect it too much. It can rot if planted in high rain season.

"Other plants: I have tried with little success to plant moringa from seed received from ECHO. I had a few that sprouted and gave them to my farmer friend when we planted a garden in his yard. Two of them grew. He told me they are locally known as Kelor and there used to be many of these trees. Nearly 70 to 80% of the farmers will say, without solicitation, that kelor is a plant eaten by people in the past to ward off black magic. The specific benefit seems to be to enable certain people to resist curses that keep them from not being able to die; apparently people with black magic can't die without breaking the "ilmu" or magic that preserves them. I have only ever seen kelor twice in my travels around West Java.

"About three years ago, while out for a walk on the island of Lombok (next to Bali), I came across a kelor tree full of brown pods. I harvested as many pods as I could, and on return to Java planted them and had a good germination rate. They seem to be a very popular plant among our farmers, though they don't seem to consume it as readily as chaya. Not sure why.

"Katuk (*Sauropus androgynus)* is also a common plant in our area. I don't see it served that often, but whenever I point it out, farmers say that it is tasty and good for you. Some plant it around their homes. In our village, one entrepreneur from Jakarta leased 25 ha of local government land and planted katuk. He is apparently harvesting it once or twice each year, taking it to the local tea factory to have it dried, and then exporting it."

BOOKS, WEBSITES & OTHER RESOURCES

Breed Your Own Vegetable Varieties

By Carol Deppe. Chelsea Green Publishing, 2000. 367 pp. $27.95 (available in the ECHO bookstore and reference library).

Although sounding a bit like a text book, *Breed Your Own Vegetable Varieties* has a little of everything for the amateur gardener and wannabe plant breeder, from stories about plant breeding and seed saving, to sections included in college-level courses on plant breeding and genetics. Overall, this book provides information to assist development workers, farmer trainers and home gardeners at all levels to become vegetable breeders. It also may enable agriculturalists working in developing communities to teach farmers how to select the best of their crop for seed, thereby breeding a select improved variety of that particular crop.

With “Breed Your Own” in hand, the beginning gardener would have little-to-no difficulty planning out and establishing a home vegetable-breeding program. And, following the author’s examples, he would be able to breed vegetables without having studied genetics. At the same time, he could go from simple basics to topics that will allow higher levels and more complicated work, if he desired.

There are appendices with information on obtaining breeding material, applying breeding techniques, and lists of specific genetic traits of many plants, particularly vegetables. The information is complete enough that even experienced breeders will find valuable material. We would recommend this book, even to a university professor as a good technical reference, in addition to providing useful (and fun) anecdotes of plant breeding that would make good lecture illustrations. There are some surprising revelations in this book. Deppe points out that some vegetable varieties that are sold as hybrids, are not. Ordinarily, if you planted seed from an F1 hybrid, it would produce a range of types, or “outcrosses” as the genes from the hybrid resort or segregate, thereby showing the varied characteristics of the 2 parent plants. However, when seed of such "pseudo-hybrids" is saved and grown out, the seedlings are identical to the so-called "hybrid," and are apparently open-pollinated varieties. In other words, some seed companies cheat, calling varieties "hybrids" in order to discourage seed saving, facilitate higher seed prices and ensure that customers will return to the company to buy seed.

In another informative anecdote, Dr. Deppe describes how Glenn Drowns, a 16-year-old high school student, "accidentally" became an amateur plant breeder. She explains how Glenn had wanted more than anything from his garden, a fresh, ripe watermelon. Since he lived in northern Idaho (US near the Canada/US border), the growing season was extremely short, and by the time melons came near to ripening, the frost would kill them. After taking high school biology and studying crop improvement and plant hybridization, he thought he might experiment on melons.

He took some "Sugar Baby" seed and a no-name lot of watermelon seed someone had given him, and began to cross-pollinate the two varieties. Within four years he produced a stable variety of watermelon that was, among other characteristics, very early-ripening!

Before he began experimenting, Glenn didn't know that cucurbits (melons, squash, etc.) have both male and female flowers. The female flower has the little fruit behind it. Here's a quotation from Dr. Deppe's book on how he made his crosses:

"Glenn starts by taping the male and female flower buds shut with masking tape in the evening before the buds open for the first time. The following day Glenn untapes the buds. If they are ready to open that day, they will slowly expand after untaping. He plucks the male flower and uses it to sprinkle pollen onto the stigma of the female flower. (The stigma is at the top of the pistil.) Then he retapes the female flower; it just shrivels at the end of the developing fruit."

