An Introduction to Fertilizers

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Presentation Organization

The presentation is organized into two parts:

The first part covers the basic science of fertilizers including definitions, classification, plant nutrition needs, application, history and natural cycles.

The second part covers some of the concerns of using fertilizers, its effects on different stakeholders and how these are being addressed.

What is a Fertilizer

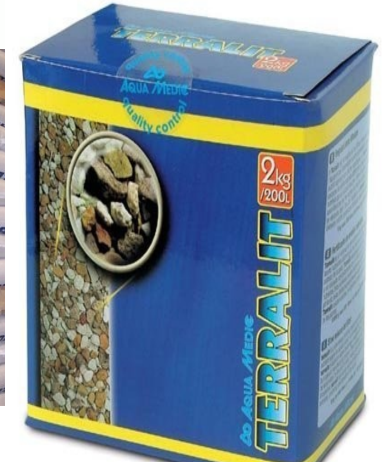
Fertilizers are chemical compounds spread on or worked into soil to increase its capacity to support plant growth.

Fertilizers are food that plants need. It is one of the three components plants need to grow – the others being water and soil.

Just as human beings need different nutritional elements such as proteins, vitamins and carbohydrates, plants need different nutrients and minerals for healthy growth. Fertilizers supply these to the plant.

Fertilizer – Classification

(Source: http://en.wikipedia.org/wiki/Fertilizer)



One way to classify fertilizer is by their origin:

- Natural fertilizers are those occurring in nature and can be used as is – without any modification.
- Manufactured fertilizers, on the other hand need some sort of processing before they can be used.

Manufactured fertilizers may be classified further as:

- those made by inducing natural processes (such as by composting) and
- those made through synthetic means. These are usually called mineral, chemical, straight or compound fertilizers.

Fertilizers may be manufactured through synthetic means like many commercially available ones (top left and right). Most of the commercial fertilizers we know are of this type. Fertilizers such as Sulfur compounds (middle) or peat (bottom right) may occur naturally. Synthetic fertilizers are made of several chemicals each of which are individually manufactured in large facilities (bottom middle). These are then mixed to create the end fertilizer. (bottom left).

Fertilizer Classification

Synthetic fertilizers may further be classified into agricultural and horticultural fertilizers.

Agricultural fertilizers usually contain only a few macro-nutrients. These are used mainly in farming. They are intended to be applied infrequently and normally prior to or alongside seeding.

Horticultural or specialty fertilizers, on the other hand, are formulated from many of the same compounds as agricultural fertilizers and some others to produce well-balanced fertilizers that also contain micro-nutrients. Horticultural fertilizers may be water-soluble (instant release) or relatively insoluble (controlled release). Controlled release fertilizers are also referred to as sustained release or timed release. Many controlled release fertilizers are intended to be applied approximately every 3-6 months, depending on watering, growth rates, and other conditions, whereas water-soluble fertilizers must be applied at least every 1-2 weeks and can be applied as often as every watering if sufficiently dilute. Unlike agricultural fertilizers, horticultural fertilizers are marketed directly to consumers and become part of retail product distribution lines. These are used in homes, gardens and in all types of farms.

Agricultural fertilizers such as the one shown on top does not contain many nutrients. They normally contain only macro-nutrients. Micro-nutrients are added later as part of manuring. Agricultural fertilizers are normally added only during seeding (as shown on the top right image). In the image, the tractor has the seeding apparatus while the tank attached to it is filled with the fertilizer. Horticultural fertilizers (shown in the right image) contain both macro and micro-nutrients. They may be formulated for specific plant types or may be for all plants. These have to be applied regularly. Some commercial garden soils come with solid fertilizers added to it. These get released slowly over time allowing the soil to be rich even if the farmer cannot apply fertilizers regularly.

Fertilizer – Classification

Fertilizers may also be classified based on their constituents' origin. This means that fertilizers can either be:

- Inorganic – made of simple, inorganic chemicals or minerals usually mined from the Earth and either applied as is or combined into one mixture

- Organic – composed of bio-matter or those that originated in a living organism such as a plant or an animal.

The term "organic" here does not refer to the chemical composition. In chemistry, an "organic" compound implies it's main constituents are carbon and hydrogen while inorganic compounds refers those that are made of other elements.

In fertilizer (and farming), the term "organic" refers to using naturally occurring compounds and plant or animal by-products as the main or sole constituents. A common example is cow-dung mix commonly seen in many parts of India. Here the main constituents are dung – which originated from a cow – and straw which was obtained from rice or wheat plants.

Most commercially available synthetic fertilizers are inorganic. The current thought is that organic fertilizers are a more balanced nutrition source.

Manure (Top) consisting of animal dung mixed with grass or straw are a very common form of organic fertilizer that require minimal processing. Compost (Bottom) consists of organic materials such as leaves or even food remnants (vegetable or fruit peels) mixed together and allowed to decompose naturally by bacteria and yeast. This can be made very easily in most households and is an excellent fertilizer.

Plant Nutrition

(Source: http://en.wikipedia.org/wiki/Plant_nutrition, http://nutrico.org/newsletter/?m=200709)

The nutritional needs of plants fall into three categories:

1. Primary macro nutrients: These are nutrients plants need in large quantities. There are six macro nutrients – Carbon(C), Hydrogen (H), Oxygen(O), Nitrogen (N), Phosphorus (P) and Potassium (K).

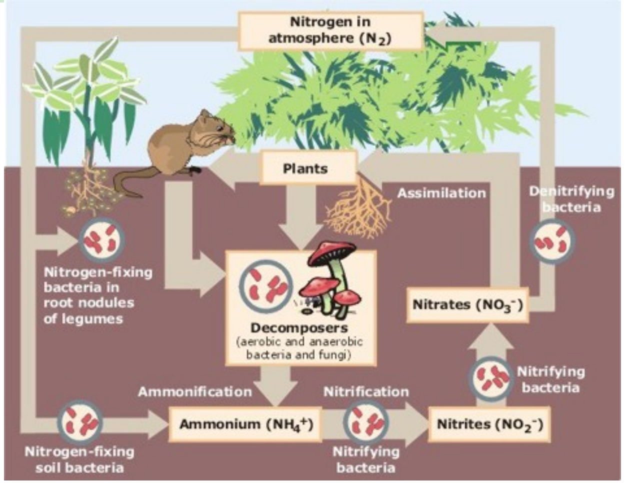
2. Secondary macro nutrients: These are nutrients plants need in significant quantities, but not as much as primary macro nutrients. There are three of these – Calcium (Ca), Sulfur (S) and Magnesium (Mg).

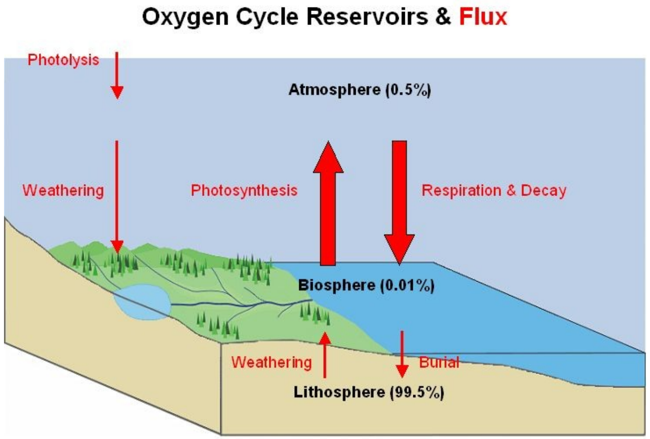
3. Micro nutrients: These are minerals plants need in small to very small quantities. There are seven such micro nutrients – Iron (Fe), Molybdenum (Mo), Boron (B), Copper (Cu), Manganese (Mn), Zinc (Zn) and Chlorine (Cl).

4. Others such as Silicon (Si), Cobalt (Co), Selenium (Se), Sodium (Na), Vanadium (V) and Chlorine may also be required in some plant varieties in small quantities.

All plants require the six primary macro-nutrients. The micro-nutrient requirements may vary from plant to plant. Some plant types may not require one type of micro-nutrient while others may require it in higher quantities.

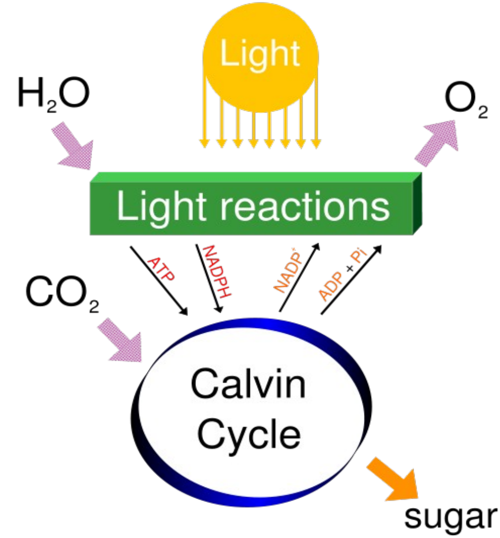
Plants are able to meet their Carbon, Hydrogen and Oxygen requirements by absorbing them either from air or water. The others it absorbs from soil or through it's leaves.





Plants depend on several natural cycles such as the Nitrogen (top) and Oxygen (bottom) for their primary nutrition. These cycles require land and water bodies, plants and other organisms from bacteria to larger animals. Each perform one or more critical steps in the cycle allowing nature to convert it's resources from one form to another, in the process feeding themselves, and eventually restoring them back to the original form.

More on Nutrients – 1



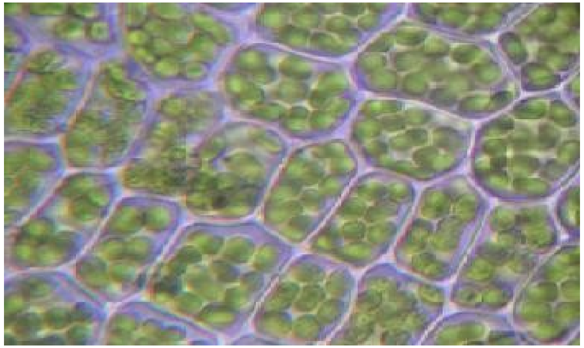
Carbon: (requirement: 450,000 parts per million or ppm) Carbon is what most of the plant is made of. It forms the backbone of many plant molecules, including starches and cellulose. Carbon is fixed through **photosynthesis** from the carbon dioxide in the air and is a part of the carbohydrates that store energy in the plant.

Photosynthesis is the conversion of light energy into chemical energy by living organisms. The raw materials are carbon dioxide and water; the energy source is sunlight; and the end-products are oxygen and (energy rich) carbohydrates or sugars (made of hydrogen, carbon and oxygen.), for example sucrose, glucose and starch. **This process is arguably the most important biochemical pathway, since nearly all life on Earth either directly or indirectly depends on it**. It is a complex process occurring in higher plants, algae, as well as bacteria such as cyanobacteria. The word comes from the Greek φώτο- (photo-), "light," and σύνθεσις (synthesis), "putting together.

Hydrogen: (60,000 ppm) Hydrogen also is necessary for building sugars and building the plant. It is obtained from air and liquid water.

Oxygen: (450,000 ppm) Oxygen is necessary for cellular respiration. It is obtained from the air. Respiration allows the plant to generate energy necessary for living.

Cellular respiration is the process of generating the energy-rich compound, adenosine triphosphate (ATP), via the consumption of sugars made in photosynthesis. Cellular respiration describes the metabolic reactions and processes that take place in a cell or across the cell membrane to get biochemical energy from fuel molecules and then release of the cells' waste products. Energy can be released by the oxidation of multiple fuel molecules and is stored as "high-energy" carriers.



Photosynthesis is the breakdown of Carbon dioxide (CO_2) and water in the presence of sunlight to form energy sources such as sugar (top). This reaction occurs mainly in plant leaves (middle). The presence of a cellular organ called chloroplast (left) enables this reaction. The excess oxygen is released into the atmosphere. Most life forms (including human beings) take in oxygen and release CO_2 when they breathe. By taking this CO_2 and returning oxygen back to the atmosphere, plants contribute to maintaining the oxygen balance in our atmosphere. By destroying plants and forests we are,in effect, curtailing oxygen production on Earth, increasing CO_2 presence in the atmosphere leading to undesirable phenomena such as global warming.

More on Nutrients – 2

Phosphorus: (2,000 ppm) Phosphorus is important in plant bioenergetics or energy creation in organisms. As a component of ATP, phosphorus is needed for the conversion of light energy to chemical energy (ATP) during photosynthesis. Phosphorus can also be used to modify the activity of various enzymes by phosphorylation (the combining of phosphorus with proteins), and can be used for cell signaling. Phosphorus is also an important ingredient during cell division. Since ATP can be used for the biosynthesis (creation) of many plant biomolecules, phosphorus is important for plant growth and flower/seed formation.

Phosphorus deficiency is most common in areas of high rainfall, especially on acid, clay or poor chalk soils. Cold weather can cause a temporary deficiency. All plants may be affected, although this is an uncommon disorder. Particularly susceptible are carrots, lettuce, spinach, apples, currants and gooseberries. Symptoms include poor growth, and leaves that turn red/blue/green but not yellow—oldest leaves are affected first. Fruits are small and acid tasting. Phosphorus deficiency may be confused with nitrogen deficiency.

Potassium: (10,000 ppm) Potassium regulates the opening and closing of the stoma by a potassium ion pump. Stoma (or stomata) are gate-keepers that regulate what goes into and out of the plant exterior. Since stomata are important in water regulation, potassium reduces water loss from the leaves and increases drought tolerance. Potassium deficiency may cause necrosis or interveinal chlorosis (lack of chlorophyll in leaf veins).

Potassium deficiency, also known as potash deficiency, is a plant disorder that is most common on light, sandy soils, as well as chalky or peaty soils with a low clay content. It is also found on heavy clays with a poor structure. The deficiency most commonly affects fruits and vegetables, notably potatoes, tomatoes, apples, currants, and gooseberries, and typical symptoms are brown scorching and curling of leaf tips, and yellowing of leaf veins. Purple spots may also appear on the leaf undersides. Deficient plants may be more prone to frost damage and disease, and their symptoms can often be confused with wind scorch or drought.

Nitrogen: (15,000 ppm) Nitrogen is an essential component of all proteins, and as a part of DNA, it is essential for growth and reproduction as well. Molecular nitrogen in the atmosphere cannot be used directly by either plants or animals, and needs to be converted into nitrogen compounds, or "fixed," in order to be used by life. Precipitation often contains substantial quantities of ammonium and nitrate, both thought to be a result of nitrogen fixation by lightning and other atmospheric electric phenomena.

