

Issue Pack

Soil Health

July 2010

1. **Introduction – two true stories about soil health**

***Story 1:*** Ayelech Fikre is a 63-year widow who farms in the highlands of central Ethiopia.When she took over the family farm from her father, she saw how heavy rainstorms had washed away her soil and created gullies.

So she began to take action to prevent the storms from robbing her of her precious soil. She improved the drain already dug into the slope above her farm and she built stone bunds on her fields. Over several years, she and her son added the bunds. Then she enlisted the help of neighbours through the local tradition of labour sharing. The work moved along quickly. Without the use of land-surveying instruments, she and her neighbours were able to put the bunds along the contour lines of the slope.

Now all of her farmland has been improved with stone bunds. The bunds vary in size from half a metre to three metres high, and in width from one third of a metre to two metres. The bunds are staggered, rather than stretching continuously across the slope from one edge to the other. This allows plough oxen to move from one level to the next in a zigzag pattern, passing through gaps in one level of bunds that lie above a continuous piece of bund at the next level.

Ms. Ayelech observed that the soil immediately below the bunds was less fertile than the soil just above them. So she added composted manure to the terraces and planted croton (*Croton macrostachyus*) in a line just below each bund. The line of croton helped to stabilize the bunds. She prunes the croton and spreads the leaves over the less fertile parts of her land. The leaves dry, then she ploughs them in during land preparation.

***Story 2***: Mercy Gumbo is a farmer in northern Malawi. In 2000, she joined a project operated by a local hospital in collaboration with Canadian and Malawian researchers. The project investigated how planting legumes might improve health, food security and soil fertility. Mercy’s four children were very malnourished. She learned that by adding legumes to their diet, their health would improve.

Her husband died shortly after she joined the project, and Ms. Gumbo worried about being able to afford fertilizer. The project helped her learn how to bury legume residues. Before, she needed fertilizer for both the top and base layers of the crops. But now that she buries legume residues, she needs to buy fertilizer for only one layer. Her soils are greatly improved. She now grows enough food to last her family for most of the hungry season. Her children enjoy eating legumes, especially soy and peanut porridge! Ms. Gumbo says that her children are much stronger now and that she no longer worries about their nutrition.

Over the last few years, she has multiplied her seed and shared it with friends and family who are not as food secure as she. She sells her surplus of soy and peanuts, and buys soap, salt, cooking oil, and pays for her children’s school fees.

1. **Background information on soil health**

This section gives basic scientific information on soil health. It will help you to understand how the health of the soil affects the success of smallholder farmers. You can check the resources in section 4 for more information.

**Soil health**

*Does Africa have a soil problem?* Soil health is a particularly pressing issue for Africa. Tropical soils have a tendency to rapidly degrade. Soil fertility is declining in many parts of Africa. In many places, there is a limited amount of good farmland. There is a high rate of nutrient depletion in soils in many areas.

Recent scientific studies have estimated the degree of soil degradation in Africa. One study estimated that Africa loses eight million metric tons of soil nutrients per year, and that over 95 million hectares of land have been degraded to the point where yields are greatly reduced. Another study reports that there are 500 million hectares of degraded soils in Africa. It has been estimated that about two-thirds of sub-Saharan Africa’s agricultural land is degraded because of water and wind erosion, chemical and physical degradation.

***A little soil science***

It’s helpful to understand a little about what soil is, how it works, and what makes it healthy. In the following section, we look at the *physical characteristics* of soil, *soil chemistry*, *biological life* in the soil, *organic matter*, and the *properties of fertile soil*.

The *physical characteristics* of the soil determine how much water a soil can hold. Soils which hold a good amount of water have many small pores. These pores hold water until it can be taken up by plant roots. Soil must also contain air. Air is stored in larger pores in the soil. Soils which have been compressed by the constant weight of equipment or livestock will not have good structure. They contain little water or air, and therefore have poor fertility.

*Soil chemistry*affects the availability of nutrients in the soil. The pH level of a soil is a measure of how acidic or alkaline the soil is. Together with how much air is in the soil, the pH level affects the form in which nutrients are found in the soil. A measure called CEC (*cation exchange capacity*) indicates the amount and type of clay in soils, as well as how much organic matter a soil contains. A good CEC level means that a soil can hold nutrients in a form which is readily available for uptake by plant roots. In general, soils which contain higher amounts of clay (rather than sand), and a high percentage of organic matter, have better CEC levels.