After Glenn made his first crosses between the two different varieties, he saved all the seed. The following year he planted it all and self-pollinated each plant. With that year's harvest, he selected the fruits that he wanted. (Selection that year was easy for him, cold weather and deer allowed him exactly one fruit!) The following year he planted that seed and "selfed" each of the flowers once again. By self-pollinating, you stabilize the genetic constituency of the plant for the traits you select for. Each season he received a few early-ripening melons. After four generations of self-pollination and selection, Glenn had a stable variety and was offering seed for others. He grew it out for several years more before he felt confident enough in its stability to offer it to a seed company.

It would have been good to have color plates and drawings in this edition of *Breed Your Own Vegetable Varieties*. The color plates included in the first edition were omitted from the second, although the flower anatomy drawings are included in both. There are techniques a novice may have trouble puzzling out without illustrations, and the few photos (first edition only) are so tantalizing, one wishes for more. The two pages of flower anatomy (although just five plants) help the reader in making crosses. The lack of illustrations isn't a major drawback to the usefulness of the book. All in all, this is a book that anyone working with plants should read.

Breed Your Own Vegetable Varieties is available from ECHO’s bookstore for $27.95 plus shipping. Orders can be placed online (www.echonet.org), by telephone (239-543-3246 ext. 202) or by postal mail.

FROM ECHO'S SEEDBANK

Making Friends with Dark Green Leafy Vegetables of the Mustard Family

By Grace C. Ju, PhD
Seed Bank Manager

When I see the incredibly productive, large and healthy dark green leaves of collards and kale growing on the ECHO farm, I get excited about introducing these tasty, easy to grow, nutritious friendly plants to you! Eating a good helping of collard greens or turnip greens makes me feel like a surge of vitamins is flowing through me!

In the town of Pignon, Haiti, where I visited last month, dark green leafy vegetables were definitely lacking in the market and in the farmers' fields. Cabbage was the main crop in the irrigated valleys, but it is the dark, leafy members of the mustard/cabbage family that I am promoting in this article. These dark green leafy vegetables (DGLV) can deliver a power punch in our diet.

Dark green leafy vegetables are good sources of vitamin A, vitamin C, riboflavin, folic acid, carotenes, iron, calcium, magnesium and potassium. DGLV are sources of trace minerals that take part in key enzymatic reactions in our body. They also are great sources of fiber. As a rule of thumb, the darker the leaves, the higher the nutrients. In many developing nations, children suffer from vitamin A deficiency, which can result in the loss of eyesight. Improved vitamin A nutrition from vegetables becomes an effective way to combat this problem. Other remarkable benefits of consuming DGLV include less chance of developing coronary disease and colon cancer. Although often eaten raw, proper cooking methods can preserve 90% of the nutrients while causing the flavor to become more concentrated and sweeter. Cooking also breaks down the cellulose and makes it more digestible. Cooking with vinegar helps to counter the bitter tastes of some of the DGLV.

Most people in the world have access to local dark green leafy vegetables. For example, amaranth leaves, chaya, moringa, katuk, and even lamb's quarters are important DGLV. Some of the more common DGLV in the United States include: Swiss chard, chicory, collards, arugula, pak choi, radish greens, turnip greens, dandelion greens, kale, mustard greens and spinach. The focus of our discussion will be on the Mustard family (Cruciferae/ Brassicaceae), and in particular the Brassica genus. The Mustard family contains 380 genera and 3,000 species. Plants are characterized by pungent flavor and four-petaled flowers arranged in a cross pattern.

The genus Brassica is the largest natural grouping in this family. Table 1 shows some of the common varieties.