Nitrogen (N) deficiency in plants can occur when woody material such as sawdust is added to the soil. Soil organisms will utilize any nitrogen in order to break this down, thus making it temporarily unavailable to growing plants. 'Nitrogen robbery' is more likely on light soils and those low in organic matter content, although all soils are susceptible. Cold weather, especially early in the season, can also cause a temporary shortage. All vegetables apart from nitrogen fixing legumes are prone to this disorder. Symptoms include poor plant growth, leaves are pale green or yellow in the case of cabbage family. Lower leaves show symptoms first. Leaves in this state are said to be etiolated with reduced chlorophyll. Flowering and fruiting may be delayed.




Nitrogen deficiency may be seen as stunted growth and yellowing of leaves (top left and right).Phosphorus deficiency (middle) results in redding of leaves. Potassium deficiency (bottom) manifests itself as scorching, curled leaf tips and purpling.

More on Nitrogen, Phosphorus & Potassium

Plants require these macro-nutrients in lesser quantities than the other three (Carbon, Oxygen and Hydrogen).

Even though Nitrogen is the most common element in our atmosphere, plants cannot absorb pure atmospheric nitrogen directly. The nitrogen needs to be converted to nitrates (mixed with Oxygen) or ammonia (mixed with Hydrogen) to be absorbed by the plant. This is called “fixing” the nitrogen. In nature, this fixing is accomplished through natural phenomena and by microbes in the soil and some plant roots. Until the beginning of 20th century, no synthetic process was available to create nitrogen fertilizers for plants. The discovery of such a process is largely responsible for the dramatic growth of synthetic fertilizer industry in the early and middle parts of the 20th century.

These three elements form the main ingredients of most synthetic fertilizers. These are marketed as N-P-K fertilizers – standing for Nitrogen(N), Phosphorus (P) and Potassium (K) – or compound fertilizers. They are named or labeled according to the content of these three elements.

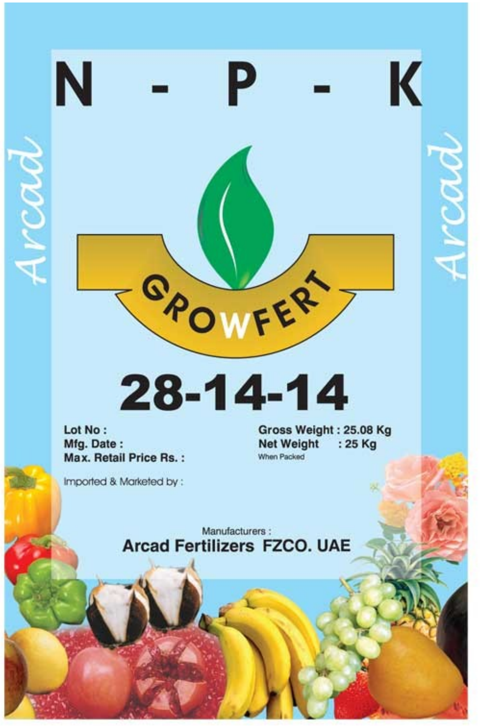
The mass fraction (percent) nitrogen is reported directly. However, phosphorus is reported as phosphorus pentoxide (P_2O_5), the anhydride of phosphoric acid, and potassium is reported as potassium oxide (K_2O), which is the anhydride of potassium hydroxide. Fertilizer composition is expressed in this fashion for historical reasons in the way it was analyzed (conversion to ash for P and K);

For example, an 18-51-20 fertilizer would have 18% nitrogen as N, 51% phosphorus as P_2O_5, and 20% potassium as K_2O, The other 11% is known as ballast and may or may not be valuable to the plants, depending on what is used as ballast. Although analyses are no longer carried out by ashing first, the naming convention remains. If nitrogen is the main element, they are often described as nitrogen fertilizers.

In general, the mass fraction (percentage) of elemental phosphorus, $[P] = 0.436 \times [(P_2O_5]$

and the mass fraction (percentage) of elemental potassium, $[K] = 0.83 \times [K_2O]$

An 18−51−20 fertilizer therefore contains, by weight, 18% elemental nitrogen (N), 22% elemental phosphorus (P) and 16% elemental potassium (K).



The fertilizer label gives an idea of the amount of the macro-nutrients it contains. Fertilizers may also have micro-nutrients mixed with these. The type and amount of these micro-nutrients may vary depending on the plants it is designed for.

More on Nutrients – 3

Sulphur: (1,000 ppm) Sulfur produces energy in plants, which is important to growth. Sulfur is regarded as secondary nutrient although plant requirements for sulfur are equal to and sometimes exceed those for phosphorus. However sulfur is recognized as one of the major nutrients essential for plant growth, root nodule formation of legumes and plants protection mechanisms particularly protection against environmental stress and pests. Sulfur is absorbed by plants via the roots from soil as the sulfate ion and reduced to sulfide before it is incorporated into organic sulfur compounds.

Without adequate sulphur, chlorophyll is not stable and plants suffer from *chlorosis* (lack of chlorophyll). Young leaves are pale green or light yellow without spots (similar to nitrogen deficiency, except nitrogen deficiency shows up primarily in older leaves as it is reallocated to new growth).

Calcium: (5,000 ppm) Calcium regulates transport of other nutrients into the plant. Calcium deficiency can be caused by insufficient calcium in the growing medium, but is more frequently a product of a compromised nutrient mobility system in the plant. This may be due to water shortages, which slow the transportation of calcium to the plant, or can be caused by excessive usage of potassium or nitrogen fertilizers.

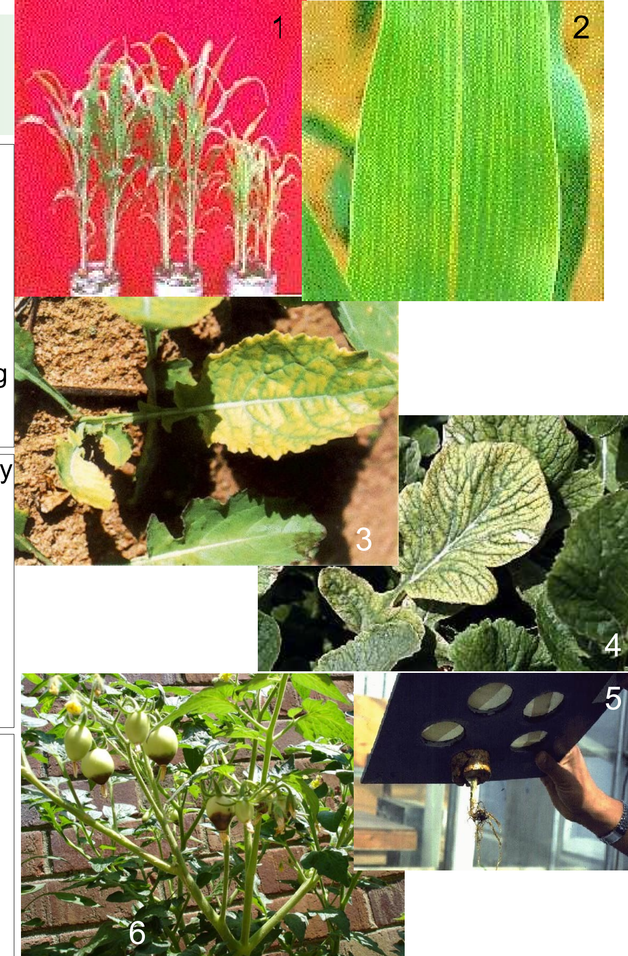
Calcium deficiency results in stunting. Calcium deficiency symptoms appear initially as generally stunted plant growth, necrotic leaf margins (or death of outer leaf regions) on young leaves or curling of the leaves, and eventual death of terminal buds and root tips. Generally the new growth of the plant is affected first. The mature leaves may be affected if the problem persists.

Magnesium: (2,000 ppm) Magnesium is an important part of chlorophyll, a critical plant pigment important in photosynthesis. It is important in the production of ATP. There are many other biological roles for magnesium. In plants, and more recently in animals, magnesium has been recognized as an important signaling ion, both activating and mediating many biochemical reactions. The best example of this is perhaps the regulation of carbon fixation in chloroplasts in the Calvin cycle.

Magnesium deficiency is a plant disorder with two main causes. Magnesium can be easily washed out of light soils in wet seasons or excessive potassium fertilizer usage can cause also Magnesium to become unavailable to the growing plant.

Magnesium deficiency can result in interveinal chlorosis or the lack of chloroplast creation which contain chlorophyll. This disorder particularly affects potatoes, tomatoes, apples, currants and gooseberries, and chrysanthemums. Plants deficient in Magnesium show stress responses. The first observable signs of both magnesium starvation and overexposure in plants is a decrease in the rate of photosynthesis. The later effects of magnesium deficiency on plants are a significant reduction in growth and reproductive viability. Symptoms include, yellowing between leaf veins, which stay green, giving a marbled appearance. This begins with older leaves and spreads to younger growth. Can be confused with virus, or natural aging in the case of tomato plants. Fruits are small and woody.

Magnesium can also be toxic to plants, although this is typically seen only in drought conditions.



Stunted growth (as seen on the plant on the right in 1) and interveinal chlorosis (yellowing of leaf veins) as seen in (2) are signs of sulfur deficiency. Yellowing of radish leaves as a result of Magnesium deficiency (3, 4). Calcium deficiency results in a stunted root growth (5), results in problems such as "Cavity Spots" in carrots and In "blossom end rot" in tomatoes (6).

More on Nutrients – 4

Iron: (100 ppm) Iron is necessary for photosynthesis and is present as an enzyme cofactor in plants. Iron deficiency is a plant disorder also known as ‘lime-induced chlorosis’. A deficiency in the soil is rare. Iron can be unavailable if pH is too high (not acidic enough) or if the soil is waterlogged, or has been overfertilised with phosphorus. Can be confused with manganese deficiency.

Iron deficiency can result in interveinal chlorosis and necrosis. Symptoms include leaves turning yellow or brown in the margins between the veins which may remain green, while young leaves may appear to be bleached. Fruit is of poor quality and quantity. Any plants may be affected, but raspberries and pears are particularly susceptible, as well as most acid-loving plants such as azaleas and camellias.

Molybdenum: (0.1 ppm) Molybdenum is a cofactor to enzymes important in building amino acids.

Boron: (20 ppm) Boron is important in sugar transport, cell division, and synthesizing certain enzymes. Boron deficiency is a rare disorder affecting plants growing above a granite bedrock, which is low in boron. Boron may be present but locked up in soils with a high pH, and the deficiency may be worse in wet seasons.

Boron deficiency causes necrosis in young leaves and stunting. Symptoms include dying growing tips and bushy stunted growth.

Copper: (6ppm) Copper is important for photosynthesis. Symptoms for copper deficiency include chlorosis especially in leaf tips, spiraling of leaves, especially the flag leaf of cereals, stunted plants or poorly filled ears (in cereals).

This is usually seen in organic, chalky or sandy soils, reclaimed health land or where there has high nitrogen fertilizer applications

Manganese: (50 ppm) Manganese is necessary for building the chloroplasts. The deficiency is often confused with, and occurs with, iron deficiency. This occurs most common in poorly drained soils, also where organic matter levels are high. Manganese may be unavailable to plants where pH is high.

Manganese deficiency may result in coloration abnormalities, such as discolored spots on the foliage. Affected plants include onion, apple, peas, French beans, cherry and raspberry, and symptoms include yellowing of leaves with smallest leaf veins remaining green to produce a ‘chequered’ effect. The plant may seem to grow away from the problem so that younger leaves may appear to be unaffected. Brown spots may appear on leaf surfaces, and severely affected leaves turn brown and wither.

Zinc: (20 ppm) Zinc is required in a large number of enzymes and plays an essential role in DNA transcription. This is usually present in organic soils, high pH soils or Soils rich in phosphorus application. Cold wet conditions may also give rise to this condition.

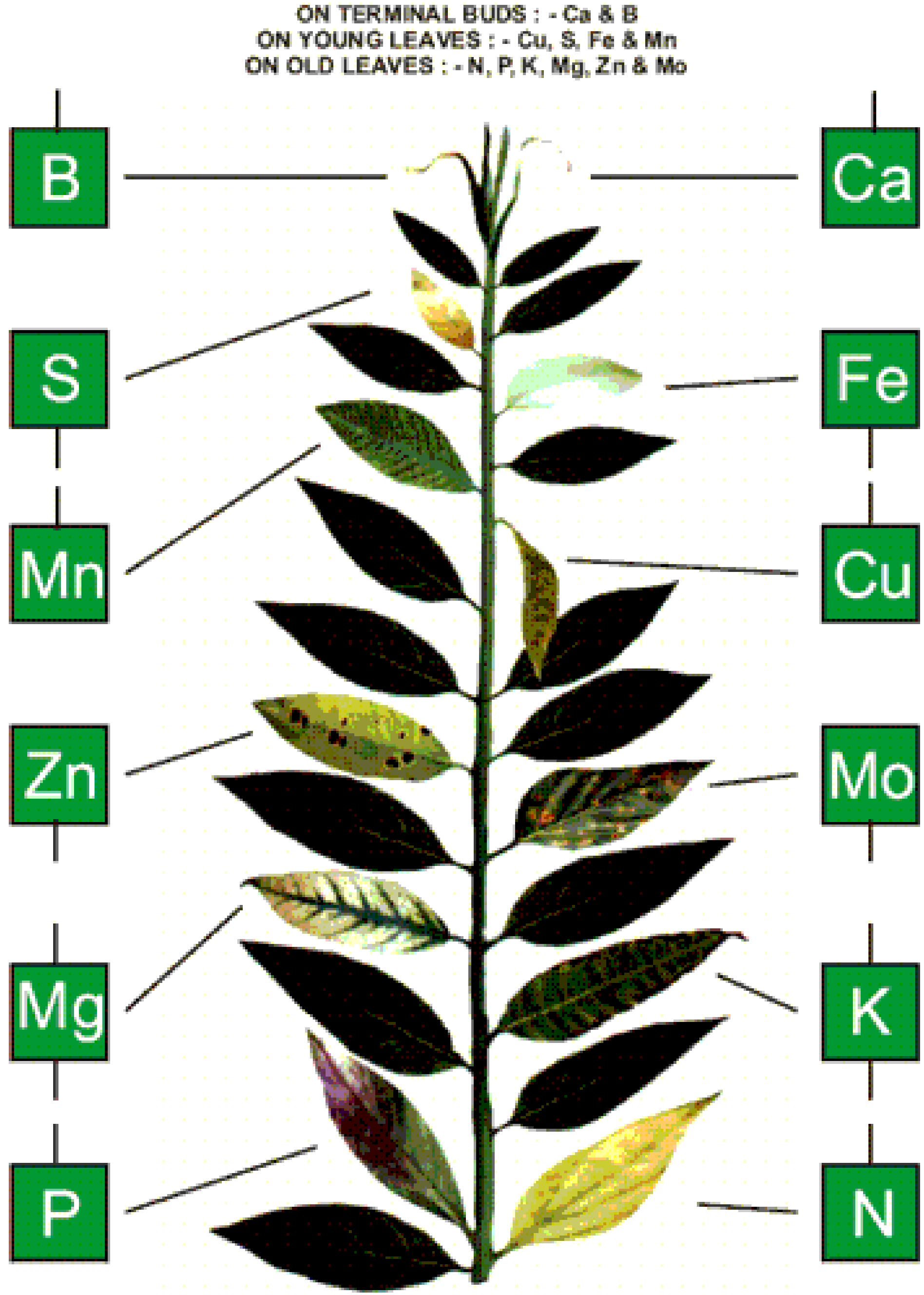
A typical symptom of zinc deficiency is the stunted growth of leaves, commonly known as "little leaf" and is caused by the oxidative degradation of the growth hormone auxin. Pale stripes to the leaf mid rib (maize). Formation of rosettes (fruit trees)Formation of small leaves. Chlorosis of young leaves.

