'THE TWO-UP TOUR' WORKSHOP MANUAL

by Gary Zimmer & Graeme Sait

Lessons in sustainable profit-building

TWO SYSTEMS OF AGRICULTURE -

BIOLOGICAL V'S CONVENTIONAL
by Gary Zimmer

Biological agriculture works with natural laws and systems and tries to help them operate more effectively. A healthy, balanced soil is the foundation necessary for healthy plants and animals. Biological farming is not against using modern technology and new methods, but uses only those that do not interfere with natural systems and do not cause harm down the road. The results of using biological methods are amazing. After a few years, soil structure improves, crop yield and quality are higher, and animals are healthy and productive. Weed, disease and pest problems almost disappear. It really works. Farming is fun again.

Compare this to the legacy of **conventional agriculture** - the hard, dead soil, the poisoned ground water, the increasing pest problems. And what about 'minor details'? The fact that today's food is so lacking in vitamins and minerals, that we have to give livestock costly ration supplements and take vitamin and mineral pills ourselves. Or the fact that most fruits and vegetables grown commercially, have to be rushed to the market before they spoil. Whatever happened to quality?

Initial results of conventional farming saw skyrocketing crop yields and animal production, but they were delivered at a cost. Has conventional agriculture really fulfilled its promise?

COMPARE THE TWO SYSTEMS IN THE TABLE BELOW

	Conventional	Biological
Basic Outlook	Control nature. Maximise yield and profit. Short-term view.	Work with natural system. Increase health and quality. Long-term view.
Soil	Supports plant; supplies about a dozen elements.	A complex system. Physical, chemical and biological factors.
Fertilisers	Synthetic, soluble salts emphasize N-P-K and pH. Replace what crop removes.	Natural or low-salt, some available and some slow-release. Balance all elements in soil. Also, feed the crop a balanced diet.
Crops	Often monoculture. Grow for market and yield.	Soil-building rotations. Grow for quality.
Weeds	Chemical control.	Manage soluble nutrients, mechanical control or spot herbicides; smother crops.
Pests/diseases	Chemical control, resistant varieties.	Natural control by good health, natural enemies and rotations.
Animals	Antibiotics. Push for production.	Probiotics. High production from quality feed, good health.
Economics	High inputs. Moderate profitability.	Low inputs. High profitability.
Environment	Chemical pollution, degraded soil with high erosion.	Little pollution. Good soil with low erosion.

A GOAL TO WORK TOWARD - THE MODEL BIOLOGICAL FARM

This is a system of farming where the farmer thinks differently.

OBJECTIVES

- **Soils:** Get the soil alive with earthworms and other soil life, and balanced with minerals.
- **Crops:** Produce a quality crop, which is a complete livestock nutrient source and which results in high yields.
- **Livestock:** Keep livestock comfortable, healthy and fed a balanced diet using high quality feeds with health-promoting 'extras.'
- **Biological farming:** Work with the systems of nature to develop a farm which is environmentally sound and which leaves the land, water, plants and animals in a healthy, productive state for all future generations.

SOILS

The biological farmer...

- Understands that the soil is living - alive with many organisms and balanced minerals. Wants the soil in the best possible health. Knows that managing decay of organic matter, crop residues, and livestock and green manures are essential to his success; these are the feeds for soil life.
- Considers the effects on soil life, positive and negative, of all inputs and practices.
- Studies and understands nutrients. Knows when plants need them and that soil life makes some of them available to the roots. Would not add more fertilizer than is needed, but certainly wouldn't starve the plant.
- Uses sources of nutrients that are non-harmful to plant roots and soil life.
- Applies suitable products to correct soil nutrient imbalances.
- Knows that money invested to get and keep his soils in a healthy state is money well spent.
- Questions use of herbicides and really questions any use of insecticides. Knows he can farm using less or none with proper crop rotations and soil health.
- Finds cultural practices that fit his land and uses tillage to manage decay and control soil air and water.
- Knows less tillage is best, but some may be necessary.
- Knows shallow incorporation of residues is good for the soil life and speeds up decay.

CROPS

The biological farmer...

- Knows that the quality of crops as complete nutrient sources is as important as yield. Does not sacrifice quality for a big harvest.
- Doesn't plant on dates; plants on conditions. Knows that early planting is not always best. Any condition less than ideal at planting is unacceptable.
- Evaluates crops and equipment, making sure plant stands are there and uniform.
- Fertilizes the crop for maximum health with a balance of nutrients in a form the plant can use on a continual basis.
- Knows that weeds, insects, soil conditions and plant growth (roots, tops, colors) are all tools and clues to evaluate his program.
- Knows the impact of crop rotation on reducing weed and insect pressure and improving soil, soil life and future crops.
- Does everything in his power to harvest at the correct time to maximize quality and yield.
- Provides proper storage to maintain crops as quality feeds. Includes inoculants on all fermented feeds to reduce spoilage.

LIVESTOCK

The biological farmer. ..

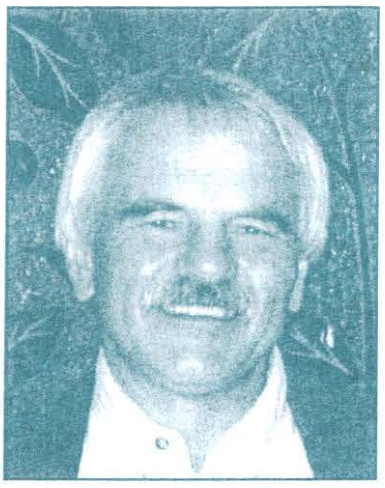
- Provides a clean, comfortable environment to keep livestock content and to promote maximum health and production.
- Feeds livestock a palatable, balanced, steady diet featuring quality home-grown feeds, fresh, clean water and access to free-choice minerals.
- Knows that feeds from a biological farming system are the best you can get. They are grown on healthy, living soils with balanced, adequate levels of minerals.
- Knows that these feeds do not always follow the "traditional" balance numbers. The rules may change.
- Frequently checks to be sure the feeds are in balance.
- Uses the best quality additions to balance nutrient deficiencies, including protein, energy and mineral supplements when necessary.
- Does not continuously feed animals antibiotics. Antibiotics are used as a treatment only when absolutely necessary to save the health/life of the animal.
- Does not inject animals with synthetic hormones in order to promote enhanced growth/production beyond the natural genetic ability.
- Understands and works with natural beneficial organisms within every animal.
- Feeds the extras -kelp, yeast, probiotics, digestive aids and extra vitamins -from day one.
- For cattle, feeds a ration of high quality forages (mineral-balanced from healthy soils), fed at high rates with lower levels of grain.
- For hogs and poultry, uses a ration of high quality grains (mineral-balanced from healthy soils) with low levels of forages.
- For breeding animals, knows that longevity is important, evaluates his livestock program based on animal appearance, health, comfort, manure, breeding efficiency and production.
- Knows that livestock must meet all of the above characteristics to be profitable.
- Treats the livestock manure to maintain nutrients and control odors (with natural phosphates, gypsum and beneficial organisms).
- Uses livestock manure as an important source of soil nutrients. Spreads manure in thin, even and timely applications.

