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Improving Human and Animal Health by Restoring Fertility to Depleted Soils

[Editor's Note: We greatly appreciate the editors at ECHO (Educational Concerns for Hunger Organization) in North Fort Myers, Florida, USA for allowing us to reprint this article. We appreciate the assistance of Dr. Martin Price, recently retired Executive Director of ECHO, and Dawn Berkelaar, editor of ECHO Development Notes (EDN), as well as Danny Blank, ECHO Farm Manager and the author of this article. This article was first published in EDN 96, and is used here in a slightly abbreviated form.]

Editor's Introduction

Many readers of this publication have written us in the past several years concerned about the declining fertility of their soils which has brought about lessened yields and poor quality of crops and forage.

This situation has led to compromised nutrition and has caused problems for the health of animals and humans in developing areas. With so many people in developing countries dependent on farming for their livelihood, a decline in the fertility of soils brings on serious problems for humans and their animals that they depend on in so many ways.

With the steadily increasing human population, less newly available land for farmers, and the declining fertility of the land in production (much of which was not of high quality and often not well maintained), a situation has arisen that is becoming more serious and gaining much attention worldwide. The great increase in the cost of petroleum-based products, especially fertilizer, over the past several years has complicated those problems and brought much attention to it. It has also brought increasing attention to the older and simpler yet proven methods of preserving and replenishing the soil.

For many years the trends were toward developing more advanced methods of farming, and many of the older and proven methods often fell into disuse and were not promoted or improved on.

While a great amount of thought and effort has been and continues to be given to solving the problem, especially by a few organizations who concentrate on the problem, the solution will be complex and long term. Most likely the solution will be a combination of refinement of those older practical methods, development of new techniques, and an emphasis on spreading that information throughout the developing areas in a way that is easily understood.

Unfortunately, much of the great amount of information available is very technical, in language that is difficult to understand by small farmers and those who advise them, difficult to translate, or not practical enough for the small farmer to put into practice in a way that they can afford.

The editor, a lifetime family farmer and veterinarian in rural areas, has spent parts of almost a half century traveling in developing countries, observing, teaching, working with small-subsistence farmers and those who advise them and developing educational materials for them. He has observed once fertile high-yielding soils become all but useless in a short period of time, because farmers did not understand how to prevent the loss of fertility or how to restore it.

We are now seeing these newer problems becoming more and more serious. Much time and effort by many people in many areas is being given toward solving them. We would hope that those efforts will result in newer methods of keeping soils from losing their fertility and of replenishing depleted soils. These newer methods being developed and a critical review of older proven methods could lead to soil improvement. Many think that the combination of the best of the old and the new will be the answer. Hopefully that will become true.

However, to have the maximum impact these techniques must be written about in a way that is easily understood, translated, spread throughout developing areas and applied by the small-scale farmers and those who advise them. In this and the following issue of International Animal Health News, we hope to contribute to solving or lessening those problems by gathering information both old and new and presenting it in a way that is easily understood and helpful.

Fortunately we have had much input and information from many other individuals and organizations who are well-respected. We who edit this publication do not pretend that we have all the answers. With limited space we cannot go into great detail on the many possibilities available except for several that other sources have suggested and provided.

However we will describe others to varying degrees, so that our readers will know that there are many things they can do to improve their soils in a relatively short period as well as over longer periods. That is the purpose of this article. [Editor]

A Fresh Look At Life Below The Soil Surface
by Danny Blank, Farm Manager, ECHO
Article first published in EDN 96.

Too often, farming and land use practices contribute to land degradation, resulting in food insecurity and poverty. This article takes a fresh look at what is going on in the soil, especially in relation to soil organic matter and the organisms it supports; how this life is impacted by our land care practices; and how it in turn impacts the productivity of our farms and the health and well-being of humans and animals.

For years ECHO has emphasized farming practices that optimize soil organic matter levels (SOM) as a key to improved and sustained food production.