The *biological life in the soil* includes macro-organisms such as earthworms and termites and micro-organisms such as fungi and bacteria. These creatures break down crop residues into organic matter. A healthy biological soil life also limits many plant diseases and soil-dwelling crop pests. There are millions of micro-organisms in a handful of soil, thousands of species of bacteria. The soil is full of life and most of it is too small to be seen with the human eye.

The level of*organic matter*in the soil is crucial for good soil fertility. Organic matter levels affect soil structure, cation exchange capacity (CEC), the amount of water that the soil can hold, and the level of nutrients available for plant growth.

Fertile soil has the following properties:

* It is rich in the *nutrients* which are necessary for plant nutrition, including *nitrogen, phosphorus and potassium* (N-P-K)*.*
* It contains *trace elements* which are also critical for plant nutrition, but are needed in much smaller quantities than N-P-K. These include boron, cobalt, copper, iron and several others.
* It contains good levels of *organic matter*, which improves soil structure and its ability to hold water.
* The *soil pH* is balanced.
* It has good *soil structure*, so it holds water well, and drains well.
* It contains a range of *macro-organisms* (earthworms, termites, etc.) and *micro-organisms* (fungi, bacteria, etc.), that support plant growth and health.

***How is soil degraded?***

When the nutrients which make soil fertile are removed and not replaced, or when the conditions that support soil fertility are not maintained, soil becomes degraded. This leads to poor yields. Some crops use up a lot of soil nutrients. Unless these are replaced, soil nutrient levels will fall. For example, continuously growing maize without adding adequate organic or chemical fertilizer will exhaust soil nutrients.

African soils are often low in nutrients to begin with. If you add to that the combined effects of short fallow times, continuous cropping, slash-and-burn agriculture, and other factors, soils can become seriously degraded or depleted.

Soil degradation can occur through too much tilling of the soil, which damages soil structure. Also, overusing inputs such as synthetic fertilizers and herbicides can leave residues which accumulate and hinder the work of micro-organisms. A buildup of salt in the soil, often associated with irrigation, can deplete fertility and limit crop yields.

Soil which is left bare after burning residues or harvesting crops is vulnerable to erosion from wind and rain. The topsoil that is washed or blown away contains most of the soil nutrients.

But there are many reasons for hope, and many ways to replenish soil health. For example, in dry areas, some soils are severely degraded. Some bare and crusted soils are virtually “dead.” Yet a project in Burkina Faso showed that farmers can achieve good success even with these soils. The farmers applied mulch to the soil surface to attract termites. The termites then broke up the hardened soil, which increased water infiltration. The land became productive enough to farm within months.

***More on organic matter***

Having sufficient *organic matter* in the soil is absolutely necessary if you want to have fertile soil. Organic matter in the soil consists of fresh organic materials (crop residues, kitchen waste, etc.) and humus. Fresh organic matter is transformed into humus by soil organisms. Humus gives the soil a dark colour and holds a lot of water and nutrients.

Low soil fertility doesn’t only decrease yields; it also increases the seriousness of many plant diseases and pest problems. This is because plants are not as healthy in infertile soils. Unhealthy crops are more vulnerable to diseases and pests. Diseases and pests lower yields, further threatening smallholder food security. But this whole vicious cycle can be avoided by improving the condition of the soil.

So the first step in maintaining soil fertility should be to increase or maintain the amount of organic matter content of the soil. This can be done in two ways. First, you can use appropriate cropping practices. These include using mulch, green manure and growing leguminous crops. Second, farmers can apply organic manure or compost and, at times, small amounts of chemical fertilizer. If the soil is very degraded, applying chemical fertilizer may be necessary. Chemical fertilizers can restore the soil fertility very quickly, because the nutrients are available to the plants as soon as the fertilizers are dissolved in the soil. It takes much longer before organic matter is transformed into humus and has released its nutrients. But organic fertilizers have a more long-lasting effect.

**Improving soil structure to hold water in the soil**

With climate change, many farming areas have unpredictable rainy seasons. When the rains do come, they are often heavy. Unless soil is healthy, it cannot retain water from heavy storms. So, the water is lost to runoff, the soil is eroded, and there are long dry periods with little water for farming or domestic use. For these reasons, it is vitally important to improve the ability of the soil to hold rainwater. Improving the soil structure is the key to increasing the amount of water that infiltrates into the soil, and is held in the soil.

