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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

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From the Editors: The article by Tony Rinaudo on "The Green Famine" in *EDN* 77 generated a lot of discussion. When Tony visited a place where everyone was talking about a serious famine, he saw an abundance of green plants. He commented that perhaps the dry conditions that caused the "famine" were actually the norm, rather than an unusual emergency. What if the real problem was that the wrong crop was being relied on as the main staple?

Before the discussion about Tony's article (page 6), we share exciting news from East Africa about an exceptionally nutritious and drought-resistant grain crop that is gaining a lot of attention. Perhaps grain amaranth will be one answer to the "green famine."

Grain Amaranth

By Dawn Berkelaar and Jacob Alemu (Christian Reformed World Relief Committee, Kenya)

ECHO's annual Agricultural Conference in November 2005 included several presentations and considerable discussions about grain amaranth as a potential new crop for Africa.

This exceptionally nutritious, high-protein grain, that requires less rainfall than corn, has potential as a staple for the general population plus seems to offer special value in managing diseases such as HIV/AIDS.

What is amaranth?

The Amaranth family contains more than 60 species (most of them wild) and thousands of varieties. Wild species are weedy and often eaten as a vegetable, especially in rural areas. The weed is called "terere" in Kikuyu, and "pigweed" in English.

Vegetable varieties of amaranth have been developed, with leaves that are eaten as a green. The vegetable varieties are called "mchicha" in Kiswahili. Sometimes amaranth is also grown as an ornamental.

In this article we are dealing with amaranth's use as a grain. Amaranth plants yield tiny seeds that can be used as a grain to make flour, porridge and other foods. Amaranth, a broad-leaf plant, is known as a "pseudocereal," because it does not belong to the grass family (as true "cereal" crops do), yet it produces seeds that can be used as flour for bread. Quinoa and buckwheat are other examples of pseudocereals.

Grain amaranth was a staple food of the Incas in Mexico. However, amaranth use was mixed with religious rituals that included eating amaranth mixed with human blood. When the Spaniards arrived, they used drastic techniques in an attempt to eliminate the use of grain amaranth. They all but succeeded for several hundred years.

Three main amaranth species are grown for grain. *Amaranthus caudatus* has the shortest season, with 45 to 75 days to maturity. This is the species mostly being grown in Kenya. The maturation date depends on altitude; amaranth grain matures faster at lower altitudes. Usually *A. caudatus* matures in 60 to 70 days in Africa. Its short growing season makes it good for areas that have a short rainy season. *A. caudatus* is also grown as an ornamental that can be identified by its red or green, nodding or drooping, tail-like inflorescences.

A. cruentus has a mid-length season of 60 to 120 days. It is often grown in Mexico and is least sensitive to photoperiod (hours of sunlight each day). *A. hypochondriacus* has the longest season, maturing in 150 days. It also has the highest yields and is disease-tolerant.

How is amaranth eaten?

Amaranth grain has a nutty taste. In Kenya, it is used in porridge (mixed

with maize or cassava) and chapattis (flatbread). Flour is also mixed with wheat (ratio of 30:70 or 40:60) and made into fried snacks like donuts. Amaranth has been incorporated into many local Kenyan dishes. In fact, in coastal Kenya, introduction of grain amaranth by the Christian Reformed World Relief Committee (CRWRC) started with cooking classes.

Amaranth grain can be popped like popcorn, and then added to many different dishes. Baby food made from amaranth is similar in composition to commercial baby food, though the amaranth cereal is higher in fiber.

Dick Dugger, a man who has been instrumental in promoting the potential of grain amaranth in Africa, says, "Many people we visited in both Uganda and Zimbabwe told us that they make a thin gruel and drink this 2-3 times a day. In Uganda, they are selling a product made from peanut butter and popped amaranth. We found popped amaranth very good as a mixture with yogurt. I like to add fruit or honey in the yogurt mix. I also sometimes like the added flavor of peanut butter to the amaranth yogurt mixture."

Figure 1: Amaranth plant in Uganda. Photo by Tom Gill.

Who is working with amaranth?

Dr. Davidson Mwangi began variety trials and recipe development in the 1990's after he received his Ph.D. studying amaranth at the University of Iowa in the USA. His book *Introduction to Grain Amaranth* would be helpful for those who would like more information than is shared in this article. It is available from ECHO's bookstore for US$8.95 plus shipping (US$4.00).