Brassica genera	Species	Variety	Common name
Brassica	oleracea	viridis (acephala)	Collards and Kale
		alboglabra	Chinese kale
		botrytis	Cauliflower
		capitata	Cabbage (red and white)
		gemmifera	Brussels sprouts
		gongylodes	Kohlrabi
		italica	Broccoli
Brassica	napus	napus	Canola. Rape
Brassica	rapa	rapifera	Turnips,Rapini
		pekinensis	Pe tsai, Chinese cabbage
		chinensis	Pak choi, Bok choy
Brassica	juncea		Mustard greens
Brassica	nigra		Black mustard
Brassica	carinata		Abyssinian cabbage, Ethiopian kale, Ethiopian mustard

Table 1: Some common species and varieties in the Brassica genus. Taxonomic references are from World Economic Plants *by John H. Wiersma and Blanca Leon.*

Brassica oleracea

The cabbage–like vegetables (*Brassica oleracea*) have a variety of shapes, tastes and color. Kale, collards, kohlrabi, cauliflower, broccoli and Brussels sprouts are all the same species. Differences among them are the result of thousands of years of selective propagation. From as early as the 5th century BC, kale and collards have been a cultivated vegetable crop. All of the brassicas grow quickly and mature in about two months. Both kale and collards like soil with a pH of 5.5 or higher, so add lime if the soil is acidic. This will also supply needed calcium to the plant. Although quite hardy, *B. oleracea* may be susceptible to aphids and cabbage loopers. It tends to be resistant to most diseases.

Collard Greens, *Brassica oleracea* var acephala or viridis (acephala means without head), have an earthy flavor and are rich in vitamin C, A and calcium. Plants have wide, smooth, blue-green leaves (see Figure 1), and are a popular winter green in home gardens of the southern U.S. Collards can withstand heat much better than many of the other brassicas.

Most likely originating in the Mediterranean and Asia Minor, collards and kale have been enjoyed as a cooked green for over 2,000 years. Confucius mentioned the cabbage family as early as 497 BC (www.vegparadise.com), and many brassicas are an integral part of Asian diets. The collards and kale we eat today are, in effect, primitive cabbages that have been retained through thousands of years. Although more highly developed forms of cabbage, such as cauliflower, broccoli, and head cabbage, have been produced in the last two thousand years or so, the

kales and collards have persisted, keeping their original primitive traits. They continue to be popular vegetables.

Figure 1: Collards growing in the rooftop garden at ECHO.

Collards can grow in poor soil and prefer drier soils. They are easy to grow as long as the crop is fertilized and watered in the early stages. The plant can withstand temperatures as low as –9ºC (15ºF). They are frost tolerant but can also thrive in warm weather.

Collards can be direct seeded or transplanted and prefer a soil pH of 5.5 to 6.5. They are ready for harvest 6 to 8 weeks after planting. The leaves can be harvested continually or the whole plant can be harvested in one cutting. The plant is a biennial, which means it will send up a flower stalk the second season of its growth. The flowers are self-infertile, as are most of the *Brassica oleracea*, and will cross with other *B. oleracea* varieties. To save seeds, let a few plants go to seed so they can pollinate one another. [Though take note that collards do not provide seed in the tropics.]

The quality and taste of collards are better when the weather is not too hot. If eaten raw, harvest the sweeter younger leaves. Collards can be cut into small thin pieces and boiled until tender, then added to soups or stir-fried. They can be boiled and simmered with onions, garlic and lemon juice. Collards flourish in almost any climate and are one of the most nutritious greens.

Kale, *Brassica olearacea* var acephala (synonym viridis), is rich in vitamin A, C, calcium, folic acid, and potassium. It is very similar to collards except for taste and appearance. Kale leaves are fringed and have longer petioles. It is the hardiest of the Brassicas and will withstand severe frosts. It will also grow in the subtropics and at higher elevations in the tropics. Pick the outside leaves, as the plant produces new leaves from inside out. Kale will thrive with well-manured soil and is drought tolerant. In the appropriate climates, where seeds will set, they are harvested and stored like collards.

Kale, which is now available in many varieties, is somewhat bitter in taste. Eat it with vinegar-based dressings to counter the bitterness or combine with other, sweeter ingredients, such as caramelized onions. Smaller leaves have a milder flavor, can be cooked whole, and have stems tender enough to eat. With larger leaves, you will need to cut out and discard the stems and petioles, and then chop the leaves into small pieces. Cool growing weather, fall frosts, and mild winters improve the sugar content and flavor. In some places in Kenya, people have chopped kale and collards, dried them, and stored them for later use. Kale can be added to soups, stir-fry and sauces.

Kale and collards are among the easiest of all vegetables to grow. Both of these humble, heroic, "headless" members of the cabbage family have ancient roots and a long history of cultivation. Nutritionally speaking, kale and collards are superstars! Making friends with these two leafy greens is a good idea.