RESULTS

- The farming system is driven by profit, not just production.
- The farmer knows that to get all these factors working in tandem takes time. Conditions differ for every soil, farm and farmer.
- Profit in farming is generated more from the farmer's knowledge and management than from monetary inputs to the system.
- The farmer works on the cause of the problem. He does not want to always be putting out brush fires (dealing with symptoms). He knows that with biological farming, the problems will continue to decrease over time.
- The farmer understands nature and works with it rather than against it. He maximizes natural interactions of pests, predators and environmental conditions to his advantage on soils, crops and livestock.
- The farmer knows that healthy crops are not plagued by insects or diseases and can compete with weeds under proper management. He can spend less and worry less.
- The farmer knows that healthy livestock don't always get sick. They breed and produce when fed balanced diets from healthy, balanced soils. He can spend less and worry less.
- Biological farmers know that this is their best shot at being profitable, sustainable farmers. They can be proud of how they take care of their land, livestock and environment, and of the food they produce.
- Biological farmers know that farming can be profitable and fun.

RULES FOR BIOLOGICAL FARMING

by Gary Zimmer



Farms that are having success with biological farming systems, have followed a few basic rules. Here they are:

***RULE 1:* Test and balance your soil:** Good soil is not just a mass of minerals, it is a living thing, with minerals, water, air, organic matter and the organisms that turn organic matter into humus. They are all necessary to grow healthy, high-quality crops. Plants need more than N-P-K. They need at least 16 elements, and they need them in the proper amounts. Major elements are needed in larger quantities than trace elements, but, as these trace elements can have an equivalent affect on health and production, they should never be ignored.

A **good soil test** is essential. You need to know what is required to start moving the soil toward a **balance**. The balancing equation involves calcium, magnesium, phosphorus, potassium, sulfur, zinc, manganese, iron, copper and boron. Less **nitrogen** is needed if the soil is in balance, particularly if there is sufficient calcium and sulfur in the picture. **Soil tests** may vary from lab to lab, and they may sometimes be inaccurate, but they are simply the best tool we have to manage soil nutrition and increased productivity.

***RULE 2:* Use fertilisers which are life-promoting and non-harmful:** My preference for fertilisers for biological farming is as follows:

1) **Soft rock phosphate** or good quality, reactive rock phosphate
2) **MAP**
3) **High-calcium lime**
4) **Gypsum**
5) **Potassium Sulfate** - has a low salt index, low chloride and contains much-needed sulfur
6) **Ammonium Sulfate** - helps to reduce high magnesium and provides the sulfur needed to make high-quality protein. Sulfur is also needed to build soil humus.
7) **Ammonium Nitrate** - favoured for liquid side-dressing
8) **Calcium Nitrate** - excellent for foliar-feeding of all crops or fertigating vegetable crops.
9) **Trace elements** - sulfate-based or chelated are the most effective and both are generally acceptable for certified organic growers.

Unacceptable fertiliser materials:

1) **Dolomite** - if used incorrectly (ie in soils that don't require magnesium), it can destroy soil structure and negatively affect soil-life.
2) **Potassium Chloride** - The 47% chloride component is not acceptable, particularly in high doses. Small amounts of chloride are required for plant growth, but never the sort of amounts often applied. This fertiliser has the highest salt index of any commonly used material. It can damage roots, kill beneficial soil life. Pests and diseases can take advantage of stressed or damaged crops and limit yields accordingly.
3) **Anhydrous Ammonia** - It can be the cheapest per unit source of nitrogen, but it will cost you in the long run. Ammonia is a highly toxic gas. It causes the soil's humus to dissolve and leach, robbing roots of potential nutrients and eventually making soil as hard as concrete. High ammonia use also causes soil to become acidic.
4) **DAP and Urea** - Both of these can release considerable amounts of ammonia in the soil, harming seedlings, roots and soil-life. Urea in liquid fertilisers is acceptable.
5) **Oxide-form Trace Elements** - They are cheap, but they don't have the availability of sulfates and chelates.

***RULE 3:* Use pesticides and herbicides in minimal amounts and only when absolutely necessary:** Pesticides and herbicides are made to kill living things. They do not distinguish between good and bad. Just as a crop can be injured by herbicide carry-over, beneficial insects and soil organisms can be killed, thus killing the natural system for growing good crops. The use of toxic chemicals should be restricted or eliminated. **Balance** and **biological activity** reduce pest problems through enhanced natural resistance. **Insects** can also be biologically controlled by an increasing armada of predators, parasites and pathogens.

Crop rotation, soil-balancing and mechanical control can help with **weed problems**. Rotary hoeing and timely cultivation are viable options.

If non-toxic methods fail or take too long to gain control, then toxic chemicals may need to be considered. If we have to use these toxins, then at least we should reduce the damage wherever possible.

Minimizing toxicity:

- Reduce amount of active ingredient, ie determine your own appropriate rate.
- Band or spot-spray herbicides in preference to blanket coverage.
- Add humic or fulvic acid to the tank to magnify uptake and performance.
- Make sure that the pH of the tank is low to maximise chemical efficiency.
- Use contact herbicides rather than residuals.
- Proper timing can also increase efficiency.

Note: Synthetic chemicals should always be thought of as **'necessary evils'**.

***RULE 4:* Use a Short Rotation:** When crops are rotated every year or two, there are fewer weed, disease and pest problems. Thus, less herbicides and pesticides are needed and better use is made of green manures and animal manures. Crop yields are also higher and inputs lower than with a long rotation or with a monocropping system. An example would be one or two years of corn, then beans, then a seeding year, followed by two years of alfalfa. Or, for the grain farmer, a corn/bean rotation interseeded with green manures works well. Just keeping continuous corn or row crops (corn/beans) without a grass or legume green manure crop will keep you from receiving many of the benefits of biological farming.

***RULE 5:* Use Tillage to Control Decay of Organic Materials and to Control Soil, Air and Water:** Good soil should have adequate air and moisture because roots and beneficial soil organisms need oxygen and water. Raw organic matter (plant residues and animal manures) should be tilled into the upper layers of the soil for optimum decay into humus. Leaving it on the surface does little good and may waste nutrients. The humus that is produced will then help improve soil structure, producing better drainage and aeration. An alternate way to add humus is to compost organic matter, then add the compost to the soil. Composting greatly reduces the volume of material to haul. When soil is tilled deeply, it should not be inverted (turned over), but can be sliced or uplifted. Never till soil that is wet, and keep field traffic to a minimum to reduce compaction. A hardpan can be temporarily broken up by subsoiling, but the best long-term solution is high calcium and adequate humus and soil organisms, especially earthworms and large, deep root systems.

