NJ AGRICULTURAL EXPERIMENT STATION
RUTGERS
COOPERATIVE RESEARCH & EXTENSION

THE SOIL PROFILE

A newsletter providing information on issues relating to soils and plant nutrition in New Jersey

Volume 17 2007

Soil Fertility in Organic Agriculture

The agro-ecological philosophy of the organic system, in combination with soil science, should guide the management of soil fertility for organic farming. The rules now officially established by the USDA National Organic Program (NOP) must also guide soil fertility management on certified organic farms, but this should be done with an understanding of organic farming philosophy. While organic certification standards have fostered growth and interest in organic farming, it has also, according to some longtime organic farmers, encouraged superficial adoption of organic farming by simply following a set of rules. Unfortunately, some agricultural professionals lack organic experience, and new adopters of organic farming have limited understanding of organic agriculture. Too often this leads to superficial soil fertility recommendations and management under organic farming that simply results in a substitution of organic approved substances for chemical fertilizer inputs. What needs to be understood is that in organic farming, soil fertility is a function of the whole farming ecosystem where biology fully employs synergisms among diverse organisms in the cycling of nutrients and organic matter while producing plant and animal products.

Historically, organic farming developed from empirical observations of nature and farming that gave rise to a philosophy, or a set of beliefs, in organic farming as can be discerned from reading the original works of organic pioneers such as Albert Howard, Walter Northbourne, Lady Balfour, and Jerome Rodale. The philosophy of organic farming is something that distinguishes it from non-organic farming. It can also provide insight into how Cooperative Extension can better serve organic clientele by providing organic-appropriate soil fertility recommendations. Below follow some of the major philosophical aspects of organic farming along with a discussion of how they relate to soil fertility management.

A common misunderstanding is that "organic" specifically refers to the carbon based chemistry of the fertilizers that are often used in organic farming. Rather, it should be understood that soil fertility inputs are not defined in terms of chemistry but that organic refers to the system of farming that can be viewed as an "organic whole" or a whole organism analogous to Gaia Theory. Thus, organic, in reference to farming, was originally described in 1940 by Walter Northbourne as "a complex but necessary interrelationship of parts, similar to that in living things." Monoculture cropping and concentrated/industrialized single species animal agriculture are discouraged. Integrating a diversity of crops with production of diverse livestock species is encouraged. Plant and animal agriculture are viewed as complimentary to the cycling of nutrients and beneficial utilization of natural waste products.

Organic farming practices should, by design, build soil fertility over time with the use of compost, appropriate mineral amendments, livestock, and crop rotations. Thus, the philosophy: "feed the soil not the crop." It takes years (a minimum of 3 years under the USDA-NOP) to transition land from non-organic farming to organic farming. Albert Howard once stated that the full benefit of transition to organic farming may take ten years. According to Howard and other organic pioneers, building soil humus and a "living soil" is central to soil fertility under organic management. In a well established organic farm, soil organisms, such as fungi and bacteria, would form living bridges (mycorrhiza was given as one example) between plant roots and soil humus. They argued that these biological linkages between soil organisms and humus had a positive influence on a chain of health from crops, to livestock, and to humans.

Nutrient Cycling and Composting

In organic farming, crop residues, animal manures, and other natural waste materials are highly valued and utilized by converting them into soil organic matter or humus. Composting is the biological or fermentation process at the core of organic farming that is used to create an attractive and pleasant to handle humus like substance from a mix of plant and animal waste materials. In organic agriculture a deliberate effort is made to recycle all available biological waste materials back to the farmland to mirror the processes of recycling that occur in natural ecosystems such as in a forest or grassland. This principle, which is central to organic farming, was promulgated by organic farming pioneer Albert Howard as "The Law of Return." In this way, organic philosophy organizes agriculture around the principle that mineral nutrients are in fact a renewable resource. This requires that all available natural waste materials are effectively recycled back to the land and that living organisms are vital participants in the process. Also, the carbon rich carriers of the mineral nutrients are food for the living organisms that build soil quality.