Iron deficiency (top) results in a bleached look to plant leaves. Manganese deficiency (middle left) results in interveinal chlorosis and floppy leaves. Boron deficiency (middle right) shows up as stunted growth and dying leaf tips. Zinc deficiency (bottom left) shows up as small yellowed (chlorosis) leaves. Copper deficiency (bottom right) results in curled up leaves.

Nutrient Deficiency

A visual aid to help identify nutrient deficiency.

Source: http://nutrico.org/newsletter/?m=200709

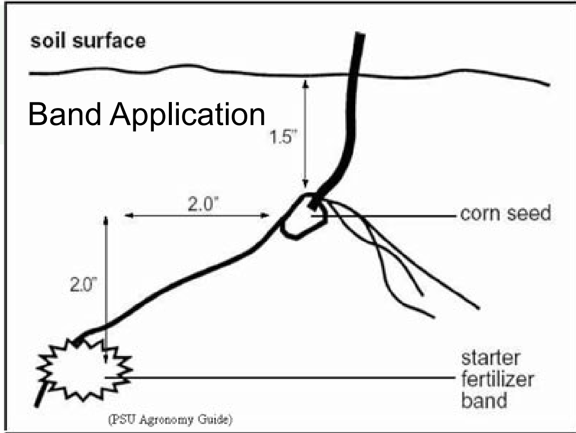


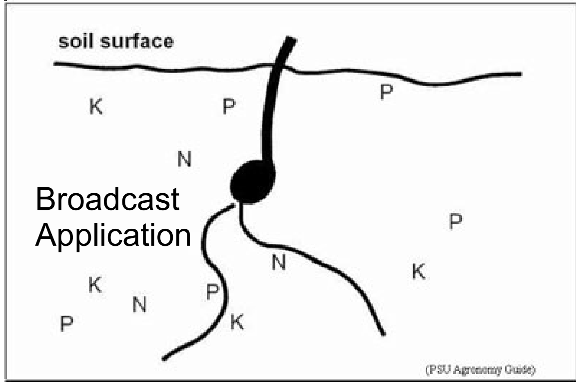
Application

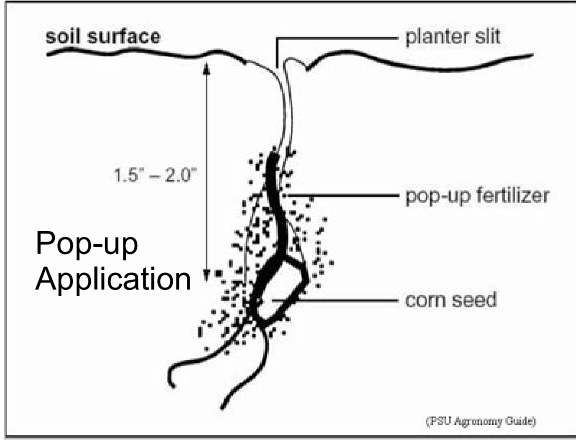
There are four common ways of applying fertilizers. The type of fertilization depends on the fertilizer, soil and crop in question. Each method has its own advantages and disadvantages. Follow the link at the bottom to learn more.

1. Fertilizer can be placed in a "band" often 2 inches over and 2 inches down from the seed during corn planting or drilling small grains or forage seedings. Since it's done in the same motion as planting, it's also called a "starter" application (i.e. to help "start" the plant off). The band is close enough to efficiently supply the young plants with nutrients, while not so close as to damage the developing roots through salt burns.
2. Planters can be configured to place a small amount of fertilizer around the seed during planting either alone or in combination with a banded fertilizer application. This type of application is called Pop-up.
3. Fertilizer can be applied on the surface across an entire field through broadcast applications. High capacity fertilizer spreaders are often used, which spin dry fertilizer or spray liquid fertilizer on the soil surface or on a growing crop. To apply N to perennial grasses or P and/or K to legumes, like alfalfa, the fertilizer is spread and left on the surface. In this case, known as "topdressing", we rely on dew and rainfall to work the nutrients into the root zone.
4. An application of fertilizer between the rows of growing crops is known as a "sidedress" application. The application of N fertilizer between the rows of a growing corn crop is the most common sidedress application on dairy farms.

Source: http://instruct1.cit.cornell.edu/Courses/css412/index.htm and
http://extension.oregonstate.edu/news/story.php?S_No=896&storyType=garde&cmd=pf







Fertilizer Application

In addition, there are some other basic strategies that should be kept in mind when applying fertilizer.

The nitrogen in chemical fertilizers is highly water-soluble and is carried to the roots by irrigation and rain. Thus, you don't need to mix these materials into the soil, but you do need to water your garden if rain doesn't fall within a day after you apply them.

Organic sources of nitrogen are most accessible to plants if mixed into the top 2-3 inches of soil.

Phosphate moves slowly in the soil. You'll obtain best results by banding phosphate-containing fertilizer two inches below the seed when you plant or by tilling it into the soil during spring preparation.

Work potassium fertilizers into the soil using the banding or broadcast methods. Do not allow potassium fertilizers to contact plant roots.

Never put granular fertilizer or fresh manure in the planting hole. The chemical salts within the fertilizer may desiccate or "burn" plant roots.

Source: http://extension.oregonstate.edu/news/story.php?S_No=896&storyType=garde&cmd=pf

Industrial Fertilizer Manufacturing Process

Source: http://www.answers.com/topic/fertilizer

Fully integrated factories have been designed to produce compound fertilizers. Depending on the actual composition of the end product, the production process will differ from manufacturer to manufacturer.

Nitrogen fertilizer component

Ammonia is one nitrogen fertilizer component that can be synthesized from in-expensive raw materials. Since nitrogen makes up a significant portion of the earth's atmosphere, a process was developed to produce ammonia from air. In this process, natural gas and steam are pumped into a large vessel. Next, air is pumped into the system, and oxygen is removed by the burning of natural gas and steam. This leaves primarily nitrogen, hydrogen, and carbon dioxide. The carbon dioxide is removed and ammonia is produced by introducing an electric current into the system. Catalysts such as magnetite (Fe_3O_4) have been used to improve the speed and efficiency of ammonia synthesis. Any impurities are removed from the ammonia, and it is stored in tanks until it is further processed.

While ammonia itself is sometimes used as a fertilizer, it is often converted to other substances for ease of handling. Nitric acid is produced by first mixing ammonia and air in a tank. In the presence of a catalyst, a reaction occurs which converts the ammonia to nitric oxide. The nitric oxide is further reacted in the presence of water to produce nitric acid.

Nitric acid and ammonia are used to make ammonium nitrate. This material is a good fertilizer component because it has a high concentration of nitrogen. The two materials are mixed together in a tank and a neutralization reaction occurs, producing ammonium nitrate. This material can then be stored until it is ready to be granulated and blended with the other fertilizer components.

Phosphorous fertilizer component

To isolate phosphorus from phosphate rock, it is treated with sulfuric acid, producing phosphoric acid. Some of this material is reacted further with sulfuric acid and nitric acid to produce a triple superphosphate, an excellent source of phosphorous in solid form.

Some of the phosphoric acid is also reacted with ammonia in a separate tank. This reaction results in ammonium phosphate, another good primary fertilizer.

Potassium fertilizer component

Potassium chloride is typically supplied to fertilizer manufacturers in bulk. The manufacturer converts it into a more usable form by granulating it. This makes it easier to mix with other fertilizer components in the next step.

From Top:An ammonia plant. A facility to synthesize ammonium nitrate which forms the basis for many nitrogen fertilizers. Toxic flurocarbide emissions from a phosphate fertlizer plant.

Industrial Fertilizer Manufacturing Process

Granulating and blending

To produce fertilizer in the most usable form, each of the different compounds, ammonium nitrate, potassium chloride, ammonium phosphate, and triple superphosphate are granulated and blended together. One method of granulation involves putting the solid materials into a rotating drum which has an inclined axis. As the drum rotates, pieces of the solid fertilizer take on small spherical shapes. They are passed through a screen that separates out adequately sized particles. A coating of inert dust is then applied to the particles, keeping each one discrete and inhibiting moisture retention. Finally, the particles are dried, completing the granulation process.

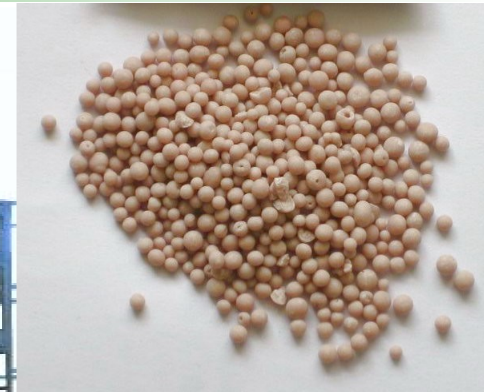
The different types of particles are blended together in appropriate proportions to produce a composite fertilizer. The blending is done in a large mixing drum that rotates a specific number of turns to produce the best mixture possible. After mixing, the fertilizer is emptied onto a conveyor belt, which transports it to the bagging machine.

Bagging

Fertilizers are typically supplied to farmers in large bags. To fill these bags the fertilizer is first delivered into a large hopper. An appropriate amount is released from the hopper into a bag that is held open by a clamping device. The bag is on a vibrating surface, which allows better packing. When filling is complete, the bag is transported upright to a machine that seals it closed. The bag is then conveyored to a palletizer, which stacks multiple bags, readying them for shipment to distributors and eventually to farmers.

Quality Control

To ensure the quality of the fertilizer that is produced, manufacturers monitor the product at each stage of production. The raw materials and the finished products are all subjected to a battery of physical and chemical tests to show that they meet the specifications previously developed. Some of the characteristics that are tested include pH, appearance, density, and melting point. Since fertilizer production is governmentally regulated, composition analysis tests are run on samples to determine total nitrogen content, phosphate content, and other elements affecting the chemical composition. Various other tests are also performed, depending on the specific nature of the fertilizer composition.



(Top Right): Granulated 20-10-10 fertilizer pellets..(Bottom Right): A fertilizer granulating facility. (Top Left) A fertilizer bagging machine. These machines can fill fertilizer bags at very high speed. (Bottom Left): Fertilizer bagging in progress.

History of Fertilizers

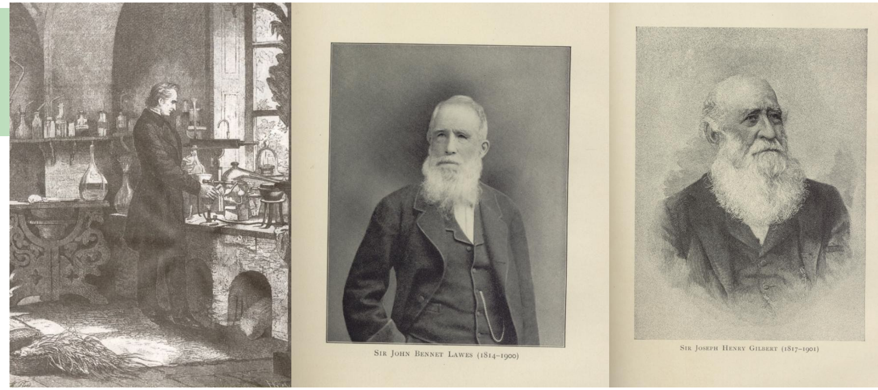
Source: http://en.wikipedia.org/wiki/Fertilizer

Traditionally Western farmers used fertilizers such as manure, slag or cinder. The history of modern chemical fertilizers begins in 18th century.

In the 1730s, Viscount Charles Townshend (1674–1738) first studied the improving effects of the four crop rotation system that he had observed in use in Holland. He noticed that the farms where this was employed was more fertile than what it would be with a single crop. He started to research soil nutrition cycles.

Chemist Justus von Liebig (1803–1883) contributed greatly to the advancement in the understanding of plant nutrition. His influential works first denounced the vitalist theory of humus – which claimed that inorganic chemicals had no part in creating or sustaining plant life – arguing first the importance of ammonia, and later the importance of inorganic minerals. He is known as the "father of the fertilizer industry" for his discovery of nitrogen as an essential plant nutrient, and his formulation of the Law of the Minimum which described the effect of individual nutrients on crops. The Law of the Minimum states that growth is controlled not by the total of resources available, but by the scarcest resource (limiting factor). This concept was originally applied to plant or crop growth, where it was found that increasing the amount of plentiful nutrients did not increase plant growth. Only by increasing the amount of the limiting nutrient (the one most scarce in relation to "need") was the growth of a plant or crop improved.

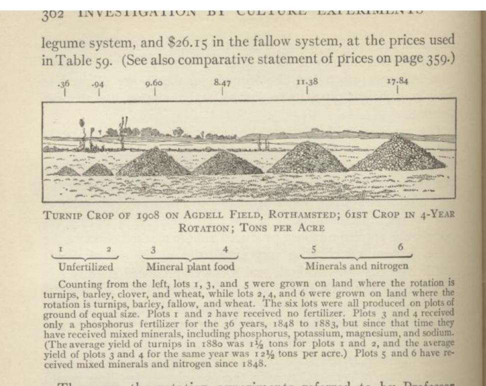
Primarily his work succeeded in setting out questions for agricultural science to address over the next 50 years. In England he attempted to implement his theories commercially through a fertilizer created by treating phosphate of lime in bone meal with sulfuric acid. Although it was much less expensive than the guano (bird droppings) that was used at the time, it failed because it was not able to be properly absorbed by crops



(Left) Justus von Liebig in his lab. (Middle) Sir John Bennet Lawes. (Right) Sir Joseph Henry Gilbert

At that time in England, Sir John Bennet Lawes (1814–1900) was experimenting with crops and manures at his farm at Harpenden and was able to produce a practical superphosphate in 1842 from the phosphates in rock and coprolites. Lawes had begun to interest himself in growing various medicinal plants on the Rothamsted estates, which he inherited on his father's death in 1822. About 1837 he began to experiment on the effects of various manures on plants growing in pots, and a year or two later the experiments were extended to crops in the field.