CRWRC began to promote grain amaranth in Kenya in 1999 when a sister organization (Partners for Christian Development) was looking for an alternative crop to the vernonia they had previously been promoting. In 1999, grain amaranth was introduced in two communities in Eastern Kenya. In 2000/01 they joined forces with Dr. Mwangi who headed a grain amaranth pilot project with the Maasai Rural Training Center in southern Kenya. Today many groups in Kenya are working with grain amaranth.

CRWRC partners with other organizations to promote grain amaranth. Groups that are not linked with CRWRC are also promoting it. Hundreds of farmers have tried grain amaranth, and interest is spreading from farmer to farmer; it is probably not an exaggeration to say that thousands of farmers in Kenya are growing amaranth.

Nutritional Benefits, including Possible Treatment for HIV/AIDS

Amaranth grain contains about 16 percent protein, compared to around 10 percent in most cereals. The protein in grain amaranth is of extremely high quality, meaning that it has a good mix of essential amino acids and is easily digested, absorbed and retained. When amaranth grain is combined with another grain, it can form a complete protein diet.

Amaranth grain is very high in lysine, an essential amino acid that is so low in most other grains that they must be combined with other protein sources to achieve a good balance. The lysine makes amaranth particularly helpful for HIV/AIDS patients. Lysine helps the body to "inhibit the growth and multiplication of the [herpes] virus" (Mwangi). Herpes weakens the immune system of those with HIV/AIDS.

Grain amaranth is high in other nutrients in addition to protein. According to *Lost Crops of the Incas*, "Amaranth grain is also high in calcium, phosphorus, iron, potassium, zinc, vitamin E, and vitamin B-complex. Its fiber, especially compared with the fiber in wheat and other grains, is very soft and fine. It is not necessary to separate it from the flour; indeed it may be a benefit to human health."

ECHO staff member Tom Gill visited farmers growing grain amaranth in Uganda. At ECHO's Agricultural Conference last November, he reported that a mix of amaranth and moringa (one cup porridge with one Tbsp moringa powder) is being used in Uganda to combat HIV/AIDS, with people obtaining better results than with anti-retroviral drugs. Afterward, a conference participant commented, "You don't have to admit you have AIDS in order to eat amaranth porridge [as you would in order to get anti-retroviral drugs]." That could be extremely important in places where AIDS is stigmatized.

Mwangi (in *Introduction to Grain Amaranth*) also wrote about amaranth in relation to numerous diseases. Apparently eating amaranth has helped to cure diseases caused by nutritional deficiencies (e.g. scurvy, kwashiorkor), helped prevent many lifestyle diseases (e.g. heart disease, high blood pressure), and helped manage or reduce symptoms of diseases such as tuberculosis, diabetes, and HIV/AIDS.

Dick Dugger has heard many comments about the benefits of eating amaranth. "[We heard] several stories of newborn babies who are taken off breast-feeding because the mother has AIDS. Babies [that are fed amaranth] are found to improve in weight and prosper ahead of schedule. We saw many cases in both Uganda and Zimbabwe of HIV/AIDS persons who tell of gaining new vitality and increased energy as a result of adding [grain amaranth] to their diet. A couple told us their blood pressure increases when they don't have amaranth.

"In Zimbabwe, we stayed with Dr. Tagwira, the Dean of Agriculture at Africa University. He has approximately 75

farmers growing amaranth and he told us that all he can purchase is sold in a mix with moringa and goes to an AIDS program for feeding to AIDS infected persons. He also told us the boost to the immune system improves quality of life and also many of these have sores in the mouth that reduce a person's eating. The amaranth/moringa combination heals these sores and he attributes this to the lysine in the amaranth." [Dr. Mwangi told ECHO that the fermented amaranth porridge that was developed to meet local tastes is so smooth that patients can eat it without the pain they feel when trying to swallow many other foods.]

Linus Ndonga in Kenya shared with us about the work that his organization is doing with grain amaranth. Strategic Poverty Alleviation Systems (SPAS) works to promote sustainable and innovative technologies and practices to fight poverty. Their work includes helping poor communities to fight disease, including HIV/AIDS.

Ndonga shared, "SPAS has been providing grain amaranth to people living with HIV and AIDS, including children, with very encouraging results. All HIV and AIDS complications disappeared. Even for those experiencing side effects from conventional ARTs [antiretroviral] drugs, the side effects disappeared completely."