***RULE 6:* Feed Soil Life:** Beneficial soil organisms are a "voluntary army" willing to work tirelessly for you, if only you will let them. If you provide them with a comfortable "home" (soil with air and moisture), food (organic matter), a good mineral balance and freedom from toxic chemicals, they will go to work. If you feed the soil microbes, they will feed the crop. That's how it should work. Soil organisms do best on a mixture of cellulose-containing (plant matter) and nitrogen-containing (animal manures and legumes) organic matter. About two parts cellulose-containing to one part nitrogen-containing material is a good mixture. The organic matter can be worked into the soil's upper layers or can be separately composted in piles or windrows. Adding

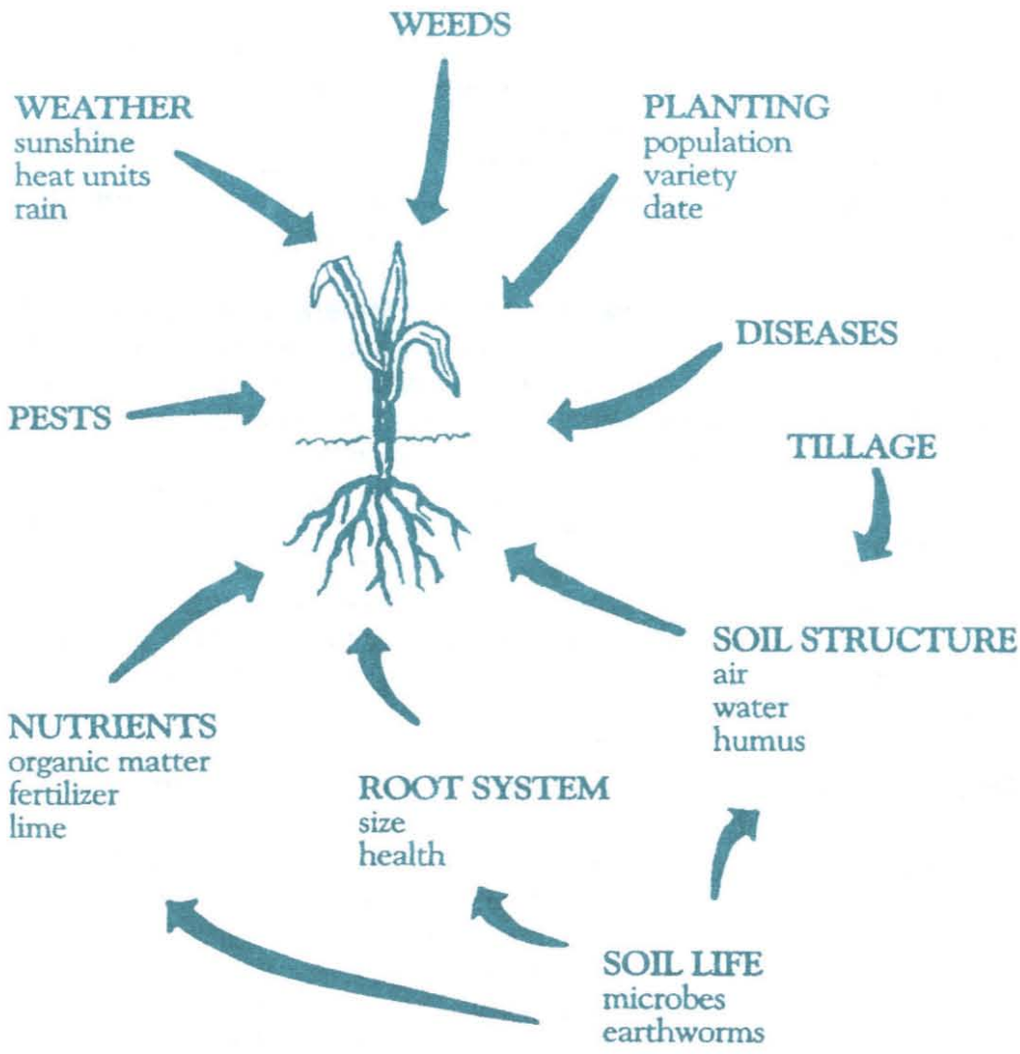
rock phosphate or a little lime to compost piles will help produce a more balanced fertilizer. Incorporating a green manure crop, like rye, red clover, Austrian field peas, alfalfa or buckwheat, is another way to feed soil life and improve soil structure. If raw organic matter is added directly to the soil, allow enough time for it to break down before planting a crop, or else some nutrients will be temporarily "tied up" by the microorganisms, starving the crop. Do not overload the soil with heavy applications of manure or other raw organic matter. It is better to apply a lighter coat over more acres. Applying composted organic matter can be done using any amount, since compost is basically humus already.

Besides animal manures and green manures, biological stimulants may be useful. Many can help improve soil structure and stimulate soil organisms. These products include kelp (seaweed), humic acids, enzymes, vitamins and hormones. Others are inoculants of beneficial bacteria, fungi or algae. Such products often produce results when used in conjunction with good biological farming practices, but you should still get the major nutrient elements in balance before relying on these "fine-tuning" products.

THE SOIL-PLANT SYSTEM - LIMITING FACTORS

FACTORS LIMITING YIELD

THE TOP TEN YIELD-LIMITERS



1) ***PLANTING:*** The main factor determining ideal planting time is **soil temperature**. Germination and root establishment occur faster in higher temperatures, so crops planted later usually catch up to earlier plantings. Many **weed seeds** tend to germinate in cool soil, giving them a headstart on crops. Some biological farmers delay planting until early weeds have been cultivated. Remember - **Any condition less than ideal at planting is unacceptable!** Why start out to fail?

   A **good seedbed** is important for good germination and stands. Aeration and soil moisture are particularly important (plant deeper in a dry soil). **Planting depth, row width and seed spacing** also affect the stand and population. High populations can mean high yields if conditions are right. However, narrow rows or high plant populations can reduce yield in some conditions, ie cloudy weather conditions, which reduce photosynthesis, or high humidity, which can encourage fungal disease in crowded conditions. On the positive side, dense stands shade out weeds.

   Re: Genetics and variety - They have an important role to play, but try to remember to avoid the trap of using a genetic bandaid on a soil balance and soil health related problem.

2) ***WEEDS:*** Weeds compete with crop plants for moisture, nutrients and light. However, weeds are often a nutritional signpost. Certain weeds grow better in poor soils that are out of balance. Biological methods reduce the worst weed problems, as soil structure and balance are improved and because soil organisms are increased. Low **calcium** and **phosphorus** levels play a large role in the proliferation of several noxious weeds, and excessive **potassium** can encourage other species.

   High amounts of soluble fertilisers and / or manures, applied early in the season, set up conditions for the growth and fertilisation of weeds. The crop planted simply can't use that amount of nutrients that early, and highly soluble fertilisers slow soil life and decrease crop root growth, making crop plants less competitive. That's why I like a balance of **soluble** and **slow-release** components. Appropriate fertiliser **balance, placement, concentration** and **recovery** are all essential parts of biological farming.