The Law of Return philosophy of recycling all available organic waste materials is an ecological practice that if fully implemented could result in significant environmental benefits by its extension to agriculture and modern lifestyles. Diligent attention to the Law of Return, as it was once practiced in traditional Asian agriculture, for example, served to keep human wastes out of rivers and sustained soil fertility for forty centuries. Today in the United States and many other countries, manure is allowed to accumulate around concentrated animal feeding operations and much of the organic and nutrient content of human manure and municipal wastes are not effectively recycled. Although careful attention to the Law of Return may never reach 100% efficiency in nutrient cycling, there is a huge potential for improving the recycling of plant and animal wastes to restore and maintain soil fertility in the United States and around the world. For example, to illustrate the potential, if human manure were collected (not by sewage treatment plants) and utilized as a source of N and other nutrients to grow crops it would have the potential to supply the N needs of about 15% of the US corn acreage. Widespread recycling of appropriate organic waste materials would also achieve significant environmental benefits by diverting a huge volume from landfills, conserving energy required for fertilizer manufacture, and reducing strip mining for raw materials such as phosphate rock. Land application of organic waste materials contaminated with heavy metals and other toxins, must, however, be avoided to protect soil quality.

It is important to be aware of the limitations of the Law of Return principle with respect to building soil fertility. Also, the commonly held perception in the organic and alternative communities that soils in their original native condition were universally fertile is not accurate. In fact, many native soils were deficient in certain nutrients before they were ever used for agriculture. When local soils are deficient in a particular mineral nutrient (a nutrient that does not cycle through the atmosphere), the recycling of local agricultural waste materials back to the land has little opportunity to correct the specific nutrient deficiency because the materials used to make compost will likely also be lacking in the nutrient. Thus, to effectively correct such a nutrient deficiency it is necessary to import some naturally occurring mineral as a nutrient source. Once the nutrient deficiency has been corrected, the Law of Return principle can maintain soil fertility level so long as agricultural exports from the local soils do not exceed imports.

Now that many agricultural soils in the United States have been enriched in nutrients from decades of using commercial inorganic and organic fertilizers, the effective recycling of all types of natural waste materials back to the soil has the potential to maintain soil organic matter content and soil fertility levels with significantly lower levels of inputs from new fertilizers. Unfortunately, the current industrial culture and non-organic farming has typically viewed disposal of waste materials as financial and managerial burdens rather than as a valuable resource to sustain soil fertility. Ready supply and access to relatively cheap and convenient commercial fertilizers to non-organic farming has contributed to this current view. Fortunately for the organic farmer, this often creates an abundance of manures and organic waste materials available for composting.

Although use of sewage sludge (also know as sewage biosolids) was once recommended in organic farming, the use of any sewage sludge in USDA-NOP certified organic farming is now prohibited. At the time when the pioneers of organic farming advocated the use of sewage sludge as a nutrient source, little was known about contaminating industrial substances, such as heavy metals in sewage sludge. How to properly manage and recycle human manure for the purpose of sustaining soil fertility is an environmental problem that needs to be solved.

The abundance of materials available for composting unfortunately has sometimes led organic farmers to apply too much compost and cause soils to be oversupplied with phosphorus (P) and other nutrients. Under the current USDA-NOP rules for organic certification, inputs need to be monitored so as to avoid an oversupply of P and other nutrients that can negatively impact water quality. Thus, the often made recommendation that compost "can be applied to any crop at any time, in any amount" must be moderated with some caution to avoid the build up of excess P. The P build up is especially problematic when compost is used as the primary source of nitrogen (N). One of the best ways to avoid importing excess P to an organic farm is to include legume cover crops into the farm's crop rotation plan. The legumes have the capacity to enrich the soil with N and organic matter but without the addition of more P.