In addition to mentioning the role of lysine in HIV/AIDS treatment, Ngonga commented, "[Grain amaranth is also] rich in trace elements such as zinc, selenium and copper. Zinc has been shown to be important for memory, immunity, and wound healing. As for immunity, people with AIDS are almost universally deficient of zinc, which contributes significantly to the continued decline of their already damaged immune systems. Restoring their supply with grain amaranth could be one of the most important strategies for stabilizing their immune function and reducing complications from the disease."

We wrote in *Amaranth to Zai Holes* about *Amaranthus cruentus* and *A. hypochondriacus* (p. 75). That book also includes information on the nutritional limitations of amaranth (p. 287). It seems that raw seed of *A. hypochondriacus* contains some anti-nutritional factors. You can find the information from *Amaranth to Zai Holes* on our website (www.echotech.org).

According to Mwangi (*Introduction to Grain Amaranth*), "small levels of heat sensitive and chymotrypsin inhibitors are present [in grain amaranth, but are easily inactivated by cooking]. Grain amaranth's anti-nutritional factors are very low as compared to [those in] soybeans."

Amaranth for Leaves and Grain

As stated earlier, there are grain types of amaranth and vegetable types of amaranth. The leaves of both types can be eaten, but the taste and yield of grain from a grain amaranth species will be better than the grain from a vegetable species.

ECHO's farm manager Danny Blank has commented: "In general, I am far more impressed with grain amaranths than with what are typically called vegetable amaranths with the exception of 'Tigerleaf' and 'Jamaican Calalu'. But if I had to choose between Tigerleaf and a grain type, I think I would still choose grain types. They are so much more vigorous. I have seen fields in the Central African Republic (C.A.R.) and Haiti of grain amaranths growing. I think in both places it was being raised for leaf production despite being a grain type. They are incredibly vigorous and can be coppiced [plants are cut back and resprout] for several harvests. However, in C.A.R. people sow incredibly thick patches and then several weeks later harvest a section of the patch and [take out] the entire plants—stems, leaves, and roots. They are about 12 inches tall and [people] sell them in the market that way with the roots still attached. (I think leaving the roots attached helps extend their life from the field to the market and home). Several patches will be sown at different times allowing for continual harvest. Some plants are left to go to seed. From what it appeared to me, the folks were using the grain types."

I (DRB) asked Tim Bootsma, working in Zambia, what experience he has had with grain amaranth. He responded, "Some years ago when Stephan [with CRWRC] came for a visit of some of our projects, he left behind some grain amaranth. I distributed it to some of our field staff. Several times over the past years I've seen it growing in gardens. When I've asked the people what they use it for they say that it's a good leafy green!!!! Clearly the information did not get through that this had great value as a grain. A close relative to amaranth grows wild here in Zambia during the rainy season. It is considered to be a weed, but they will pluck the leaves to cook as greens."

Clearly amaranth seems to have a larger profile as a leafy vegetable than as a grain. Even when growing the plant for grain, it is okay to harvest some of the leaves to eat as greens. Just be careful not to harvest too many, since the leaves are necessary for photosynthesis and for grain production.

Drought tolerance

In addition to its nutritional excellence, amaranth is extremely drought tolerant. Some grain will be produced as long as there is enough moisture in the soil for the seeds to germinate, and as long as there is one good rainfall about three weeks after emergence. Mwangi wrote that when Kenya experienced a severe drought between 1984 and 1985, amaranth was still harvested from trials, when even sorghum crops had failed.

Amaranth's drought tolerance seems to result from two things. First, the plant develops a deep and extensive root system. Second, it can go dormant under extreme drought conditions. Amaranth has a C4 metabolism, meaning that it uses a type of photosynthesis that is particularly efficient, especially under dry, high temperature conditions with bright sunlight. Amaranth requires much less water than maize, even under good conditions (i.e. conditions that will result in a high yield). It requires 40 to 50% less water than maize.

A. caudatus, the grain amaranth species with the shortest season, is very photoperiod sensitive, and the number of days

to maturity will depend on the variety, the region, and environmental factors such as day length, temperature, and available moisture.

Small Seeds

Amaranth seeds are very tiny; an individual seed is between 1 and 1.5 mm in diameter. 1000 seeds weigh less than 1 gram. By contrast, 1000 wheat seeds weigh 35 to 45 grams. The small size of amaranth seeds means they can be difficult to work with. For planting, you only need ½ to 2 pounds per acre (for wheat the planting rate is 90 to 120 pounds per acre). Planting more densely would not be of benefit, because amaranth seems to be self-suppressing. Under a high population, a number of plants will not produce seed.