3) ***WEATHER:*** Soil conditions can modify the effects of weather on crops, ie a hardpan can cause suffocation of roots from wet soil after rain.

   a) ***Temperature:*** Biological farmers can have an advantage in cool weather, since biologically active soils tend to be warmer, due to microbially produced heat (as anyone who has ever composted will know).

   b) ***Light:*** Plants need sunshine for photosynthesis. The amount of light in a day (versus the length of the night) regulates the time of flowering of some plants). Soybeans and rice are 'short-day' crops. Wheat and red clover are 'long-day' crops, and corn is neither.

   c) ***Precipitation:*** This usually involves rain, which provides moisture, nitrogen and minerals washed out of a dusty atmosphere. Soils need to be 'weather-proofed' to avoid degradation. The moisture needs to be soaked in and stored, so in dry weather it can move up by capillary action and get to the plant. Soil structure, soil life, organic matter and large root systems ensure success, even under adverse weather conditions.

   d) ***Wind:*** Wind increased water evaporation from the soil and from the leaves of the plants (transpiration). Humus is the key here for drought resistance, because of its moisture-retaining capacity. Humus also helps the soil resist erosion.

4) ***PESTS:*** Pests and disease usually only attack plants that are under some kind of stress. It may be stress from cold, cloudy weather (low photosynthesis), wet soil (low soil oxygen - roots suffocate), out-of-balance nutrients or perhaps stress from the use of toxic fertilisers or herbicides. **Biological methods, which decrease pest pressure, include:**

   a) **A good soil rotation**, which discourages soil-inhibiting pests.

b) **Interplanting** - growing different species of plants close together - repels some pests or confuses their plant-locating ability.

c) **Maintaining good soil structure** and **nutrient balance**, which can remove or reduce stress factors.

5) ***NUTRIENTS:*** The biological farmer maintains good calcium levels and works toward a good balance of nutrients. He encourages soil life, works to increase soil humus, uses slow-release fertilisers and chelating materials (chelated trace elements, kelp and humic acid).

6) ***CROP ROOT SYSTEM:*** There is a direct correlation between yield and root size. A larger root system improves moisture uptake and nutrient-scavenging capacity. Drought resistance is improved, and a larger root system also anchors the plant more effectively. The plant is also better able to withstand an attack from pests.

7) ***SOIL LIFE:*** Microorganisms play a pivotal role in enhancement or limitation, due to their positive impact on soil structure, soil chemistry and crop growth.

8) ***SOIL STRUCTURE:*** Soil structure determines the availability of air, water and humus. **Oxygen** is arguably the most important element for beneficial microbes, as they are all aerobic.

9) ***DISEASE:*** Biologically active soil is the key to disease management. Sometimes the beneficial microbes simply coat the root surface and form a protective barrier. Often they actually inhibit or kill pathogens. Some do this by producing antibiotics such as penicillin or streptomycin. Others are predators that feed on pathogens. Again, a good crop rotation will often reduce soil-borne diseases.

10) ***FARM MANAGEMENT:*** Often the single biggest yield-limiter is the closed mind of the farmer. In a rapidly changing world, an open, questioning mind is an essential prerequisite. Doing it the way your Daddy did it is not always the answer.

PRACTICAL HINTS

As a summary of this section, let's list some practical things you can do to increase crop yield and quality:

- Plant a variety that can give high yield (genetic potential, resistance to pests and/or Diseases), that fits your soil types and farming methods, and that produces quality crops.
- Plant a high enough population (be sure soil water and nutrients are sufficient). As the soil improves, you tan increase the plant population.
- Eliminate physical soil restrictions such as compaction, hardpan or drainage problems.
- Provide timely applications of balanced fertility.
- Recycle organic matter (animal manure, green manures, previous crop roots and residues), and foster soil life. Don't just rely on outside fertilizer inputs.
- Do everything possible involving soil structure to weatherproof a crop. Practices to achieve this may include sub-soiling, zone tillage, promoting biological activity (use green manure crops to feed soil life), and root stimulation.
- If crop stress develops from weather or insufficient fertility, try foliar feeding.
- Our yield potentials are much greater than what we have been producing, as the winners of crop-growing contests regularly demonstrate. Over 200-bushel corn and over 60-bushel soybeans, with less input than conventional systems use, are easily possible with today's knowledge and biological methods.

SOIL TESTS AND THEIR INTERPRETATION

by Gary Zimmer

The soil test is an important tool in biological agriculture. There are a variety of different ways to monitor your soil, including:

1) The standard **CEC Test**
2) **LaMotte Test** - measuring plant-availability of nutrients
3) The **Ergs Test** - This is a measurement of soil conductivity, viewed as a guide to the soil's 'energy' level. Usually, the higher the 'Ergs' readings (Millisiemens / meter) on the conductivity meter, the higher the available nutrients and the higher the soil's energy. Desired readings run from 100 to 800 Ergs, depending on the crop and the time of the year. A reading above 800 may indicate a serious salt or salinity problem.
4) **Microorganism Tests** - These can vary from a simple plate count, covering fungi and bacteria, to comprehensive microbe identification tests utilizing DNA analysis. **Dr Elaine Inham**, of Soil Foodweb, Inc in Oregon, is a leader in this field. She has identified specific microbial balances that are suitable for specific crops. Tree crops, for example, prefer a fungal-dominated soil, while pasture crops prefer a bacterial-dominated soil.

The physical condition of the soil can be monitored using a **penetrometer**. It is also possible to monitor some aspects of soil conditions using a **refractometer**.

Earthworm counts are good indicators of the health of the soil. An earthworm population of 25 worms per cubic foot of soil indicates excellent soil conditions, while less than 5 earthworms per cubic foot of soil is considered poor. Counting should be conducted while the soil is moist by either counting worms in the soil or by counting their castings on the surface. Remember that some areas simply don't have many earthworms, even in fertile soils, and sandy soils invariably have low counts.

In this section we will deal with **understanding the CEC test**, as this is the most widely used soil analysis system.

HOW TO READ A SOIL REPORT

In working toward balancing soil nutrients, if pH and/or calcium are low, and phosphorus and potassium are low, you need to start there. If you have livestock, a major reason to test the soil is to know where to spread the manure. You want all fields to be in the medium to high range. This will give you better overall crops and a uniform feed supply for better livestock health and performance.

Two things are at work here. One is **soil balance**; the other is **crop fertilizers**. The crop fertilizer can be adjusted to make up for soil deficiencies while you are in the process of balancing. The fertilizer should always be balanced for the growing crop, with major, secondary and trace elements.