Another concern with composting is the problem of heavy metals in some compost raw materials. The potential presence of high levels of arsenic and copper in some manures and lead in yard waste from some urban regions needs monitoring. Samples of compost raw materials should be analyzed by a soil testing laboratory.

Nitrogen

Compost as a nutrient source can vary widely in N content and N availability depending on source materials and different batches from the same source. An important feature of compost is that it releases nutrients slowly in soil over a period of years. The carbon to nitrogen (C:N) ratio of compost influences the rate at which N will become available to crops. The C:N ratio needs to be equal to or less than 20:1 to achieve a short-term net N mineralization when applied to soil. The amount of N available in compost amended soil is influenced by the combined release of N from both the current and continued release from previous years of compost application. In addition to N and P, compost also supplies a good amount of sulfur (S).

Nitrogen derived biologically from crop rotations that include legumes or from legume cover crops is a preferred source. Synthetic sources of N (i.e. industrially manufactured nitrogen sources) are prohibited. Animal manures and compost are considered acceptable sources of N because they are derived from once living sources. Nitrogen applied to soil as complex plant and animal sources, as opposed to highly soluble inorganic/synthetic sources, is favored for providing sustenance for soil organisms that are important to maintaining soil quality.

Under organic management, soils typically receive applications of compost and are cover copped to build up soil organic matter content. Nitrogen stored in the organic matter has the potential to slowly release stores of plant available N during the growing season. This approach to supplying nitrogen to crops is consistent with the philosophy of "feeding the soil". Predicting the amount and rate of N availability and synchronizing this with annual crop uptake is one of the challenges of organic crop production.

While non-organic growers typically apply sidedress N fertilizer to their annual crops during the growing season to ensure that N supply matches crop demand for N, organic growers generally do not apply sidedress N. Soils under organic management, after several years of building soil organic matter content and as part of an effective crop rotation, will in many cases supply sufficient available N to annual row crops without the need for sidedress N fertilizer.

Organic growers, like non-organic growers, can make good use of the Pre-sidedress Soil Nitrate Test (PSNT) to monitor and manage soil N supply. This soil test is based on sampling the soil to a depth of 12 inches during the growing season but at an early crop growth stage of an annual crop. If the PSNT soil test level is less than 25 ppm nitrate-N, the soil is generally considered N deficient. Sidedress N should be applied to the crop to correct the deficit. If the PSNT test is more than 25 ppm, the soil is supplying sufficient N to grow the crop. But if the PSNT is more than 50 ppm the soil is supplying too much N. Although organic growers do not typically apply sidededress N, they may do so with an organically approved fertilizer. The main reason for using the PSNT in an organic cropping system is to provide valuable feedback. Organic growers can learn from experience how their soil building program and crop rotation cycle are working to supply N to annual crops and make adjustments in future years as needed. The PSNT can be especially useful to transitional organic growers where soil N supplying ability is often limiting and sidedressing is often necessary. For sidedress N, organic growers may use natural organic N sources such as manure, soybean meal, alfalfa meal, fish emulsion, or dried blood. More information on how to use the PSNT is available on the RCE web:
http://www.rce.rutgers.edu/pubs/pdfs/e285.pdf

A problem with natural organic sources of sidedress N is that the N may not be released and available for crop uptake at a rate that is commensurate with crop N demand. This is especially a problem with annual row crops like corn which have a very high rate of N uptake during the critical vegetative growth stage. If the rate of N uptake is limiting, crop yield may be depressed. In a well designed organic farming system, crops with a high N uptake demand might be grown in rotation with alfalfa or other forage legumes which can effectively supply N rapidly enough to match the needs of crops like corn.