Pak choi (Bok Choy), *Brassica oleracea* var chinensis, is an extremely versatile Asian cabbage which can be boiled, sautéed, steamed, braised, stir fried or eaten raw in salads. There are four major types of pak choi identified by appearance: Chinese white stem; Soup spoon type; green-stemmed and Squat Canton type (www.dpi.gld.gov .au /horticulture). The most popular are the white stem and green-stemmed types. Pak choi is a cool season crop, and like the other cabbages will bolt in high temperatures and increasing day lengths. Some varieties will tolerate both heat and cold. The seeds are very small and should be sown in flats and thinned in 15 to 30 days. Transplanting may reduce bolting in the summer. Like all cabbages it prefers good drainage, moist soil and good air circulation for the roots. Pak choi can be harvested 35 to 55 days after sowing.

Brassica juncea

Mustard Greens, *Brassica juncea*, are a cool season annual. *B. juncea* has been developed into many different varieties especially in China. It was cultivated in Europe and Asia for thousands of years. Mustard greens have a hot spicy flavor and are rich in vitamin A, C and calcium. Mustard greens are best eaten raw in salads, or in stir-fry and soups. This mustard is grown for its green leaves (in contrast to the mustard *Brassica nigra* from which we get the mustard condiment). The leaves of *B. juncea* have a sharp flavor when eaten raw; cooking makes them taste milder. In Florida, we plant mustard greens in September or October and can plant a second crop in January. These leaves mature quickly—usually in thirty days! Harvest the leaves as soon as possible, as the plant will bolt and go to seed quickly. You can plant a succession of crops or cut the plant at soil level and let it produce

	Calcium	Fiber	Iron	*Vit C
Collard Greens	145 mg	3.2 g	0.9 mg	35 mg
Kale	135 mg	2.0 g	1.7 mg	120 mg
Pak Choi	105 mg	1.2 g	0.8 mg	45 mg
Mustard Greens	103 mg	3.3 g	1.1 mg	70 mg
Turnip Greens	190 mg	3.2 g	1.1 mg	60 mg
Ethiopian Kale	176 mg	1.6 g	2.9 mg	NA
Spinach	99 mg	2.2 g	2.7 mg	28 mg

*Table 2: A comparison of the amount of various nutrients in 100g of selected Brassica varieties. *One fresh orange contains 180 mg of Vitamin C. Nutritional information from http://www.nal.usda.gov/fnic/foodcomp /search/index.html.*

new leaves. It will withstand temperatures as low as –4ºC but not temperatures above 29ºC. It will bolt more quickly at higher temperatures and as day length increases. The mustard seed can be made into a paste. Mustard greens have no serious pests.

Brassica rapa

Turnip Greens, *Brassica rapa* var rapa, have been developed for their edible roots and/or leaves. The turnip roots come in many shapes and colors. They are extremely high in calcium and fiber, and can grow to be 2 to 3 pounds at harvest.

Like other greens in the cabbage family, turnips have been cultivated for over 2000 years. They are not very popular in America and are sometimes snubbed as a food for poor people and livestock. However, they are an important food source in much of the world. Turnip plants produce high quality forage if harvested before heading.

Turnips are easy to grow and adapted to almost any soil. They are one of the most cold tolerant of vegetables (to temperatures as low as 15ºF/ ºC. Sow the seeds thickly and then thin to about 4 inches apart. Turnip greens are ready to harvest in 5 to 7 weeks. Take a few leaves from each plant and they will continue to grow new leaves and develop roots. The greens can be frozen like spinach. They are usually served with vinegar or hot sauce and can also be used in stir-fries.

Brassica carinata

Ethiopian Kale (also called Abyssinian cabbage or mustard collard), *B. carinata*, is a leafy green that is cultivated in parts of East Africa. The flavor is milder than collards and mustard. It is one of the few Brassicas that can tolerate higher temperatures. One key feature is that it will set seed in the tropics, whereas most other brassicas will not. The plant was imported to the US from Ethiopia in 1957 (Stephens, http://edis.ifas.ufl.edu/MV096) and is also used in Europe under the trade name "Ethiopian rapeseed." Ethiopian kale produces quite well at ECHO in Florida.

