KNOW YOUR SOIL

A HANDBOOK FOR UNDERSTANDING AND UTILIZING A SOIL ANALYSIS FOR ORGANIC GROWING

3rd Edition

Amigo Cantisano
Organic Ag Advisors
N. San Juan, CA 95960
(530) 292-3619
orgamigo@gmail.com

INTRODUCTION

Welcome to my booklet on interpreting your soil analysis. This booklet, written by Amigo Cantisano of Organic Ag Advisors, represents 35 years of knowledge accumulated from reading, interpreting and using thousands of soil tests.

We have attempted to utilize the most benign organic practices to enhance the soil for optimum production, using state-of-the-art as well as time-proven methods. We believe strongly that organic agriculture represents the only truly sustainable form of agriculture. If we are to survive as a species we must respect and use the natural methods that have brought us through millennia. At the same time it is important to recognize that scientific developments have significantly advanced our accuracy in judging soil fertility and plant health.

As we continue to explore the fascinating world of plants we will no doubt discover new wonders among the nearly hidden secrets of the natural universe. Therefore please understand that this handbook is a piece of work in the making and that the future will invariable create changes to this third edition. We would love to hear from you as you implement the suggestions contained herein. It is important to learn of successes as well as problems so that we may better understand the mysterious world beneath our feet.

Organic growing is *very* different from growing with chemicals. With the latter, the grower merely applies soluble fertilizers, usually in large amounts, and often fails to understand the importance of the living world that is being affected. The organic grower has a *much* more intimate relationship with the soil and plants. It is this most important relationship that we will attempt to foster and explain as you read this booklet.

Please remember that in Nature no fertilizers are applied, except the leaf mold and other organic materials that naturally occur. This is more than adequate for countless plant species that exist in Nature, but just relying on the falling leaves would leave the average gardener or farmer significantly disappointed! We want plants that race from tiny seeds to huge plants with big crops of tasty, nutritious healthy food in a matter of a few weeks – a growing habit quite different from the oaks or pines that may take decades or centuries to reach maturity. Success in the garden and farm requires very healthy soil and no small amount of work! Remember that even the best soils in the world, such as the Salinas Valley or Oxnard Plain, still require frequent fertility additions and adjustments. If your soil is less than the best, expect the need to work on improving for many years.

We must come to appreciate the microscopic world from which all fertility springs. The bacteria, algae, yeast, fungi and earthworms in the soil contribute to vast majority of fertility from which plants naturally grow. The organic grower must nurture these microscopic "good guys." They are the key to the successful organic garden or farm. We may think that we are feeding the plants when we bring composts or fertilizers to the soil, but in reality we are feeding our friends the soil microbes, who perform a very important bit of magic and provide fertility and abundance for the plants.

There are libraries full of information on growing. It can get extremely complex and confusing. Hopefully this booklet will give you enough information to make an informed decision without overwhelming you with detail. Happy growing!

Amigo Bob Cantisano

January 2012

BACKGROUND INFORMATION

This booklet is intended to provide organic fertility advice using results from soil analysis performed by A& L Laboratories, which utilizes advanced scientific laboratory equipment. As laboratory methodologies can very greatly, using these guides for other labs results may be difficult. However if the lab you use states a

particular nutrient is Low, Medium, High or Very High, you can interpret these as similar to the levels used by A & L, even if the actual numbers on the lab report are different.

While both A & L Laboratories and Organic Ag Advisors are competent and experienced, we make no guarantees as to the accuracy of this data or interpretation. Our ability to interpret and analyze a situation does not guarantee results, as the actions of the grower and Nature play a bigger role than our lab work.

All recommendations are based on a working soil depth of 6", the usual depth when the soil is prepared using a rototiller, disc, spade or garden fork. If you work your soil deeper than 6" (i.e. if you have raised or double-dug beds, deep containers, etc.) increase the recommended amounts by 100% for each additional 6" of worked soil depth.

Please be aware the accuracy of the lab work is directly related to the accuracy of the soil sample. Variations or extremes in the soil type or fertility will not be distinguished unless sampled separately.

Laboratory analysis is an accurate "snapshot" of a particular portion of soil at the time of analysis. However, natural changes are constantly taking place in the soil. Over time these changes will alter the lab reading, even if *the grower takes no actions*. The actions you *do* take, such as fertilization, composts, cover crops, irrigation, cultivation, compaction, crop selection, choice of planting dates, pest management, etc. impact the changes of Nature. All this adds up to a dynamic situation, that you can modify and improve.

Finally, it should be noted that even with the best soil fertility program there are occasionally plants that do not respond as expected. This can happen when the soil has adequate amounts of an element, but for some reason(s) the plant is unable to absorb it. In these cases it is worthwhile to explore plant tissue analysis to better understand the balance of elements within the plant itself, rather than just the quality of the soil.

The information you are receiving here is based on the lab process used by A & L. Since lab techniques and procedures vary widely, it is not possible to transfer the numbers from these reports to other lab work, unless the same lab procedures were used. However if your lab report states a nutrient level is very low, low, moderate, high or very high, you may interpret and utilize the information from this booklet, even though the nutrient numbers may be different than those from A & L Labs, due to the different methods of extracting nutrients from soil.

Most of the numbers on the report are followed by letter symbols that indicate the relative level of that particular nutrient.

VL=VERY LOW, L= LOW, M=MODERATE, H=HIGH, VH= VERY HIGH.

It is not necessary or desirable for all levels to be high or very high. Many of these levels are excellent in the moderate range and some (such as Sodium, Magnesium or Soluble Salts) must be moderate or low to be healthful for the soil and plants. More information about interpreting these relative figures is found under the specific headings that follow.

This booklet is laid out in the same order as the lab report. You may not need to read the entire booklet, but it is important to check to see if a particular nutrient is in balance. Look for the underlined sentences near the beginning of each section.

ACKNOWLEDGEMENTS

We are indebted to the work of Dr. William Albrecht, Dr. E. E. Pfeiffer, Charles Walters, Jr., Carey Reams, Dr. Dan Skow, C.J. Fenzau, Edwin McLeod, Ralph Jergens, Steve Pavich, Russell Derber and others. Some of the technical information for this booklet was provided by the "A & L Agronomy Handbook," "Feed the Soil," "The Nature and Property of Soils," "The Albrecht Papers" and "An Acres USA Primer."

HOW TO TAKE A SOIL SAMPLE

The accuracy of the soil analysis is greatly dictated by the accuracy of the sample that you submit. The lab results are going to more meaningful if you carefully sample the area you want to know more about. When selecting an area for testing, try to get as uniform of a sample as possible.

Soils that vary by texture, drainage, soil type, past cropping history (annuals vs. pasture vs. perennials), tillage vs. non tillage, previous fertilizer or soil amendment practices, contamination, species of native plants or weeds present, etc. are going to vary in their actual nutrient values, and should not be mixed into one composite soil sample. One strategy is doing a composite sample from the "best" soil, and another sample from the "worst". Or sample from as many different areas as will be valuable for you, keeping each significant varied area as an individual composite sample. Never sample from more than 20 acres in a composite sample, preferably a smaller subset.