How to Read a Soil Report

Let's go through the typical items on a hypothetical soil report. Parts Per Million (ppm) or Pounds Per Acre. An acre of topsoil six to seven inches deep weighs about 2,000,000 pounds, so one ppm = two pounds/acre. Multiply parts per million by two to get pounds per acre, or divide pounds per acre by two to get parts per million.

Organic Matter (OM)

A measure of plant and animal residues in the soil, including both raw and decomposed organic matter. Some labs offer a separate test for percent humus, which measures only the decomposed organic matter. The **humus** provides many valuable functions in the soil. It is related to the soil's color. Darker soils are usually higher in organic matter. I like to see at least 2 and up to 5 percent OM. Not using excessive nitrogen applications and adding plant and animal matter (such as corn stalks, manure or cover crops) will raise soil organic matter levels.

Some labs will also give **Estimated Nitrogen Release (ENR)**, which is calculated from the percent OM. It is supposed to be the amount of nitrogen that should be released from the soil by microbial action through the growing season. But that is all hypothetical since actual nitrogen release depends on the type of organic matter (humus versus raw organic matter), soil conditions (aerated versus waterlogged), and weather (temperature, moisture). If a heavy rain leaches away most of your nitrogen, you will probably need to side dress more. There is no "ideal" level for ENR, and it is not a very useful number for the "real world." You can grow your own nitrogen (legumes, organic matter, microorganisms), but you can't grow mineral nutrients. Therefore, I don't emphasize measuring soil nitrogen, but I try to provide it as needed to the crop, only using purchased synthetic nitrogen as a last resort.

Cation Exchange Capacity (CEC)

This is a measure of the soil's ability to hold nutrients. The higher the CEC, the greater the soil's holding capacity. Colloidal soil particles (clay and humus) hold the nutrient ions. Sandy soils have a lower CEC and require more frequent nutrient additions than heavier soils. The CEC can be increased by adding organic matter. Organic matter holds both nutrients and water. There is no "desired" CEC -it is what it is. Generally, a CEC below 10 is low and over 25 or 30 is higher than average. Low-CEC soils will require supplemental fertilization to grow high-yielding crops.

Percent Base Saturation

This is the relative amount of cations (positively charged ions, or bases) held on soil colloids, expressed as a percent (they all total 100 percent; it is calculated from the CEC). It includes the three nutrient cations calcium, magnesium and potassium, plus hydrogen and sodium if they are present. The desired levels are 70 to 85 percent calcium, 12 to 18 percent magnesium, 3 to 5 percent potassium and less than 5 percent hydrogen. Ideally, sodium should be zero since it is not an essential plant nutrient, but many soils in the western United States will have high levels. I am speaking here primarily of temperate climate soils; many tropical soils, where high rainfall causes severe leaching, will have a different "best" balance.

You should realize that the percentages, or proportions, of nutrient cations could be "ideal," but the soil could still not provide them in sufficient quantity to the crop. This is because in a low CEC soil, there is not a large enough capacity to hold what the crop needs. This means the farmer will have to supplement low CEC soils with extra fertilizer. See the following table.

pH

This is a measure of the acidity or alkalinity of the soil, caused by hydrogen ions. A pH of seven is neutral. Anything below seven is acidic, and above seven is alkaline. Any pH that is a whole number above or below another has 10 times fewer or greater hydrogen ions (it is a logarithmic scale); for example, pH 5.4 has 10 times as many hydrogen ions as pH 6.4. Soil pHs between 6.2 and 6.8 are "ideal" for most crops. The hydrogen percent saturation is zero when the pH is seven. In an acid soil, hydrogen has replaced calcium, magnesium, potassium and sodium on soil colloids. The first three elements should be replenished in proper proportions (see above, "Percent Base Saturation").

Potassium (K)

A measure of readily available potassium (much more tied-up or unavailable potassium is present in soils). Desired levels: light soils = 125 ppm or 3.5 percent base saturation, medium soils = 150 ppm or 3.0 percent base saturation, and heavy soils = 175 ppm or 3.0 percent base saturation. High-magnesium soils above 20 percent base saturation require extra potassium.

Magnesium (Mg)

Soils in dolomitic bedrock areas may have a problem with too much magnesium, while light sandy soils may have too little. The desired range is 100 to 250 ppm, or 12 to 18 percent base saturation. A 2:1 ratio of magnesium to potassium (in parts per million or pounds per acre) is good.

Calcium (Ca)

Calcium is the nutrient needed at high levels for both plants and beneficial soil organisms. It improves soil structure and helps bring the balance of other elements into line. Calcium is a necessary plant nutrient, so even if pH is high, additional available calcium may be required. In high pH soils, sulfur or sulfate should be added with calcium. Desired levels are 1,500 to 2,000 ppm (or higher), or 70 to 85 percent calcium base saturation. There is some controversy over the balance of calcium and magnesium. I like to see a calcium to magnesium ratio of 5: 1 to 7: 1 in parts per million or pounds per acre (see Chapter 10 for more details).

Sodium (Na)

A measure of this element is normally only made on soils classified as sodic (high-sodium) or saline-sodic, such as are found in the western United States. High sodium in soils destroys soil structure by dispersing the small particles, and some crops are harmed by high sodium.

Phosphorus (P)

There are two tests usually done for phosphorus
PI (weak Bray extraction). This is what is readily available to a plant now. Twenty~five ppm is a minimum level on soils with 3 percent organic matter, but 50 ppm would be ideal. At that level, except for corn starters, specialty crop requirements, and to "winterize" alfalfa, no additional phosphorus would be required.

P2 (strong Bray extraction). This measures the readily available phosphorus plus a part of the active reserve phosphorus, which should become available later in the season. Fifty ppm is a minimum level, while going to 100 ppm adds more crop quality and health. The ratio of P1:P2 should be 1:2. Wrong calcium levels and a pH too high or too low can change this ratio, indicating a soil condition for poor crop performance.

Sulfur (S)

Sulfur is a much-neglected nutrient. More sulfur than phosphorus is needed to grow some crops, and sulfur is essential for complete proteins. The sulfur-to-nitrogen ratio is very important since sulfur improves nitrogen availability. Twenty-five ppm is a good minimum soil test level, with a S:N ratio of 1:10 in the feeds.

Trace elements comprise the other half of the soil test report. I'll let Graeme highlight their importance in the fertility equation.

NITROGEN RULES!

by Gary Zimmer and Graeme Sait

Gary:

I place supplemental nitrogen in the same category as herbicides. They are both sometimes 'necessary evils'. Use as little as possible to get the job done, always evaluating need and the amount you use, the objective being to use less all of the time.

When asking farmers what source of nitrogen they use, 95 percent respond by saying, 28 percent solutions, anhydrous ammonia, urea, etc. My answer would be:

1) I have some manures in my rotation.
2) I work down rye and other green manure crops.
3) I use crop rotations with nitrogen-loving crops and legumes rotated.
4) I have 25 earthworms per cubic foot of soil, and on an acre basis, that's approximately 75 units of nitrogen per acre per year.
5) My soils have 2.5 percent organic matter and are loose and well-aerated. Many more symbiotic organisms provide extra nitrogen in the soil.