In this article I share some insights from a course I took with Dr. Elaine Ingham of Soil Foodweb Inc. (www.soilfoodweb.com). My goal is to help you better understand how LIFE below ground is inter-connected with LIFE above ground, and how to repair damaged soils through land care practices that maximize and maintain SOM and diversity of life in what is called the “soil foodweb.”

Soil is often described in textbooks as rock and minerals, air, water, living organisms and decaying organic matter. Though an accurate description, soil biology often takes a backseat to soil chemistry and physics--soils are often classified largely by presence or absence of certain minerals. However soil organisms play a huge and underestimated role in the productivity and health of soils.

When a rainforest is cleared, burned and the land subjected to annual tillage and burning, we often see this once highly productive landscape barely able to support a maize crop. What happened?

There is a growing understanding that the answers to this all too common question are found in the abundance and diversity of life hidden below the surface.

Soil Foodweb Concept
The soil foodweb is essentially the community of organisms that live in the soil. Every agricultural field, forest, prairie or pasture has its own soil food web with a unique set of soil organisms. Healthy soils contain massive populations of bacteria, fungi, nematodes, soil arthropods and earthworms.

Just as the plants we see above ground differ from place to place, the ratios and diversity of soil organisms change with region, climate, vegetative succession and soil disturbance. Grasslands and agricultural fields generally have bacterial-dominated food webs while forests usually have fungal-dominated soils. Healthy productive agricultural soils tend to contain about equal weights of bacteria and fungi (Soil Biology Primer).

Soil Life is dynamic and complex. Understanding the soil foodweb is critical to understanding how the plant world grows and flourishes. It is the foundation for knowing how to restore damaged lands, improve agricultural production and ultimately improve the health and livelihoods of people. Soil microorganisms play a big part in supporting healthy plant life through nutrient retention and cycling, disease suppression, and improved soil structure, water filtration, absorption and holding capacity.

Soil Foodweb Functions

Nutrient Retention

In a healthy soil foodweb, vast reserves of important plant nutrients are stored in the bodies of bacteria, fungi and other soil organisms. For example, no known organism is more concentrated in nitrogen than bacteria. Fungi are typically the second most concentrated in nitrogen (Ingham, An introduction to the Soil Foodweb). They also contain other critical plant nutrients.

Decomposition happens almost exclusively through the activity of bacteria and fungi, which in turn store nutrients from decomposed organic matter in their bodies, immobilizing nutrients, and thereby reducing leaching [removal of essential soil elements by heavy rainfall]. The presence of decaying organic matter in the soil—broken down leaves, roots, dead organisms etc—along with diverse populations of bacteria and fungi are key to immobilizing and storing nutrients in the soil. These nutrient-rich organisms then become the basis for the critical cycling of nutrients to plants.

Nutrient Cycling

As previously mentioned, fungi and bacteria have considerably more nitrogen in their bodies than other organisms. When other soil organisms eat the fungi and bacteria, nutrients are released in a form that plants can use. A healthy soil contains diverse species and huge populations of protozoa, beneficial nematodes, micro arthropods and earthworms (Figure 1). These soil organisms cycle nutrients and make them available to plants.