Sampling depth should be determined by crop. If sampling for crops such as vegetables, or pastures, sample for 0-8" depth. For deeper rooted perennial crops, a series of samples is desirable. Sample from 0-8", 8-18", and 18-36", if possible. Keep these sample depths separate.

Collect a composite sample from the depth desired. A common practice is sample from 10-12 sites with the desired sampling area, removing soil from the entire horizon of the chosen sampling depth. A clean shovel is adequate or you can use a soil probe or auger. Scrape away any weeds, cover crops or grasses before removing any soil. Dig to the desired depth and include soil from the entire depth desired (0-8", or 8-18", etc.) Place the soil in a clean plastic bucket, do not use metal buckets. Do not touch the sample with your hands. After collecting the 10-12 subsamples in the bucket, mix all them together to get as homogenous mixture as possible. Send the lab 1 cup, or more, of this composite mixture.

Do not dry the soils before sending to the lab. Send the sample within one or two days of sampling. Send the samples in paper bags clearly marked with your name and contact info, the sample number or name and depth. You can send the sample via regular ground or USPS transportation; overnight or 2nd day shipping is not needed. If you are sending soil for microbial analysis, check with the lab for specific sampling and shipping procedures.

ORGANIC MATTER (OM)

Organic Matter is defined as all living and decaying residues, including weeds, crop residues, decaying roots, microorganisms and anything which is added to the soil in the form of composts, manures, cover crops, mulches, leaves, etc. These materials all contain many nutrients for future plant growth, including Carbon, which is the most basic food source for the soil's microlife and (indirectly) for the plants themselves. This Carbon feeds the microbes and earthworms, stimulation their activity and increasing their populations.

As the microbes proliferate they in turn act as food for other microbes, which also "mine" the soil for the minerals that the plants need. Carbonic, humic and fulvic acids are secreted by the microbes that "etch" rock surfaces and expose mineral particles for microbe food as well as plant nutrients. The microbes also secrete gum-like substances that help form soil aggregates, thus improving soil structure and the penetration of air, water and roots.

This whole process of Organic Matter accumulation is critical to the formation of topsoil and the growth of crops. It is necessary to have a regular supple of Organic Material for the soil's microlife. This is particularly important in soils that are tilled or exposed, because desiccation by sun and wind causes the loss of Carbon to the atmosphere as Carbon Dioxide (CO_2).

Increasing the Organic Matter content will improve water penetration, water-holding capacity, soil structure, microbial biomass,

nutrient availability, drought and heat stress resistance, resistance to compaction and more. Increasing the soil's Organic Matter content is perhaps the most important single improvement an organic grower can make.

Soils that are below 2% Organic Matter (OM) in the upper horizon are, for all purposes, "dead" in that they do not have essential food (Carbon) to feed the micro and macro organisms that provide all fertility to plants. Soils below 2% OM require fertilization. Soils above 3% Organic Matter, up to a maximum of 10% OM will have adequate food to provide for the needs of most plants.

Raw Organic Matter decomposes, under proper conditions, into Humus. Humus has been "digested" by soil microbes and earthworms, creating a soil-like material with high levels of organic acids (i.e. Humic, Carbonic and Fulvic Acids), and a very high Cation Exchange Capacity (the ability to mobilize Calcium, Potassium, and other cations as plant nutrients).

Humus is full of soil microbial life and acts in much the same way as a yogurt culture of sourdough starter, to increase these organic good guys. Humus also, as a product of the soil digestion process, is a highly concentrated source of plant-available nutrients.

One way to visualize Humus is to think of the difference between raw organic material going into a compost pile and the rich earth-like material that comes out of a finished pile. Humified compost smells like the forest after a rain, rich and earthy aroma, which is the respiratory odor of Actinomycetes, a group of fungal like organisms directly involved in the production of Humus

It is best to add Organic Matter and Humus at least once a year to most soil, more often to soils with very low (under 2%) OM content. The two best, and least expensive, ways to increase the OM are to add compost and to grow cover crops. OM can also be increased with manures and sheet composting, but the results are inferior to those achieved through aerobic composting and cover cropping.

A: COMPOST

PURCHASING OR MAKING GOOD COMPOST

Compost provides available and slow-release forms of all necessary plant nutrients and vitamins. It is also an excellent source of Humus, beneficial soil microbiology, soil buffering (the soil's resistance to radical change), and more. Compost contains significant amounts of plant-available Nitrogen, Phosphorus, Potassium and trace minerals. Compost is an inoculant for the soil of trillions of beneficial microorganisms. One teaspoon of good compost can contain more than 1 billion beneficial microbes.

When making or shopping for compost, quality is more important than quantity. Look for compost that is dark brown, smells like the forest floor after a rain, has no identifiable large materials in it and is low in un-decomposed residues. Compost that is black has gotten too hot and has "burned" thus reducing organic matter, humus and biological activity. Choose a material based primarily on animal manures, is low in wood or rice byproducts and is fully aerobically composted. Avoid municipal and garbage company "composts" as these are usually very poor quality and contain a lot of contaminants.

There are many "composts" on the market that in fact are nothing more than raw organic material. Beware of "compost" made from cedar or redwood as these materials contain substances that can negatively affect plant growth for a long time after their application.

Poor compost can actually set plant growth back as it decomposes in the soil, because it robs essential nutrients such as Nitrogen from the plant and soil until it decomposes fully and become like earth. In addition, poor compost may introduce weed seeds, pathogens, contaminants and other problems that you would rather avoid.

Quality compost, on the other hand, is immediately available to the plant, has no negative effects on the soil or plants, and will make your gardening or farming easier.

For further information, please request our "Questions to Ask Your Compost Supplier" bulletin.

COMPOSTING TIPS

Composting is an art and science, the details of which are beyond the scope of this paper. For further information on making compost please see "How To Grow More Vegetables" by Jeavons, "Rodale's Handbook of Composting," "Designing and Maintaining Your Edible Landscape, Naturally" by Kourik or "Let It Rot" by Campbell. Also I have written a thorough bulletin on composting, available for $10 upon request.

Compost can be improved by the addition of some of the same minerals that may be deficient in your soil. Materials that are appropriate to add to a working compost pile include Soft Rock Phosphate (10-50 pounds per cubic yard of composting material), Greensand (10-100 pounds/yard), Kelp Meal (1-2 pounds/yard), Rock Dusts (10-100 pounds/yard), Azomite (1-5 pounds/yard), Wood Ash (1-2 pounds/yard). Avoid using more than the recommended amount of wood ash, as this can quickly raise the pH too high for healthy microbial activity. These materials should be thoroughly mixed into the pile at the beginning of the composting process. Do not add lime or gypsum to compost piles, as these materials cause nitrogen to be lost during the compost process, and can negatively affect the pH of the pile, thus inhibiting the compost biology process. It is OK to blend lime or gypsum into the finished compost just prior to application.

The composting process will benefit greatly from the addition of a compost inoculant such as Lactobacillus (LAB) culture or Biodynamic Compost Starter. Inoculants provide an active culture of beneficial microbes which speed the decay process of the compost and increase the Humus and microbial content of the finished material. Inoculants are applied as liquid sprays or are watered on, as the compost pile is being made up or turned. Adding some mature compost (up to 10% by volume) from a previous aerobic compost pile will inoculate the new pile with beneficial microbes. Directions for making your own LAB are available from us for $5.

