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Editor: Martin Price, Ph.D.
Assistant Editor: Dawn Berkelaar

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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

Nutrient Quantity or Nutrient Access? A New Understanding of How to Maintain Soil Fertility in the Tropics

By Roland Bunch

Introduction

In order to achieve high levels of agricultural productivity in the tropics at the lowest possible economic and ecological costs, we need to properly understand the relationship between nutrients in the soil and crop productivity. For this to happen, the current understanding needs to change. **The conventional view of the relationship between soil nutrients and crop productivity in the tropics is leading to both damaging agricultural policies and inefficient and damaging farm-level practices.** There is no need to use the huge quantities of chemical fertilizers that are so often recommended. In fact, often times the use of such fertilizers is unnecessary, expensive and harmful to the environment, especially because farmers often stop using organic matter when they use chemical fertilizers.

Much of the theory described here was originally developed by Drs. Artur and Ana Primavesi. For a much more in-depth analysis of the chemical and biological issues described in this article, the best book at present is Ana Primavesi's *The Ecological Management of the Soil* (unfortunately this book is currently available only in Spanish and Portuguese). This article will discuss the conventional concept of soil fertility and some of its shortcomings; a new conception of soil fertility; and how the new theory can be put into practice.

The Conventional Concept of Soil Fertility

Soil fertility is more than the soil's content of available nutrients. For the purposes of this article, we will use the definition of soil fertility presented in Anthony Young's book *Agroforestry for Soil Conservation*: "soil fertility...is the capacity of soil to support the growth of plants, on a sustained basis, under given conditions of climate and other relevant properties of land."

The traditional concept of soil fertility to a large extent sees fertility as a reflection of the overall quantities or concentration of nutrients in the soil. According to this concept, as long as enough nutrients are present, soil pH is within a certain range, and cation exchange capacity (CEC) is high enough to hold nutrients, there is good soil fertility. The basic idea is that the soil operates like a bank: add nutrients repeatedly, over a long period of time, and they will gradually build up like a savings account, increasing the soil's fertility and therefore crop productivity. We will refer to this idea of soil fertility as the Nutrient Quantity Concept (NQC).

In most books on soil properties and management (the majority of them written by proponents of the NQC), little attention is paid to organic matter or soil biology. Rather, sources and quantities of nitrogen (N), phosphorus (P) and potassium (K) dominate the discussion. As a result, most recommendations to restore soil fertility and improve food production in the tropics rely on the application of chemical fertilizers.

First, a short explanation for the benefit of the layman: crops are capable of absorbing some nutrients that exist in the soil at levels of less than 0.2 parts per million, while other nutrients are often difficult to absorb at 100 times that concentration. (Ahn) Thus there is actually little relationship between a plant's physical ability to absorb a nutrient and the nutrient's concentration in the soil. Also, plants do not absorb the various nutrients primarily according to the levels present in the soils, but rather in accordance with the plants' own needs, and in ratios between the nutrients that are relatively stable for each species or variety of plant, regardless of the supply of the nutrient in the soil. Thus, the Nutrient Quantity Concept is really saying that, other conditions being adequate, the growth or productivity of any plant will depend largely on the quantity and availability of the nutrient that is the limiting factor for the plant to achieve maximum growth. According to this theory, in practice maximum crop growth should be achieved by having large enough reserves of these nutrients in the soil so that adequate quantities of them will exist in available forms. (Cresser)

The Inadequacies of the Nutrient Quantity Concept

Theoretical Inadequacies of the Concept

1) The Nutrient Quantity Concept is oversimplified. Other factors are far more important for productivity than the total quantity of any single nutrient or group of nutrients. These other factors include: the chemical form in which the nutrient occurs; the depth in the soil at which it occurs; the kinds and numbers of macro and microorganisms that exist; the presence of soil compaction layers; and the equilibrium that exists between the nutrients, the pH of the soil, its moisture content, its organic matter content, its macro and microorganisms, its texture and structure, etc. These factors also influence each other, so that the microenvironments within the soil are constantly changing. At some times a plant may be able to access most of a given nutrient in the soil, while at other times it may only be able to access less than 1% of the total store of that same nutrient. The key is the bioavailability of the nutrient, that is, how much of the nutrient is actually **available** to the plant.