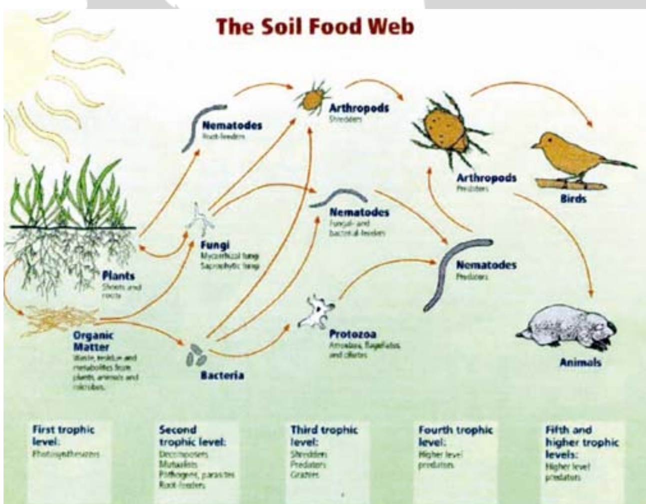

Figure 1: The Soil Food Web

Other soil organisms are involved in more direct forms of nutrient cycling. Nitrogen-fixing bacteria convert air nitrogen into a usable plant form as they colonize roots of legumes. Mycorrhizal fungi colonize root systems of perennials such as coffee, staple grain crops such as maize and sorghum and vegetables like onions. In so doing, these specialized fungi cycle nutrients by secreting enzymes that solubilize calcium phosphate and pump the phosphorous directly to the plants, thus making an otherwise unavailable nutrient now available to plants (Ingham, An Introduction to the Soil Foodweb). Mycorrhizae also benefit crops by aiding in disease suppression and water absorption. In field trials at Zamorano University in Honduras, mycorrhizal fungi were applied at the time of planting and then one time a year later. As a result coffee production increased by 30 percent, plantain production 23 percent and jicama production by by 35 percent. In addition, fertilizer use for avocado nursery tree production was reduced by 50 percent (personal Communication with A. Rueda).

Improved Soil Structure, Air and Water Dynamics

As bacterial populations increase, they secrete glue-like, sticky materials that bind sand, silt, clay and small SOM particles into micro-aggregates (micro-clusters). Fungi, the largest known organism on the face of the earth (since one organism can cover many acres in a forest), bind the micro-aggregates to form larger aggregate structures, creating air and water passageways. Larger passageways (pores) are created by bigger organisms like nematodes, soil arthropods (e.g. sow bugs, termites, millipedes, roaches and soil mites) and earthworms that burrow through the soil looking for food.

Earthworms 'glaze' the passageways they create with a nutrient rich and microbially active slime layer that greatly enhances water-holding capacity and soil structure. Earthworms and many soil arthropods also shred organic matter, grazing on the microorganisms present, and then excreting the nutrients in a plant-available form.

All of the small channels made by this variety of organisms become a series of reservoirs and a transportation network for air, water, nutrients, roots and organisms. Water use efficiency has been improved by as much as 50 percent in Australia by reintroducing missing soil biology—meaning the same amount of crop is grown with half of the water due to the improved soil structure and water dynamics that come with a healthy soil food web (Ingham, An Introduction to the Soil Foodweb).

Pest and Disease Suppression

Soil organisms break down toxic compounds in the soil, produce plant-growth promoting hormones and chemicals, suppress disease-causing organisms and buffer soil pH. When there is a healthy balance and abundance of soil organisms in the foodweb, pests and diseases can be out competed or preyed upon. When a balance is not maintained (for example, if fungal diversity and biomass is reduced) micro-arthropods and fungal-feeding nematodes may attack plant roots instead of feeding on fungi.
A mature healthy soil with sufficient organic matter and a full supporting cast of diverse soil organisms reaps vast and untold benefits.

Having laid the groundwork with an in-depth technical discussion, we will now focus on topics that will be more relevant to practical hands-on work at the farm and community level.

Where Does one Begin in Trying to Apply this Approach?
Understanding soil organisms' habitat is the key. All of these organisms need food, water, and a 'home' to live in. The suitable food depends on the species, but the base of the soil food chain is diverse bacteria and fungi breaking down leaves, stems, roots and dead organisms. Without crop residues or some added organic matter, there is little food to feed this web of life. Consequently, soil organism populations, along with all their soil-building benefits, decline. Organic matter is the long-term food source for bacteria and fungi.