Natural organic N sources, such as seabird guano, fish emulsion, feather meal, corn meal, blood meal, alfalfa meal, and soybean meal, can be expensive, bulky, unstable, lack uniformity and have a variable rate of N availability to crops. According to the USDA-NOP rules, organic growers may also use Chilean nitrate to supply a portion of the crop's need for N. An advantage of Chilean nitrate, as a source of sidedress N, is that the N is readily available for crop uptake. However, while Chilean nitrate is a naturally occurring inorganic mineral, it is often frowned upon in organics and is not permitted for use in organic farming in many countries outside the USA. Also, Chilean nitrate fertilizers are known to contain perchlorate which interferes with iodine nutrition and thyroid health in humans.

Nitrogen Availability from Natural Waste Materials

The ratio of carbon to nitrogen (C/N) in natural waste materials has a major influence on the rate at which mineral N will become available with the application of these materials to soil. Table 1 shows percent N concentration, C/N ratio, and N released into soil as nitrate after 20 or 40 days of incubation of some common materials. In general, materials which have a high C/N ratio release N at a slow rate. C/N ratios greater than 30 generally cause a temporary tie up of soil N. In the case of wheat straw, the material has a C/N ration of 197 and therefore causes tie up of N rather than release of N. Of the materials listed, soybean meal, caster pomace, hoof meal, dried blood, and guano have the most rapid rates of N release. (Soil Science 1942 Vol. 54:411-423)

Table 1: Nitrogen concentration, carbon nitrogen ratio and release of nitrogen after 20 days or 40 days following addition to soil.

Fertilizer Material	Total N %	C-N Ratio	Added N converted to nitrate in soil at 20 days (%)	Added N converted to nitrate in soil at 40 days (%)
Seed Meals				
Soybean meal	7.6	4.7	61	65
Cottonseed meal	7.2	5.4	49	54
Castor pomace	5	9.4	60	67
Cocoa meal	3	15	14	22
Plant materials				
Alfalfa hay	2.8	21	24	32
Peanut hull meal	1.2	54	15	15
Wheat straw	0.31	197	-16	-15
Animal products				
Hoof meal	14.3	3.3	65	68
Bone meal	4.2	3.5	7	10
Dried blood	13.8	3.5	60	66
Dry fish scrap	9.3	4.4	59	63
Animal tankage	8.8	5.3	37	45
Manures				
Peruvian guano	14	1.3	80	77
Horse manure	1.5	33	-19	-16

Nutrients from Rock Powders

For sources of P, potassium (K), calcium (Ca), magnesium (Mg), and micronutrients organic farming favors, in cases where adequate supply is not available from manures or compost, the use of low solubility materials such as natural rocks pulverized into powders. Chemically altered minerals, such as rock phosphate reacted with industrial acids are unacceptable.

Pulverized limestone rocks, such as calcite or dolomite, are acceptable materials that are used as liming agents in essentially the same fashion as in non-organic farming. Burnt lime (calcium oxide) and hydrated lime (calcium hydroxide) are caustic substances and prohibited as liming agents.

While soil testing for P and K is typically used in a prescriptive manner to determine fertilizer application rates in non-organic farming, the function of soil testing in modern organic farming is primarily one of monitoring for nutrient balance and prevention of excess nutrient build up or depletion. This is a consequence of the fact that many organic farms today import substantial amounts of P and other nutrients when compost is used for the purpose of building soil organic matter content and supplying N. Also, much of the farm land that is being transitioned to organic production often has a greater than native level soil nutrient status as a result of previous years of commercial fertilizer or manure application. Nevertheless, P, K, or micronutrients are still found limiting in some soils.

One approach organic grower's use for building mineral rich soils is to apply heavy applications of long-term slow release materials such as rock phosphate, granite dust, or other mineral fines. For the patient farmer, this approach works in principle since soils that developed from parent materials with P and K bearing minerals are generally naturally fertile with these nutrients. Use of rock powders in effect adds fresh parent material to the soil. While this may rapidly increase a soils total nutrient content, the initial increase in plant available nutrients is relatively small. With the help of natural weathering processes that are responsible for soil formation, these new "soil parent materials" will slowly weather and release nutrients to build soil fertility over the long-term. Potentially, the unique biological and chemical properties of soils under organic management may accelerate the release of nutrients from these rock source materials.