APPLYING COMPOST

If the compost is of good quality, aerobically digested and at or near a completely humified level, it can be safely applied at almost any period of plant growth.

The prime times for compost application are just prior to planting the desired crop or cover crop, or when incorporating (i.e. "turning in") the residues from the previous crop or cover crop. Compost should be worked into the soil where possible, as this will best preserve the nutrients, microbial life, moisture and humus. As this is not possible in perennial plantings, it is best to apply the compost to the soil surface and then mulch with another organic material, or irrigate after application. Keeping the compost moist, and/or protected from sunlight greatly increases the microbial activity and nutrient release rate.

In all cases it is best to apply the compost when the soil is moist or to irrigate immediately after application. This is particularly important to the beneficial microbes in the compost, which are damaged by the desiccation of sun, wind and heat.

Compost can and should be applied along with any other fertilizer or soil amendment that is being used in the soil-building process. The Humus and biological activity of the compost greatly assist the decay process of other fertilizers, rapidly increasing the level of nutrients available to the plant. Compost will also limit leaching of other fertilizers.

COMPOST: RATES TO USE

Application rates for compost are the subject of much debate. Our feeling is that regular moderate applications of compost are the most sustainable soil-building method.

Compost should be incorporated at least once a year, and 2-3 times per year is better. If it is applied this often, there is no need for a large amount at any one time.

When first developing a piece of ground into a garden or farm, use relatively large amounts to build the soil up quickly. If the soil is highly sandy, rocky, or heavy clay, think of compost as a major soil amendment. Heavy doses will make a big difference quickly.

People often apply far more compost than the soil needs, particularly in small garden situations. You never "need" to put on more than 1" layer of good compost and for most situations this is too much, unless you are in the first year of a soil-building program. In a really poor soil, in the first year of application, it may beneficial to double or triple this amount. A 1" layer is equivalent to over 400 tons (approximately 600 yards) of compost per acre. Keep in mind that many successful organic farmers grow excellent, high yielding vegetable crops with 5-10 tons of compost per acre! More is not necessarily better in the case of compost applications.

Quality compost will yield a great plant response when spread ¼" deep (equivalent to about 3 yards (2 tons) per 1000 sq. ft., or 120 yards (90 tons) per acre on vegetable crops. Less is effective and cost effective for farmed annual crops. Rates of 5-20 tons per acre on vegetables are common. For orchards and vineyards use 2-5 tons per acre or 20-60 pounds per mature tree or 5-10 pounds per vine, less on young ones. For flower gardens use the same rates as vegetable gardens. For new lawns apply 1/4-1/2" depth. For renovating existing lawns, apply 1/4-1/2" before coring or aerating turf.

If you have extra compost save it for future crops or other areas. Keep in mind the need to apply the compost at least 2 times per year and you will never have an overload of material at one time. If you over-apply the material you will essentially give the soil a stomachache that will take months to go away, while the soil biology tries to digest the organic material.

B. MANURES

All forms of animal manures can be used to build your soil. Manures can be a source of macro and micronutrients, Organic Matter and beneficial soil microbes. It is best to turn the manure into compost before application. Aerobically composted manure is far superior to raw or undigested manure for the following reasons:

1) Raw manure cannot be utilized as nutrients by plants until it is converted to Humus by soil and compost microbes. This decay process ties up certain minerals in the soil, causing a temporary but significant reduction in available nutrients, especially Nitrogen. A Nitrogen deficiency can highly impact rapidly growing plants. The deficiency is magnified if the manure has been mixed with something high in Carbon, such as wood shavings, sawdust, straw, or rice hulls (all common manure contaminants). The problem gets worse when large amounts of raw manure are added to the soil.

2) Heavy applications of poultry (chicken or turkey) manure can cause an oversupply of "hot" Nitrogen which can burn plant roots, until it is fully decomposed by soil microbes.

3) Raw manure can carry soil contaminants such as pesticide residues, unwanted salts, soil and human pathogens, weed seeds, antibiotic residues, etc., which can give your crop or humans problems.

4) When large amounts of raw manure (or other raw organic material) are worked into or laid on top of the soil, there is a definite risk of increasing some species of pest insects. Raw manure acts as a food source for sowbugs, slugs, snails, garden centipedes (symphyllans) and earwigs. After they consume much of this raw Organic Matter they will grow to a large population that will then search for other things to eat, especially your crops! Centipedes and symphyllans can also increase to crop-damaging levels. Both of these organisms feed on the roots of growing crops and stunt their growth.

All of the problems of manures can be eliminated, or greatly reduced, by composting. Manure makes an excellent addition to the compost pile in nearly any amount. In order to receive full benefit from the manure, compost it aerobically.

There are no proper application rates for raw manure, but if you use it, never apply more than a 1" layer at a time. Certified organic regulations require that any application of raw manure must be done 90-120 days before the harvest of the crop, the length of time determined by the crop harvested.

C. MULCHES

Mulches can be described as (usually) organic materials that are placed on the top of the soil to provide a blanket effect. A good mulch will increase the soil's water-holding capacity, reduce evaporation, keep the soil structure soft and open, increase the Organic Matter content, suppress weeds and provide slow-release nutrients. Mulches are generally applied during the warm and active growing season to help keep soil temperatures in balance and reduce stress to the crop.

Mulch is applied from ½ to 6" deep. The deeper the layer, the greater the effect of the mulch on soil building, temperature regulation, water loss and weed suppression. Raw manures are sometimes laid on top of the ground as mulch (1/2" to 6"). This technique can work well for perennial plantings, but keep in mind the above drawbacks of using raw manures.

Other materials that are used for mulching include compost, straw, hay, clippings, leaves, grasses, weeds, wood products, etc. Wood products (chips, sawdust) may reduce the amount of available nitrogen for the crop mulched. Do not incorporate wood products into the soil.

Keep in mind that raw organic matter can increase populations of pest insects, or reduce nutrient availability (See #4 above). These critters love mulches. Quality aerobic compost is far and away the best mulching material. Also be aware that mulches can hide the action of gophers, moles, voles, mice and other critters.

D. HUMATES and HUMIC ACIDS

Humates are a geologically composted form of Humus. They are found in the earth in conjunction with coal deposits.

Humates generally have a very high Cation Exchange Capacity, and can make a quick improvement in the soil's ability to provide plant-available Cation minerals (such as K, Mg, and Ca). Humates are also an excellent source of the organic acids, humic and fulvic acid, which will increase the availability of most nutrients. In addition, Humates act as a food source for soil microbes and increase their activity.

There are a number of Humate materials in the marketplace. We have had the best results with the "soft" humates from New Mexico. Rates of application are 1-2# per 100 sq. ft. or 400-500 pounds per acre. This can be broadcast or banded on the soil and incorporated. It can also be applied to the surface of a "no till" or permanent planting, but the reaction time will be longer. *Humates are economically justifiable on any soil with a CEC (Cation Exchange Capacity) below 15*. Soils with high pH, high sodium or other high salts have often benefited from on-going humate applications. Humates are not a replacement for good soil organic matter management, but are a very effective supplement.