Tim Bootsma commented, "[Of] all the grain amaranth that I have seen growing in Zambia, most of it remains very small, about knee high when fully mature. Only in my garden have I grown amaranth that was 2 meters tall. I'm thinking this is partially because people plant it too close together (too high population) and secondly the average soil fertility is not good enough to get the good growth. However these are only my observations and not based on researched data." [Ed (MLP): Grain amaranth is very sensitive to day length. When we plant it during the shortest days of the year at ECHO, some varieties begin flowering when only a few centimeters tall, and plants do not have enough energy to produce a meaningful crop.]

In a document called "Promoting Amaranth Grain in Kenya," Jacob Alemu states that thinning of an amaranth crop is what determines the yields.

Amaranth grain is well suited for manual planting and harvesting. For hand seeding, the tiny seeds can be mixed with sand, ground corn or a similar material so that a "pinch" of the mixture will likely contain only one or two seeds.

Harvesting amaranth by hand is labor-intensive. However, seed threshers and cleaners that can handle amaranth are available.

Difficulty establishing crop

The small seed size means shoots might have difficulty emerging. If possible, plant in low-clay soils to reduce crusting. Seeds should not be planted too deep. Between ¼ and ½ inch (6 and 12 mm) has been recommended.

Weed control is very important while seedlings are getting established, because the amaranth plants grow slowly while their root systems are developing. Once plants are about six inches tall, they begin to grow rapidly.

Franklin Voorhes in Guatemala tried several varieties of amaranth and wrote in July 2005 that his results had been disappointing, with none of the seeds sprouting. "We've had a lot of rain—I don't know if that's bad for amaranth. We've had several days with 2-3 inches of rain in an hour." He planted other amaranth seeds (from a food store), which sprouted but "seem a little too yellow to be healthy."

Voorhes added, "I visited another project on the other side of the same mountain, and they have a little amaranth that is doing very well. It was 30 inches tall and seemed great. So I know it can grow around here, but there's a secret I'm missing."

Danny Blank responded, "Even though the store-bought seed sprouted and the seed from ECHO did not, I would say it has more to do with the rain than seed quality. If one gets over 2" of rain in one rain event while the seed is germinating I would presume it washed away. Amaranth seed is so small." [Ed: Ants might have carried it away too.]

Tim Motis wrote from Haiti in July 2005, to share his experience with amaranth. "I have tried eight ECHO varieties in the garden at HAFF. Four were grain varieties; the other four were vegetable. The first time we planted all eight direct-seeded in rows, chickens got in and scratched the beds to the point that the seeds probably became exposed to the hot sun and very few survived. Those that did germinate and form small seedlings endured more damage by chickens and were destroyed.

"I tried again with all eight varieties this rainy season. Chickens are much less of a problem during the rainy season because there is more forage around. Again, I planted in furrows and covered the seeds with a thin layer of fine soil mixed with bat manure (very powdery and fine-textured). The furrows were also covered with sugarcane bagasse after planting. The bagasse was removed little by little as the seeds germinated. Germination was fine for all eight varieties. Interestingly, though, insects "decapitated" (cut the stems close to ground level) almost all the plants of the vegetable varieties. It almost looked like they didn't even germinate, but the stems (minus the leaves) could be seen by looking closely at the ground. Some of the seedlings of grain varieties were destroyed by insects, but they seemed to have more seedling vigor, grew quickly, and soon developed stems that were thick enough to withstand the insects. The grain varieties are now growing beautifully. I have not given up on the vegetable varieties, but am starting them in the nursery in pots instead of direct seeding. Even in the nursery, I have had quite a few seedlings destroyed (presumably by small caterpillars we have seen once or twice)."

Other Suggestions and Comments

Amaranth has minimal fertilizer requirements. Cow manure seems helpful when added to the soil.

Spacing suggestions vary. 75 cm (30 inches) has been suggested between rows. During a discussion at ECHO's Agricultural Conference last November, spacing of 1 m (40 inches) by 30 cm (12 inches) was suggested.

Amaranth seed heads are not damaged by birds to the extent that sorghum and millet are. In addition, Stephan Lutz (with CRWRC) commented that stored amaranth is less appealing to insects than are other stored grain crops. Practice of good rotation will help minimize diseases and insects. Suggested rotation crops include millet, maize, potatoes, and cowpea.