One immediate consequence was that in 1842 he patented a manure formed by treating phosphates with sulphuric acid, and thus initiated the artificial manure industry. Encouraged, he employed Sir Joseph Henry Gilbert, who had studied under Liebig at the University of Giessen, as director of research. To this day, the Rothamsted research station that they founded still investigates the impact of inorganic and organic fertilizers on crop yields.



302 INVESTIGATION BY CULTURE EXPERIMENTS

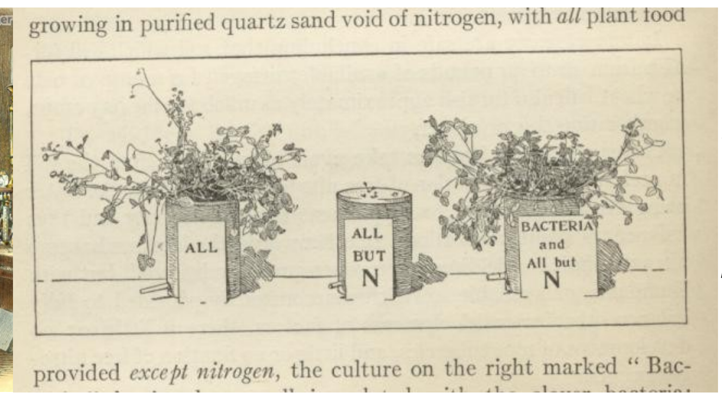
legume system, and $26.15 in the fallow system, at the prices used in Table 59. (See also comparative statement of prices on page 359.)

TURNIP CROP OF 1908 ON AGDELL FIELD, ROTHAMSTED; 61ST CROP IN 4-YEAR ROTATION; TONS PER ACRE

1 2 Unfertilized — 3 4 Mineral plant food — 5 6 Minerals and nitrogen

Counting from the left, lots 1, 3, and 5 were grown on land where the rotation is turnips, barley, clover, and wheat, while lots 2, 4, and 6 were grown on land where the rotation is turnips, barley, fallow, and wheat. The six lots were all produced on plots of ground of equal size. Plots 1 and 2 have received no fertilizer. Plots 3 and 4 received only a phosphorus fertilizer for the 36 years, 1848 to 1883, but since that time they have received mixed minerals, including phosphorus, potassium, magnesium, and sodium. (The average yield of turnips in 1880 was 1½ tons for plots 1 and 2, and the average yield of plots 3 and 4 for the same year was 12½ tons per acre.) Plots 5 and 6 have received mixed minerals and nitrogen since 1848.

These are the rotation experiments referred to by Professor

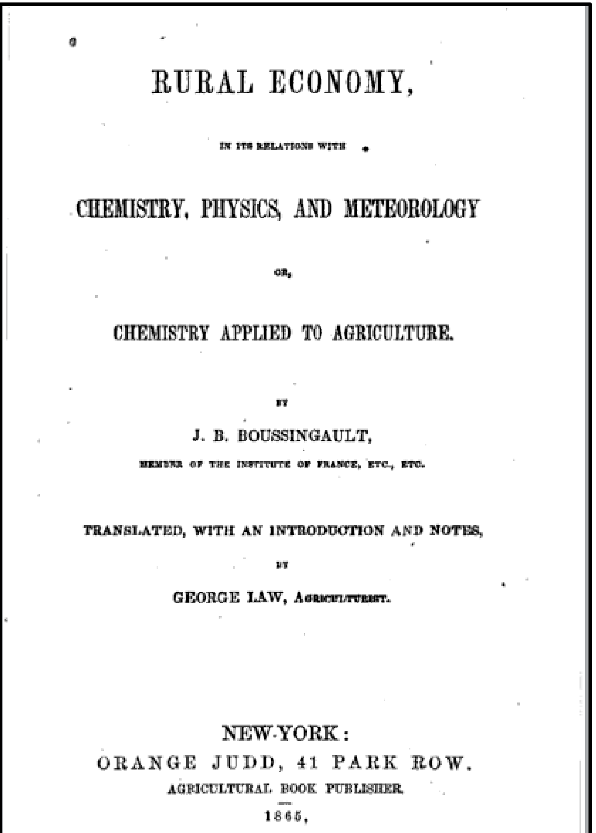


growing in purified quartz sand void of nitrogen, with *all* plant food

provided *except nitrogen*, the culture on the right marked " Bac-

(Left) Effects of crop rotation from a 1908 study. (Middle) The laboratory facility where Justus von Liebig researched on plant nutrition. (Right) An early plant nutrition experiment on nitrogen and nitrogen fixation in a clover plant

History of Fertilizers - contd.



RURAL ECONOMY,

IN ITS RELATIONS WITH

CHEMISTRY, PHYSICS, AND METEOROLOGY

OR,

CHEMISTRY APPLIED TO AGRICULTURE.

BY

J. B. BOUSSINGAULT,

MEMBER OF THE INSTITUTE OF FRANCE, ETC., ETC.

TRANSLATED, WITH AN INTRODUCTION AND NOTES,

BY

GEORGE LAW, AGRICULTURIST.

NEW-YORK:

ORANGE JUDD, 41 PARK ROW.

AGRICULTURAL BOOK PUBLISHER.

1865.

In France, Jean Baptiste Boussingault (1802–1887) was instrumental in understanding the importance of Nitrogen fixing on plants. A chemist, who started out in the mining industry, he was appointed to the chair of agricultural and analytical chemistry at the Conservatoire des Arts et Metiers in Paris in 1839. From 1836 he devoted himself mainly to agricultural chemistry and animal and vegetable physiology, with occasional excursions into mineral chemistry. Through his wife he had a share in an estate at Pechelbronn in Alsace, where he carried out many agricultural experiments. His work included papers on the quantity of nitrogen in different foods, the amount of gluten in different wheats, investigations on the question whether plants can assimilate free nitrogen from the atmosphere (which he answered in the negative), the respiration of plants, the function of their leaves, the action and value of manures, and other similar subjects.

Metallurgists Percy Gilchrist (1851–1935) and Sidney Gilchrist Thomas (1850–1885) invented the Thomas-Gilchrist converter, which enabled the use of high phosphorus acidic Continental ores for steel-making. The dolomite lime lining of the converter turned in time into calcium phosphate, which could be used as fertilizer known as Thomas-phosphate.

In the early decades of the 20th Century, Nobel prize-winning chemists Carl Bosch of IG Farben and Fritz Haber developed the process that enabled nitrogen to be cheaply synthesized into ammonia, for subsequent oxidization into nitrates and nitrites. Both scientists were working for the German company BASF. This was an extremely important development as until then, there was no method to synthesize Nitrogen to a form that plants could take in. However this discovery was first used in manufacture of explosives and chemical weapons for World War I (1914-1919). Agriculture was not given much importance at that time.

Post war (after 1920), this development enabled industrial production of Nitrogen fertilizers. It is now widely believed that this process enabled an increase in food production which in turn has caused the World's population to go from 1.6 billion in 1948 to the current 6 billion.




Counterclockwise from top left: One of Jean Baptiste Boussignault's research papers on agro-chemistry. Jean Baptiste Boussingault. Fritz Haber. Carl Bosch. Haber on a battlefield during World War I. Haber was one of the scientists leading the development of poison gas such as Chlorine for Germany and championing its use during the war. Thanks to the Haber process, Germany had a monopoly over synthetic ammonia production. The profits enabled Germany to set up research facilities where chemical weapons could be developed.

History of Fertilizers - contd.

The earliest fertilizer companies were established in England in the early 1800s and processed naturally available sources such as fossilized bones to obtain fertilizers – primarily phosphate fertilizers. By the end of the century, this had become a major industry on the east coast of England. As the industry grew, so did the variety of fertilizers. Colonization mean access to natural resources from around the world which enabled supply of different sources. After World War I these businesses came under financial pressure through new competition from guano (bird droppings), primarily found on the Pacific islands, as their extraction and distribution had become economically attractive.

The inter-war period (1919-1938), with the application of the Haber-Bosch process, saw innovative competition from Imperial Chemical Industries (ICI) who developed synthetic ammonium sulfate in 1923, Nitro-chalk in 1927, and a more concentrated and economical fertilizer called CCF based on ammonium phosphate in 1931. Competition was limited as ICI ensured it controlled most of the world's ammonium sulfate supplies. Other European and North American fertilizer companies developed their market share, forcing the early English companies to merge.

The post-war environment was characterized by much higher production levels as a result of the "Green Revolution" and new types of seed with increased nitrogen-absorbing potential, notably the high-response varieties of maize, wheat, and rice. This has accompanied the development of strong national competition, accusations of cartels and supply monopolies. In the ever-changing marketplace, the original names no longer exist other than as holding companies or brand names: Fisons and ICI agrochemicals are part of today's Yara International and AstraZeneca companies.

Today industrial fertilizer is seen as a commodity by itself and industries try to maximize their own profits by promoting its marketing. Similar to pesticides, one-sided campaigns that highlight fertilizers as a cure-all for food production have become common. This has led to overuse and several studies have been conducted in the recent past to observe its effects on the target plants and environment. Significant problems ranging from eutrophication (increase of nutrients in an ecosystem leading to decay and death of the entire system) to green-house gas warming from excessive nitrous oxide and ammonia are evident leading to questions about its usage. These questions have led to an increased awareness, development of composting and other organic fertilizer manufacturing methods as well as a partial return to traditional nutrient sources such as manure.

(Top) A demonstration of the effects of fertilizing a farm in Tennessee, USA with agricultural fertilizers from 1942. (Middle) Eutrophication of the Potomac River, US, caused by excessive fertilizer runoff. The excess amount causes algae (seen as the light blue tinge) to breed in high numbers. This results in oxygen shortage in that part resulting in death of other organisms (fishes etc.). Eutrophication generally promotes excessive plant growth and decay, favors certain weedy species over others, and is likely to cause severe reductions in water quality.

Natural Fertilizers

In the wild, plants and trees get their nutrients from naturally occurring fertilizers.

Fertilizers can occur naturally in soil as compounds such as peat or mineral deposits. Also, bio or organic materials such as bark, leaves or even bone and food wastes break down into nutritional elements as they decay. The breakdowns are made possible by scavenger, detritivore and decomposer organisms in the soil such as bacteria, yeast, fungi, insects such as ants, woodlice, millipedes, worms and through natural phenomena. The soil has bacteria that can convert atmospheric nitrogen into nitrates and ammonia. Likewise, certain plant varieties have nitrogen-fixing bacteria in their roots. When these plants die, the bacteria gets released into the soil and provide the same function.

When a plant or animal dies, it leaves behind nutrient's and energy in the organic material that comprised its body. Scavengers and detritivores (such as vultures, foxes and bugs) can feed on the carcasses, but they will inevitably leave behind a considerable amount of unused energy and nutrients. Unused energy and nutrients will be present both in the unconsumed portions (bones, feathers or fur in the case of animals, wood and other indigestible litter in the case of plants) and in the feces of the scavengers and detritivores. Decomposers complete decomposition by breaking down this remaining organic matter. Decomposers eventually convert all organic matter into carbon dioxide (which they respire) and nutrients. This releases raw nutrients (such as nitrogen, phosphorus, and magnesium) in a form usable to plants and algae, which incorporate the chemicals into their own cells. This process resupplies nutrients to the ecosystem.

Thus nature is able to use it's "waste" products to generate its own fertilizers without any outside inputs. This cycle is called the "food chain".

(Top Left) Dung beetle transporting dung to their nest. The beetles feed on the dung, in the process breaking it down to nutrients. By burying and consuming dung, they improve nutrient cycling and soil structure. (Top Right) A bed of decaying leaves serve as food for newer plants. As the leaves decay, they release several essential nutrients into the soil. (Bottom Left) Leaf-cutter ants in tropical Costa Rica (USA) harvest plant leaves which they allow to decay in their nests. Fungi grow on these decaying leaves which the ants consume. (Bottom right) Earthworms are also crucial to enriching soil. Its activity aerates and mixes the soil, and is constructive to mineralization and nutrient uptake by vegetation. Certain species of earthworm come to the surface and graze on the higher concentrations of organic matter present there, mixing it with the mineral soil. Earthworm casts (see bottom right inset) are partially digested remains of leaves and other organic matter the worm consumed. They are very rich in nutrition.

"In forests, decay of leaves replaces nutrients taken up by plants. In home landscapes fallen leaves are often removed resulting in reduced soil fertility. This practice breaks nature's nutrient cycle."

http://pitt.ces.ncsu.edu/index.p ?page=news&ci=LAWN+121

"Although many ignorant gardeners rake leaves up in the fall and stack them in unproductive piles for burning, the truth of the matter is that leaves are rich in many vitamins and minerals that could nourish the garden. Trees are very good at taking up minerals, and these tend to concentrate in the leaves. In nature, the minerals return to the earth as the leaves decay. This is not possible when the leaves are removed, which may eventually lead to nutrient depletion."

http://www.wisegeek.com/how-can-i-use-leaf-mold-as-fertilizer.htm

"We recommend doing everything you can to encourage earthworms to live in the soil of your home landscape. While they do lots of good things for the soil, their greatest role is as a major producer of natural fertilizer. Your earthworms produce their weight in castings every day, and worm castings are an absolutely wonderful fertilizer, with nutrients available in a form all plants can use. In a 200-square-foot area of lawn for example, with a density of only five worms per cubic foot (considered a low population), your earthworms will give you over 35 pounds (about 1/3 pound per worm) of top-grade fertilizer during each year. They not only produce this valuable fertilizer, they also spread it evenly throughout the top 12 inches of soil, and in many cases they will go much deeper, sometimes as far down as 6 feet. A well-managed soil rich in humus can easily support 25 worms per cubic foot, which, in that same 200-square-foot of lawn , means at least 175 pounds of fertilizer! This fertilizer contains the key plant nutrients nitrogen, phosphorus, and potassium, plus many of the essential micronutrients plants need to grow and remain healthy."
Source:
http://yardener.com/YardenersPlantHelper/MakingForAHealthyYardEcology/SoilEcolo

More on Natural Fertilizers

Nutrients are created or transported from one region to another through natural phenomena. Common events like lightning during thunder storms helps combine Nitrogen with Oxygen and Hydrogen to form Nitrates and Ammonia. These are absorbed by rain drops and brought to Earth's surface.