Microorganism, earthworm and insect populations decline with reduced oxygen levels, often caused by soil compaction, waterlogging and poor soil structure in the absence of sufficient organic matter and soil life. During dry seasons, covered soils remain moister than bare soils. Many of these organisms 'go to sleep' during intense dry seasons, but when the rainy season comes, microbial activity immediately intensifies resulting in nutrient cycling and flushes of available plant nutrients to newly planted crops. In terms of a "home," healthy soils (e.g. in a forest or no-till field) are covered by an organic litter (mulch) that provides an umbrella and sanctuary against extremes of temperature and moisture and buffers the impact of raindrops in heavy rains .

The habitat and food resources for soil biology improve when there is minimum disturbance of soil, maintenance of a soil cover, rotation of crops, and avoidance of excessive fertilizer and pesticide use (ACT Info.Series No.1). Cover cropping, leaving crop residues, and planting diverse poly culture systems also positively impact the soil biology.)

Conversely, tillage infuses tremendous oxygen into soils resulting in rapid decomposition of soil organic matter; damages soil structure (significantly reducing arthropod and earthworm populations) and often causes 'hardpan' which is a compaction zone that reduces root growth, oxygen and water infiltration into lower soil levels.

Most ploughed fields have a period during which they are bare and sun-exposed. To various degrees, the land becomes subject to erosion by wind and water, hot surface temperatures, and sealing from the 'hammering' impact of raindrops that results in water and soil runoff.

Removal of crop residues by burning is especially injurious to soil biology. Many soil organisms are killed and the food for the decomposing organisms is eliminated. Once again, the ground is left bare and exposed. Fertilizer is well known to positively impact yields. However, fertilizer contains a mixture of chemical salts and damages soil biology if applied in too high concentration. Also, nitrogen fertilizers such as urea and ammonium phosphates are converted rapidly into nitrate by bacteria, resulting in a release of acids and an increase of acidity at the soil surface. If soil acidity is already a problem, both crop production and the diversity of the soil biology may be reduced (at pH values below 5). Pesticides, most notably broad spectrum and fumigation types like methyl bromide, kill both good and bad life in soil.

Can Damaged Soils Be Restored?
Yes if farming practices are changed to favor increased soil organic matter and soil biology. In addition to what has already been mentioned (minimizing soil disturbance, leaving crop residues, keeping the soil covered, practicing rotation, using pesticides and fertilizers in moderation), soil biology can be restored. Missing soil biology can be returned to fields and gardens through quality compost.

What is Meant by Quality Compost?
Compost is the result of aerobic (with oxygen) decomposition of organic matter by bacteria and fungi. However, contrary to the current understanding of compost, compost is much more than a fertilizer with nutrients, enzymes and hormones. In addition to all of these, quality compost is an inoculum of beneficial soil organisms foundational to healthy soils. Quality compost is the outcome of a diverse, active microbial population.

Explain The Compost Process!
Think of compost like making bread. The soil organisms, then, are the yeast, and the dried grass stalks, leaves, and manure are the flour, eggs, and sugar. The right 'food' for the organisms, the right conditions, and the right biology needs to be present. Bacteria and fungi rapidly consume the high concentration of simple sugars and proteins in compost piles, generating heat as they grow and multiply at enormous rates. As those 'super' foods are consumed, microbial activity and multiplication can be become so great that oxygen levels are depleted, requiring the pile to be turned to keep it from becoming anaerobic (without oxygen). The time to turn a pile can be determined by carefully monitoring the temperature inside the pile. If possible, check temperatures daily. The temperature inside the pile should not exceed 160 degrees F (71 degrees C). In the absence of soil thermometers, farmers may need to be trained by feeling the temperature of a long stick placed in the pile. A pile may need to be turned four or five times if a lot of high nitrogen foods are present or only once if less nitrogenous material is used. Try to maintain 135 degrees F (57 degrees C) for at least three days to kill seeds and pathogens (disease-causing germs).

Once the high concentrations of simple foods are consumed, compost piles stabilize while the more complex compounds like fats, cellulose and lignin continue to decompose. A stabilized pile means a healthy foodweb is present with minimal nutrient loss due to leaching or volatilization. Maximum diversity is achieved after about six months. Compost can be stored well over a year, but biology and nutrient levels begin to decline.