Kenya and Uganda are between 4ºN and 4ºS of the equator. CRWRC suggests trials for other semi-arid parts of West Africa, such as Niger, Mali, Burkina Faso, Chad and Nigeria. These countries range in latitude from 2 to 24ºN. It is not yet known what effect different latitude would have on days to maturity. At ECHO, we only plant grain amaranth in the spring when days are lengthening. If we plant too early they bloom when the plants are tiny and we get no yield. The summers are too wet to be able to harvest, so we plant as early as we dare so we can harvest before the rainy season begins. We do not plant in the fall because by then caterpillars have become such a problem that we would need to use a lot of spray to control them.

High levels of rainfall are undesirable. Too much water can waterlog the soil; can lead to tall growth and lodging; and can promote mold growth. If lodging (falling over during storms) is a problem, try planting seeds slightly later to reduce plant height. The Rodale Institute in the United States did extensive research on amaranth but concluded that you can't grow amaranth well east of the Mississippi because of high humidity and rain during harvest time. Also note that amaranth is not at all frost-tolerant.

Prices for grain amaranth are higher than those for maize. Prices shared at the conference in November were 40 to 50 shillings per kg for amaranth grain used for food, compared to 10 shillings per kg for maize. Amaranth seed being sold specifically for planting was quite a bit more expensive at 480 shillings per kg (but you need very little for planting).

Where can I get seed?

ECHO's seed bank carries several species and varieties of grain amaranth. Trial-sized packets are available free to those working overseas in agricultural development. All others may purchase the seeds from ECHO. The overseas price for seeds is $3.50/packet and the domestic price is $3/packet. Enormous variability exists between varieties of amaranth of the same species. Before you decide to introduce amaranth, it would be wise to evaluate several varieties. When you request amaranth seed, you can choose from ECHO's varieties or request that we choose a few for you. However, if you plant them as a variety trial (several varieties planted in the same time and place), there is danger of outcrossing; after harvest you will need to request another trial packet of any varieties that do particularly well (or save some of the seed from the trial packets before planting). Alternatively, you can separate the varieties as much as possible, or plant them one at a time. Also note that *A. caudatus* is considered an "heirloom" seed variety, and can be purchased through most commercial seed catalogs and at most lawn and garden stores in the US. We are trying to find a seed source for readers in East Africa and will share that on the web and in a future issue of EDN when/if we succeed.

Dr. David Brenner at Iowa State University suggests that seed multiplication of grain amaranth should be done locally. This would improve the local economy and would help keep seed costs lower. However, producing seed locally has its challenges. A higher level of management is needed to produce seed than to produce the grain for consumption. Care must be taken to avoid out-crossing with wild or weedy types, such as the red root pigweed, *A. retroflexus*. Seed color is often an indicator of out-crossing. Grain amaranth is usually light in color, while outcrosses are dark in color. When growing for seed, weed out the pigweed; save seed from large seed heads; and take seed from the center of the patch (where seed will be most pure).

ECHOES FROM OUR NETWORK

Thoughts on the Green Famine

[Eds: We received a lot of feedback from network members in response to Tony Rinaudo's article on the Green Famine (*EDN* 77). Some of the comments are condensed below.]

Roger Sharland, working with Rural Extension for Africa's Poor (REAP) in Nairobi, Kenya, shared the following. "In 2002, I spent two weeks in Ethiopia, about 400 km south of Addis Ababa. Shortly before leaving for Ethiopia I had read Tony Rinaudo's article on "The Green Famine." The BBC news was announcing that 40 million people were likely to be in need of food aid, but as we drove from Addis Ababa to Soddo there seemed to be a reasonable harvest [of crops other than maize]. In Soddo the place was green and again appeared to have no problems. However, in our discussions there was a major focus on being ready for major relief efforts in early 2003.

"Having visited five project sites in the zone, the project staff had tried to show me the real situation and yet I was still confused. What met the eye did not match with what people were saying. Things *appeared* normal. The concept of a green famine was very close to the surface in my thinking, and as I observed, maize seemed to be the main culprit. There were indeed clear signs of dried-up non-producing maize, though I understood most of the failed crops had already been ploughed in with little or no yield.

"After the visits to the project sites, we had three days of discussion with the development team. Using popcorn seeds, I asked the participants to try and represent the relative amount of rain, two seasons a year, for the last ten years, based on their memories rather than available statistics. The results were striking, with a clear difference between two good years (1997 and 2000) that had many seeds and the rest with a varying number of only a few seeds (see Table 1 on page 6).