Humic Acid Derivatives (HAD), often called liquid humic acids, liquid humates or just humic acids, can be a very effective temporary addition for crops. These are usually applied in irrigation water at rates of 1-5 gallons per acre, often 3-5 applications pre crop. They are also used as a seed soak or seed dressing prior to planting. Note that Humic Acid products vary greatly in composition and effect, and are regulated under the National Organic Program. Get advice before buying humic acids.

E. COVER CROPS

Cover Crops are our favorite method for building the soil's Organic Matter and Humus content. All soils must have a cover crop in their rotation to affect a truly sustainable agriculture. There is a season for a cover crop on every garden or farm.

The principle reasons for planting a cover crop are:

1) To provide erosion protection.

2) To build the soil's Organic Matter and Humus content and improve the structure of the topsoil and subsoil. To increase the microbial activity and biomass in the topsoil. To provide food for the soil microbes and earthworms which are so vital to plant health.

3) To provide competition for, and suppression of, fall, winter, spring or summer weed growth.

4) To increase water infiltration from rainfall and irrigation. In standing water areas and in heavy soils, to increase Oxygen content and improve drainage. In lighter soils to increase water holding capacity.

5) To recycle, increase and conserve nutrients. Cover crops extract nutrients from the subsoil and deposit them in the topsoil, increasing their availability for subsequent crops. Legumes cycle Phosphorus, Sulfur and other nutrients, and increase available Nitrogen. Grasses and broadleaves forage for nutrients in the topsoil, preventing loss by leaching and accumulating those nutrients in their tissue, particularly nitrogen, for use by subsequent crops.

6) To provide habitat, prey, nectar and pollen for beneficial insects and mites. The blooming periods of most covers are tremendous stimulants for beneficial insects, particularly Lacewings, Big Eyed Bugs, Predatory Mites, Ladybugs, Syrphid Flies, Minute Pirate Bugs, Anagrus and many other Wasps, and Spiders, as well as hundreds of other good guys. They provide nectar and pollen for bees.

7) To provide aesthetic value and color. A bright, lush green cover crop is definitely more attractive than the bare ground!

8) The roots break up the subsoil, clay layers and plow soles for increased water and air penetration, improve biological activity and crop growth.

9) Cover crops can be grazed, or harvested for hay or green chop. Their soil building qualities may be reduced, but they can be a superior feed.

CHOOSING A COVER CROP

COVER CROPS FOR COOL WEATHER

Winter annuals are often used for cover cropping because they make maximum use of the winter and spring rains, and reach their peak before the garden or farm space is needed to grow spring and summer crops.

Best results come from mixtures of compatible species of cover crops. A mixture increases the potential for successful germination and growth, diversifies rooting depth and beneficial insects, increases total biomass, extends nutrient release and makes maximum use of cropping space. Mixtures may contain 2-7 species, sometimes more.

For example, vetch/pea/oat mixtures are used with excellent result in orchards and vineyards because they are vigorous, compete well with weeds, fix Nitrogen, grow quickly, can be mowed to increase regrowth and Organic Matter, and reach their peak in March through May, depending on the climate and rainfall. They are also excellent predator habitats and will reduce the incidence of many pests.

Other good Fall/Winter cover crops include Bell Beans, Fava Beans, Austrian, Magness, Biomaster or Dundee Winter Peas, Purple and Lana Vetch, and White Lupine. For maximum biomass and Nitrogen fixation a mixture of bell beans, vetch, peas and oats are commonly used. In climates dropping below 10°F a mix of ryegrain and Lana vetch is used. Nematicidal mustards are commonly added to mixes in any soil with nematode pressure. Daikon radish is used to improve soil structure and open up the subsoil, with its large root.

All legume cover crop seeds (beans, peas, clovers, vetches, alfalfas, etc.) *must* be inoculated (coated) with the proper strain of Rhizobium bacteria to insure Nitrogen fixation. Inoculation is not difficult or expensive, and is *well* worth the effort. Purchase fresh, specific Rhizobium inoculant from your seed supplier. It comes mixed in peat moss, and is sprinkled onto and mixed with the seeds immediately prior to planting. Organic growers should be aware there are some genetically engineered legume inoculants that are not allowed in certified organic production. Ask your supplier.

COVER CROPS FOR HOT WEATHER

Summer covers can be grown in rotation with spring or fall crops, or as a quick catch crop, with the aim of building fertility, suppressing weeds and attracting beneficial insects. Best choices for vegetable gardens and farms, or open field soil improvement include legumes such as Cowpeas, Sesbania, Crotalaria or Soybeans, or non-legumes such as Sudangrass and annual buckwheat. In cooler climates such as high elevation or coastal a mixture of Sudangrass and purple vetch works well. All of these species are frost sensitive and require irrigation or rainfall.

COVERS FOR NON-TILLED CROPS

Perennial crops such as grapes, nuts and fruits may benefit from non-tillage. This is site and crop specific. If you choose non tillage, make sure to plant mixtures of low growing legume species such as New Zealand White, Strawberry, Berseem, Rose or Sub Clovers, or Alfalfa. Low growing perennial grasses may be mixed in with legumes but keep the grasses under 25% of the mix, except on extreme slopes where more grass will be needed for erosion protection. These covers are usually maintained for many years and do not require annual incorporation; mowing or grazing are used to manage their growth.

INCORPORATING (TURNING UNDER) THE COVER CROP

When the legumes in cover crop mix reach full bloom, it is at its greatest soil building potential, both in organic matter and nitrogen fixation. If turned into the soil at this point, it will be decomposed rapidly by the soil's microbes, and will contribute the maximum amounts of organic matter, Nitrogen and other nutrients to the soil for the next crop. Waiting until the cover crop dessciates or dies reduces the amount of organic matter and nitrogen to the soil and makes incorporating the cover much more difficult.

Covers can be incorporated into the soil by disking, rototilling, spading or forking. If the cover crop is shredded with a mower, weed-eater or scythe prior to incorporating, it will incorporate easily and break down into humus faster, releasing nutrients quicker. To maximize the benefit from the cover, it must be covered by soil within 4-6 hours of shredding, preferably sooner. The longer the cover is exposed to sun desiccation the greater the loss of nitrogen, carbon and moisture, and the harder it will be to incorporate.

The best way to speed up Humus-building decomposition and nutrient release is to spray or sprinkle the cover crop with a microbial inoculant, just prior to working it into the soil. A microbial inoculant is a culture of plant-decomposing bacteria and fungi. Commercial products are available including BD Field Spray. I have had excellent success using compost tea prior to incorporation. Use 1 gallon of tea per 1000 sq. ft., diluted in 10 gallons non-chlorinated water (or 40-50 gallons per acre in 100-200 gallons of water). If you would like to brew your own compost tea please request our technical bulletin on building your own tea maker and compost tea recipes. $10

Another strategy to add decomposing bacteria and fungi is to apply a light application of compost just before or during the incorporation process.

If it is too difficult for you to turn the cover crop under, an option would be to cut the cover at ground level and put the tops into the compost pile to break down. Then till or spade the roots. As with any composting, a compost inoculant, or compost tea, will enhance decomposition. Get the cover crop into the compost pile as quickly as possible to conserve nutrients, organic matter and water.