[Editor's Note: This means that a well-planned, ongoing farming operation needs to have compost piles in varying stages of development so as to have some ready when needed.]

Maintain moisture levels around 50%. This is monitored by the 'squeeze test'. Grab a handful of soil and squeeze. One or two drops of moisture should come out. If you are working on a compost pile during the rainy season or extreme dry season, the pile may need to be covered to achieve proper moisture levels. Too much moisture will fill air pores, cause anaerobic conditions and negatively impact microbial activity.

In the ideal compost pile, no more than 5% of the particles in the pile should exceed one inch (2.5 cm) in diameter. It requires a lot of machete work or knife chopping to create the small size materials, but you will be well rewarded for your work. When the compost process is finished, you should not be able to recognize the original plant material.

How do you Know What type of Compost to Make?
Tree crops in general prefer fungi-based soils; vegetable crops like brassicas (e.g. cabbage, collards and broccoli) and carrots prefer more bacteria-based soils; and field crops like maize and wheat prefer soils with about equal amounts of fungi and bacteria (Ingham, The Soil Foodweb Approach). Maximizing diversity and selecting for organisms best suited for to crop needs is achieved by carefully choosing the types and ratios of foods added to the compost pile. Bacterial foods are generally green, with simple sugars, high in nitrogen and easily digested; these include manure, legumes, thin succulent stems, food scraps, coffee grounds, green grass and leaves. Fungal foods are usually brown plant materials that are woody or fibrous, like dried corn stalks, dried weeds, sawdust, straw, shredded newspaper and wood chips.

For a bacteria-based compost, on a volume basis: mix 25% high-nitrogen materials (manure, legume plants), 45% green materials (diverse materials of grass, leaves, succulent stems) and 30% woody material (brown plant material). For fungal compost, mix 25% high-nitrogen, 30% green and 45% woody material.

Material is added in these ratios and this order. For example, if making a bacteria-based compost for growing cabbages, you would take one shovelful 25%) of high-nitrogen material like manure. Follow this with two shovelfuls (45%) of green matter like fresh cut grass or finely cut succulent weeds. Next a heaping shovel (30%) of brown woody material like coarse grass or weeds is added. This pattern--high nitrogen, green, brown--is repeated over and over. With larger amounts (e.g. wheelbarrow or larger), it is best to mix the layers.

What are Some Different Compost Methods?
1. Thermal Composting--a quick approach, used to produce quality compost in as short as one month. This is most often used for commercial scale production. Usually a high-nitrogen recipe is used to generate the necessary heat for killing off weed seeds, plant and human pathogens, and plant-feeding nematodes. Once made, the pile quickly heats up beyond 135 degrees F (57 degrees C), the temperature necessary for death of most weed seeds and disease organisms. When the pile reaches 160 degrees F (71 degrees C), usually on day two or three, it is turned (i.e. contents thoroughly remixed) and the cycle repeats itself. This is done four or five times and the time between turns steadily increases until the simple sugars and proteins are consumed and the temperature no longer spikes. The piles are often constructed in long windrows and must be a minimum of 3 feet (1 m) tall to generate enough heat. Ideally aim for 5 feet (1.5 m) but make piles no taller than 8 feet (2.4 m).

2. Worm Composting--'cold composting' that depends on worms to turn the pile as they shred organic matter and consume bacteria and fungi. Their nutrient rich waste (called casts) is left behind and the organic matter reappears in smaller fragments inoculated with microorganisms from the gut of the worms. This process increases microbial activity as the organic matter area increases. Large populations of worms are needed to produce significant amounts of compost. Worm composting is usually done in confined structures (large crates, raised beds), and in cool shaded areas. Worms prefer a higher moisture content (60-70%) than standard compost piles (approx. 50%). Food comprising 50% green and 50% brown material (including shredded newspaper) is usually applied in thin layers at the surface. Frequency and amount depend on worm populations. Too much food in the bin can result in anaerobic conditions. Worm composting does not kill seeds, so avoid adding weeds with seeds.