Wind, rain and sunlight breakdown rocks into pebbles or silt. Flowing water such as those during rains expose and transport mineral rich soil from one area to another providing nutrients to areas that are depleted. Of course, during floods, they also wash away nutrient-rich soil. Wind erosion also ends up in similar results. Volcanoes bring both nutrients and poisonous chemicals buried inside the Earth to the surface. Once cooled volcanic soils are usually very fertile.

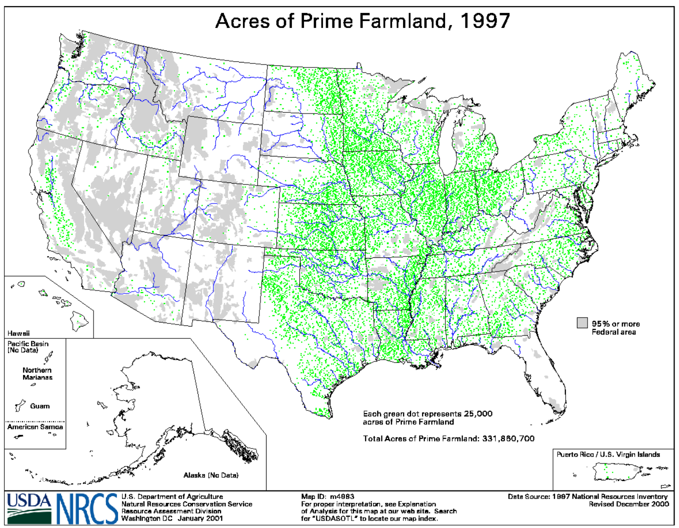
Clockwise from Top: Phenomena such as lightning (Top image) combines atmospheric nitrogen with hydrogen and oxygen to form nitrates and ammonia in the atmosphere. These are transferred to the soil during rains. Tree canopies absorb (2nd image) most of the ammonia allowing the nitrates to reach the soil. Flowing water such as rivers and streams (3rd image) breaks down rocks and pebbles into silt and transport them over long distances. River deltas (4th image) where most of these accumulate are extremely fertile areas where farming is a common activity. Lava flows from volcano (5th image) contain several nutrients such as Potassium, Magnesium and Calcium brought from Earth's interiors. Winds (6th image) remove the top soil and transport them to other parts. This is often undesirable and is a common occurrence in deserts and grasslands where not enough vegetation is present to hold the soil together.

Fertilizers & Soil

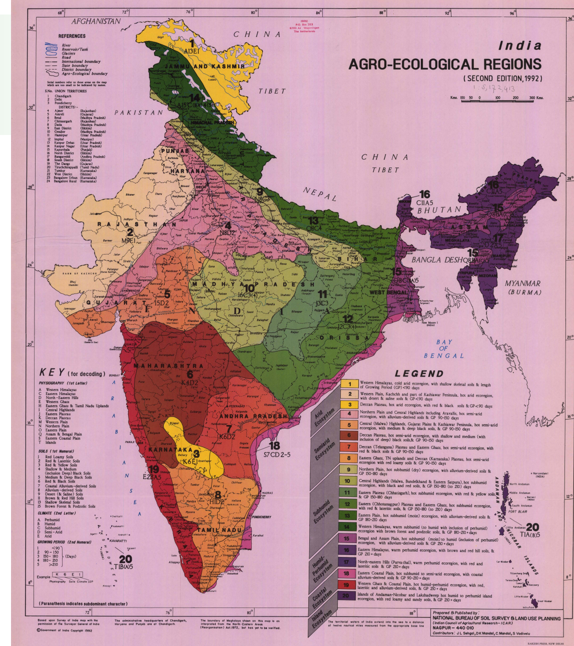
As plants grow, they consume nutrition naturally available in the soil. These are replenished by natural food and environmental cycles. The consumption and rate of growth of plants is dependent on available nutrition. Different types of soil have different chemical composition and may have some nutrients available in large quantities while lacking in others. These differences are created and enhanced by climate, surrounding vegetation (which decay and provide a natural source of nutrients) and biodiversity.

In cultivation, however, the consumption can occurs a rate faster than what nature can generate. These need to be replenished over time, usually with fertilizers.

There are many varieties of fertilizers with different nutrition contents. The type of fertilizers and quantity needed depend on the soil type, climate and plants that need to grow. For example, the fertilizer that needed to be applied to grow rice in Madhya Pradesh will be different than what is needed to grow the same variety of rice in Kerala due to differences in the soil type and climate.



Farmland designation is a way to identify regions suited for farming. Prime farmland (see US Prime farmland map on left for an example), as a designation assigned by U.S. Department of Agriculture, is land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops and is also available for these uses. It has the soil quality, growing season, and moisture supply needed to produce economically sustained high yields of crops when treated and managed according to acceptable farming methods, including water management. In general, prime farmlands have an adequate and dependable water supply from precipitation or irrigation, a favorable temperature and growing season, acceptable acidity or alkalinity, acceptable salt and sodium content, and few or no rocks. They are permeable to water and air. Prime farmlands are not excessively erodible or saturated with water for a long period of time, and they either do not flood frequently or are protected from flooding.



Agro-climate maps (top) combine the climate of a region with the soil type. They provide a very good idea of the types of crops that can grow in a region. India has about 15 agro-climate zones. Soils come in many different type (see bottom image). Each type has different mineral content, acidity and moisture retaining capacity. All these determine the crops that can be grown and required type of fertilizers.

Fertilizers & Farming

There are two ways to looking at farming:

1. As part of the natural food chain: Here, farm crops are seen as a part of the natural food chain to which we also belong. At the bottom level are microbes and other creatures that break down naturally occurring chemicals into simple elements or combine natural elements into more complex forms through their metabolism. These form a plant's food and is processed into more complex forms that become food for higher animals including us humans. Eventually, these are returned back to Earth and atmosphere through processes listed in the previous pages. Affecting even one layer can have repercussions to the whole chain as we shall see later. Thus there is an emphasis on preserving or even nurturing this cycle. Fertilizers are used where it benefits not just the crop, but also the environment.

2. As an industry that treats plants and crops as commodities i.e. entities from which profits can be made. This approach puts profit ahead of every other factor including health of soil and environment. However, over time, this affects the production of crops. This is mitigated through technology and use of fertilizers.

How fertilizers are viewed and used depends on which approach is adopted. Sustainable farming requires minimal damage to the factors and parts of nature on which farming depends.

All of our food has been derived from plants growing in the wild. Plants such as rice (bottom), coconuts, mangoes and bananas (top) were first noticed in the wild as seen here. Even today, many forest dwelling tribes depend on these wild sources for their food. By identifying which of these plants produce edible food, we are able to create our food sources. We then recreate conditions necessary for them to grow well and in plentiful quantities in our farms.

Concerns on using Fertilizers

As we saw before, the advent of chemical fertilizers and industrial farming methods since the 1950s has led to a dramatic increase in food output. The early successes of these methods, together with the Green Revolution technology, convinced several farmers and policy makers to abandon traditional techniques and opt for these instead. The first few decades since has been seen as a success story for industrial farming.

However, as time progressed, several problems started to surface around the globe where these techniques were being adopted. A closer look at these problems has led several proponents to believe that fertilization techniques associated with industrial farming are fundamentally flawed. If continued further, it will lead to global ecological and economical disasters. These may be classified as:

1. Improper use of fertilizers.
2. Overuse of fertilizers
   i. Problems for farmers
   ii. Environmental effects
3. Cost
4. Unbalanced nutrition and effects on consumers

We will examine these in some detail over the next few pages.

Problems with Improper Fertilizing

It is important to understand that nutrients available in the soil have to be balanced for the plant to have a healthy growth. Any imbalance will result in problems ranging from stunted growth to the plant's death to environmental and ecological damage. Plants can only absorb a small amount of each nutrition. Any more application results in these going waste.

Most synthetic fertilizers supply only some chemicals, usually macro-nutrients. The many varieties available in the market have different constitution and are applicable only in very specific circumstances. Applying the wrong fertilizer creates a nutrition imbalance in the soil and is seen on the plant. Any imbalance will result in part of the fertilizer remaining unused in the soil.

Improper fertilization also damages the soil by changing the structure and affecting microbial and organic life in the soil that are crucial for plant growth. A common phenomenon observed in many synthetically fertilized farms is soil quality degradation caused by the decrease in enriching micro-organisms and micro-nutrient content and of moisture retention capacity.

Plant nutrition is still a poorly understood subject. Research efforts constantly lead to newer findings, often contradicting earlier thought. Much of it it concerns the interaction between various macro and micro-nutrients and how these affect the health of the plant. It is now apparent that intake of some chemicals require other chemicals to be present. For e.g., Magnesium is required to improve the intake of Potassium, Iron helps absorb Phosphorus etc. If a soil is supplied with just Potassium but no Magnesium, the Potassium intake will be poor. An excess of Potassium will create Iron deficiency as the available Iron will be used to absorb Potassium leaving very little for other functions. Such fertilizers cannot all be absorbed by the plant. The remnants react with the soil or are washed away (leached) either into the soil or onto other natural bodies like lakes and streams.

"Today immense amounts of ammonia are synthesized from methane (natural gas) and used to produce synthetic fertilizers. But less than half of that applied to the soil is actually used by the plants; the rest evaporates or leaches into streams, ponds, and groundwater, where it causes nitrate pollution so diffuse and widespread it may be impossible to clean up."
http://justsopress.typepad.com/garden_smarts/2005/03/a_short_history.html

This corn fields in Vermont was devastated by the overuse of fertilizers and pesticides, which left it unable to retain nutrients or moisture.

Carina Sorensen / The McGill Daily

http://www.mcgilldaily.com/view.php?aid=5452

Overuse of Fertilizers – Farmers' Issues

With the ready availability of synthetic fertilizers and their high concentration in primary nutrients, overuse has become a very serious issue. The overuse stems from several reasons:

1. It is very easy to mis-select the fertilizer to be applied for one's farm. The innumerable varieties of synthetic fertilizers and their different nutrition content often confuse the farmer. When the wrong fertilizer type is selected, it does not yield positive results for the farmers. Without tools to identify the issue, farmers believe the problem may be lack of nutrition and over-apply the fertilizer.

2. Many farmers do not know the nutrition requirement amount for their crops. They are also unaware of the very high concentration of nutrition in synthetic fertilizers. Even a slight over-application can cause over-nutrition.

3. Many farmers have moved from traditional farming methods to ones recommended by the local policy makers. Often, the latter are not properly educated on the need for balanced plant nutrition and on soil. Their recommendations, gleaned from outside and biased sources, may not be accurate and encourage overuse of the fertilizers.

4. Since fertilizers are a commodity, increased sales are seen as a positive outcome for the manufacturer and salespeople. Their goal is to sell as much of the fertilizer as possible and are unconcerned about the effect on farmers. Thus their marketing strategies are targeted at encouraging the farmers to use as much of their commodity as possible without providing any safeguards against overuse. The uneducated farmer often buys into their campaign and ends up over-fertilizing the field.

Overuse of fertilizers causes serious issues to farmers. Often, the excess fertilization is not easily seen in the beginning when the soil is fresh and full of micro-nutrients and beneficial microbes. The fertilizer together with the soil provides a burst of nutrients to the plant. This is a misleading state and often the farmer thinks the nutrition level is satisfactory. However, as time progresses, the soil composition changes and the fertilizer becomes ineffective. In extreme cases, the soil loses it's capacity to retain nutrients and moisture.

1. As we saw before, unused fertilizers in the soil damages the soil significantly by destroying nutrient holding structures and microbes. Beyond a point, the soil is no longer able to support plant life.

2. As the soil quality degrades, it requires more (and a different variety of) fertilizers and water for the same yield. Since synthetic fertilizers are expensive, this added expense often ruins the farmer.

3. Synthetic fertilizers often contain trace amounts of contaminants (heavy metals and such) from their source that poison the soil. Over time, with over-application, these amounts accumulate and eventually, ruin the soil. In the US, Federal Law allows companies to sell industrial sludge (waste) as fertilizer additives and substitutes. The sludge may contain several harmful chemicals such as Aresnic and Cadmium.

4. In some cases, the excess fertilizers actually help pests leading to bigger problems for the farmer.

Farmer Andy McElmurray inspects a dead patch of a field he owns, Monday, Oct. 15, 2007, in Hephzibah, Ga. McElmurray says the patches are from fertilizer that contained industrial sludge given to him by the city of Augusta. A federal judge is challenging the validity of data behind the government's assertion that converting industrial pollution and raw sewage into free fertilizer for farmers poses no health risk. U.S. District Judge Anthony Alaimo last week ordered the Agriculture Department to compensate a Georgia farmer because his land was poisoned by a sewage treatment plant's sludge containing levels of arsenic, toxic heavy metals and PCBs two to 2,500 times federal health standards. His ruling raises new doubts about a 31-year policy of encouraging farmers and landscapers to spread millions of tons of sewage sludge over thousands of acres each year as a safe, nutrient-rich alternative to commercial fertilizers. See http://www.daylife.com/photo/073jdvCeKsfdb for more details.

Overuse of Fertilizers – Farmers' Issues

Ministry looks to prevent soil degradation
He Na in Changchun and Huan Xin in Beijing
2006-03-18 07:05

The two hectares of land covered with black soil that were once the pride of farmer Lei Guangsheng are now a problem without an easy solution. Per-hectare corn output is approximately 23 tons, seven tons less than five years ago, Lei complained.
...
In many regions, soil degradation is largely attributable to the irresponsible use of fertilizers, according to Jiang Yalun, a senior agronomist in Jilin. He said farmers mostly use only one kind of chemical fertilizer for several years in a row, without testing what elements the soil actually lacks. In Lei's village, most farmers fertilized the soil with farmyard manure 10 years ago, but now most have opted for chemical fertilizers. However, it seems that each year, the more chemical fertilizers are used, the poorer the soil is, Lei said.
Source:
http://www.chinadaily.com.cn/english/doc/2006-03/18/content_544032.htm

2020 Brief No. 58
Soil Degradation: A Threat to Developing-Country Food Security by 2020?
Sara J. Scherr
February 1999
...
There is growing concern in some quarters that a decline in long-term soil productivity is already seriously limiting food production in the developing world, and that the problem is getting worse.

Despite this increased public attention and the commitment of land management specialists, many policymakers remain unconvinced that agricultural soil degradation warrants priority attention. Policymakers typically consider soil quality not as a policy objective in itself, but as an input into achieving other objectives. Before taking concrete action, policymakers need a clear understanding of policy and research priorities, that is, which geographical regions and which farming systems are experiencing what types of degradation problems, and how important these problems are in relation to other challenges facing the farm sector.
Source: http://www.ifpri.org/2020/BRIEFS/NUMBER58.HTM

"Perhaps we should remember that the collapse of the Mesopotamian and the Roman Empires is often blamed on degradation of their grain growing soils.