In general, most natural mineral fertilizer materials can be applied heavily with minimal adverse effect on the environment because of their low solubility and low salt index. These materials are, however, bulky and expensive to transport and store. A disadvantage of many natural mineral fertilizers is that the rate of nutrient solubility is slow and this may limit crop growth and yield. The amounts of P, K, and micronutrients present in naturally occurring rock fertilizers is not easily translated into percentages of available nutrients that are used to classify chemical fertilizers. More importantly, factors to consider include the rate of release of a nutrient into a form that is available for plant uptake and the variability in nutrient content from one lot of the material to another.

Potassium Sources

In the case of low soil test levels (especially during the transition years), organic growers, without access to enough manure or compost, may want to use rock phosphate or bone meal as a source of P. Potassium sulfate and potassium-magnesium sulfate (also called langbeinite, Sul-Po-Mag, or K-Mag) are two commonly used sources of K in organic agriculture. Potassium chloride is the most widely used source of K in non-organic agriculture, and it is allowed under the USDA-NOP rules, but use of this material has historically been disfavored in the USA due to its high salt index. Some countries prohibit the use of potassium chloride in organic farming. Organic growers sometimes apply rock sources of K, such as feldspar, and granite dust. These low solubility sources release K and other nutrients very slowly over a period of years.

Greensand, a mineral mined in New Jersey, has long been popular for use in organic agriculture. While greensand is useful as a soil amendment for the its special properties of being a sand sized material with a high water holding capacity and high cation exchange capacity, it also contains about

8% K_2O and smaller amounts of P and micronutrients that become available to plants very slowly. More information about greensand is available on the web:
<http://www.rcre.rutgers.edu/pubs/publication.asp?pid=E279>
<http://www.ipni.net/> search for "Greensand as a Soil Amendment"

Unlike rock powder fertilizers, wood ash is a good source of soluble minerals. While it varies in nutrient content depending on the tree species, an average analysis for wood ash is: 2% P_2O5, 6% K_2O, and 23% Ca. Be aware that wood ash is also a liming agent which has a calcium carbonate equivalent (CCE) of about 50%. Thus, wood ash application is not appropriate for soils that already have a high pH.

Rock Phosphate

Direct application of rock phosphate provides a slow release source of P that sustains long-term soil fertility. Rock phosphate, depending on the source may contain 28 to 38% P_2O_5. Due to rock phosphate's low solubility, it is typically applied at about 1000 lb/acre. Soil pH is a very important factor influencing the availability of P from rock phosphate. The availability of P from rock phosphate to crops improves at soil pH levels below 5.0. Since the effectiveness of rock phosphate decreases as the soil pH is raised, limestone applications may be delayed as part of an organic/agronomic strategy for a period while acid tolerant crops are being grown. Although most N fixing legumes grow best at soil pH levels above 6.0, they are among the most efficient users of rock phosphate because of their tendency to acidify the rhizosphere (the thin layer of soil that surrounds plant roots). For this reason, legume cover crops such as red or sweet clover may be strategically grown as green manure crops after rock phosphate is applied to enhance P availability.

In the Eastern United States, rock phosphate is mined from deposits in North Carolina, Florida, and Tennessee. Generally rock phosphates are very finely pulverized to maximize surface area contact with soil and enhance the availability of P. North Carolina rock phosphate, however, is more reactive in soil and the P is more available to plants even though this source may be less finely ground than other rock phosphates.

The USDA-NOP rules allow the use of some synthetic, soluble micronutrient fertilizers so long as the need for the micronutrient can be documented based on soil testing and plant analysis. In this regard, plant tissue analysis is generally used and interpreted for organic farming in ways similar to its use in non-organic farming.