So the question is, how much extra nitrogen do I need to purchase for the situation I am in now? Excess nitrogen is a negative. It slows down I biological activity (fewer nodules on alfalfa and beans}, makes the soil "lazy" and takes extra carbon to balance it out, meaning it could be burning up your soil organic matter. Extra nitrogen also takes calcium out of the soil. Insect pressure, diseases, plant imbalances (they slow dry-down in corn) are all affected by excess nitrogen. Other results are environmental pollution and lower feed quality. A carry-over of nitrogen from corn to next year's alfalfa is not a benefit.

You should do all the practices to grow and take advantage of free [nitrogen. Nitrogen is an element you can "grow" and don't need to buy, or at least you can reduce purchased nitrogen. Not knowing for sure the kind of season you are going to have or how much you really grew which the crop could actually use this year, how do you decide what and how much nitrogen to purchase? I think it is simple and involves no figuring (it's just a guess, anyway}. Nitrogen use is not a numbers game.

My Nitrogen Rules Are:

1) **Split applications** whenever possible if you need more than 60 purchased units.
2) **Put the nitrogen where and when it is to be used and needed.**
3) **Use additives to reduce losses of applied nitrogen**. I don't like the biological-suppressing kinds; they probably suppress other soil biological systems, and I believe the risk in using them is too high. My preferred addition is a carbon source; I prefer humic acid. My rule of thumb is one quart per 20 gallons of liquid nitrogen.
4) **Trade some of your nitrogen units with sulfur**; the minimum to use is a 10: 1 ratio N:S in application.
5) **Do add calcium to your fertilizer program**. It stimulates roots and biological activity.
6) **Don't plant in hard, tight soils**; anaerobic organisms denitrify your supplement and send the nitrogen into the atmosphere as gas.

7) **Never drive on soil when and after the nitrogen has been applied**. Denitrification will take place because of soil compaction.

8) **Grow large roots**. What stops root growth is hard, tight soils with too many soluble nutrients and a shortage of root feeding materials.

9) **Provide a balance of all the minerals**. For example, trace element manganese aids in nitrogen uptake.

My preferred purchased nitrogen source is ammonium sulfate. We usually put this in the row fertilizers. For many farmers with rotations, manures and healthy soils, this is all you need. We place it where it is needed, but a little earlier than needed. Ammonium sulfate has a 1:1 nitrogen-to-sulfur ratio and is a slower-release material. This source is limited to about 50 pounds nitrogen per year, based on returns for your money and amount of sulfur wanted.

If I want more nitrogen, I like using liquid ammonium nitrate sources or URAN blends. These materials allow me not to have to violate the above rules of nitrogen. I can side-dress at cultivation or if available, put them through the irrigation system, often at lower rates with humic acid added. For corn, I generally recommend 10 to 40 gallons side dress.

To side dress, you need saddle tanks on your tractor. These same tanks can be used to band herbicides (if needed) at planting; however, you will then be forced to cultivate for weed control. At the time of cultivation (foot-tall corn or so), side dress the liquid nitrogen with the humic acid or other beneficial materials added. Vary the rate, and you can determine what level works best for your farm. While doing this cultivation, interseed a clover/grass blend, making your trip over the field pay in many ways.

The more nitrogen production methods you have in place, the less you need to purchase. Keep checking your system for what responds for you. Many farms with medium to heavy soils, without livestock, on a corn/soybean rotation with some green manure crops, see no benefit of added nitrogen above 20 gallons per acre in addition to their crop fertilizer. Moving to lower nitrogen use and growing high-yielding, high quality crops is definitely achievable.

If you are unable to match what I call the ideal situation and side dress, there are some things and methods you can use which will help. Farmers want us to tell them how much they need to use, and they want to surface-apply it or bulk spread in early May before the corn comes up. There is no way I or anyone else can guess that amount. As with herbicides, salesmen and crop advisors in these and other situations recommend very high levels at your expense. They don't like taking responsibility for potential crop failures. You, the farmer, need to become knowledgeable and make the management decisions. Follow the practices to improve the soils. Set yourself up to be flexible and put the nitrogen on where and when it is needed. This not only reduces risk of poor crops, but puts you in charge of your own success, taking your own responsibility for success or failure.

WEED RULES

WEED CONTROL STRATEGIES

by Gary Zimmer

A weed is often defined as a plant growing where we do not want it usually where we are trying to grow crops or a lawn. Weeds generally cause some kind of harm or economic loss:

- Compete with crops for water.
- Compete with crops for soil nutrients.
- Compete with crops for light.
- Lower crop yields and quality.
- Contaminate grain with seeds.
- Harbor crop diseases or pests.
- Taint milk with unwanted tastes or odors.
- Harm livestock by poisoning or from thorns and spines.

In spite of all these bad things, weeds are not totally worthless. They have their place in nature. They quickly colonize bare soil and prevent erosion. Their roots help loosen hard soil and may bring up nutrients from the subsoil. They can scavenge and conserve excess nitrogen that might otherwise leach away. When they die, they add organic matter to the soil.

Some weeds even make nutritious animal forage (lambsquarters and pigweed are sometimes grown for forage in Europe). Weeds also provide food and shelter for wildlife. Some are useful as herbs or sources of medicine, as natural dyes and even as tasty "wild foods" for people. Finally, some weeds can teach us something about our soil and agricultural practices. Those weeds that prefer certain types of soil are called indicator species. For example, foxtail, velvetleaf mustards (yellow rocket, etc), fall panicum and crabgrass like hard or crusted soil with little air. On the other hand, lambs quarters and redroot pigweed generally indicate fertile soil.

WEED CONTROL PRINCIPLES

Weed seeds can still sprout after 50 years, so it's safe to assume that weeds will always be with us. The best we can do is to manage them, as they will never be eradicated. There are several central principles that govern efficient and sustainable weed management.

1) **Consider the economic threshold:** Evaluate yield or quality restrictions likely to be related to weeds before wiping them out solely for the sake of a clean crop.
2) **Timing:** Early in the growing season is the critical time to reduce weed pressure. Weed seedlings can be easily killed before they can harm the crop.
3) **Let weeds germinate before the crop and kill them before planting:** Many weeds germinate at cooler temperatures than crops, so they will be first on the scene, provided you haven't planted too early.
4) **Kill weeds before they seed**
5) **Herbicides are bandaids:** Sometimes they are 'necessary evils', but they don't cure the sick patient.

NON-TOXIC WEED CONTROL

There are five main categories of control strategies, including:

1) **Crop rotation:** Monoculture attracts weeds. When crops are rotated, not only do yields increase, but soil structure improves and weed populations change. A short or 'tight' rotation works best. The idea is to keep the weeds 'off balance' by changing crops every year or two. Some crops suppress weed growth through the release of toxins (called allelopathic effects). Common allelopathic crops include rye, barley, oats, wheat, corn, tall fescue, sorghum, soybeans, alfalfa, red clover, peas, field beans, sunflowers and buckwheat.