There are several ways to do this. First, maintain or increase organic matter by using mulch, incorporating crop residues, and using conservation or no-till techniques. All these practices improve the structure of the soil.

A few recent studies have shown that some deep-rooted native shrubs can be used to enhance the fertility and overall health of soils without competing with crops. For example, in the groundnut zone of arid Senegal, native shrubs provide carbon to the soil, increase nutrient availability in soil beneath and near the crop canopy, and move water deep in the subsoil to the surface. Studies have shown that they can increase yields in groundnut and millet by more than 50%. These shrubs are normally cut and burned each year. So alternatives for fuel will be needed if they are not cut.

**Seven soil health practices**

Here are seven practices that are commonly used to enhance or help maintain soil health. Each has its benefits, while some have disadvantages. It should be remembered that, no matter how beneficial these practices are, smallholder farmers will use and benefit from these labour- and knowledge-intensive practices only if doing so improves their food security and/or income. In other words, no matter how beneficial the practice might be for long-term soil health, if yields are reduced in the short-term, or if there is insufficient labour available to implement the practice, smallholder farmers are very unlikely to try it.

1. **Conservation tillage**

The principle of conservation tillage is that soil should be disturbed as little as possible. Tillage is either discouraged completely or minimized, and most or all crop residues remain on the soil surface. Farmers sow their seeds directly into the residues. These residues protect the soil from erosion by cushioning it from the impact of raindrops. They also reduce the downslope movement of water. This decreases soil erosion and increases the amount of water which penetrates into and stays within the soil. Crop residues also reduce water evaporation from the soil. Residues and roots build up in the soil over the long term, improving soil structure.

For example, some African cotton farmers use conservation tillage systems in which they dig planting holes with a hand hoe, and follow a few days later with a light, early weeding using an ox-drawn weeder.

See *resource organization #1* and *resource documents #5 and #6* in section 4 below for more information on conservation tillage, also called conservation agriculture.

1. **Burning vegetation**

Many African farmers burn crop residues at the end of the season, and burn grass or other vegetation at the beginning of the planting season. Burning provides clear short-term benefits to the farmer. It creates a very “clean,” pest and disease-free planting field. And it saves a lot of labour – there is no need to fell trees and shrubs or cut grasses and weeds. The ash from the burn holds soil nutrients in a form that plants can use. Yields usually increase in the first harvest after burning fallow vegetation.

But these benefits are not long-lasting. The burn releases large amounts of soil nutrients into the air, especially nitrogen and sulphur. These nutrients are then no longer available for plant growth. Large amounts of nitrogen are leached away by heavy rains after burns. After the burn, the soil is unprotected and vulnerable to water and wind erosion; it may form hard crusts. Wind and water can easily carry away the very light ash. With the ash go the nutrients, and the soil lacks enough nutrients for the next crop. The soil temperature during the day rises very high on unprotected soil. This can kill soil organisms and cause poor seed germination.

However, for many farmers, the short-term benefits of burning residues and grasses outweigh these long-term disadvantages. They cannot afford the labour involved in incorporating crop residues into the soil, do not have sufficient organic matter to apply mulches, and cannot afford to devote precious land to a green manure crop. The benefits of a pest- and disease-free field, and of not having to hand-control weeds are obvious. But over the long-term, burning crop residues and grasses robs the soil of the fertility it needs to produce good yields. And over time, it robs the farmer of his or her livelihood.

The “soil bank” is like a financial bank, into which you deposit dollars or other currency. If you have a lot of money in the bank, you can leave the “principal” intact, and live on the interest paid by the bank. Burning vegetation reduces the amount of “principal” in the “soil bank” every year. After a certain number of years of burning, the principal may be too low to give you a good yield.

1. **Termites**

In some areas, farmers have traditionally taken advantage of termite activity to increase soil fertility and health. Here’s how it works: farmers apply straw, woody materials and manure to the surface of soils which have developed a hard crust. Over a period of few months, the termites make tunnels in the crusted-over soil, and decompose the organic materials. This raises soil fertility and improves soil structure. Thus, over a short period of time, this farmer-termite partnership transforms soil from a hard crust in which nothing grows to soil which supports growing plants. Though it is time-consuming to gather and spread organic materials, the benefits are realized quickly and are long-lasting. Termites are also used in Burkina Faso’s traditional zai/tassa system. Organic materials are placed in small holes, in which termites enhance decomposition and increase water infiltration.