Soil testing is used by organic growers to determine the need for limestone in much the same way as in non-organic farming. Some organic growers, however, have a keen interest in the base cation saturation ratio concept of soil fertility management. These growers attempt to carefully select and apply liming materials and other soil amendments in an effort to achieve the “ideal” percent base saturation of the CEC: calcium 65%, magnesium 10%, potassium 5%, and hydrogen and others as the remainder. Although there is limited research to support this “ideal” ratio there are many ardent proponents that cite anecdotal observations in support of this cation saturation ratio approach to soil fertility management. While there is no harm to soil from trying to achieve this ratio in practice, and in fact many soils with good levels of fertility are close to the “ideal” ratio, one potential downside of attempting to achieve this “ideal” is that farmers may sometimes incur a greater cost for soil amendments such as limestone.

When organic growers conduct soil tests, they tend to be particularly interested in the performance of their soil management practices on building soil organic matter content. They should be cognizant of the fact that soil organic matter levels are slow to improve and that it is important to track changes in soil organic matter content over a long time frame such as a decade. Also, organic growers should consider the influence of soil texture and drainage class while attempting to interpret soil organic matter content levels. The point is that it is easier to build and maintain soil organic matter levels on fine textured soils than it is on a course textured soils. For example, in New Jersey an organic matter percentage of less than 3.0% might be considered poor for a silt loam soil but an organic matter percentage of 3.0% might be considered very good for a sandy loam soil. A soil organic matter content of 4 to 5% is considered good for a loam or silt loam soil.

Soil organic matter, which is derived from plant and animal residues, originates from the primary productivity of photosynthesis – the biological process by which plants fabricate biomass from carbon dioxide taken from the atmosphere. Thus, an important aspect of generating biomass to make compost or build soil organic matter is to ensure that an adequate supply of all essential mineral nutrients are in balance and not limiting to plant growth i.e. photosynthesis. In this regard, soil testing and plant analysis are the critical tools used to assess deficiencies and monitor nutrient balance.

Building soil organic matter content on organic farms is facilitated by keeping livestock and the use of crop rotation cycles that include perennial forage crops to feed the livestock. Perennial crops (trees, grass, and forbes), especially in association with livestock, are critical components of organic farming systems for building soil organic matter content.

Soil Testing

Philosophically, traditional organic farmers hold a keen interest in plant and animal health in connection with soil fertility. In addition to using soil testing and plant analysis, farmer observations on plant and animal health, as well as food quality, are seen as being reflections of and useful tools to gauge soil quality and fertility.

One consideration with respect to soil test interpretation for soils under organic management is that nearly all of the research on soil test calibration has been conducted on soils under non-organic management. Without soil test calibration research data on soils under organic management, it is difficult to know how soil test critical levels and the soil fertility categories of "below optimum", "optimum", and "above optimum" might be impacted. Since soils under organic farming may develop unique chemical and biological properties and have different crop production capabilities, it is quite possible that soil fertility test interpretations may require different criteria. Soils rich in organic matter and high in biological activity have the potential to have a positive influence on many processes (such as celation, mycorrhiza symbiosis, etc) that affect plant root access to soil nutrients. Soil quality enhancements associated with organic farming might also influence crop uptake of nutrients by affecting root proliferation, rooting depth, soil moisture availability, and earthworm activity.

Finally, before embarking on a soil fertility program to transition into organic production, become familiar with the classical as well as the current literature in organic farming. For sources of the classical literature see my newsletter article *Classics from the Organic Book Shelf* in the December 2002 Rutgers Cooperative Research and Extension, Plant and Pest Advisor. For information about organic certification in New Jersey contact Eric Bremer, Supervisor, Organic Certification Program, New Jersey Department of Agriculture, PO Box 330, Trenton, NJ 08625, phone 609-984-2225. Also become acquainted with the USDA-NOP rules for certification which are on the web: <www.ams.usda.gov/nop>.