The factors listed above are recognized by proponents of the Nutrient Quantity Concept. However, their thinking is dominated by one particular fact: that in a **uniform soil** environment, if more of a certain nutrient is present in the soil, more will be in an available form. They do not take into account the fact that soil is non-uniform and that often the relationship does not exist, especially in the tropics. For example, soil phosphorus can be as much as fifty times more available in an organic environment than in an infertile acid soil environment—and yet most soil scientists still advise adding phosphorus to acid soil, rather than applying the phosphorus to a mulch, for instance.

2) The Nutrient Quantity Concept seems to assume that nutrients are relatively stable in the soil. They really are not, especially where CEC of the soil is low and/or where erosion occurs. Nitrogen and potassium in particular do not remain in the soil for long, and phosphorus is less stable in tropical soils than has long been assumed. "Money" is constantly leaking out of the "bank." And the more money there is in the bank, the more will leak out.

Chemical fertilizers do not maintain levels of most micronutrients in soil and they reduce soil pH. This means farmers may need to use expensive lime or alkaline fertilizers because of low soil pH due to use of chemical fertilizers. Admittedly, organic matter also fails to increase soil nutrient quantities dramatically over the long term in the tropics. The use of either chemical fertilizers exclusively or organic matter exclusively will fail to achieve long-term improvement in nutrient quantities. It is not that chemical fertilizers are completely bad; replacement of some chemical elements in the soil is acceptable and often even desirable.

3) Proponents of the Nutrient Quantity Concept have largely avoided taking into account the tremendous impact in tropical soils of such factors as their macro and microbiology, organic matter content, microenvironments and compaction layers.

Inadequacies in Practice

Most conventional soil scientists have concluded that "low external input" technologies must inevitably lead to "low output" results; that "ecological agriculture" is inevitably unproductive and has virtually no future; and that soils with very low CEC's, like those of most of West Africa, have very little potential for decent crop productivity. None of these conclusions is based on the scientific understanding we have of soils in its totality. Concrete evidence from tens of thousands of farms around the world, as well as from many scientific experiments, provides considerable evidence that not one of these conclusions is, in fact, accurate.

Thus, the Nutrient Quantity Concept is failing us. It fails to lead us to proper conclusions about agricultural priorities. It fails to predict what will happen if we apply a whole range of agricultural technologies that are now being tried in the tropics, and it fails to help us understand a series of both natural and agricultural phenomena that we are observing. Above all, it is failing to lead us to promising new technologies that can provide tremendous benefits at low cost to poorer farmers within the tropics.

Let's look a little more closely at these failings.

1) The traditional Nutrient Quantity Concept in tropical environments has caused many scientists to dismiss ecological agriculture out of hand. According to the Nutrient

Quantity Concept way of thinking, if not much is put into the bank account, not much can be withdrawn. Because of this thinking, promising technologies like ecological agriculture and agroecology have been largely ignored (Pretty and Hine).

2) The Nutrient Quantity Concept leads to the claim that soils with very low CEC's will never be able to produce large harvests, because these soils cannot hold very many nutrients over a crop's entire lifespan. Thus large areas of the tropics have been written off as "low-potential" areas, where investments in agricultural development are not seen as worthwhile (Mosher). This mistaken policy has aggravated already serious problems of economic injustice and downright hunger. And all because of a theory of soil fertility that is questionable at best.