A soil can degrade in 3 ways:

- Physical, chemical or biological run-down causing a reduction in vigour. This can result from excessive product removal (depleting soil nutrients), reduction in plant growth, lowered organic cycling, increasing soil temperatures, leaching, compaction and surface crusting.
- Reduction in mass and volume through erosion. This reduces the physical size of the soil ecosystem.
- Accumulation of specific soil chemicals to levels that detrimentally effect plant growth. Such materials include: soluble salts (causing salinity); hydrogen ions (causing acidification); and, some chemicals from industrial, mining and agricultural activities (chemical contamination)."

Source:
http://www.dpi.vic.gov.au/dpi/nreninf.nsf/childdocs/-2BAF4D73531CD1544A2568B30005

"Overuse of fertilizers could result in more harm than good. Excessive use of Nitrogen will predispose the plant to disease (blast in rice) and pest attacks due to the softer cell walls present. In some species the use of nitrogen often induces/prolong the vegetative phase of the crop and can subject the crop to pest and disease attack due to the prolonged maturation stage." Source: http://www.sdnp.org.gy/minagri/nari/publication/fertilizerusuage.htm

Fear in the fields: Part 1: How hazardous wastes become fertilizer
by Duff Wilson
Seattle Times staff reporter

When you're mayor of a town the size of Quincy, Wash., you hear just about everything. So it was only natural that Patty Martin would catch some farmers in her Central Washington hamlet wondering aloud why their wheat yields were lousy, their corn crops thin, their cows sickly. Some blamed the weather. Some blamed themselves. But only after Mayor Martin led them in weeks of investigation did they identify a possible new culprit: fertilizer.

They don't have proof that the stuff they put on their land to feed it actually was killing it. But they discovered something they found shocking and that they think other American farmers and consumers ought to know: Manufacturing industries are disposing of hazardous wastes by turning them into fertilizer to spread around farms. And they're doing it legally.
Source: http://www.crcwater.org/issues/fertwaste7397.html

Fertilizers & The Environment

Environmental problems caused by fertilizers often relate to overuse.

What is good for plants is not necessarily what is good for other organisms, including those present in the soil. In other words, nutrients that may help plants often have reverse effects on other living beings, especially when the quantities are large. Overuse of fertilizers implies that some of the fertilizer cannot be absorbed by the plant and remains in the soil.

The first serious issue in most industrial farming nations is run-off. Here, the excess fertilizer is washed away and ends up in streams and other water bodies. This phenomenon is called "Eutrophication". Elements such as nitrogen and phosphorus can get washed into our surface waters and cause algae blooms and excess plant growth. This excess growth in plant material can cause numerous problems, such as reduction of oxygen which can lead to fish kills. Some of the excess nitrogen fertilizers are also toxic to soil organisms like earthworms and to water based creatures. In particular, Urea is toxic to fish and many other water-based lifeforms. You can learn more about this at http://openlearn.open.ac.uk/file.php/2811/formats/print.htm

Likewise, Nitrogen leaching into our ground waters and drinking water supplies is a concern because excess nitrogen in drinking water can contribute health problems for us such as "blue baby" syndrome in infants under one year of age.

Another environmental issue with synthetic fertilizers lies during their manufacture. The raw material extraction may have serious environmental consequences. Their synthesis often creates harmful byproducts. When released into the environment, these affects living things close to the facility, including humans. Sometimes, these effects are felt even faraway and over years.

(Top) Pesticide runoff into a lake causes algae development. The algae eventually develop in large numbers and throttle other forms of life in the lake. Such a development causes the water to become unfit for other forms of life. Smoke from a fertilizer factory (Middle) in Eastern Europe travels over a long distance. These are very toxic pollutants and cause serious health issues. (Bottom) A bird's eye view of the tiny island of Nauru in South Pacific, once the source of phosphate from bird droppings which is now a barren desert thanks to years of mining and exploitation. Extensive environmental degradation caused by mining since 1906 has left the population with no means of livelihood. Birds that used this island as a habitat for centuries have been driven away by years of deforestation and strip mining.

Fertilizers & The Environment

"...adding synthetic nitrogen fertilizers may repel earthworms. Worms are very sensitive to physical and chemical changes and will flee the salty conditions that result from the application of chemical fertilizer." Source: http://www.hfrr.ksu.edu/DesktopModules/ViewDocum

"Central Florida knows it well. So too does Garrison Montana, Cubatao Brazil, and any other community where phosphate industries have had inefficient, or non-existent, pollution control: Fluoride.

The Canadian Broadcasting Corporation (CBC) called the phophate industry a "pandora's box." That, while it brought wealth to rural communities, it also brought ecological devastation. The CBC described the effects of one particular phosphate plant in Dunville, Ontario:

"Farmers noticed it first... Something mysterious burned the peppers, burned the fruit, dwarfed and shriveled the grains, damaged everything that grew. Something in the air destroyed the crops. Anyone could see it... They noticed it first in 1961. Again in '62. Worse each year. Plants that didn't burn, were dwarfed. Grain yields cut in half...Finally, a greater disaster revealed the source of the trouble. A plume from a silver stack, once the symbol of Dunville's progress, spreading for miles around poison - fluorine. It was identified by veterinarians. There was no doubt. What happened to the cattle was unmistakable, and it broke the farmer's hearts. Fluorosis - swollen joints, falling teeth, pain until cattle lie down and die. Hundreds of them. The cause - fluorine poisoning from the air."

Fluoride has been, and remains to this day, one of the largest environmental liabilities of the phosphate industry. The source of the problem lies in the fact that raw phosphate ore contains high concentrations of fluoride, usually between 20,000 to 40,000 parts per million (equivalent to 2 to 4% of the ore). When this ore is processed into water-soluble phosphate (via the addition of sulfuric acid), the fluoride content of the ore is vaporized into the air, forming highly toxic gaseous compounds (hydrogen fluoride and silicon tetrafluoride). In the past, when the industry had little, if any, pollution control, the fluoride gases were frequently emitted in large volumes into surrounding communities, causing serious environmental damage." Source: http://www.fluoridealert.org/phosphate/overview.htm

Farm runoff worse than thought, study says
Long-term impacts seen on lakes from fertilizer, manure

MADISON, Wis. - Farmers' routine application of chemical fertilizers and manure to the land poses a far greater environmental problem to freshwater lakes than previously thought, potentially polluting the water for hundreds of years, according to new research.
Source: www.msnbc.msn.com/id/8214501/

"During the last 80 years, there has been a marked increase in the concentration of nitrate in the Lower Mississippi River that has been attributed to the increasing use of fertilizers (Turner and Rabalais, 1991). Before 1940, nitrate concentrations ranged from 0.2-0.4 milligram of nitrogen per liter (mg N/L); since 1940, they have ranged from 1.0-1.2 mg N/L. In the last 10 to 15 years, however, nitrate concentrations do not appear to have changed." Source: **Nutrients in the Mississippi River**. US Govt. Pub. http://pubs.usgs.gov/circ/circ1133/nutrients.html

Rapid Growth Found in Oxygen-Starved Ocean 'Dead Zones'

By BINA VENKATARAMAN

Published: August 14, 2008

Many coastal areas of the world's oceans are being starved of oxygen at an alarming rate, with vast stretches along the seafloor depleted of it to the point that they can barely sustain marine life, researchers are reporting.

The main culprit, scientists say, is nitrogen-rich nutrients from crop fertilizers that spill into coastal waters by way of rivers and streams.

Source: http://www.nytimes.com/2008/08/15/us/15oceans.html?_r=1&oref=slogin

Maine's New Fertilizer Law Cuts Back on Phosphorus

Posted April 07, 2008 10:45AM

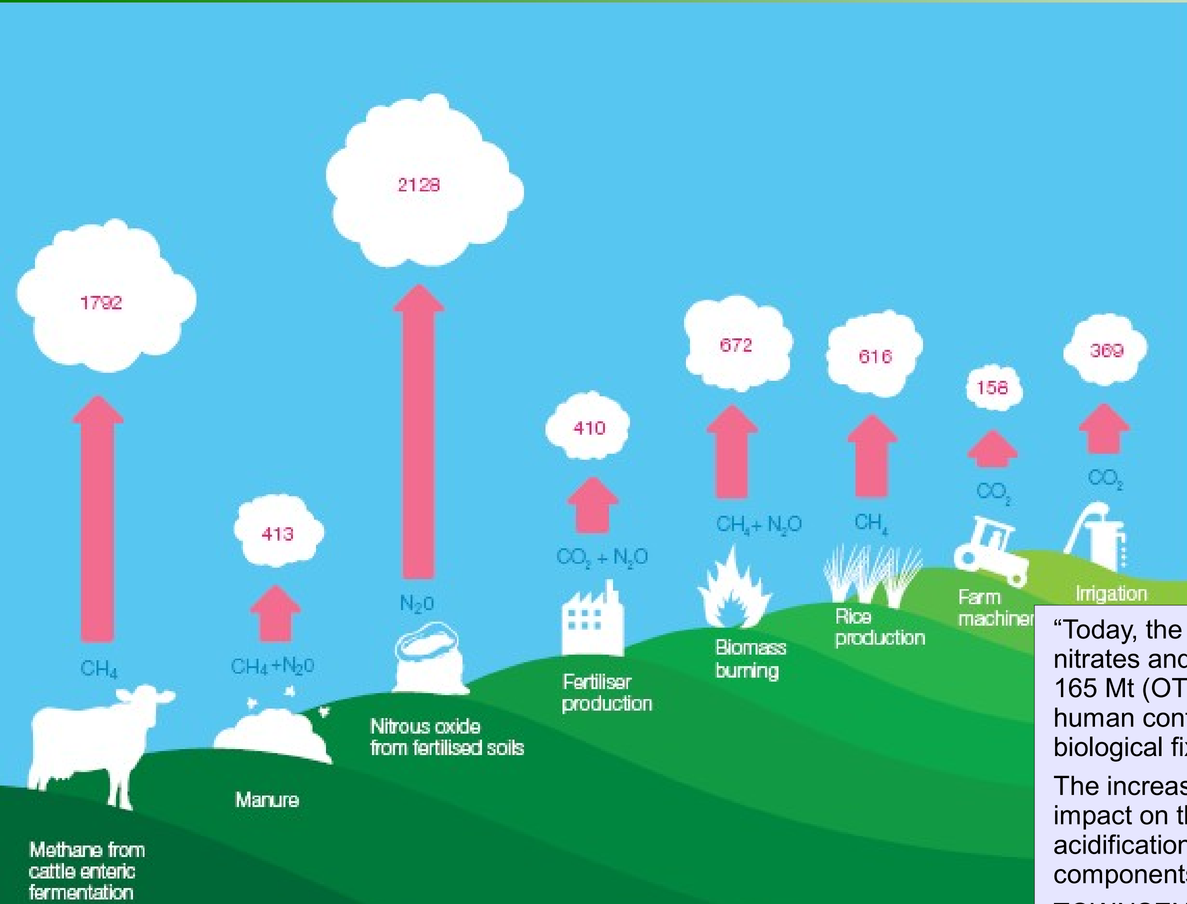
AUGUSTA, Maine, April 7, 2008 (ENS) - This year, a new Maine law discouraging the use of lawn fertilizer that contains the nutrient phosphorus must be taken into consideration when planning yard care. Legislators passed the measure in an effort to keep state lakes and streams healthy. Effective January 1, the law is meant to discourage the use of lawn fertilizer containing phosphorus where it is not needed.

Rainwater and melting snow wash fertilizers and other pollutants from lawns down driveways, from road ditches into storm drains or directly into nearby waters. Excess nutrients from fertilizers, particularly phosphorus, can turn waters green, lead to smelly scums, and rob the water of its oxygen, potentially causing fish kills.

Source: http://www.sundancechannel.com/blogs/ecommunity_news/390333255

"Badui (an isolated village near the Yellow River in western China's Gansu Province) is known locally as the "village of dunces." That's because of the large number of mentally retarded people here — as well as the profusion of birth defects, skin rashes and physical deformities. Residents are sure that the problems result from a nearby fertilizer factory dumping effluent that taints their drinking water." Source: http://earthfirst.com/we-can%E2%80%99t-offshore-our-pollution-to-china-anymore-%E2%80%

Fertilizers & Global Warming



"A recent study by Greenpeace found out between 17 and 32% of greenhouse gases responsible for global warming is contributed by agriculture. Of these, nitrous oxides produced by excess fertilizers in the soil i.e. those unused by the plant, is the biggest contributor." Source: http://www.greenpeace.org/international/press/reports/cool-fa

"In response to the negative environmental effects of fertilizer and pesticide consumption, several countries and U.S. states have enacted taxes upon or banned the use of these chemicals." Source: http://www.cool2012.com/cool/fertilizer/

Fertilizer and Pesticide Bans and Taxes

Tax Policies

Several countries and states have found that increasing the costs of agricultural inputs is an effective way to reduce their use. Austria, Finland, Norway, Sweden, and the states of Iowa, Nebraska, and Wisconsin all have enacted fertilizer and/or pesticide taxes. Among the most aggressive of these countries, Norway taxes Nitrogen (N), Phosphorus (P), Potassium (K) at 15%, while Sweden taxes N at $0.08/kg, P at $0.15/kg in addition to an across the board 20% levy on the retail price of fertilizers. (See information on Nominal tax rates of environmentally related taxes in Sweden - from OECD Database of Environmental Taxes)

While the level of taxation is in some cases not high enough to directly discourage pesticide and fertilizer use, indirect reductions occur as a result of channeling revenues towards sustainable farming practices which tend to use less pesticides and fertilizer inputs.

Source: http://www.newrules.org/environment/fertilize.html

"Today, the release of reactive N into the environment in the form of ammonia, nitrates and their derivatives as well as in the form of organic N is in the order of 165 Mt (OTTER and SCHOLES, 2003), which is about 15 times greater than the human contribution in 1860 and twice the current amount of reactive N from biological fixation.

The increasing release and accumulation of reactive N in the environment have an impact on the global climate (greenhouse gas, ozone destruction), and on acidification of terrestrial and aquatic ecosystems to mention only the major components.