"Based on what we saw, I asked the team which were the normal years. Immediately they identified 1997 and 2000. I responded that perhaps they had not understood, from the trend analysis, which was the normal year? Thinking that I did not want two years they decided it was 2000. I repeated the question stressing the word *normal* and asked what normal meant. The reaction then was fascinating as they all realized

what I had noticed, and responded that perhaps this year with a low rainfall is indeed the normal year. In fact rather than terming this year a drought year shouldn't we be terming it a normal year?

"This revelation then enabled us to think creatively about a strategy. Aren't farmers using the wrong indicators? They are planning not for the expected rainfall, which is low and unreliable, but the Utopian ideal rainfall that is heavy and regular. Only two years in the last ten have been good years and yet everyone plans for the good year. In order to work towards household food security the farmer needs to plan for a year of unreliable rainfall, while also being able to benefit from greater rainfall in those few years when the blessing comes. The opposite is happening.

"We concluded that, far from being the crop to save the family from famine, maize is indeed the problem. Not only is maize sensitive to drought stress, particularly at the time of tasseling, it does not recover from this drought as do crops like sorghum (which sends up side shoots called "tillers") or cassava (which just goes dormant). Diversification seems to be the message that comes through very strongly. On top of this is the problem of a high external input system of production. Landrace varieties of maize are just not available because the whole market is swamped with hybrid seeds. Because farmers have to wait for the seed to be available, they often miss the early planting, and they have to borrow heavily to buy the seed and fertilizer. At harvest time they have to sell the crop at the lowest price in order to pay back the loan. If the year is poor there is very little harvest, so very little income, and often nothing to pay back the loan. In a good year the price is so low that most of the crop still has to be sold in order to cover the loans. It is a no-win situation for farmers, but they know no other.

"The present famine is almost certainly caused by an over reliance on high input dependent varieties of one crop, maize."

Howard Gibson with Farmhands Ltd in Mbale, Uganda, wrote about the "green" Ethiopian famine in light of Tony Rinaudo's observation that though the maize crop had failed, the weeds were doing OK.

"As a result of Tony's article, we commenced our own enquiries. Two years later, we have reached a conclusion that, if substantiated by further academic research, could fundamentally change the African perspective forever.

"Our investigation was conducted in Uganda where one can readily observe the same phenomena of "green famine" as observed in Ethiopia. Thus, we believe our conclusions to be relevant to "green famine" as conceptualized by Tony Rinaudo.

"Initial research consisted of conversations with farmers as to their experiences with maize. Overwhelmingly, farmers pointed out that, when they grew maize, they either got good harvests or complete crop failure.

"We had witnessed, close to the time of these inquiries, a bumper harvest of maize that resulted in the price of maize falling so low as to not even cover the cost of growing it. While our people had food enough for their families for the next year, it was impossible to generate significant amounts of cash with the sale of the enormous surpluses. With either too much or too little rain, however, maize crop failures were not uncommon.

"Was this "feast or famine" with maize a clue? Maize is an import from South America, so it is not a "child of the soil" of Africa. We talked to some of the older members of the community who commented that, when they were young, they never had maize as a food and dearly missed the "old" foods of their youth, the principal among them being millet bread!

"We then decided to ask farmers about these "old" foods, millet and sorghum. Immediately upon mentioning these crops in conversations with farmers, the almost universal response was "Ah! Those are "stubborn" ones!! Even during two or more seasons after harvest, those ones STILL KEEP ON GROWING!!!!!" The second response was nearly always "With these crops, no matter what the weather, you always get something."—In other words NEVER A TOTAL CROP FAILURE. Whatever the extremes of weather, millet and sorghum produce a family-sustaining harvest even when the worst weather conditions cause a reduction in yield.

"We wanted to find out why food production was so much more dependable with millet and sorghum than with maize. It seemed to us that the answer was more likely related to water than sunlight. This was consistent with the observation that, while Ethiopia's maize had failed, we in Uganda were having a bumper harvest. Assuming the answer was water-related, why did maize fail to produce a crop with the same amount of water sufficient for the growth of local weeds, millet, and sorghum?

"Being agricultural engineers, we approached the question based on our knowledge of soil mechanics and soil reaction to varying conditions. We noticed that, while the plant itself is very tall above ground, the root system of maize is very shallow. The majority of the root is spread close to the surface.