2) **Improve soil conditions:** The basic cause of most weed problems is an 'out-of-balance' soil. Soil structure is particularly important here. The seeds of many weeds are 'programmed' to germinated when the soil is poorly aerated. The first step toward discouraging weeds that flourish in hard, tight, crusted or wet soils is to break up the compaction with **tillage**. Never till or drive on wet soil, if you want to avoid further compaction. **No-till farming** is sometimes helpful to weeds. In courser, light soils no-till can work well, but in fine-textured, heavier soils in cool climates the top six inches tends to become more dense and poorly aerated. Don't use no-till because it's fashionable - check to see what it does to your soil.

   Humus tends to stimulated crop plants rather than weeds. Building your organic matter levels is a viable weed control technique.

   Cover crops improve soil structure and reduce weed pressure. They should ideally include a grass / legume mix.

   Fertilisers like muriate of potash and anhydrous ammonia create imbalances, which weeds favour, and the use of these materials tends to fertilise the weeds.

   Earthworms and microorganisms also build soil structure and reduce weed pressure.

   Creating a **fertile, balanced soil** with sufficient calcium will eliminate many weeds. They just don't want to grow in that type of soil. A good strategy to encourage crop plants and discourage weeds is to fertilise in the row but not between the rows. Crops will inevitably outcompete weeds when we tip the balance in their favour.

3) **Grow smother crops and cover crops:** An excellent approach to agriculture, which helps to control weeds and improve soil, is to keep the soil covered at all times. Almost any plant will languish or die when it is shaded. It just can't get enough sunlight to make sufficient food to sustain itself. Gardeners and vegetable growers use this principle when they control weeds with a mulch of straw or other shade-producing material. Most weeds germinate and get a foothold on bare soil, the same situation that farmers create when they till and plant a crop. A plant cover shelters the soil from erosion and from temperature extremes (it also shelters earthworms). Plants improve the soil (both structure and fertility) by the organic matter they add and the organisms they encourage. And densely growing plants can effectively shade out or crowd out weeds. They can also be turned under as green manures. Certain species can kill weeds by **allelopathic effects** (see the previous section on crop rotation). Crops grown to provide ground cover are called **cover crops**, and those planted specifically to control weeds are often called **smother crops**. The nurse crops for new seedlings of legumes, such as oats or barley, also make good cover crops.
   A cover or smother crop can be grown as a main crop in a rotation, such as a hay or forage crop. Perennial (several-year) species can effectively eliminate annual (one-year) weed species. Or, if you have no need for such crops, a temporary cover crop can be grown between the main crops in your rotation. Typically, the cover crop is planted in the late summer or fall, stays on over winter, and is turned under the next spring.
   Another method that provides ground cover and weed control in row crops is **interseeding** the cover crop between the rows (overseeding by broadcasting also works well). If the main crop's canopy provides a lot of shade, the cover crop may sprout, but then "stand still" until

the row crop is harvested. Then the cover crop will grow more rapidly and be there for the winter.

Some good cover and smother crops include (1) legumes such as clovers, vetch, birdsfoot trefoil, alfalfa, peas, soybeans, annual medics and lespedeza (2) grasses such as rye, ryegrass, barley, oats, winter wheat, sorghum or sudan, millet, reed canary grass, crested wheatgrass and fescue; (3) corn for silage; (4) buckwheat; (5) forage brassicas such as turnip, rape and kale); and (6) sunflower. Also good are mixtures, including rye-vetch, oats-rye, alfalfa-brome, alfalfa-red clover, alfalfa-sweet clover-red clover, red clover-annual ryegrass, and yellow sweet clover-rye.

4) **Mechanical control:** This involves the killing of weeds by some kind of physical disturbance. Techniques include cultivation, burning, mowing and hand-weeding.

Cultivation loosens and aerates the soil. Sometimes the yield benefit from this practice comes more from soil aeration than weed control. The rotary hoe and the disk-hiller are two of the most successful tools to control weeds with minimal herbicides. Rotary hoeing should be done three to five days after planting and again when the row crop is two to three inches high. Hoeing early in the morning, at fast speed, loosens surface soil and allows the sun to dry and kill weeds.

Ploughing and **disking** can kill deep-rooted or perennial weeds.

Burning: A hot propane flame to fry weeds is generally used for in-row weeds that cultivation cannot reach. One advantage here is that crop roots aren't disturbed. There is, however, quite a skill involved in using a burner efficiently.

Mowing: If weeds are beyond cultivating, mowing can be used to reduce their seed production.

5) **Herbicides as a backup:** If it appears that non-toxic methods will not give effective control, then herbicides should be seen as a backup or supplementary control. Most biological farmers have devised ways of using less herbicide than the 'full' rate. Effective control can often be achieved at half rates, particularly if you include **humic acid** with the herbicide. Another good way to reduce per acre herbicide use is to band-spray in the rows and use cultivation or other mechanical methods between the rows. Finally, biological farmers tend to reduce herbicide use by only spot-spraying the worst areas of their field and avoiding blanket sprays at all cost.

PEST AND DISEASE RULES

by Gary Zimmer

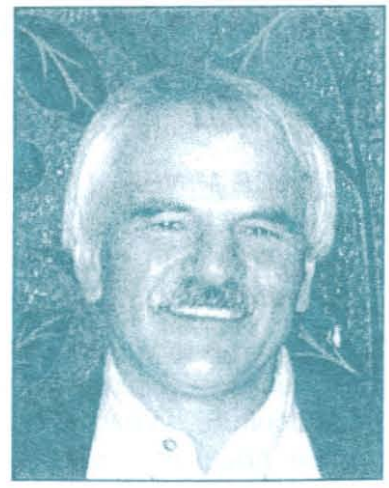
1) **Pests and diseases function in nature to eliminate the sick and unfit.** Numerous research projects have confirmed the relationship between plant health and pest and disease pressure.
2) **Vigorous, healthy plants have natural defenses against pests and diseases.** This conferred immunity is directly related to soil balance and soil health. Natural resistance factors include the following:
   a) **The genetic factor:** Some species and some varieties within a species have genetically controlled mechanisms that can confer resistance.
   b) **Induced resistance:** Natural or man-influenced external factors can magnify a plant's resistance capacity. For example, improved plant metabolism due to good soil fertility and beneficial microorganisms would fall into this category. There are several

      There are several mechanisms involved in resistance, including

      - **Barriers:** Waxy coating or a dense mat of hairs on the leaf or stems can form effective barriers against insects.
      - **Repellent chemicals:** Some plants produce strong smelling odours or toxic chemicals that prevent insect attack. Conifers, garlic, citrus and onions all produce these volatile oils.
      - **Phyto-alexins:** These are chemicals produced by the plant, which can kill or inhibit invading fungi, bacteria, viruses and nematodes.
      - **Certain proteins and amino acids** also appear to give natural resistance to some plants. There is considerable research at present, looking at disease control using synthetic amino acids.
3) **Various stresses can break down the plant's immunity to pests and diseases:** Stress can come from:
   a) **The weather**, ie temperature extremes, lack of sunshine and storms.
   b) **Poor soil conditions:** Too much or too little water, poor aeration, high salts and out-of-balance nutrients.