EST. NITROGEN RELEASE (ENR)

Nitrogen (N) is released from Organic Matter and Humus by the actions of soil microbes. The higher the Organic Matter and Humus, the more N is available in the soil. The ENR is an estimate of the amount of N per acre that will be released by the microbes over a growing season. This amount can vary greatly based on soil temperature, biological activity (or lack of it), soil moisture and the ability of the soil's organic material to release N through biological decay. Soils that have been amended with high levels of carbonaceous materials (i.e. sawdust, wood chips, straw, hay, leaves) will release the N very slowly, if at all, until the soil microbes have digested the Carbon. Green manures, incorporated while still green and lush, will release their N fully and quickly.

When soils test at 3-5% Organic Matter, most crops will receive adequate N over the season, requiring only small supplementation with outside sources. Heavy feeding vegetables may require additional N fertilization.

The ENR of a healthy soil will be between 125-300. Soils below this level will require supplemental Nitrogen for additional N supply (see ahead).

PHOSPHORUS (P)

The soil Phosphorus level is the most important factor after Organic Matter and Humus levels. When the most fertile soils in the world are analyzed, the levels of Humus and Phosphorus are always superior.

P controls and activates plant roots, fruit bud formation and flowering, as well as the processes of cell division and sugar formation in the sap. Sugar levels regulate the plant's resistance to insects, disease and cold, and determine the crops eating and keeping qualities. P also impacts the N fixation and growth of legumes, the formation of seeds in all crops, crop maturation, and more.

The lab measures P in two ways. The P_1 is the plant-available form of P, and will be used by the crop immediately. The P_2 is the reserve form which is unavailable to the crop, but which becomes available (converts to P_1) by the action of the soil microbes. P_1 and P_2 levels in the soil are constantly changing due to the action of the microbes.

The majority of soil P is held for the plant's roots in the Humus. The higher the Humus, the greater the available P. P availability is also greatly affected by the soil pH, which should be maintained between 6.0 and 6.5 (see pH Section, ahead). If pH levels are outside this range, the soil may require supplementation with P, even though the soil test may show adequate levels.

When growing winter crops, the cold soil temps reduce the biological activity and thus reduce the plant availability of P. Winter crops often require P supplementation. Applying additional microbial activity in the form of compost teas or Lactobacillus sprays will increase the P mobilization in cold soils.

Most soils for vegetables and flowers should have a least 40 PPM of P_1. Some vegetable crops require more than 60 PPM. Grains can get by with 20-30 PPM, but the yield and quality will increase when above 40 PPM. Fruits, grapes and berries should have at least 40 PPM. Nuts should have 30+ PPM. Pastures and lawns should have at least 30 PPM.

The P_2 level should be at least 60 PPM for all crops. There are no toxic levels of P, though no increase in crop response is noted in soils above 60 PPM.

HOW TO INCREASE PHOSPHORUS

The best way to increase the available P level is to increase the Organic Matter and the Humus. Compost and cover crops are the most efficient ways to do this. Composts made from bird manure such as chicken or turkeys are the highest in P; cow and horse manures are low. Adding P materials such as soft rock phosphate to the compost pile greatly increases P content and availability.

All legume plants help cycle P by pulling it up from the subsoil, concentrating it in their bodies, and leaving it near the surface in plant-available form when they die or go dormant. Buckwheat is not a legume, but is an excellent accumulator of P. However, there must be adequate reserve P_2 in the soil for these plants to capture and accumulate P.

Mycorrhizal fungi have an important role in phosphorus uptake. Myco fungi increase the effective rooting area of the plant by up to 500 times the visible root mass. Theses extra "roots" are very efficient at extracting P from the unavailable P in the soil. Inoculating the crop with mycorrhizae has proven to be a cost effective practice, particularly in low P soils. Myco fungi provide many other benefits as well, including producing probiotic compounds that prevent soil pathogens from colonizing the crops roots. Inoculation can be done at time of seeding, in seedling starting mixes, as a root dip at planting, or applied directly into the soil at time of planting perennials.

ORGANIC PHOSPORUS MATERIALS

P is very immobile in the soil and generally not water-soluble. If a soil is low in P, it is wise to put some P into the subsoil when planting all perennials. This will stimulate the root activity and subsequent plant growth. If working with deep beds, etc., incorporate the P thoroughly so that the roots will come into contact with it quickly.

Composts and manures contain some phosphorus and should be taken into consideration when determining the need for additional supplementation.

The best fertilizer for raising soil P is Soft Rock Phosphate (aka "Colloidal Phosphate" or "Soft Phosphate"). This fine powder contains up to 20% P, as well as Calcium and many trace elements that the plant and soil will utilize. Use from 250-2000# per acre (1/2-5#per 100 sq. ft.).Use 250-500# per acre (1/2-1# per 100 sq. feet) if the P_1 level is
30-50 PPM. Increase the application rate to 750-1000 pounds per acre (2-3# per 100 sq. ft.) if P1 levels are between 20-30 PPM. Use the maximum rate if the P1 level is below 20 PPM.

Soft Rock Phosphate should be broadcast over the soil and worked in where possible. Soft P can also be banded under the plant row. It will not burn plant roots. Applying soft P with compost or compost tea increases the release rate of the phosphate.

In no-till situations, broadcast Soft Rock Phosphate on the surface, and plant legumes or Buckwheat to move the P down into the soil in the crop available form.

Generally one application of Soft P at the above rates will be adequate for 2-3 years, longer if compost and cover crops are added regularly.

Another option for P is Bone Meal, which is an excellent source, but considerably more expensive than Soft P. Rates to use and application methods are the same. Bone Meal is slightly more available to the plant than the Soft P, especially in cold soils so some growers use equal amounts of each. Bone Meal outperforms Soft P in greenhouses, cold frames, seedling mixes and small containers.

Seabird and Bat Guano are soluble, rapid acting and expensive forms of quickly available P, and are used when an immediate supply of P is needed. They can be top dressed, sidedressed or applied in a liquid form as a fertigation or foliar feed.

In some cases it is necessary to supply P immediately, with liquid feeding (fertigation) or foliar feeding. Hydrolyzed fish solubles and spray dried fish powder contain some soluble P. Higher levels are found in High P Bat or Seabird Guano. These materials can be mixed with water and applied as a side dressing or foliar fed to the plants. See foliar feeding for more information.

The application of compost tea or compost will increase the release rate and results with any applied P fertilizer.

POTASSIUM (K)

Potassium (aka "Potash") is important for increasing crop resistance to disease, and for stimulating rooting activity, photosynthesis, starch formation, translocation of sugars, chlorophyll production and more.

Potassium is a positively charged ion (Cation) that binds to clay and humus in the soil, where it is held for the uptake by plant roots. The higher the concentration of humus and clay in the soils, the greater the availability of potassium, and all other cations. See Cation Exchange Capacity (ahead) for more information.

The lab report indicates the quantity of the available form of Potassium, K_2O. Most soils contain high levels of total Potassium (K), but in forms that the plant cannot absorb. A primary challenge in an organic growing situation is to "liberate" the soil's fixed, unavailable K and convert it into the plant-available form K_2O. This process takes place very slowly in soils and is greatly influenced by soil texture, Organic Matter level, soil oxygen content, aerobic microbial activity, soil temperature and soil structure. Loose, non-compacted soils with liberal amounts of Humus are rarely low in available K. Clay soils are often high in available potassium. Soils without these attributes require good management to improve the available K.