3. Small Back-yard Composting--a type of thermal composting more appropriate for farmers who do not have soil thermometers and may not need to produce compost in such a short time. This method requires a lower nitrogen ratio and minimal turning. The recipe is 10% high-nitrogen, 45% green and 45% woody. The pile should still achieve 135 degrees F for 3 days to kill seeds and pathogens. When it reaches 160 degrees F (71 degrees C) the pile should be thoroughly turned. With the lower nitrogen ratio, the pile is usually turned only once, but several months are needed to achieve quality compost. The backyard compost method can be made in long windrows as well. Experimentation with this method is currently going on at ECHO. The main challenge thus far is finding enough high-nitrogen and green material to get the temperature above 135 degrees F for more than 3 days. It is possible to add small quantities of urea or ammonium nitrate to piles without harming soil biology to get the needed high-nitrogen percentage up to kill off the weed seed and pests and pathogens, but the recommended rate has not been worked out.

How Can You Tell if a Compost Pile Has Become Anaerobic?
An anaerobic pile will be poorly functioning and unlikely to produce quality compost. Color and smell are excellent indicators. Compost should be rich brown, not black. It should have a pleasant earthy smell. Rotten egg, sour milk, putrid or vomit-like smells are the results of acids formed under anaerobic (without oxygen) conditions. Hopefully in finished compost you will see thick fungal strands growing through the pile.

How can one Really Know Whether or not there is Adequate Diversity and numbers of soil organisms in Soil or Compost?
Laboratories can test to determine what soil biology is present, but the cost makes this unaffordable for most small farmers. However, using farming practices that increase soil organic matter (as described in this article) will provide the habitat needed by soil organisms.

[Editor's Note: I noticed early on in working in very isolated rural areas that there always seems to be at least one farmer in a general area or large community who appears to be typical of farmers in the area. However, while not appearing to be doing anything much different, he/she was producing much greater yields of much higher quality farm products. Hopefully this type person, if approached in the right way, will share some of the secrets of their success. In their own way, they learned how to do successfully what it might take programmed experiments by outsiders a long time to do. Fortunately, there are individuals and organizations with experience in analyzing this type of situation and sharing the information, to the great benefit of many others. (ECHO who provided this excellent article and Christian Veterinary Mission who publish this IAHN and others are well into this work.)]

What Can one Do to Maximize soil Organism Diversity in The compost Process?
At the initial construction of a compost pile, beneficial organisms can be added for multiplication, just like yeast in dough. Small-scale farmers who cannot afford expensive inputs can add material from other quality compost sources, as well as numerous soil samples collected from nearby successful farms (with permission, of course!) and from forest soils. ECHO has brought in soil samples from various forest soils to add to their compost pile. Maximize Diversity!

How Much Compost Do I need to Make?
This will take time and experimentation, because every field, farm and area is different. Rates vary from 1 to 10 tons per acre per year for vegetable, grain, orchard and pasture applications. Remember that compost is both a fertilizer and an inoculum; remember that the primary benefit at modest levels is the inoculant you are adding, not the fertilizer. This makes field applications a real possibility, whereas previous thinking suggested that this may have been impractical. Ideally, apply compost at least once a year and well in advance of planting.

What are some Compost Application Methods?
There are many ways to apply compost. It is great as a starter media for vegetable transplants or nursery stock (if weeds can be eliminated). A simple but effective method of using compost is mixing maize seeds or potato seed pieces with compost in a bag before field planting, to inoculate them with good soil biology just as one would inoculate legume seeds with selected nitrogen-fixing bacteria before planting.