See *resource document #16* in section 4 below for more information on using termites to promote soil fertility.

1. **Compost**

Compost is a very useful fertilizer. To create a compost heap, collect organic materials such as crop residues, straw, manure, kitchen wastes, and pile them together. Over time, soil organisms will decompose the material in the heap. When the finished compost is spread onto a field or worked into the soil, it supplies nutrients and increases the level of organic matter in the soil. *See resource documents #1 and #10 in section 4 below for more detailed instructions on making and using compost.*

Composting is particularly useful in dryer areas where crop residues decompose more slowly. In dryer areas, composting provides greater yields for the farmer than using green manure or cover crops.

Composting can be done at the beginning of the rainy season in prepared composting sites. Planting fast-growing trees for firewood provides organic material for composting.

Compost increases the level of organic matter in the soil, which positively affects soil organisms, soil structure, water infiltration, and the soil’s capacity to hold water. As well, composting decreases the erodability of the soil. And compost is rich in nutrients that are readily available to the plants.

A well-constructed and managed compost pile is hot enough to destroy disease organisms, pests and weed seeds. Composting preserves the nutrients and organic matter in crop residues and fallow vegetation and ensures that they have long-lasting beneficial effects when applied. This contrasts to the benefits of burning residues and fallow vegetation, whose positive effects last for only one season.

But making compost presents several challenges. First, compost making is labour-intensive. If labour is in short supply, making compost can be difficult. On the other hand, compost is such a valuable fertilizer that it makes the investment of labour very cost-effective. But it’s a good idea whenever possible to make compost heaps during a time when there is relatively little other work to be done on the farm.

Another challenge is that organic materials may be scarce, or they may be used for cooking fuel or for fodder. This issue can be addressed by planting trees for firewood, for example by planting a living fence. Also, a compost heap can attract vermin, especially if it contains kitchen scraps. It can also stink. But this shouldn’t be a problem if the compost heap is in the field instead of near the house.

1. **Manure**

Manure is animal excrement, usually mixed with straw or leaves. Good manure is aged. Using aged manure is a good way to retain or increase soil fertility. Applying aged manure increases the level of organic matter in the soil, increases the level of nutrients in the soil which are available for plant use, and improves the structure of the soil.

Manure feeds soil organisms, which also improve soil structure. When cattle graze freely, their excrement is spread randomly over the field. A great deal of nitrogen is then lost to the air, or to runoff water when it rains. So it is best to keep animals in a stable if you want to use animal excrement as manure.

But it can be difficult to keep animals in a stable in semi-arid and arid areas. Feed may be scarce, and it is usually not possible to grow enough feed. One solution is to let animals graze during the day and keep them in a stable at night. Their manure can be protected by a cover to keep it from drying out too fast.

It’s not a good idea to add fresh manure to your soil. Aged manure has a number of advantages over fresh manure:

* The ratio of carbon to nitrogen in the manure decreases during aging. This makes it easier for microorganisms to transform the manure into nutrients which are usable by plants.
* Weed seeds are decomposed or lose their ability to germinate.
* Fewer nutrients are lost to air or water.
* Aged manure is easier to transport.

There are several challenges associated with using manure as fertilizer.

**Challenge:** Households often use aged manure as a cooking fuel.

**Solution:** One solution to this is to plant firewood trees as living fences or along paths.

**Challenge:** If cattle normally graze freely, keeping them in a stable requires the extra work of gathering straw and cleaning out the stable.

**Solution:** Allow cattle to graze on crop residues after harvest, and gather some manure from the field afterward.

**Challenge:** Transporting manure to the field is labour-intensive.

**Solution:** Manure can be brought to the field at a time that is relatively labour-free, such as before sowing.

1. **Improved fallows**

Farmers often try to rest or fallow their land when it becomes “tired” and yields are poor. Fallowing is one way to improve soil fertility. But with growing populations and scarce land, fallow periods are often very short. Some farmers are enriching fallowed land with fast-growing trees and/or shrubs. This is called “improved fallows.” It accelerates the process of rehabilitation and shortens the length of fallow periods.   
  