1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
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Table 1: Trend analysis of rainfall in Wolaitta over the last ten years from workshop with Terepeza development team.

"We also noted that, even though the rainfall amount in East Africa is comparable to that in South America (the origin of maize), there were some interesting differences in the actual rainfall pattern. When it rains here in Uganda, the rain comes all at once as a solid downpour of water hitting the ground with the power of a steam hammer. In half an hour, we can get a week's worth of rain in the locations where corn originates in South America.

"Following a downpour in Uganda, the sun comes right back out again and bakes the ground into a solid brick. The sun also causes much of the rainfall to evaporate before it gets the chance to really soak into the ground (if it even could, as it is still rock-hard from the last soaking and subsequent baking into a horizontal brick wall). Run-off is huge, flash floods common, and the penetration of surface water is negligible.

"Our poor maize plant roots have about half an hour to take up as much of this rainfall as possible before the sun returns with all its potential to dry out the crop.

"However, our "old timer" crops thrive in this situation by way of their "secret weapon"—the taproot!

"Most of the plant-available water in Africa comes from ground water that is moved upwards to plant root zones by capillary action. Only when this moisture is brought to within a few inches of the surface is it subject to evaporation loss by the intense sun. These top few inches of soil are precisely where the vast majority of maize plant roots are found. Thus, the roots are not only in the driest but also the hardest, sun-baked portion of the soil profile! Intense solar radiation also results in the absence of bacteria and microbes. Our maize visitor is not a very well adapted resident, yet 65% of agricultural effort is expended in trying to force a means of survival from this plant.

"An example of the inappropriateness of maize as a crop can be seen within 100 yards of our workshop where a large maize plot is "infested" by a strange plant that has persisted there despite the best efforts of the landowner to eradicate it. For years this plant has kept coming back. The landowner thought it was some kind of wild cassava. We discovered that the "offending" plant was in fact Castor! It was the remains of a defunct project from the early 1970's! This crop had "self- propagated" for over 40 years and still managed to thrive despite the best efforts of the present landowner who had no idea as to the history of his land!! Anyone know where we can find a market for Castor oil?

"How many other local crops might there be that could be grown instead of or in addition to maize?

"The above observations bring us to our aforementioned "catastrophic conclusion": the introduction of maize into African agriculture **to the exclusion of local crops** could be the principal cause of food insecurity on the continent."

ECHO's Farm Manager, **Danny Blank**, read Gibson's comments and shared some of his thoughts based on his experience growing maize at ECHO.

"In my experience with maize on the marginal soils of SW Florida, I have found that: 1) maize demands far more nutrients (principally nitrogen) and water than other grain crops such as amaranth, sorghum, and millet; 2) we have a similar experience of either complete crop failure or mild success.

"When interns plant maize, I tell them they need to commit to using irrigation and a fairly regimented fertilizer schedule. Without both of those, we nearly always fail with maize at ECHO, whereas we still get a harvest with millet or sorghum.

"So in light of [Gibson's] statements, I can see how dependence on maize could be devastating, because it is such a demanding crop. With fertile soil and plenty of soil moisture, though, I have seen corn flourish even in very poor regions of Haiti. The problem that he alludes to seems to be a matter of mismatching a crop with the soil and climatic conditions. He speaks in rather sweeping terms about maize being a poor crop choice in Africa, but there are obviously places in Africa where it consistently flourishes.

"I recall conversations with Lance Edwards (former ECHO staff member) about his father's ranch in Zimbabwe. Lance told me that his dad tried to convince his ranch workers to grow sorghum or millet in their fields. But even though they would succeed in only one in ten years, they stayed with maize because they preferred it.

"It is my understanding (as a "rule of thumb") that most people prefer maize when given the choice between it and other grains (excluding rice). Maize is easy to harvest, clean, store and prepare; has wide appeal; and has potential for incredible yields. I agree that maize is often a poor choice, but maize is not the great evil in Africa; maize is a great gift from God. Many plants, not just maize, result in failure when mismanaged or mismatched with the soils and climate.

"The point I think is well-made by the author is that maize is a very demanding crop that, from an agricultural perspective, is a poor choice under marginal conditions.

"Getting people to try alternatives is wise but obviously challenging. I certainly would encourage promotion of other crops; however, I think it wise to experiment with more sustainable maize production systems. I recently returned from a 10-week trip, mainly to southern Africa where maize is the staple. One maize system having great success is a method of conservation farming called "Farming God's Way," pioneered by Brian Oldreive, from Zimbabwe. Of all the systems I observed being promoted by research stations and NGOs, I thought this by far had the most promise for farmers. In a future issue of *EDN*, we will feature this and some other ideas to help in growing corn in marginal areas. In the meantime you can check it out at www.farming-gods-way.org.