Organic Agricultural History Reference

Heckman, J.R. 2006. A History of Organic Farming: Transitions from Sir Albert Howard's War in the Soil to USDA National Organic Program. Renewable Agriculture and Food Systems. 21:143-150.

To access journal article on-line:
<http://www.ingentaconnect.com/>

The Law of Return Concept

The Law of Return is a teaching principle that Albert Howard used to encourage adoption of farming practices that follow nature's example of recycling all natural/organic waste products back to the soil. To illustrate the Law of Return concept, Howard wrote about how, in a forest, all dead plant and animal residues are added to the soil and serve to enrich the soil in humus. Minerals contained in the dead plant and animal residues are also recycled by this natural process that occurs in all native forests and grasslands.

When man converts land to agriculture and harvests crops and livestock from the fields, mineral nutrients are removed from the soil. The failure of man to effectively return the waste products of agriculture back to the land results in mineral depletion of soil and represents a lost opportunity to build soil humus. Building soil humus is vital to maintaining soil quality and healthy soil biological activity. This was of great concern to Albert Howard who strongly advocated the Law of Return as a key principle of soil fertility management.

While the importance of recycling natural wastes products back to the soil is a highly valued practice in organic farming, it is widely neglected in modern agricultural systems. Conventional agriculture, often practiced without an ecological foundation, tends to separate livestock production from crop production and treats manures and other natural waste materials as a liability (because they are bulky and expensive to transport) or simply as a waste product in need of disposal. The frequent failure of conventional agriculture (as a result of poor farming system design) to effectively recycle and utilize natural waste products for sustainable soil fertility management has increased the need to manufacture chemical fertilizers as a replacement for lost soil fertility.

All people who consume food and fiber products from agriculture, including those who are not farmers, have a responsibility to participate in the recycling of nutrients embedded in natural waste products back to the soil. When food wastes, such as peelings, bones, spoiled leftovers etc., are placed in landfills, instead of being composted and returned, these are lost opportunities for building and maintaining soil fertility for future generations. Mineral nutrients are truly a renewable resource when managed as such. Through a renewable agricultural system that effectively recycles nutrients, minerals can be reused repeatedly to grow crops and livestock without exhaustion.

Modern societies could learn from traditional cultures that knew how to design living systems where everyone was a participant in sustaining soil fertility. One way that this could be achieved, for example, would be by becoming active participants in sustaining soil fertility through community supported agriculture (CSA). The members could return natural organic waste materials to the farm for composting when they visit the farm to pick up vegetables, eggs, and milk.

The Law of Return is a useful ecological principle that if more widely taught and practiced by society, could, in addition to sustaining soil fertility; contribute to the resolution of a number of environmental problems. For example, it could diminish the need for more landfill space, reduce energy demand for fertilizer manufacture, and decrease the need to strip mine for raw materials such as rock phosphate ore. A few caveats, however, must be mentioned here. Firstly, waste materials must be kept free of contamination from heavy metals or other hazardous substances. Secondly, the waste materials must be properly composted to destroy pathogens. Thirdly, farmers should be aware that the recycling of the waste products of agriculture often does not in itself do a satisfactory job of providing all of the minerals needed to achieve a fertile soil in a proper balance. Thus, in addition to practicing the Law of Return principle, mineral supplements or fertilizers are sometimes needed. This is a result of nutrient losses from soil by leaching and erosion. Also, some soils have been depleted due to unsustainable farming practices and other soils are inherently low in their natural capacity to supply nutrients from their inception.

The Soil Profile
Rutgers Cooperative Research & Extension
Plant Biology and Pathology Department
Rutgers, The State University of New Jersey
59 Dudley Road
New Brunswick, NJ 08901-8520
Email: heckman@aesop.rutgers.edu

Joseph R. Heckman, Ph.D.
Specialist in Soil Fertility

"To simplify information in this newsletter, trade names of some products are used. No endorsement is intended, nor is criticism implied of similar products not named."

Desktop Publishing by Mike Bucuk