This variety is unknown in the wild. It is cultivated in Ethiopia as a vegetable and as an oil crop. In India, *B. carinata* has been shown to significantly out yield mustard (*Brassica juncea*) under rain fed conditions. Higher production of seed and oil was seen in comparison to other mustard plants. This plant has potential as an oil crop in hotter, drier climates.

(continued on page 12)

Dear Member of ECHO's Network, March 2005

Appropriate Technology magazine – FREE subscription offer for organizations

To qualifying organizations (see below), we are pleased to offer a free subscription to our magazine *Appropriate Technology*. You can view a recent sample copy of this quarterly magazine at www.appropriatechnology.com. *Appropriate Technology* focuses on **practical approaches to development**.

This offer for a complimentary subscription will be sponsored by **MISEREOR/KZE (The German Catholic Bishops' Organisation for Development Cooperation/The Catholic Central Agency for Development Aid)**.

For a limited number of institutions (but not to individuals), MISEREOR/KZE provides the possibility of financing **FREE subscriptions** to this important journal. Qualifying organizations (both indigenous and non-indigenous) must be:

- non-formal training institutions
- self-help organizations (farmers co-operatives, loose associations, etc.)
- development structures or social services of the Church.
- located in a developing country and unable to finance a subscription by own funds

If you qualify, please remove and complete the "Questionnaire" on the other side of this page, sign and return it as soon as possible, so that we can forward it to MISEREOR/KZE who will review your request. If approved, your free subscription will run for two years.

Should you require any further information please do not hesitate to contact me. Please answer the questions on the questionnaire (reverse side), clearly write your delivery address, sign and return to: **Mr Kumar Patel, Research Information Ltd., 222 Maylands Avenue, Hemel Hempstead HP2 7TD, UK.**

Return by POST or send by **fax** to **+44 (0) 1442 259395**. (If sending by fax, please CLEARLY complete your own fax number and email address on the form).

Yours sincerely,

Kumar Patel, Director

(*continued from page 11*)

Nutrition Comparison

Different leafy green vegetables provide different amounts of nutrients. Table 2 (page 10) shows a chart with the amount of calcium, fiber, and iron in a 100g serving of each chopped raw green in comparison to spinach.

These DGLV provide vitamins and nutrients that supplement the protein and energy from maize, rice, wheat and cassava. They also offer farmers a chance to generate income. DGLV can be used to produce biodiesel, oil that can be used as a fuel. Brassicaceae oils are ideal because, in comparison to soy oils, they are relatively low in saturated fats, have a lower pour or melting point, and have better cold flow properties. Currently biodiesel is relatively costly compared to petroleum diesel. Marketing of canola and mustard seed by-products can help reduce costs.

Seed Source

The Brassica vegetables that we have in the ECHO seed bank are: collard greens, kale, pak choi, mustard greens, turnip greens, and Ethiopian kale. Although the brassicas are considered cool weather vegetables, some of them (such as collards and Ethiopian kale) will do well in warmer climates. They are fast growing, some can be harvested continuously, and the seeds are easy to save [though only if you live where they produce seeds; collards and nearly all kales will not produce even in Florida]. We offer both hybrid and open-pollinated varieties in the seed bank.

Trial size packets are available free to those working overseas in agricultural development. All others may purchase the seeds from ECHO. The overseas price is $3.50/packet and the domestic price is $3.00/packet. Please contact us at echo@echonet.org or go to www.echotech.org.

------Detach along this line and return form to address on reverse side of form----------

MISEREOR/KZE FREE SUBSCRIPTION FORM

Delivery Address (CAPITALS PLEASE):
(DEVELOPING COUNTRIES ONLY)

Ref: ECHO (Mar05 – Offer)

1. Do you want to receive a **FREE subscription**? YES [ ] NO [ ]
2. Please explain why this subscription to Appropriate Technology is useful to your **organization** and why your organization is interested in receiving a free subscription. **Please also attach an original letterhead or compliment slip (without which we cannot consider your request).**

   .....
   .....
   .....

   Please describe the activities of your organization/institution and how they serve to help the poor.

   .....
   .....
   .....

3. Please CHECK that you have clearly completed your delivery address above. Now sign, date and return this form to the address above.

Signature: ..... Date: ……

Name and Function: .....……

Email (Clearly please): ……

Telephone:…….. Fax:…….