3) The Nutrient Quantity Concept leads almost inevitably to an excessively high use of chemical fertilizers, which is particularly expensive for resource-poor farmers in the tropics. Yet experience in nation after nation has shown that for a much lower total expense, farmers can achieve the same or even higher yields. Over time, the use of most chemical fertilizers mine the soil of micronutrients, acidify the soil even more, and help to erode away, burn out, or simply fail to replace the soil's organic matter. Then the response to chemical fertilizers is reduced until eventually there is no more economic advantage to using them. The recent increase in petroleum prices (from $12.00 a barrel to somewhere between $19.00 and $32.00 a barrel) will increase the cost of fertilizers because of higher production and transport costs. Let's learn about technological possibilities that will let farmers be productive without relying so much on chemical fertilizers!

4) The Nutrient Quantity Concept lacks predictive abilities. Very high productivity is being achieved on soils that could never produce such yields according to traditional thinking, using only one-half to one-tenth of the amount of nutrients recommended by the Nutrient Quantity Concept. We can pinpoint several specific cases in which the Nutrient Quantity Concept has failed to predict present phenomena.

- The increases in yields achieved by the use of green manure/cover crops (gm/cc's) in system after system are much greater than the conventional Concept would have predicted. The "green manure/cover crops" technology grows biomass, often leguminous, intercropped with regular crops, under fruit trees, during the dry season, during frosty periods or on degraded soils too poor for cropping (i.e. in all cases on land with little or no opportunity cost), thereby **adding huge net** quantities of high-nutrient biomass *in situ* to agricultural systems and applying it to the surface where it is highly accessible to subsequent crops (see Bunch 2001). "Dispersed trees" is another traditional practice around the world which has only recently been studied and promoted in Central America, but which apparently has tremendous potential for increasing biomass production in much of the lowland tropics.

  Farmers using green manure/cover crops, resulting in increases of only perhaps 100 kg of fixed N and no additional P or K, have often doubled yields of maize (Buckles; Bunch and Lopez; Pretty and Hine, for example). Furthermore, in northern Honduras, yields of 2.5 t/ha have continued to be produced on relatively poor, humid tropical soils every year for 40 years, with no application of chemical NPK. Of course, what is happening here is due to biological, physical, and chemical dynamics within the soil, not just those of soil nutrients. Nevertheless, according to the Nutrient Quantity Concept, the levels of P, at least, should have become a major limiting factor years ago. Yet applications of chemical P on these soils still, after forty years, give no economic response. (Buckles)

- Using the System of Rice Intensification (SRI) in Madagascar, hundreds of farmers are achieving yields of 12 to 15 t/ha, and occasionally 18 t/ha, using only moderate amounts of compost and no chemical fertilizer on low CEC, acid soils (a classic case of "low potential soils") (Uphoff; see also *ECHO Development Notes* Issue 70). Yet the world's rice experts hold that the "biological maximum" for the rice plant is less than 10 t/ha. The attitude that "low input agriculture is low output agriculture" cannot come even close to explaining rice yields of 15 t/ha on these "low potential" soils with so little N introduced into the system.

- In West Africa, on very old, low CEC soils, women frequently grow 4-mt-tall, 4 t/ha maize on small plots around their homes. The only addition to the soil is the grey water and kitchen scraps from the household, which are applied daily.

- Traditional slash-and-burn or shifting agriculture has been an age-old, world-wide method of regenerating soils. The techniques cannot be fully explained by the dominant interpretation of the Nutrient Quantity Concept. Close to half of fields that West African farmers indicated were ready to be "slashed and burned" had no visible vegetation on them other than grasses. If grasses can regenerate soils by themselves, how can the Nutrient Quantity Concept explain this worldwide phenomenon?

- The biomass productivity of natural rainforests is much higher than its CEC would allow under the traditional Concept. Scientists who normally adhere to the Nutrient Quantity Concept freely admit that the rapid recycling of nutrients in tropical rainforests permits tremendous levels of biomass production in the presence of very low levels of nutrients and CECs in the soil in general. Yet many deny the possibility that this same phenomenon of the rapid circulation of nutrients could be the basis of highly productive crop agriculture under similar conditions. In other words, Nutrient Quantity proponents freely admit in the case of rainforests that "low input forests produce high output forests," yet they refuse to admit that the same principle might be applicable to agriculture in the very same environments.