Compost can be applied in furrows or placed on top of a vegetable bed in a layer up to two inches (5 cm) deep. ECHO is experimenting with applying 250-500 grams of manure, worm compost and/or regular compost in holes directly below a vegetable transplant and maize planting station. In the most recent trials, they have been substituting compost in place of fertilizer, placing the compost below the surface and laying down a thick mulch (e.g. cut vetiver grass, wood chips, leftover stems and leaves from goat feed) at the surface of most plantings. This targeted below-plant application of compost and surface mulching is consistent with the successful maize production system promoted in southern Africa called Farming God's Way, which we will briefly cover later in this issue or the following issue of this publication.

What are The Implications (of These Microbial Dynamics) for Reforesting Denuded Hillsides?
Earlier in this article a scenario was mentioned where a tropical forest was cleared for an agricultural field but after one or two seasons the land could barely support a maize crop. So what happened? For centuries, there existed a dynamic forest system that never needed any fertilizer, lime or other chemical input. Under the forest's tall giant canopies, in the deep shade and protection of leaf litter, the soil was teeming with an abundant, diverse balance of soil organisms. Nutrients at the surface were rapidly recycled; complex humic substances were formed; an extensive mycorrhizal fungi biomass was present; and countless other species were present to perform all the necessary and important life-supporting functions that exist in mature forest systems.

With the disappearance of the forest, removal of the litter layer, and rapid oxidation of the remaining organic matter due to damaging agricultural practices, the number and diversity of soil organisms dramatically declined. Their habitat and food were gone. The soil remained exposed to the sun and impact of rain, further limiting the potential for restoration. With declining organic matter and soil biology, and with continued bad practices of fire, tillage, and exposure, the ground became increasingly compacted. With the biology largely missing, the soil became defined by the leftover mineral composition of the soil--low pH, low water-holding capacity, low fertility, etc. Chemical inputs now become the norm and a devastating cycle of dependence develops. Hope is defined as the next lime or fertilizer subsidy.

If we only knew that life below the surface is what supports the life above the surface many would find that in a short time, damaged lands can be restored to their productive potential without excessive inputs. Land care practice would change to be truly that, care for the land, patterned after the marvelous and elaborative design in the prairies and meadows that causes them to flourish.

UPDATES

Introduction to Green Manure
Green manure crops are crops that are grown to be turned under to increase soil fertility. Leguminous green manure crops, i.e. those which can make nitrogen fertilizers from atmospheric nitrogen, can offer small-scale Third World Farmers a tremendous number of advantages, including:

- They provide large quantities of nitrogen for the soil.
- They add many tons of organic matter to the soil, thereby improving topsoil depth, water-holding capacity, nutrient content, friability, and texture of the soil.
- Inasmuch as the green manure crop grows in place, it presents no transportation problems, in contrast to either compost or chemical fertilizers.
- Green manure crops require absolutely no capital outlay after the initial purchase of a handful of seed. Because they require no chemical inputs, dependency on outside sources of fertilizer, nutrients, and pesticides is reduced.
- Green manure crops can shade the soil up to eleven months out of the year, a factor extremely important in tropical climates for preservation of soil moisture and organic matter.
- The cover they provide for the soil protects the soil from wind or water erosion.
- Green manure crops provide generous amounts of high protein fodder for animals, which can be especially valuable if it is available during the last months of the dry season (inasmuch as fodder at this time of year is the limiting factor in traditional animal raising in much of the Third World).
- Some green manure crops provide human food, including various kinds of edible beans, peas, and pods.
- Green manure crops can provide cash income, by selling firewood, food or feed (and maybe seed).
- They often provide an incentive for people to abandon harmful traditional practices, such as burning crop residues or letting animals loose in the dry season to devour everything in sight.
- Some green manures, when intercropped with basic grains, can control most weeds, thereby eliminating costly weeding operations.

Something like 30% of all the increases in harvests achieved by small farmers in the third World during the last three decades has been achieved through the use of chemical fertilizers. Should petroleum prices shoot up once again, as could easily happen sometime in the next decade, prices of chemical fertilizers could easily become too expensive to be economically feasible for use with traditional basic grains. Almost overnight, Third world basic grain production could plummet, causing famines the extent of which would make the present situation in Africa seem mild by comparison. Widespread use of green manure crops could avert much of this impact.