"Obviously, there are some places where maize cultivation should be

discouraged. Yet entire cultures have come to know and depend upon this crop, so I think encouraging more sustainable systems of maize cultivation in the tropics is of great priority."

Martin Price wrote back to Howard Gibson with a few questions: "My post-doctoral research was on grain sorghum, so I have been aware that where maize often fails due to dry weather, one should consider sorghum. Where sorghum often fails due to dry weather, one should consider millet.

"The thing you did not address (except that old men missed eating the old crop) is whether tastes have changed so much that there is now little desire or market for sorghum in the younger generations. I wonder the same thing about millet.

"A second question is, how serious is damage by birds to sorghum and millet in this area? I know that in some east African countries, the quelea finch can come in by the hundreds and cause extremely heavy damage to sorghum because the grains are sitting unprotected on top of the plant like "bird candy." Do the older people recall this being a problem?"

Gibson replied, "Have tastes changed? In essence no! What has happened is that, because of 25 years of absolute terror, they have actually LOST the knowledge of how to prepare and process millet and sorghum into food. They have even lost the knowledge that it CAN be processed into food.

"Birds can be a bit of a problem, but not as big of a problem as losing all of a maize crop. In fact they are not much of a problem at all here, though maybe a bit of a problem in Karamoja."

Unaware of these exchanges regarding maize, **Stacia Nordin,** Registered Dietition, sent us a document called "Improving Nutrition through Permaculture in Malawi." It contained some interesting comments about maize, excerpted below.

"In Malawi we began to notice a relationship between the emphasis on maize, activities that are leading to environmental degradation, and the resulting nutritional problems we are currently seeing. The agricultural systems that are being promoted now involve planting solely maize in combination with fertilizers and chemicals to control insects and other plants that may interfere with maize growth. This system is unhealthy for both the human body and for the environment….

"In the past, Malawi's environment and diet revolved around a wide variety of local fruits, vegetables, nuts, seeds, millets, sorghums, roots, and various animal foods. Although many of these foods are still available, they are vanishing quickly because of the push to supply maize year-round either by forcing the land to produce it or by bringing in maize aid when the environment is unable to meet our maize demands.

"Maize is not the only culprit; people are becoming more interested in obtaining foods of the west than in giving attention to the abundance of foods right around them. Expatriates who come in to 'help' often do not take the time to learn about these valuable food resources. These local foods that are being crowded out by maize and western foods are often higher in nutrients than similar types of western foods, are available with no work or money, and are delicious!

"Our project has categorized over 500 plant foods that are available in Malawi and are able to meet all the nutritional needs of people living here. We are trying to revive the knowledge of these plants. We have gradually been collecting these food plants, sharing the seeds, teaching about their importance in nutrition and the environment, using them in our own meals, and encouraging their use for anyone living in Malawi. In two years, we have established over 150 different local foods just in one small half-acre plot."

Another Green Revolution?

Tony Rinaudo sent a comment about the article about a recent workshop on "Resilient Crops for Water-Limited Environments" (*EDN* 90-5). In particular, he referred to the statements:

The meeting looked mainly at maize, rice, and wheat, which account for more than half of the calories consumed by people in the developing world. What is needed now is a Doubly Green Revolution to lift up the African and Asian smallholders left behind.

Tony shared a quote from a paper he cowrote: "The green revolution that dramatically increased grain crop yields in the tropics and subtropics bypassed Africa (Vietmeyer, 1996). If there is to be a "green revolution"™ for the arid and semi-arid subtropics, it will have to be through plants that thrive under such conditions, yield well and require minimal inputs. Millions of third world farmers have no access to the usual green revolution inputs. Increasingly they are farming on exhausted, marginal lands under adverse climatic conditions that are unsuitable for conventional crops. For them, a biological revolution is needed, in which plants are selected and bred to suit the prevailing environmental conditions, rather than a green revolution to suit the plants, in which the crop environment is modified (through irrigation, fertilizers and pesticides)." Tony concluded, "There are many drought resistant food plants—both domesticated and not—which already have what it takes to meet food needs under various degrees of drought conditions." (Quote from Conservation Science W. Australia 4(1):161-169 (2002))