Nutrient pumping (the bringing of nutrients to the soil surface from deeper layers by trees) might seem to cloud the above issue somewhat. However, many rainforests produce large amounts of biomass above subsoils that, even under extremely efficient nutrient pumping, provide fewer nutrients than those added artificially under many "low external input" systems. Besides, areas deep in the soil from which nutrients are presumably "pumped" virtually always possess much lower concentrations of nutrients than do the soils above them. Therefore, even **with** nutrient pumping, natural forests provide clear evidence that sufficient nutrients for very high levels of biomass production are being extracted from soils with an extremely low total concentration of nutrients.

- ❖ Chemical fertilizer companies have spent millions of dollars to research "slow-release" forms of chemical fertilizer. These companies thus admit through their actions that the overall quantity of nutrients available at any given time is not the primary issue in productivity. Rather, the **constant supply** of nutrients is more important than the total quantity available at any particular time.

Given the apparent inaccuracies and even logical inconsistencies of the traditional Nutrient Quantity Concept, it is time to develop a new, more comprehensive and accurate concept of soil fertility in the tropics.

The Nutrient Access Concept of Tropical Soil Fertility

To illustrate the Nutrient Access Concept of soil fertility, we start out with an experiment reported in Ana Primavesi's *The Ecological Management of the Soil*. In this experiment, crops were grown in four hydroponic solutions. The solutions were as follows:

1) A normal concentration of nutrients for maximum maize plant development was used, and replenished every 4 days.
2) Twice the normal concentration was used and replenished every 4 days.
3) The normal solution was diluted 50 times and also replenished every 4 days.
4) The normal solution was diluted 50 times, but was replenished every 2 days.

Plant growth (measured in grams of dry weight) was less in the second case than in the first. Plant growth in the third case was also less than in the first. But in the fourth case, plant growth was slightly better than in the first. **Even when the nutrient solution was $^{1}/_{50}$ what the traditional Nutrient Quantity Concept would have seen as optimal, the plants grew equally well, as long as the solution was replaced frequently enough and the roots could access the nutrients**.

Crop growth above a certain extremely low concentration does **not** depend on the concentration of nutrients. Instead it depends on the plant roots' constant access to the nutrients, even when these nutrients exist in very low concentrations. What is needed is a constant supply of a small but well-balanced amount of nutrients over time, and the unobstructed access of plant roots to these nutrients.

This experiment shows that the relationship between concentrations or overall quantities of nutrients and plant growth is, above a certain minimum concentration, altogether **nonexistent**. As long as plants enjoy the right conditions of nutrient balance, accessibility to nutrients, and a constant resupply of nutrients, the relationship between the concentration of nutrients in the soil and its productivity is either zero (i.e. there is no relationship) or negative (i.e. more concentrated nutrients reduce plant productivity).

These results are more relevant to tropical soils and farmers than to temperate-zone soils and farmers for several reasons:

1) Tropical soils tend to have lower concentrations of nutrients and fewer cation-exchange sites (lower ability to hold nutrients).
2) The ambient heat of the tropics makes it difficult for plants to create enough osmotic pressure to absorb nutrients from highly concentrated solutions. Limited concentrations of nutrients are often better.
3) Most farmers in the tropics work by hand or animal traction, so they can micromanage the soil by hand and create different microenvironments. In some of these microenvironments, nutrients are more accessible.
4) Resource-poor farmers can't afford to over-fertilize. And they often lose more nutrients than temperate-zone farmers because of high rainfall, steep slopes, or factors of soil chemistry.