To create an improved fallow system, farmers scatter seeds or plant seedlings of fast-growing plants after crop harvest. Typically, nitrogen-fixing plants are used. N-fixing plants grow vigorously, are deep-rooted and tolerant of drought, and accumulate nitrogen in their root nodules (*see Resource #23 in Section 4 below*). The trees and shrubs grow on the fallow site for several months or a few years. During this time, they accumulate nitrogen from the air and soil, and drop their leaves to enrich the soil and conserve moisture. When the trees are removed at the end of the fallow period, their roots stay in the soil to decompose gradually, releasing additional nutrients to newly-planted crops. There are other kinds of improved fallows species as well: farmers may plant useful or income-generating trees and shrubs, which generate firewood or fruits for sale while the land is being restored to fertility.

Some African research shows that trees and shrubs in improved fallows can replenish soil fertility in one or two growing seasons. Planted fallows can be used to control striga (*Striga hermonthica*), and other weeds such as couch grass, especially if the fallows are repeated or are 18 months or longer.

Using improved fallows allows deep-rooted trees and shrubs to bring nutrients up to the surface of the soil, which the traditional crops would otherwise not be able to reach. The roots and leaf material from the legumes add organic material to the soil as they decompose. This improves the conditions for beneficial microorganisms, worms, etc., and the soil’s ability to retain water and nutrients. Leaves and twigs can be cut for animals and provide fodder in the dry season, when there is no fresh grass. Trees help to reduce the destructive forces of heavy rains and protect the soil from erosion.

For example, in Zambia many thousands of farmers have tried improved fallows. In the drought year of 2002, the average yield of maize grown with this system was 3.4 tonnes per hectare. Other small farmers who used neither fertilizer nor improved fallow harvested only 1.3 tonnes per hectare. The improved fallows also produced up to 10 tonnes per hectare of fuel wood per year. This can greatly help women (and men fetching firewood) in areas where sources of firewood are distant. The system thus helps to preserve the woodlands around villages. Two to three tonnes per hectare of fodder can be harvested every year.

1. **Controlling soil erosion with stone and vegetative barriers**

On sloping fields, farmers sometimes build barriers of stone or living plants across the contour of the slope to reduce the speed of runoff water. These barriers also prevent soil from being carried away by runoff water. Instead, soil that is carried by water piles up behind the barrier. Gradually, terraces are built up behind the barriers. The runoff water slows down on the terraces and infiltrates into the soil. Soil erosion is reduced.

It’s a good idea to build these barriers on a small area before trying them on a larger piece of land. Talk to other farmers who have built barriers to control erosion. It should be noted that these kinds of barriers are only suitable for gentle slopes.

1. **Production ideas**

There are many ways to create radio programming on soil health. Here are a few:

* ***Interview farming families*** whose food security and income are threatened by infertile or eroding soil. Also interview farming families whose food security has been improved by making changes in their farming and livelihood system to protect soil and improve soil fertility.
* ***Write and produce a five-minute drama*** about a farmer who has saved his farm from soil erosion or improved soil fertility. Contrast this farmer’s story with a neighbouring farmer who has not taken measures to protect his soil or improve soil fertility.
* ***Interview individual farmers or members in a farmers’ group*** about changes they see in the health of the soil. These interviews might be best conducted in the field, but could be also done in the studio. Ask the farmers:
  + What changes have you noticed in the weather and in the fertility and quality of your soil?
  + Have you made any changes to your farming and livelihood in response to these changes?
  + Have you received advice from extension workers, farmers, or other people on how to improve your soil fertility or to protect your soil from erosion?
  + Are there barriers or difficulties in adopting any of the changes that have been suggested?
* ***Interview an expert on soil fertility or an expert on soil conservation*** from a national or international agricultural research institute, an agricultural university, or an NGO. Questions to ask include:
  + What kinds of improvements to soil fertility or to protecting the soil from erosion have proven successful in your country, your region, or your community?
  + Are these approaches affordable and practical for small-scale farmers? If not, what barriers might prevent small-scale farmers from adopting them? How can these barriers be overcome?
  + How is information about successful approaches being communicated to farmers?
  + Are there successful indigenous or traditional methods for improving soil fertility and conserving soil, ones which will help farmers adapt to the future?
* ***Produce a call-in or text-in program.*** Invite soil fertility or soil conservation experts to the studio, and invite callers to call or text questions about how to adapt to problems caused by problems or changes in soil health. The expert could be, for example, a farmer, an academic researcher, or an extension agent.
* ***Produce 4-6 radio spots*** which explain the importance of improving soil fertility and protecting against soil erosion. Each spot could start with the same “punchy” lead line and discuss one important element of an integrated approach, including:
  + using leguminous plants as intercrops
  + planting vegetative barriers to reduce erosion
  + agroforestry techniques to improve soil fertility
  + using contour bunds to reduce erosion
  + using cover crops and green manures to improve soil fertility
  + best use and storage of animal manure
  + microdosing of synthetic fertilizers
* Host or chair a roundtable discussion on problems affecting soil health in your community. Invite representatives from various groups: civic and traditional leaders, leaders of women’s groups, educators, health professionals, NGO representatives, and concerned citizens.
* Farmers often have their own classifications and ways of describing soils. Invite several local farmers to the station to present information about this system of indigenous farming knowledge on the radio.
* Interview members of nearby (or distant) communities that have successfully addressed issues concerning soil fertility or soil conservation, including desertification. Follow up with a call-in or text-in program which considers whether these solutions would work for your community.
* Hold a poetry contest: invite listeners to submit poems about soil health and offer a prize to the “best poem.” Read all the good submissions on the air.