CAUTION:
NO feces from cats, dogs, pigs or humans should ever be used for composting and fertilizer as they can lead to human health problems.

Composting is one of the most beneficial things you can do to your soil. There is not a potential human health problem when using manure-based compost for in ground vegetables as potatoes or peanuts as long as the compost is well prepared and according to directions in this article and is not made from manure-feces from the animals and humans listed above are NOT used.

Answers to Questions Sent in by Readers

Answers provided by Mr. Larry Willians, Director of Agrimissions (http://www.agrimissions.com/)

Question related to using legumes to help provide some nitrogen:

"Does the nitrogen carry over enough to affect the following crop?

- Yes, but not all legumes are created equal. Some are better than others and some are better in some areas due to soil quality, the following crop being grown, weather and many other factors.

"Does the old primitive farming method used where legumes as field peas were alternated in rows really help the adjacent non-legume?"

- Yes, intercropping is still used worldwide and taught by Agrimissions as a vital method of improving soil and adding nitrogen. The key is timing: For instance, if you are planting legumes with corn the corn should have time to emerge before planting legumes in the row. Other methods are strip cropping, crop rotation and interplanting. Especially effective is agroforestry for improving pastures. Growing legume trees adds nitrogen to the areas within the root zone of the pasture grass. It also provides shade for cattle and habitat for birds. It is always best to inoculate any nitrogen plant seeds with rhizobium inoculant. There are commercial sources of the inoculant which are generally best but in some areas farmers have been able to come up with ways to do it.

(**Editor's note**: *many of these are discussed in detail in the following issue of this two part series.)*

Pneumonia

In this short section we are also answering questions from our readers on another very important subject. Too often we do not recognize the serious impact of Pneumonia, especially it's role in chronic stunting and poor feed efficiency, nor do we usually realize the serious effect of parasites, both larvae and adults in the condition. In many areas where livestock are grown, a part or all of the farm land is low and at least borderline wet, or for parts of the year. That plus a warm climate provides excellent environment for the worms to survive and reproduce. There are many practices as pasture rotation, removal if possible from the lowest areas and providing fresh uncontaminated drinking water plus strategic deworming.

***(Editor's Note:** we are much indebted to Dr. Karen Dolce for this brief but excellent overview of Pneumonia in Farm Animals and its Impact on Animal Health. Dr. Dolce is a pathologist at the Clemson University Animal Diagnostic Laboratory near Columbia, South Carolina, USA.)*

A Short Overview of Pneumonia in Farm Animals and its Impact on Animal Health

Pneumonia is defined as an inflammatory process involving the lungs. In general, pneumonia can have various causes including inhalation of foreign materials (aspiration pneumonia), inhalation of toxins, parasitic infections, viral infections, bacterial infections and fungal infections. Pneumonia can also result from hypersensitivity (allergic) reactions. In many cases, viruses and specific types of bacteria, such as Mycoplasma and Chlamydia, can cause damage to the respiratory tract, which leads to a secondary bacterial pneumonia. If damage to the lung tissue is sufficient such that oxygen exchange cannot occur properly in the lungs, the animal may die of hypoxia (where tissues in the body do not receive a proper amount of oxygen). In cases of pneumonia caused by viral, bacterial and fungal agents, death may also be due to systemic infection or toxemia.

Parasitic pneumonias in livestock are mostly caused by primary parasites of the lung tissue (lungworms) as well as parasites that have a larval stage that migrates through lung tissue, such as roundworms (visceral larva migrans). Lungworms live in the airways of the lungs and can cause coughing and airway inflammation and obstruction. Death can occur in heavy infestations if there is severe obstruction of the airways. Parasite migration can cause significant lung damage which can also cause coughing, weight loss and scarring of the affected tissue. Death is possible in severe, heavy infestations.