<u>The available K should be at least 250 PPM for most annual crops, with 350 PPM for highest-yielding vegetable and root crops. Perennial crops should be between 200-300 PPM K_20</u>

HOW TO INCREASE POTASSIUM

Increasing the Organic Matter and Humus will have a dramatic impact on the K status. Improved soil structure (through reduced tractor or human compaction, raised aerobic beds, double-dug beds, additional Organic Matter, etc.) is the cheapest and best fertilizer there is! Shallow cultivating a soil mixes air into it and stimulates aerobic microbes that release potassium. Growing cover crops and applying aerobic compost will greatly increase available K. These remedies take months and may not correct very low potassium within one season, but are well worth the effort.

ORGANIC POTASSIUM MATERIALS

Some situations warrant the addition of potassium fertilizers. Root crops, particularly potatoes and carrots, often respond to additional K as fertilizer. If the soil test indicates between 50-150 PPM K_20 and you are growing root crops, liberally apply composts made from animal manures (excellent sources of K)

You can use wood ash, which contains up to 50% K_20, plus other minerals. CAUTION! It is *very* easy to overdose the soil with wood ash. Too much ash will sterilize a soil! Recommended rates are 1# per 100 sq. ft. annually (400-500# per acre) if the soil tests at 100-150 PPM. Above 150 PPM use half the above rate. The ashes can be surface applied or worked in. Do not put wood ash near germinating seeds.

For farmers and market gardeners, a cost-effective K supplement is mined Sulfate of Potash (aka Potassium Sulfate), which contains 50% K_20, as well as 18% Sulfur (SO_4). This material is quite concentrated and quickly available to the plant and should be used at low rates. If the soil test is below 150 PPM add 300-400 pounds per acre (1 pound per 100-150 square feet). Soils testing at 150-300 PPM need 100 to 150 pounds per acre (1# per 200-250 sq. ft.). Soils testing above 350 PPM need no additional Potassium. Use standard grade Potassium Sulfate for soil building, solution grade for quick response (see Fertigation, below).

If the soil is deficient in potassium *and* magnesium, the appropriate material is Sul-Po-Mag (22% K_20, 22% SO_4 Sulfur, 11% Magnesium). Broadcast application rates of 350-500 pounds per acre (1 - 1 ½ # per 100 sq. feet) if K_20 is below 150 PPM. Use 200-300 pounds per acre if soil is 150-250 PPM. Use 100-150 pounds per acre over 250 PPM.

Kelp Meal (not kelp extract powder) or Azomite are good sources of K for gardeners, as well as a broad spectrum of other elements, growth hormones, vitamins and more. These materials greatly stimulate earthworms and microbes. If soil is below 150 PPM use 2-3# per 100 sq. ft. (800-1200# per acre), broadcast and worked in. Above 150 PPM, use half that rate. Add to a working compost pile at 2-3# per cubic yard.

An excellent supplement to good soil K, is regular foliar feeding with liquid Kelp Extracts, which contain about 2% K_20, in a quick uptake form. Rates are 2-5 Tbs. per gallon of spray. Foliars will not make up for poor soil practices, but can increase the crops uptake of multiple elements in the soil, as well as provide direct nutritional support to the plant.

Fertigation is a popular method to provide quick potassium, and other nutrients. See the Fertigation section (ahead).

REDUCING EXCESS POTASSIUM

If your soil contains more than 350 PPM Potassium there is a potential for a toxic Potassium condition. K in large amounts can be toxic to soil microbes and plants. Suggested remedies for this problem:

1) Do not add any more K! Eliminate the use of wood ash, potassium fertilizers, manures, or other known high K sources. Compost will still be beneficial, even if it contains substantial K. Avoid using raw manures!

2) Add Gypsum to the soil surface or irrigation water. Gypsum with water will leach excess Potassium out of the topsoil and below the crop root zone. Because Gypsum is highly mobile in water, it may be necessary to apply Gypsum more than once a year to detoxify the soil quickly. For ground application use standard grade gypsum at 5# per 100 Sq. Feet (1 ton per acre) per application. You may apply up to 4 times per season. Broadcast the Gypsum on the soil surface and water thoroughly. If using solution grade gypsum, apply maximum of 500 pounds per acre (2½ pounds per 100 sq. feet) per application, up to 4 applications per season

3) Grow crops with uptake a lot of K, such as corn, Sudangrass or potatoes.

MAGNESIUM (Mg)

Each molecule of chlorophyll produced in the plant leaf is built around a single atom of Magnesium. As chlorophyll is essential for photosynthesis, Magnesium plays a very important role in crop production.

Most soils in the Western U.S. contain adequate to high levels of Magnesium. A deficiency is rare, but possible. There are a number of areas in the high-rainfall East where Magnesium can be deficient.

Magnesium is a cation (positively charged) element that binds closely with clay and Humus. Soils that are high to excessive in Magnesium can be described as clays, gumbos and adobes. Magnesium is the element that binds clay together. Clay that is used for pottery is extremely high in Magnesium. Something that is good for pottery lacks porosity and is death to soil microbes and plants.

An overabundance of Magnesium can cause Phosphate, Calcium, Potassium and Nitrogen deficiencies. High Magnesium and low Calcium levels cause Organic Matter residues to decay into alcohol, a sterilant to bacteria and other soil microlife. High Magnesium may cement clay soils tightly together, creating a crust that excludes Oxygen, preventing water retention and proper insoak or capillary return during dry spells.

As stated earlier, deficiencies of Magnesium are rare.

If your soil tests higher than 150PPM magnesium there is adequate Magnesium available. Virtually all soils contain much more Magnesium than indicated on the soil test.

If the test indicates VH (Very High) or if levels are above 300 PPM you should take corrective action to minimize the negative effect of too much Magnesium.

HOW TO DECREASE MAGNESIUM

The best remedies are to add Humus and compost, grow cover crops, and add mined Gypsum at least twice a year. Gypsum (a source of Calcium and Sulfur) can be broadcast on the surface and irrigated in. Or you can use solution grade gypsum mixed with irrigation water to speed the process. If your soil can be described as clay and your soil test has very high Magnesium numbers, apply standard mined Gypsum at 2 tons per acre (10 pounds per 100 square feet) twice the first year, with annual applications thereafter of one ton per acre (5 pounds per 100 square feet), followed by a complete irrigation or substantial rainfall. Solution grade gypsum is typically mixed into irrigation water with a specially designed machine, and then watered into the soil. Typical application rates are 250 pounds per acre per irrigation, up to 4 applications per irrigation season. For further information on Gypsum, see the section on Calcium.

HOW TO INCREASE MAGNESIUM

In the unusual event that your soil tests at L or VL, the simplest remedy is the application of Dolomite (a source of Calcium and Magnesium). Use light rates to avoid creating a toxic level of Magnesium. Never apply more than one ton per acre (5 Pounds per 100 sq. ft.) per application. It would be better to use half this amount and to apply it twice, 6 months apart. Do not apply Dolomite more than one year without re-checking your soil via a test. It is easy to use too much Dolomite. For more information on Dolomite see the Calcium section.