1. **Further resources on soil health**

One of your most useful resources may be your local agricultural extensionist. It is extremely valuable for broadcasters to develop an ongoing relationship with local extensionists and agricultural researchers who work in the local area. These people can often offer insight into soil health issues, and can also refer you to other experts. As well, you can consult the following organizations, online/print documents, and radio programs.

***Resource organizations***

1. African Conservation Tillage Network: <http://www.act-africa.org/>
2. Animal Traction Network for Eastern and Southern Africa <http://www.atnesa.org/>
3. International Institute of Rural Reconstruction, Africa Regional Centre, PO Box 66873, Nairobi, Kenya. Email admin@iirr-africa.org, internet [www.iirr.org](http://www.iirr.org)
4. Tropical Soil Biology and Fertility Institute of CIAT: <http://webapp.ciat.cgiar.org/tsbf_institute/index.htm>
5. The Food and Agriculture Organization of the United Nations (FAO): <http://www.fao.org/>
6. The International Federation of Organic Agriculture Movements (IFOAM): <http://www.ifoam.org/>
7. Country ag research organizations
8. CGIAR agricultural research organizations: <http://www.cgiar.org/centers/index.html>

***Resource programs and documents***

*Radio programs:*

* Plant your own fertiliser factory – AGFAX, January 2010, <http://www.agfax.net/radio/detail.php?i=305>
* Sustain the soil – AGFAX, May 2009, <http://www.agfax.net/radio/detail.php?i=253>
* Nakuru’s compost cooperative – AGFAX, February 2009,  <http://www.agfax.net/radio/detail.php?i=233>
* Safe fertiliser from toilet waste – AGFAX, October 2008, <http://www.agfax.net/radio/detail.php?i=181>
* Halting soil erosion – AGFAX, April 2008, <http://www.agfax.net/radio/detail.php?i=57>
* Trapping plant food in the soil – AGFAX, September 2007, <http://www.agfax.net/radio/detail.php?i=22>
* Calliandra, the fertility plant – AGFAX, June 2007, <http://www.agfax.net/radio/detail.php?i=22>
* Cell phones for soil fertility – AGFAX, May 2007, <http://www.agfax.net/radio/detail.php?i=105>
* Better soil, better food – AGFAX, April 2007, <http://www.agfax.net/radio/detail.php?i=100>
* Nurturing nitrogen – AGFAX, February 2007, <http://www.agfax.net/radio/detail.php?i=93>
* Seeds and fertiliser for African Fields – AGFAX, November 2006, <http://www.agfax.net/radio/detail.php?i=114>

*Internet / print documents:*

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10. CTA Rural Radio Pack on soil fertility: *Technical information, pack usage details, resources and full scripts.* Word document available at <http://ruralradio.cta.int/SoilFertility.htm>
11. Farm Radio International scripts on soil fertilization at <http://www.farmradio.org/english/radio-scripts/fertilization.asp>
12. Farm Radio International scripts on soil conservation at <http://www.farmradio.org/english/radio-scripts/soil.asp>
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