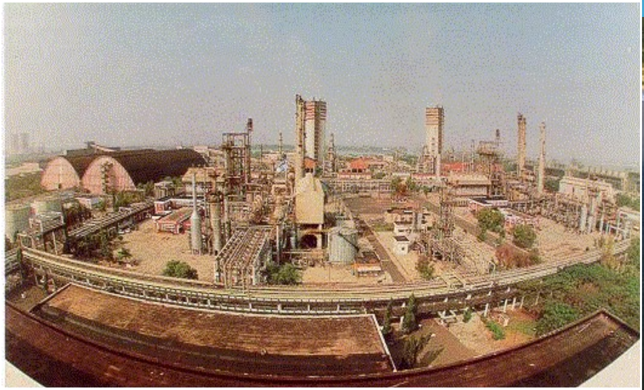
TOWNSEND et al. (2003) consider that the changing global N cycle has effects on human health well beyond the associated benefits of increased food production and that excessive air- and waterborne N is linked to respiratory ailments, cardiac diseases and several cancers. These authors also see a link between increasing release of reactive N and the increased allergenic pollen production as well as with the changed dynamics of several vectorborne diseases like malaria and cholera. In other words, they suggest that the benefit to the public that comes from better crop yields and nutrition and improved transport and heating, will be more and more concealed by the negative impact of the increasing release of reactive N to the environment and its effects on air and water pollution and ecological feedbacks." Source: http://www.ipipotash.org/presentn/bftktif.html

Fertilizer Cost

Most synthetic fertilizers need large industrial complexes for manufacture. The nature of raw materials, their handling facilities, chemical reactions needed to produce the fertilizers and treatment and release of the by-products – all require elaborate infrastructure that can be provided only in a large facility. Consequently, only a few such facilities can be constructed and these have to be large enough to produce enough quantities. Raw materials needed for production have to be transported from their source and the end product manufactured have to be transported to farms, each often several hundred miles from each other.

This nature of production and transportation affect cost of fertilizers significantly. Being a manufactured commodity, fertilizer prices are affected by a variety of factors such as raw material cost, energy prices, demand versus supply and others. These are recouped from the sale of the fertilizer. Locally manufactured fertilizers may provide some relief as the transportation involved is minimal. The cost differences are even higher if the raw materials are also locally available and the manufacturing process energy efficient. In the past, government subsidies helped farmers purchase fertilizers and make farming a viable occupation. This being phased out in several countries.

Raw materials for fertilizers are usually mined around the country (and world). These have to be transported to the manufacturing facility. This is usually accomplished by trains (top right) if the source is close enough. Else, ships (middle right, bottom right) are used to transport it across waterways and continents. The facility itself (bottom middle) is extremely large, often the size of a small town! Fertilizer manufacture is a complex operation and requires several steps(bottom left). All these are accomplished in the facility.



Fertilizer Cost

Food and energy: Another way to count calories

Today a big proportion of the energy going into food production and distribution is fossil fuel energy. Fossil fuel energy is a finite resource, and its use in food isn't always easy to see. As with other resources, we in the U.S. consume more than our share. Here's some facts:

- The U.S. expends three times as much energy per person for food than developing nations expend per person for ALL energy activities. And fossil fuel energy inputs into food production and distribution increased dramatically in the second half of the twentieth century.
- The modern production and distribution system expends 10-15 calories of energy for every calories of food energy produced.
- Chemical fertilizers, herbicides, and pesticides are based on petrochemicals. Between 1960 and 1980, chemical fertilizer use in the U.S. expanded three times, and herbicide use, over 4.5 times.
- Chemical fertilizers alone accounted for 30% of energy use in agriculture in 1974.
- Different food sectors use different amounts of the total fossil fuel energy used in food production and distribution: on-farm production represents just 17.5 percent of the whole, while processing accounts for 28.1 percent, distribution for 9, transportation for 11, restaurants for 15.9 percent, and home preparation for 25 percent.

Source: http://64.233.167.104/search?q=cache:0OXhoz5KVGQJ:www.cias.w

Economist says cost of fertilizer and fuel will rise

July 24, 2008

FROM ASSOCIATED PRESS

CHAMPAIGN, Ill. -- Crop prices are high, but a University of Illinois economist says the cost of the fertilizer, fuel and other things needed to grow them will go up sharply next year, too.

Source: http://www.suntimes.com/business/1073688,crops072408.article

Fertilizer Outlook: United States and World Supply and Demand Trends

Like corn, beans and wheat, fertilizer is a commodity with price determined by tight supply and demand balance.

It is also important to remember that increases in nutrient production, particularly nitrogen, over the coming years will occur outside the U.S. Transportation and distribution costs have jumped driving up the delivered price of nitrogen since the U.S. has turned to these global sources of nitrogen. Ocean freight fees rose from 300 percent to 400 percent from January 2003-8 and shipping anhydrous ammonia by rail has almost doubled since January of 2005 (2). The U.S. imports 41 percent of its urea from the Middle East and 45 percent of its Urea Ammonium Nitrate (UAN) from the former USSR (1). Because of long transportation times, purchasers and distributors take financial risks to secure nutrients early and pass the cost onto the end user. Transportation costs might be alleviated if more vessels are put into transit and if harbors decrease congestion by increasing storage capacity. However, consolidation of fertilizer production to fewer countries may also maintain high transportation costs because of the distance required for delivery (3).

Potash and DAP prices have also been significantly impacted by global supply and demand. Strong international demand and limited potash production capacity have driven up prices.

Source: http://www.ncga.com/news/notd/pdfs/041408_NCGA%20Fertilizer%20Outlook%202008.pdf

World fertilizer prices surge 200% in 2007

World fertilizer prices surged by more than 200 percent in 2007, as farmers sought to maximize corn production for ethanol, according to the International Center for Soil Fertility and Agricultural Development (IFDC). Poor African farmers were hardest hit by the increase.

IFDC says the rise in fertilizer prices is fueled by new demand for grain for biofuel production, higher energy and freight prices, increased demand for grain-fed meat in emerging markets, and increased use of natural gas as liquefied natural gas (LNG).

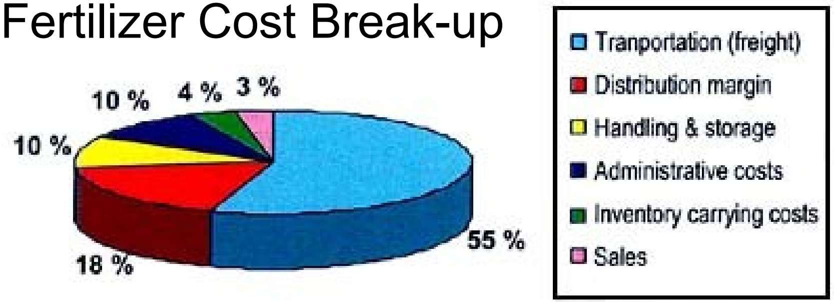
"Farmers in industrialized countries are applying high levels of fertilizers to maximize harvests of grain at the highest prices ever," said Dr. Balu Bumb, leader of the Policy, Trade, and Markets Program of IFDC. "Those forces drive fertilizer prices higher."

"The unprecedented rise in fertilizer prices—more than 200% in the past year—is creating a fertilizer crisis for resource-poor farmers in developing countries," Bumb says. "Particularly hard-hit are farmers in Sub-Saharan Africa. Farmers there need fertilizers desperately, to replenish their nutrient-depleted soils. But fertilizer use in Africa is the world's lowest—about 8 kg per hectare. The lack of fertilizers in Africa accentuates hunger and poverty. To stimulate adequate fertilizer use, the purchasing power of the poorest of the poor must be enhanced through market-friendly safety nets so they can be included in the marketing process."

"The sharp rise in fertilizer prices emphasizes the need for more research to improve the efficiency of fertilizer use," said Dr. Amit Roy, IFDC President and Chief Executive Officer. "For example, most rice farmers in Asia broadcast urea directly into the floodwater. But only one bag in three is used by the plants. The rest is lost to the air and water." [Source: http://news.mongabay.com/2008/0220-fertilizers.html]

Fertilizer & farm subsidies

Indian Fertilizer Cost Break-up



Source: http://www.fao.org/docrep/009/a0257e/A0257E06.htm

... As fertilizer is an essential input for agricultural production, the (Indian) Government's objective is to make this critical input available to the farmers at affordable prices. Until 24th August 1992, the prices of all the fertilizers were controlled, the Government setting the maximum retail prices of various fertilizers. With effect from 25August 1992, the prices of phosphate and potash fertilizers were decontrolled. The prices of urea continued to remain under control. Following decontrol, the prices of phosphatic and potassic fertilizers rose sharply. Since 1997/98 the Government has fixed indicative maximum retail prices of decontrolled fertilizers, uniform throughout the country.

"(US) Taxpayers sent $13.4 billion in farm subsidies to more than 1.4 million recipients in 2006, according to a new update of the Environmental Working Group's Farm Subsidy Database website.

The new data bring the 12-year subsidy total tracked online by EWG to more than $177 billion."

Source: http://farm.ewg.org/farm/summary.php

Subsidies Bypass Independent Farms (USA)

"Your independent farmer struggles. Your corporate farmers do well," said Kouts-area organic farmer Andy Velasquez, whose farm doesn't qualify for subsidies.

"... I'm a 20-acre organic farm. We received zero dollars (in subsidies) since I've been doing this. Everything's out of my pocket."

...

Farmers counter that many of them wouldn't make it without subsidies, and that critics fail to account for skyrocketing expenses such as fuel and fertilizer, both of which are influenced by petroleum costs.

A Lake County farmer, who receives subsidies but didn't want to be named, said many farmers couldn't make it without subsidies.

Source: http://www.ewg.org/node/26994

... The profitability of fertilizer use has been calculated on the basis of the value of crop output and the cost of the input (fertilizer). The profitability of P_2O_5 and K_2O use has declined significantly after the decontrol of the prices of these fertilizers in 1992. However, with the steady increase in the procurement / support prices of crops over the years and almost stable fertilizer prices, the profitability has increased in the past few years in the cases of all the three nutrients

... Over the years, the aim in India has been to become and remain self-sufficient in foodgrain production. Fertilizer is the key input that has made this goal achievable. Historically, the prices of fertilizers have been kept below the cost of production and importation. The prices of fertilizers in India, particularly of urea, are lower than in developed and neighbouring developing countries. The objective behind the low prices is to maintain a favourable input:output ratio. The aim of the Government has been to ensure that the farmer receives a price that makes fertilizer use acceptable and remunerative. The Government provides a fertilizer subsidy to fill the gap between the cost of production / import cost plus distribution of fertilizers, and their retail prices. The objective of the introduction of the fertilizer subsidy was: (i) to provide foodgrains to the people at affordable prices; (ii) to insulate farmers from variations in production costs and to ensure reasonable returns from fertilizer use; and (iii) to ensure a reasonable return to the fertilizer industry.

... The subsidy on fertilizers is given to the farmers by routing it through fertilizer manufacturers.

... Most farmers cannot afford to purchase fertilizers on a cash basis. Similarly, not every dealer can pay cash for fertilizers.

Source: http://www.fao.org/docrep/009/a0257e/A0257E06.htm

Food & Nutrition

The nutrition content of the food from plants is dependent on the nutrients they absorb during growth. If the plant is not provided with proper balanced and sufficient nutrients, it is reflected in the fruits and vegetables it produces. Thus, the nutrition content of the food depends on health of the soil it grows on.

Studies now show that industrial fertilization harms not only the environment, but is also unable to provide sufficiently nutritious food. These studies trace the lack of nutrition to the farming methods, particularly to the debilitating effects fertilizers (and pesticides) have on soil health over time. Industrial farming often focuses more on quantity than quality and sacrifices the latter for the former. The focus on quantity leads to short-term gains, but the long-term effects may not be positive. A direct consequence of the lack of nutrition is that, more food is required to obtain the same level of nutrition as before. This leads to a greater land requirement or more aggressive technologies among the cultivators and to greater consumption and diseases associated with it among consumers.

Furthermore, yield rates have started to fall and it requires a great amount of resources to retain output levels, resulting in financial burden for the farmers. As over-fertilized land becomes unusable after a while, fresh land is required for farming. With pressure from urbanization and land development, this has led to large scale deforestation and environmental destruction.

A growing number of people have now started to turn to sustainable and eco-friendly farm products. The basis for these is in the protection and nourishment of natural cycles and to see farming as a step in this process. They feel that products that come out of such a process will be of better quality i.e. more nutritious with less harmful additives.

Fertilizer & Food Quality

Chemical Fertilizers and Pesticides and poor and depleted soils the major cause of ill health...

Submitted by Richard Belshaw on 22 March 2007 – 11:43am.

“Graham Harvey's second book is a timely reminder that we ignore the health of the soil at our peril. Chemical farming has subjected its vital microorganisms to a toxic barrage, and does its best to obliterate them. By depending on synthesised nitrate fertilisers, agribusiness has depleted the soil of the minerals it needs to grow healthy plants. Over the last 50 years, according to some analyses, vegetables in the UK have lost a quarter of their magnesium, more than a quarter of their iron and nearly half of their calcium. The result is impoverished food, sick animals, and a catalogue of degenerative human diseases. Our lack of physical activity has halved our need for calories, yet we still need the same amount of vitamins and minerals. That the nutrient content of our food should now be so depleted is therefore disastrous” – From a review of “We Want Real Food” by Graham Harvey. Source:
http://www.greenparty.ca/en/node/1023

IPNI Supports New Professorship to Explore Link between Fertilizer and Food Nutrition

“The quality of the food we eat is directly related to the fertility of the soil where the crop was grown. The nutrients in food crops originate from the soil, but soils do not have an unlimited supply of nutrients and may not supply plant nutrients in proper balance … hence the need for fertilizer nutrients,” said IPNI President Dr. Terry L. Roberts. “It would be difficult, if not impossible, to manage food crop nutrition without understanding how to manage the fertility of agricultural soils.” Source:
http://www.ipni.net/ipniweb/portal.nsf/0/A28D1A0A000CA7E1852574

Is Organically Grown Food More Nutritious?

Virginia Worthington / The Co-op Connection Nov01

There are more than 30 studies comparing the nutrient content of organic crops and those produced conventionally with chemical fertilizers and pesticides. In these studies, various individual nutrients in individual crops were compared, such as zinc in organic versus conventional carrots, or Vitamin C in organic versus conventional broccoli. In the more than 300 comparisons performed in these studies, organic crops had a higher nutrient content about 40% of the time, and conventional crops had a higher nutrient content only about 15% of the time. Overall, organic crops had an equal or higher nutrient content about 85% of the time. These results suggest that, on average, organic crops have a higher nutrient content.

For three individual nutrients — Vitamin C, nitrates and protein quality – there is enough evidence to suggest that organic crops are superior to conventional ones. Compared to crops grown with chemical fertilizers and pesticides, organically grown crops generally have a higher Vitamin C content, a lower content of carcinogenic nitrates and better protein quality. Further work is needed on other nutrients before any definitive conclusions can be drawn.

The most relevant studies are not those that simply assess nutrient content, but are those that feed organic or conventional feed to animals and then look at how healthy they are. There are 14 such animal studies that have been performed over the last 70 years. In ten of these, the organically- fed animals fared better; in one, the animals fed organic feed came in second among several chemically-fertilized feeds; and three studies showed no difference, possibly due to weaknesses in the study designs. The positive effects are most striking in sick or otherwise vulnerable animals such as newborns and in sensitive areas of reproduction such as sperm motility.