The best long-term approach to crop pests and diseases is not to kill the attacking pests or pathogens but to prevent the problems by correcting soil conditions. Once again, we need to stop **treating symptoms** and address the **root-cause**.

PROFIT-BUILDING RULES!
by Gary Zimmer



1) **Test and balance soil** as a guide for what crops to grow and how to apply fertilizers, lime and manure. The lower-testing fields should receive the manure and should not be left in hay very long. Forage crops are the ones that remove a lot of nutrients from the soil. Match your starters, plant food and corrective fertilizers to soil needs. Soil balancing creates an ideal home for soil organisms and a "balanced diet" for crop plants. Adding fertilizers above soil balance requirements wastes money and causes problems. Balanced soils will produce high quality, nutrient-balanced feeds. More than N-P-K must be used. When the major elements, plus calcium, magnesium, sulfur and the trace elements are balanced, profitability improves because crops grow better. Soil testing is a must then you know where you are.

2) **Fertilizer use and placement:** Split applications and row side dressing or banding of fertilizer (especially nitrogen) gives equal yields and better quality than one-time, pre-plant applications, with less environmental pollution. Often less than one-half the usual rate of nitrogen can be used. A split application of nitrogen can be applied when you cultivate. Seed-applied and in-row plant foods and growth stimulants are very effective and efficient. Row-applied fertilizers allow you to grow a good crop on low-fertility ground with a minimal input.

3) **Seed use:** Soil structure, chemical carry-over, soil calcium level and earthworm activity (plus other soil organisms) all affect seed germination. Twenty pounds of alfalfa seed per acre is 100 seeds per square foot. Twenty-five plants per square foot is a very good stand, so high seeding rates are unnecessary. Less expensive alfalfa seed can do well in good soil. Also, look at lower priced smaller seed corn companies' products, and open pollinated corn.

4) **Run a short rotation:** This is one of the "rules" of biological farming. It allows you to drop insecticides, reduce herbicides and incorporate more green manures into a growing cycle. Crop rotation allows you to grow your own fertilizer (legumes add nitrogen for corn), plus it improves crops and reduces chemical input (you get better weed and pest control).

5) **Cover crops:** Anything that you can fall-seed or interseed into an existing crop can make a good cover crop, including rye, vetch, clovers, oats, buckwheat, etc. Not only do these crops protect the soil from erosion, they protect the soil life and grow food for them. They increase and save soil nutrients, and their benefits far exceed the N-P-K value put on them.

6) **Root systems:** Keep in mind your crops' root systems and what will help them. Roots need air and warmth to grow and function. Soil balance with soil life creates looser soils and therefore stimulates root growth. Kelp and humic acid are known root and bacterial stimulants. If you double the root system, you greatly increase the water and plant nutrients taken in by the crop. Chloride and ammonia from commercial fertilizers may bum roots, and heavy nitrogen applications early in the season decrease root growth.

7) **Pests and weeds:** Vigorous, healthy plants are naturally immune to pests and diseases. Diseases and insects are "nature's clean-up crew," eliminating the sick and weak. Weeds grow best under certain soil conditions. Improving soil structure and balance reduces weed problems.

8) **Herbicide use:** Crop rotation, banding herbicides, adding humic acid to herbicides, using a

rotary hoe or cultivator, using nitrogen or sulfuric acid to burn in-row weeds, and flame cultivation are some methods which greatly reduce chemical weed control. Banding can be done with either dry or spray herbicides when planting row crops, or with an early cultivation system. Contact herbicides are good in that they have a lower carry, over and you are selectively putting them on only when needed. Getting your soil well aerated, balancing nutrients and promoting soil life will discourage most weeds.

9) **Insecticides:** Crop rotation and healthy plants growing on "healthy," balanced soil make the need for insecticides minimal or obsolete. Continued reliance on insecticides simply creates pesticide-resistant insects and pollutes the environment.

10) **Quality crops and forages:** A good "healthy" soil with balanced fertility and lots of organisms makes for high quality feeds, with good mineral balance, high sugar level and good quality protein. All of these reduce farm costs for protein and mineral supplements, along with animal health care. This increases profitability -the bottom line. For top, quality alfalfa, you need a complete balance of all soil nutrients, including calcium, sulfur and boron. Put excellent quality, ideally stored forages in your silo or mow. Inoculate them to improve storage and pH; make sure there are no molds.

11) **Set up a controlled grazing system** to graze pasture land more efficiently and to keep high quality forages growing. Fertilize pastures for added production and quality.

12) **Feed livestock quality minerals with lots of extras:** probiotics, yeast, kelp and B vitamins. These are things that keep livestock healthy and productive.

13) **Dairy calves:** Many farmers fall short here. Sick calves equal sick cows. They need balanced diets, good nutritional supplements and ideal living conditions.

14) **Dry cow care for dairy farmers:** I always say, give me your dry cows and give me your alfalfa. That's how you make money. Dry cows need special feeds, not left-over junk. Good grass is the best dry cow feed.

15) **Livestock manure management:** Storage and handling are part of it. Another part is application. A light coat on many acres is a better use of the nutrients. Heavy doses can do as much damage to the soil and environment as they do good. Stockpiling and/or composting are excellent ways to save livestock manure nutrients. Adding a rock phosphate not only helps save the nitrogen in the manure by making ammoniated phosphates, but also reduces odors and makes a convenient way to add phosphorus to the soil. With liquid manure, adding rock phosphate (but not the colloidal type of phosphate) minimizes crust, flies and odor. Manure should be tilled into the soil, but keep it near the surface so soil organisms can convert it to plant-usable forms.

16) **Corn stalk management:** Right behind the picker or combine, apply some nitrogen or manure and get the stalks mostly worked into the soil. Stalks rot down faster that way. Management of decay is essential for nutrient release and insect control.

17) **Tillage:** Keep these objectives in mind: use tillage to manage organic matter decay and to control the soil's air and water. Avoid compaction-causing operations. A system of tillage will probably include some form of deep tillage occasionally. This will break up a hardpan and aerate soil, although high humus levels and soil life (especially earthworms) will do the job permanently.

18) **Erosion:** Compacted and "dead" soils erode easily. Most of your soil's fertility is near the top. Proper management, ground cover, good soil structure and keeping toxins off -all greatly reduce your chance of having compacted soil. Building humus levels, thereby providing better water absorption, will reduce run-off and erosion, as well as increase fertility.