Rather than emphasizing the concentration of nutrients in the soil, the new concept emphasizes the access of plant roots to soil nutrients. We will refer to this concept as the Nutrient Access Concept of soil fertility. Here are the main claims of this concept:

Maximum plant growth can best and most cheaply be achieved in the tropics by:

1) the constant supply of soil nutrients (most inexpensively achieved with fairly low concentrations)
2) a healthy balance between the nutrients
3) maximum access of plant roots to these nutrients (e.g. the maintenance of good soil structure and/or mulches)

The Adequacy of the Nutrient Access Concept

Can the Nutrient Access Concept explain the phenomena mentioned above better than the Nutrient Quantity Concept could? For one thing, the Nutrient Access Concept admits that high levels of productivity can be achieved through high concentrations of nutrients in developed nation agriculture, and even in highly capitalized plantation agriculture on the best soils of the tropics. This is true in many circumstances, especially in cooler climes, when soils are compacted or optimal soil structure has otherwise been damaged, when CEC is high and when farmers are well-capitalized.

However, where soils have very low CEC's, where soil organic matter is or could be abundant and cheap, where capital is scarce, and/or where temperatures are high, the Nutrient Access Concept points to agricultural practices of a radically different kind from those presently used.

Many farmers, in southern Brazil and scores of other countries, have realized competitive yields at relatively low cost on very "low potential" soils, with more positive long-term ecological impact than agriculture done according to the Nutrient Quantity Concept.

Thus the Nutrient Access Concept could reduce significantly the costs of producing competitive yields in the tropics. It also confronts the present unjust discrimination against those farming on so-called "low potential" soils. In fact, with fairly small, inexpensive applications of highly accessible nutrients, these soils can produce harvests several times their present levels. The "potential" of the soil depends more on the proper management of the soil than it does on the addition of large quantities of very expensive nutrients.

The Nutrient Access Concept also calls into question efforts to subsidize huge quantities of expensive chemical fertilizers to African nations that are already practically bankrupt. Such proposals are based on the Nutrient Quantity Concept. Adoption of the Nutrient Access Concept would force a major rewrite of these proposals, gearing them instead toward the goal of increased yields through higher levels of biomass production, soil structure improvement and mulch-based systems.

In addition, the Nutrient Access Concept can explain very adequately those observed phenomena mentioned previously, which the traditional theory cannot explain:

- Green manure/cover crops. Rather than depending on high concentrations of chemical nutrients, yields in gm/cc and agroforestry systems depend on the fixation of N and the recycling of large amounts of organic matter which makes the P and other nutrients in soils much more soluble (i.e. chemically available), and places most of these nutrients near the soil surface, where they are easily accessible to plant roots.

- SRI yields. With the SRI methodology, the soil is aerated and plants grow almost six times more roots per plant. This means they can access many more nutrients in the soil.

- West African kitchen gardens. The organic matter thrown out of kitchens daily maintains a small, steady supply of nutrients.

- Regeneration of tropical soils. The regrowth of forests or grasslands maintains or improves soil structure so that on newly cleared land, crops can more efficiently access the low concentrations of nutrients. Organic matter on or near the soil surface (from years of fallow) supplies nutrients in small quantities.

- Rainforests. Good soil structure and mulches are maintained, so that trees can access the small amounts of nutrients that are constantly being supplied by the breakdown of soil organic matter. Trees with deep roots and lots of feeder roots can capture many nutrients even though they are present only in low concentrations.

- Slow-release chemical fertilizer. The benefits of slow-release chemical fertilizer are much more understandable based upon the Nutrient Access Concept rather than upon the Nutrient Quantity Concept.