It is particularly interesting to see that the fertility of animals fed fodder grown with chemical fertilizers and pesticides declined over several generations.
Source:
http://www.mindfully.org/Food/Organic-Crops-Superior-WorthingtonJul99.htm

Overweight? Hungry? Blame “Hollow Food”

According to the new British analysis of government nutrition data on meat and dairy products from the 1930s and from 2002, the mineral content of milk, cheese and beef declined as much as 70 percent in that period.

“These declines are alarming,” Ian Tokelove, spokesman for The Food Commission that published the results of the study, told Tierramérica. .“It seems likely that intensive farming methods are responsible for this,” Tokelove said from his office in London.
Source:
http://stephenleahy.wordpress.com/2007/07/27/overweight-hungry-blame-hollow-fooc

Organic Fertilizers

Much of the problems with synthetic fertilizers can be avoided with the use of organic fertilizers.

- Unlike synthetic fertilizers, organic fertilizers are usually a combination of micro and macro-nutrients and often contain microbes essential to improve soil health. Thus, the nutrient content in organic fertilizers are usually better balanced than synthetic fertilizers.
- Unlike synthetic fertilizers, the organic variety is often slow acting (or slow-release) i.e. the nutrients are released over a longer period of time. This may be both beneficial and disadvantageous in some cases. Slow release fertilizers provides the plant a constant supply of nutrients over a longer period of time ensuring a healthy and uniform growth pattern. Synthetic fertilizers provide instantaneous nutrition which ceases until the next application.
- Organic fertilizers can be (and usually are) produced locally and avoid transportation costs associated with synthetic fertilizers. The manufacture of organic fertilizers from local resources also means these may be more suited for that region. The inexpensive nature of organics mitigates the financial burden to the farmer. The energy costs to organic fertilizers are also significantly lesser through such processes as composting.
- Organic fertilizers cause significantly less, if any, harm to the environment. Because they are made of matter that is found commonly in nature, they do not alter their surrounding environment. Of course, this refers to locally manufactured fertilizers. Care has to be taken not to bring in organic fertilizers manufactured elsewhere as their biological content may be very different and ends up introducing alien organisms in the local environment.

July 13, 2005

Organic farming produces same corn and soybean yields as conventional farms, but consumes less energy and no pesticides, study finds

By Susan S. Lang

ITHACA, N.Y. -- Organic farming produces the same yields of corn and soybeans as does conventional farming, but uses 30 percent less energy, less water and no pesticides, a review of a 22-year farming trial study concludes.

Source: http://www.news.cornell.edu/stories/July05/organic.farm

A strong case can be made for the desirability and urgency of using organic fertilizers. Given the impact of global warming, climate change and increased environmental degradation, we must now prioritize the restoration of ecological balance. The use of chemical fertilizer not only damages our soil fertility, which we need to produce our food, it also threatens our health and well-being. However, moving immediately and completely to organic fertilizers is often not realistic.

One of the agencies I supervised at the Department of Agriculture (DA) was the Bureau of Soils and Water Management. Its research, which I witnessed first-hand, showed that when one moved to purely organic fertilizers in one season, production generally dropped.

The recommended approach is to use a balanced fertilization strategy, using an optimal combination of organic and chemical fertilizers for a given site. The organic fertilizer component restores the important macro and micro nutrients needed to recover soil fertility, while the chemical fertilizer help sustain production volume. In the long run, production volume increases with the rise in use of organic fertilizers.
Source: **Benefits of Organic vs Chemical Fertilizers**
http://www.mixph.com/2007/10/benefits-of-organic-vs-ch

Organic mulches decompose with time, releasing small amounts of nutrients and organic matter to the soil.
Source:
http://www.ces.ncsu.edu/depts/hort/consumer/factsheets trees-new/text/muching.html

Organic Vs Chemical

Advantages Of Organic Fertilizers

1. Better for the soil: provides organic matter essential for microorganisms. It is one of the building blocks for fertile soil rich in humus.
2. Nutrient release: slow and consistent at a natural rate that plants are able to use. No danger of over concentration of any element, since microbes must break down the material.
3. Trace minerals: typically present in a broad range, providing more balanced nutrition to the plant.
4. Won't burn: safe for all plants with no danger of burning due to salt concentration.
5. Long lasting: doesn't leach out since the organic matter binds to the soil particles where the roots have access to it.
6. Fewer applications required: once a healthy soil condition is reached, it is easier to maintain that level with less work.
7. Controlled growth: does not over-stimulate to exceptional growth which can cause problems and require more work.
8. Stronger plants and grass: greater resistance to disease and insect attacks.
9. Beneficial to environment. Won't build up harmful residues or cause pollution due to run-off from irrigation or rain.
10. Encourages soil life. Microbes convert the organic matter to the form of nutrients that plants need. Earthworms feeding on organic materials aerate and loosen the soil.
11. Specific formulas: adapt to any application by changing the ingredient blend. Pre-blended formulas or individual items allow flexibility for plant preferences or needs.

Disadvantages of Organic Fertilizers

1. Slow to release nutrients. Cooler soil temperatures are not as conducive to the release of elements.
2. Dependent on microorganisms in the soil to break down organic material. Soils depleted of these beneficial microbes further delay the results from organics.
3. More expensive than chemical fertilizer applied to equal square footage. Some retailers do not offer larger size bags that would make it more economical.
4. Application less convenient in some forms. Meal form, unlike pellets, is difficult to apply on large areas like lawns.
5. Residue in liquid forms: some, like fish concentrate, may not be finely strained, and clogging of sprayers can occur.
6. Limited availability in some areas. All of the blends may not be offered, or the choice of individual ingredients may be limited, depending on locale.
7. Can attract bugs in storage if not protected in sealed containers (not paper bags).
8. Animal manures that are not fully composted can cause problems when used directly as fresh fertilizer. Homemade natural fertilizers are not automatically a good idea.

Advantages of Chemical Fertilizers

1. Readily available: as the most common form used, it is found everywhere.
2. Formula variety: it is easy for chemical companies to vary the elements to produce blends for different seasons and for specific plants.
3. Fast acting. Usually see results within 1-2 weeks if the formula used is appropriate for the season.
4. Inexpensive: typically, except for the better quality blends that have controlled release pellets.
5. Ease of application: using fertilizer spreaders. Rates and settings are usually calculated and displayed on bag.
6. Multiple forms: available in pellets, granules, liquid, tablets, spikes, and slow-release, to suit every preference.

Disadvantages Of Chemical Fertilizers

1. Water soluble in most forms. Since water releases the nutrients, it is not uncommon to lose one-third of the nutrients by leaching out of the soil before the plant can access them.
2. Short life span, unless using a controlled release form.
3. Doesn't build up the soil. The basic synthetic elements contribute nothing to enhance soil fertility.
4. May decrease soil fertility. Chemical nitrogen stimulates the growth of existing microorganisms, which then use up organic matter in the soil. Repeating this cycle regularly leaves soil depleted.
5. Excess growth can occur with some varieties or with surplus application. This results in more mowing or pruning, places stress on roots.
6. Danger with incorrect application. Potential of harm from excess, especially lawns getting coverage overlap.
7. Salt burn risk. Synthetic fertilizer is salt. Over-concentration can cause dehydration and plant tissue is destroyed.
8. Trace nutrients missing, in many synthetic blends. Excess of major nutrients can bind up other nutrients in the soil, making them unavailable to the plant.
9. Environmental problems occur with chemical run-off.
10. Excess phosphorous can collect in the soil and cause pollution problems.
11. Nitrogen is volatile: is lost easily into the atmosphere when fertilizer is left on the ground and not watered into the soil. It is also lost from bags in storage, if not sealed properly.
12. Absorbs moisture easily in storage. This results in caking, or hard fertilizer, which is difficult or impossible to use.
13. High energy consumption required to produce these products.

Source: http://www.garden-counselor-lawn-care.com/organic-vs-non-organic-fertilizer.html

Organic Vs Chemical

Study supports benefits of organic food

By Anthony Fletcher

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A new academic study strongly backs the organic sector's claim that it is a viable environmentally friendly alternative to conventional agriculture.

The study comes on the back of numerous other studies supporting the practice, which is increasingly occupying shelf space in European supermarkets. Food makers, after all, are waking up to the fact that ethical consumerism is a growing phenomenon and is a sector with disposable income. Writing in the online edition of Proceedings of the National Academy of Sciences (PNAS), Stanford University graduate student Sasha B. Kramer and her colleagues found that fertilising apple trees with synthetic chemicals produced more adverse environmental effects than feeding them with organic manure or alfalfa.

"The intensification of agricultural production over the past 60 years and the subsequent increase in global nitrogen inputs have resulted in substantial nitrogen pollution and ecological damage," said Kramer. "The primary source of nitrogen pollution comes from nitrogen-based agricultural fertilizers, whose use is forecasted to double or almost triple by 2050."

Nitrogen compounds from fertilizer can enter the atmosphere and contribute to global warming, adds Harold A. Mooney, the Paul S. Achilles Professor of Environmental Biology at Stanford and co-author of the study. "This study shows that the use of organic versus chemical fertilizers can play a role in reducing these adverse effects," he said.

Other studies have suggested that modern farming practices have also led to nutrient-poor food. Dr David Thomas, a primary healthcare practitioner and independent researcher, recently made a comparison of government tables published in 1940, and again in 2002. He found that the nutritional quality of vegetables has significantly fallen over the last few decades.

"Why is it that you have to eat four carrots to get the same amount of magnesium as you would have done in 1940?" he asked. Thomas argues that food manufacturers need to promote not just good looking, wonderful tasting and great smelling food, but also nutrient-rich food.

Such concerns have been absorbed by consumers, who have begun to demand better quality food. A recent study by the Co-operative bank suggests that UK spending alone on 'ethical' food, including organic, fair trade and free range, was up from £ 3.7bn to £ 4.1bn in the 2004-5 period.

Organic food is therefore now big business. The European market was worth € 20.7 billion in 2004, and has been growing by 26 per cent since 2001.This most recently study will therefore likely reinforce consumer perceptions of organic food as something that is both better for the environment and the individual.

The PNAS study was conducted in an established apple orchard in central Washington, US, one of the country's premiere apple-growing regions. Some trees used in the experiment had been raised with conventional synthetic fertilizers. Others were grown organically without pesticides, herbicides or artificial fertilization. A third group was raised by a method called integrated farming, which combines organic and conventional agricultural techniques.

"Conventional agriculture has made tremendous improvements in crop yield but at large costs to the environment," the authors write. "Organic farming cannot provide for all of our food needs, but it is certainly one important tool for use in our striving for sustainable agricultural systems."

Source: http://www.foodnavigator.com/Science-Nutrition/Study-supports-benefits-of-organic-food

Cost of Chemical Vs Organic Fertilizers

A logical question in the chemical versus organic debate concerns the relative cost of the two types of food.

If food with organic fertilizers has better nutrition and causes less damage, then by all accounts it should be cheaper. But in most places, it is more expensive than food produced by chemical fertilizers and industrial farming.

This discrepancy can be explained through a few factors:

1. Most governments heavily subsidize industrial farming in a variety of ways. There are subsidies for manufacturing and buying fertilizers, seeds, cleanup, setting up transportation and marketing infrastructure etc. On the other hand, organic farming is still a very small-scale industry which is not supported by the government. The producer (farmer) bears most of the cost of production, transportation and marketing. Thus in a sense, we are already paying extra for food from industrial farming through our taxes.

2. The production of organic food is still at a very small level. For most products, the production and product costs comes down as the production level increases. As the amount of organic food sales go up, the costs are expected to come down.

3. Consumers of chemically grown food are not (yet) paying for environmental damages caused by that farming method. This is absent in organic farming. If that cost was factored in, chemically grown food would cost substantially higher.

The (still) high cost of organic food

Most organic farms in the U.S., for instance, are still small, often family-run operations that don't necessarily fit the economy-of-scale model, because they don't usually have high distribution costs that could be cut as demand rises. Many rely on farmers' markets, community-supported agriculture, and other small-scale distribution channels. "We're too local and hands-on for high distribution to change our costs significantly," confirms Sarah Coddington, co-owner of Frog Hollow Farms in northern California.

So to win these folks over, do organic producers have to start offering cheap cheese and budget bonbons? Dobbs makes a surprising estimate: if just one-third of American shoppers bought organic foods on a regular basis, most prices would come down to that 10 to 30 percent markup we're seeing on produce today.

... Conventional crops are heavily subsidized by the federal government in the United States, making them artificially inexpensive. Couple those subsidies -- which have been in place since the New Deal -- with the cost of cleaning up pollution and treating health problems created by conventional farming, and we're paying a lot in taxes in order to pay a pittance at the grocery store.

A study last year by Iowa State University economists showed that the annual external costs of U.S. agriculture -- accounting for impacts such as erosion, water pollution, and damage to wildlife -- fall between $5 billion and $16 billion. (For context, that's as much as twice the EPA's 2005 budget.) And Michael Duffy, a coauthor of the Iowa paper, says his team's estimate is conservative.

... So will this drive frustrated consumers to the o-side? Hardly. If anything, the taxes consumers already pay to support conventional farming are a disincentive to paying "double" for organics. To encourage a shopping shift, as European agricultural researchers Stephan Dabbert, Anna Maria Haring, and Raffaele Zanoli write in Organic Farming, government has to throw farmers a bone.

... "In Western Europe, most countries have decided that organic agriculture needs special support to bring production [and consumption] up to a significantly higher level," Dobbs notes. In countries including Denmark, Sweden, Germany, Austria, and Switzerland, and also at the European Union level, governments contribute to organic markets. In fact, many European policy makers treat organic farming as an instrument to help mitigate environmental problems, manage marginal lands, and address falling farmer incomes, according to Dabbert, et al.

Meanwhile, in the U.S., scant federal money is set aside strictly for organic farmers.

http://www.eartheasy.com/article_high_cost_organic_food.htm

Where are we now?

It is certainly clear that industrial fertilizers is not the cure-all it is made out to be. The gains it has made in terms of increasing grain output and yield rate are undeniable. At the same time, several problems, ranging from farmers' impoverishment to environmental disasters to health issues are related to the large-scale use of these chemicals. A big part of this problem is the lack of understanding concerning use of these fertilizers. Allied to this is our ignorance on nature cycles and their players which have been affected by use of chemical fertilizers. A growing feeling among many agriculturalists is that this form of farming is unsustainable in the long run and a large crisis is at hand.

At the very least, it is clear that industrial fertilizers need to be limited in their use. Gains made by organic and chemical-free farming suggest that there is potential to altogether avoid industrial fertilizers and the associated method of food production. These need to be studied in detail and supported to develop an alternative if necessary.