If the soil is deficient in potassium *and* magnesium, the appropriate material is Sul-Po-Mag (22% K_20, 22% SO_4 Sulfur, 11% Magnesium). Broadcast application rates of 350-500 pounds per acre (1-1½# per 100 sq. feet) if K_20 is below 150 PPM. Use 200-300 pounds per acre if soil is 150-250 PPM. Use 100-150 pounds per acre over 250 PPM.

CALCIUM (Ca)

Calcium is the most important element for soil structure, aerobic microbial activity and cell building in the plant. It is associated with the development of protein, assists root development, movement of carbohydrates, cell wall formation, seed production, disease resistance, insect resistance and other important plant processes. Soils that are low in available Calcium are said to be “tight,” “sticky” or “hard to work” and tend to have poor structure, water absorption, and water-holding capacity. Low calcium soils commonly have surface crusting, cracking and numerous “bad” weed species problems

A shortage of available Calcium severely limits the soil’s microbial activity and ability to create Humus and plant available nutrients. Low Ca can result in mite and insect infestations, weather stress, reduced biological Nitrogen fixation, increased susceptibility to foliar diseases (such as mildew and Botrytis), poor water infiltration and more. The Brix and keeping quality of crops low in calcium is poor. Low calcium crops lack flavor and “crunch”.

Soils low in Calcium and high in Magnesium tend to be exceptionally tight and low in air and microbial activity, with consequent plant stress, particularly in the root zone. Calcium is the main element in each cell, and a shortage of Ca will cause poor plant growth, fruit density, small clusters, flower abortion, poor set, etc.

Calcium is a cation (positively charge ion) that is held in the soil on the clay and humus colloids. The higher the CEC of the soil the greater Calcium holding capacity, and increased Calcium availability to soil microbes and the

crop. Calcium is a highly mobile element that quickly leaches out of soils low in Organic Matter and microbial activity, and is utilized in large amounts by plants, particularly high yielding crops. High rainfall and irrigation with Calcium-poor water can increase the deficiency.

Most fields will respond to low rates of Calcium fertilization. Severely deficient soils require higher rates, applied annually or semi-annually until the levels are corrected. 95% of all soils will require some Calcium applications in the first 1-3 years of soil building.

HOW TO INCREASE CALCIUM & CHOOSE THE PROPER MATERIAL

The practice of adding Calcium is often called liming, because Ca deficiencies often (but not always) show up with low pH, and lime raises both pH and Ca levels. However, lime is not the only choice for correcting low Ca. To determine the appropriate Calcium material to apply, first look at your soil pH.

If the pH is less than 7.0 and the Calcium is below optimum but the Magnesium is adequate (above 150 PPM) the material of choice will be Oyster Shell Flour Lime or high Calcium Mined Limestone. Both these materials contain primarily Calcium Carbonate, a source of Calcium and Carbon.

If the pH is below 7.0 and both the Calcium and the Magnesium levels are rated as Low or Very Low (a very rare occurrence), use Dolomite (a mined material rich in Calcium & Magnesium). 99% of Western soils do not need Dolomite, although there is an occasional exception to the rule.

If the pH number is 7.0 or higher the best Calcium material will be mined Gypsum (composed of Calcium and Sulfur). Gypsum is not a lime and will have minimal effect on pH, which, in the case of 7.0 or higher pH, you do not want to raise. See pH below for more information.

Note: "Acid loving" crops such as rhododendrons, camellias, azaleas, and strawberries are actually acid tolerant. They will grow fine in a soil up to 7.5 pH if adequately supplied with Phosphorus, Nitrogen, Sulfur and trace minerals. When growing acid-loving plants, use Gypsum to correct Calcium deficiencies. Blueberries should be grown in an acid soil condition with a pH of 5.0-5.5, and will need sulfur applications on most western soils.

HOW MUCH CALCIUM TO APPLY

Once you have selected the appropriate Ca source for your Ca situation, use the following procedure to determine how much to apply (the application rates will work for any of the materials discussed above).

First, find your Cation Exchange Capacity (CEC) and your Calcium reading. Next see the chart below. Locate the CEC that corresponds with your soil test. Then look at the optimum Calcium level. If your soil Calcium level is below the optimum, subtract your level from the number on the chart. Take that remainder and multiply by 4. This will give you the amount of Calcium to apply per acre. For smaller areas, divide the per acre figure by 400, to find the amount of Calcium necessary per 100 Sq. feet.

Example: Your soil has a CEC of 13.3 Round that off to 13. Looking at the chart, you will see the optimum Calcium level is 1690 PPM. Your soil test reads 1400 PPM of Calcium.

1) 1690 (optimum) – 1400 (your level) = 290
2) 290 x 4 = 1160 lbs. of Calcium per acre (round off to 1200 pounds per acre)
3) 1200 divided by 400 = 3 pounds of Calcium per 100 sq. ft.

If the final figure is greater than 4,000 pounds per acre (or 10 pounds per 100 sq. feet) it is best to apply half the material at one time, with 3-6 months between applications. See below.

If your soil report indicates a number higher than the optimum on this chart, there is no need to add any Ca. Soils with excess Calcium levels may have problems with availability of trace minerals. Add compost and Soil Sulfur if trace

mineral deficiencies appear in the plants. See Sulfur for further information.

SOIL CEC	OPTIMUM CALCIUM (PPM)
30	3900
29	3770
28	3640
27	3510
26	3380
25	3250
24	3120
23	2990
22	2860
21	2730
20	2600
19	2470
18	2340
17	2210
16	2080
15	1950
14	1820
13	1690
12	1560
11	1430
10	1300
9	1170
8	1040
7	910
6	708
5	650
4	520

APPLYING CALCIUM TO THE SOIL

It is better to apply small amounts of Calcium annually or biannually than to use large amounts sporadically, as Calcium will leach down below the crops roots with rainfall and irrigation.

Calcium should be broadcast prior to incorporation. Incorporating Calcium into the soil when tiling or digging will cause the fastest reaction and soil improvement. Calcium can also be applied on the surface in "no till" or permanent plantings, although the reaction time will be slower.

No matter what the application method, try to spread the material as evenly as possible. An over-application of Calcium can be more detrimental than no application at all. Do not add Calcium to the planting hole of a perennial. Always spread it on the surface. MORE IS NOT BETTER!!!!!

You can also mix Calcium materials with your compost after the compost is finished. Mix in the Calcium just prior to applying the compost to the soil. Mixing calcium with compost causes loss of Nitrogen to volitization, and should done immediately prior to application to avoid significant loss of N.

Calcium can also be applied via fertigation. Calcium is often applied as a foliar nutrient, although this does nothing for correcting the soil needs, only addresses the immediate needs of the crop. See foliar feeding ahead.

SODIUM (Na)

Sodium is an essential element for plant growth, but is never found deficient in the soil. Excessive Sodium is the most common problem. High levels of Sodium cause plant health and microbial problems, and very high levels cause soil sterilization and plant damage or death. High sodium limits the penetration and availability of water to crops.

Sodium is a cation (positively charged ion) that attaches itself to the clay and humus sites in the soil and negatively competes with the other Cations for crop uptake.

The test level should be below 100 PPM. Levels under 100 PPM generally have no problems with Sodium. Soils above 100 PPM may have problems depending on the Organic Matter content and the crop grown. Orchard crops, strawberries and vineyards are sensitive to excess Sodium. Soils above 150 PPM need corrective action.