Of course these explanations are very simplistic. Plants' access to nutrients is a very complicated phenomenon which involves a large number of factors. These include soil temperature, soil organic matter levels, pH, soil chemical properties, the presence of compaction layers, and nutrient positioning and equilibrium. All of these factors are in turn affected by the activity of hundreds of thousands of microorganisms in every teaspoonful of soil. **Nevertheless, the Nutrient Access Concept seems to come much closer to explaining the overall sum or average of all these varied and mysterious processes than does the Nutrient Quantity Concept.**

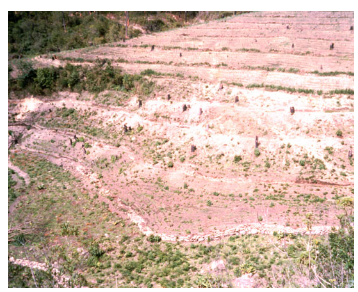

Figure 1. The techniques associated with the Nutrient Access Concept can result in dramatic changes. Above is a bare, eroding piece of land. To the right is the same piece of land only two years later. Photos from Roland Bunch.

Putting the Nutrient Access Concept Into Practice

The Nutrient Access Concept can most easily be put into practice through the copious use of organic matter. Organic matter supplies low to medium concentrations of nutrients, almost always in well-balanced quantities. Organic matter also by its very nature has a slow-release mechanism, allowing the nutrients to become available to plants over a period of several months or years. And lastly, soil organic matter can gradually improve soil structure, both directly (through the provision of binding materials to improve flocculation) and indirectly (by feeding earthworms and other soil organisms which also improve soil structure) (Minnich).

The best way to apply organic matter is to apply it either to the soil surface or, during the period of transition (from fertilizer-based to mulch-based agriculture), within 20 cm of the surface. During the first year or two of a transition into mulch-based agriculture, soil compaction below the surface is a serious limiting factor. After the first year or two, virtually all the organic matter should be applied to the soil surface.

The Nutrient Access Concept does not necessarily support a totally organic approach. But it suggests a greatly reduced use of chemical fertilizers in the short run. In the long run, it suggests use of chemical fertilizers only to replace nutrients not supplied by organic matter and nitrogen fixation.

Based on the Nutrient Access Theory, the following Five Principles of soil management have begun to be used around the world in small farmer agriculture:

1) Maximize organic matter production. Organic matter production can be increased by a) intercropping of crops or gm/cc's with annuals or tree crops; b) establishing two- to four-story fields and gardens; and c) growing trees or gm/cc's on wasteland or during the dry season. Watering/irrigation can help increase organic matter production in dry areas. It is best to produce biomass on site.

2) Keep the soil covered. Covering the soil will help to reduce both weed growth and the heating of the soil. The latter can accelerate soil organic matter burnout, reduce crop growth rates, and cause the death of beneficial organisms in the soil. By maximizing biomass production and keeping the soil covered, the need to let land lie fallow can often be eliminated. Keeping the soil covered reduces the decomposition rate of soil organic matter, which means the provision of nutrients to the soil will last longer and be more constant, even if mulches tend to lose a certain amount of N to volatilization.

3) Use zero tillage. In order to be effective, this technique should be used in the presence of a maximum production of biomass, so that the supply of nutrients and good soil structure can be maintained. Systems with plentiful biomass production can remain highly productive over decades, as a whole series of gm/cc and agroforestry systems have proven. Often zero tillage cannot be practiced the first or second year of the transition. But the populations of organisms that naturally till the soil increase rapidly as soil organic matter levels increase and soil becomes covered. (Scientists have shown, for instance, that earthworms alone can move more soil/ha/year than is moved with one ploughing using a tractor-pulled moldboard plough.) (Minnich)

In the conventional textbooks, zero tillage is linked with a major increase in the use of herbicides. However, if the soil is kept covered through an adequate use of gm/cc's and agroforestry, most small-scale farmers will find they never, or only rarely, need to use herbicides.

Tillage damages soil structure and increases the rate of soil organic matter burn-out. It also exposes the soil (i.e. violates the principle of keeping the soil covered) and removes or incorporates the mulch, which violates the fifth principle below.

4) Maximize biodiversity. This principle is primarily important in maintaining the systems' long-term sustainability. It can also be very important in maintaining the balance of nutrients required by the Nutrient Access Concept (Primavesi).

5) Feed the crops largely through the mulch. Many humid tropical soils are not very hospitable environments for crop roots because of their low pH (below 5.0), their aluminum toxicity and compaction layers. Crops will often grow much better if they can also access nutrients from a thick litter layer or mulch. Most feeder roots will likely spread immediately under or up into a mulch layer **as long as it remains fairly moist**. The impact of chemical fertilizers can also sometimes be greatly increased by being applied to the mulch rather than the soil.

Feeding plants through the mulch helps compensate for poor soil structure or less than ideal conditions of root growth. In poor soils, if nutrients are on the soil surface, plants will have better access to them.

Small farmers and NGO's have developed a number of simple ways that plants' access to nutrients can be inexpensively enhanced during the transition period. For example, Edwin Asante, of World Vision/Rwanda has developed a small farmer version of "precision planting" for potatoes. In this case, an 8-cm ball of organic matter, lime, and about one-fourth the normally recommended amount of chemical fertilizer are placed less than 0.5-cm directly below the seed. Yields in very poor soils with a pH of 3.5 have averaged 20 t/ha, as opposed to 9 t/ha without precision planting (personal communication, during field visit). In Honduras, Elías Sánchez developed a type of strip tillage or in-row tillage (locally called "minimum tillage" or "labranza mínima") which concentrates the organic matter in the crop row, where it is more accessible.

These Five Principles are the very same principles a humid tropical forest employs to maintain its high "productivity" for millennia, even on soils with very low CEC's. A tropical rainforest maximizes biomass production and biodiversity, keeps the soil shaded at all times, and feeds its plants largely through the litter layer. And, of course, no human beings have to plough a forest to keep it growing lush and green, century after century.

Additional Impacts of the Nutrient Access Concept

We can expect a few major results of the Nutrient Access Concept of soil fertility.

1) **An increase in optimism about the plight of resource-poor farmers**. Given the Nutrient Access Concept, even those farmers with heavily depleted soils should be able to increase their yields dramatically with very little investment other than that of more increased knowledge and the adoption of new agricultural techniques. Gm/cc's provide cheaper nitrogen than fertilizer factories, while zero tillage and cover crops can practically eliminate the comparative advantage provided by tractors.

2) **More sustainable agriculture.** With the use of the aforementioned practices, the world's agriculture will become a good deal more sustainable. Increased sustainability will come from the reduced use of chemical fertilizers (reducing groundwater and stream pollution, nutrient imbalances and soil acidification). It will also come from the positive impacts on the environment of increased biomass production, soil cover, soil organic matter and biodiversity, and the decrease of farmer dependency on increasingly expensive fossil fuels.

Full article with full references (20 pages total) available on request.

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FROM ECHO'S SEEDBANK

'Uberlandia' Carrot

By Dawn Berkelaar

Several years ago (in EDN Issue 43, December 1993), we wrote that seed was available for a carrot that will set seed in the tropics (normally carrots only produce seed in temperate climates with a cold winter). Dr. Warwick Kerr sent us the original 'Uberlandia' carrot seed from Brazil nearly ten years ago. In our 1993 article, we mentioned that someone familiar with plant breeding could do a great service to the peasant farmer by selecting seed from plants producing better quality carrots.

In 1994, Reed Franz, a retired vocational agriculture teacher from central Florida, took up the challenge and started with a packet of Uberlandia carrot seeds. He planted the carrots in the first week of January. At the beginning of May, he evaluated the carrots by digging down alongside each, checking the tip, and cutting a notch in the side. Reed was selecting for several characteristics: pleasing appearance, acceptable size, nearly parallel sides and a somewhat blunt tip, tenderness, pleasant taste (not woody or bitter), a high ratio of xylem to core, and an intense orange color. Unsatisfactory carrots were pulled out and burned before the seed stalk began to grow rapidly. (These same selection techniques can be used with other carrot varieties.)

Figure 2. A thick xylem with a small, bright orange core indicates higher carotene content. Photo by Reed Franz.

When flowers opened and pollen appeared, Reed hand-shook the flower heads over each other to transfer pollen. He did this two or more times per day during peak pollination time. Seed heads were gathered as soon as they turned brown, then put in shallow trays and brought inside for drying. When umbellets became brittle, the seed heads were hand crushed and worked through homemade screens of various mesh sizes. A small amount of seed was set aside for the next year's crop, but Reed brought the majority to ECHO for distribution to our network.

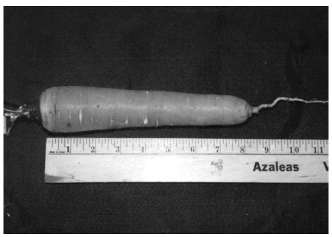

Figure 3. This carrot was part of Reed's 2000 harvest. Note the size and the blunt tip, both characteristics for which Reed was selecting. Photo by Reed Franz.

At the first harvest more than six years ago, only 3-4% of the carrots were orange, and many of them were very thin. With each generation, the size and color of the carrots improved. The carrots Reed is producing now are a good size and a deep orange color. At this point, the Uberlandia carrot is ready to be grown and selected in specific locations.

Rick Burnette has grown these carrots at the Upland Holistic Development Project (UHDP) Center in Chiang Mai Province, Thailand. He says that at UHDP, Uberlandia carrots have been planted for at least one year and they have already harvested two generations of seeds from the plants. He recalls that the carrots set seed in one plot during the early cool season and later during the late hot season. Although they hadn't dug many roots (because they are trying to save seed), the mature ones that they did pull up were about six inches long. The plants were sprayed weekly or biweekly with a botanical pesticide spray made of neem, lemongrass and galangal. Despite this treatment, a few of the roots were infested with root maggots and later rotted.

Burnette writes, "I've been encouraged that the variety seems to have performed fairly well so far and I consider it to be a likely good source of vitamin A for home gardeners in the area. Although wealthier lowland Thais are familiar with hybrid carrots grown in local plantations and sold in the market, the hill tribe minorities are less familiar with the crop. Although their acceptance of carrots isn't certain, early response to carrots at the Center appears favorable."

If you would like to try these carrots in your area, write to us for a trial packet. Those working in agricultural development can request one packet for free. For others, the cost is $4.00. When you grow these carrots, make sure you do not dig up and eat the very best ones before seed heads have formed; if you do, you will in a sense be doing a negative selection, saving seed from the worst carrots each year. We will be interested to know how Uberlandia carrots grow in your area. In the meantime, we say, "Thanks, Reed, for a job well done!"

UPCOMING EVENTS

International Conference on Biblical Holism and Agriculture

Sponsored by Food for the Hungry International and Dordt College
May 14-17, 2002
Dordt College, Sioux Center, Iowa, USA

The topic of Biblical holism in agriculture is primarily about the healing and restoration of man's relationship to God and His creation; and, secondly, about the healing and restoration of man's relationship to knowledge, ethics and purpose as those areas relate to agriculture.

The conference is intended for agriculturalists, students, and practitioners interested in following God's design and purpose for those who love the land.

The conference costs less than $300 for registration, food and lodging. For registration forms and information, contact Dordt College at BHA Conference; 498 4th Ave. NE; Sioux Center, Iowa 51250; USA; Tel: (712) 722-6285; Fax: (712) 722-6336; email: bhaconference@dordt.edu. Forms and information are also available on the conference web site at <www.fhi.net/gme/fse/bha_conference>

Konferans Agrikol 2002

April 22-26, 2002
Global Outreach TiTyen, Haiti (Rue National #1, Km 25 across from La Minoterie d'Haiti)

The contact person for Konferans Agrikol 2002 is Dr. Keith Flanagan, c/o Agape Flights, 7990 15th St. E., Sarasota, FL 34243. E-mail in Port –au-Prince, Haiti: jkf@haitiworld.com