The higher the Organic Matter, the lower the risk of Sodium toxicity. Increase the Organic Matter if the Sodium reads above 100 PPM. Be careful to use organic matter sources low in Sodium. High sodium irrigation water should be

treated with SO_2 and/or solution grade gypsum in the irrigation water.

Soils above 150 PPM should follow the directions below to leach the excess Sodium from the soil.

HOW TO LOWER SODIUM

1) Do not add any salty materials. Many problems have been caused from the over use of salty manures or other materials excessive in Sodium, especially salty water.

2) Increase the Organic Matter. Most soils with high Sodium also have low OM, which compounds the problem, as OM acts as a buffer for excess Na. Cover crops are the best way to improve this problem. Sudangrass is particularly salt tolerant. Humates have also proven valuable in these high stress situations. Humates should be applied at 1-2# per 100 sq. ft. (400-800# per acre).

3) Leach the excess Na with Gypsum and low salt water. Use 5# of standard grade Gypsum per 100 sq. ft. (1 ton per acre) Severe high sodium soils use double this rate. Broadcast on the soil and leach in with low salt water. Apply at least twice within the next year. Four applications at the above rate would be better.

4) Increase the soil microbiological activity by inoculating the soil with Sodium-eating microbes. These microbes occur in aerobically digested compost and may be increased by using a high quality microbial inoculant. Compost teas made from high quality, low sodium composts will inoculate the soil with beneficial sodium digesting microbes.

5) Fertigation with solution grade gypsum and humic acids is proving very effective. Application rates of 250# solution grade gypsum and 1-2 gallons of high quality humic acids per acre, applied 4-6 times per crop are common.

SOIL pH

The pH is a general indicator of the balance between the soil acidity and the cation elements Calcium, Potassium, Magnesium and Sodium. The test measures the amount of active Hydrogen in the sample. The pH has a dramatic impact on plant growth and soil microbial activity. Balanced pH is essential to good crop growth.

The pH is changing constantly, even influenced by the waxing and waning of the moon as it moves water through the soil. The lab test indicates where the pH was at the time of sampling. But it is a good indicator of the trend of the soil. A pH of 7.0 is neutral. Below 7.0 the soil is considered acidic; above 7.0 the soil is alkaline.

Most plants, and beneficial soil microbes, grow best when the pH is between 6.0-6.5, slightly acidic.

Generally soils that are low in Organic Matter or are in high rainfall areas tend to have a low pH. A soil with a pH below 6.0 usually requires the addition of one of the cation elements to raise the pH to the desired level. Calcium is the most commonly added Cation. See Calcium for further information.

Increasing the Organic Matter/Humus will raise a low soil pH over a period of time or eventually acidify a high pH soil. OM beneficially adjusts pH imbalances, but can take years of applications to affect a needed pH change. Usually quicker actions are needed, and require more additions than just organic matter.

Soils above 7.0 pH (alkaline) have an excess level of one of the cations calcium, magnesium, potassium or sodium (salts). Reducing the toxic levels of that element will lower the soil pH and bring the microlife into balance, and the crop will grow much better. We suggest the use of Gypsum, Soil Sulfur and/or increased Organic

Matter to lower the pH. See the specific cation sections for further information in reducing excess levels.

HYDROGEN (H)

All soils which have an acid pH (less than 7.0) contain mobile Hydrogen. It is desirable to have some mobile Hydrogen, which often comes in the form of water, for the use of the soil microbes and plant growth. There is no significant method of adding Hydrogen to a soil. The best strategy is to obtain and maintain a slightly acid pH between 6.0 – 6.5 for Hydrogen activity of .5 to 1.5, which will be optimum for most plants and soil microbes. See the section on soil pH for more details.

CATION EXCHANGE CAPACITY (CEC)

Cations are positively charged minerals in the soil, primarily Potassium, Calcium, Magnesium and Sodium. These cation minerals are stored, mobilized and delivered to the plant's roots as available nutrients, by interaction with the negatively charged particles of clay and Humus in the soil, known as "exchange Sites". This phenomenon is called Cation Exchange, and a soil's concentration of these "exchange sites" is known as the Cation Exchange Capacity (CEC). CEC is influenced by the quantity and quality of clay and Humus in the soil. The higher the CEC, the more clay and humus are present, and the more cation minerals are available to the plants and the soil microorganisms.

The CEC, measured in milliequivalents per 100 grams, runs from 0 (pure sand) to 100 (pure Humus). Quality soils have CEC's from the high teens to the mid 20's, with the best soils in the upper 20's to low 30's. High quality compost ranges between 50-75 CEC. Soils below 15 are weak, with little microlife and nutrient exchange ability, and will benefit from increasing the CEC.

Plant growing in low CEC soils may exhibit nutrient deficiencies, even if the soil analysis indicates adequate levels, because the lack of exchange sites keeps the roots from getting adequate Cation nutrients (particularly Potassium and Calcium).

Soils with a CEC below 15 have little capacity to "hold" the cations and prevent their leaching. In these soils it is necessary to "spoon feed" any cations that are low, since large applications will leach out of the soil before the plants and microbes can make use of the nutrient.

CEC is strongly affected by the Organic Matter content in the soil because Organic Matter decomposes into Humus. Humus is a highly charged, highly concentrated, soil-like substance that provides the soil and plants with many benefits, including cation exchange sites.

The best way to increase the CEC is to raise the Humus content of the topsoil. The best materials for this purpose are high-quality compost, cover crops and Humates. See the preceding discussion on Organic Matter for further information. An ongoing program of Humus building can increase the CEC by .5-1 per year, sometimes more. Adding clay will also raise the CEC but is generally not economical, and does not provide all the benefits that Humus does.

BASE SATURATION

The soil contains a mixture of positively charged (base) minerals called cations or cation salts (described above) that are important plant nutrients. These include Potassium (K), Magnesium (Mg), Calcium (Ca), Hydrogen (H), and Sodium (Na). The Base Saturation on the soil analysis indicates what percentage of the cation mix each mineral comprises.

These positively charged minerals are competing for position on the negatively charged clay and Humus particles in the soil, and very greatly from soil to soil, based on the presence or absence of these minerals and the CEC. The work of Dr. William Albrecht established an "optimum" balance of these cation elements. When this balance is achieved, maximum biological activity and plant growth will occur.

The desired balance of cation elements for most crops is:
5-7% Potassium (K), 10-15% Magnesium (Mg), 70-80% Calcium (Ca), 5-10% Hydrogen (H) and less than 3% Sodium (Na).

Few soils are naturally in cation balance. Inherent soil concentration of these cations, fertilization, cultivation and irrigation all change the balance, as does the cropping pattern. If the soil test shows significant deviation from the optimum levels noted above, it is important to take corrective action.

A soil that is low in Calcium, for example, can be improved to the optimum balance over a period of 2-3 years by adding the appropriate Calcium source.

If instead of a deficiency, the report indicates a particular element is too high, the balance can be modified by increasing any cations that are below optimum, and by leaching of the excessive element.

A common situation is excess in magnesium and/or sodium. These elements can be leached off the Cation Exchange sites with the application of gypsum. Gypsum contains sulfate sulfur, a positively charged element that will combine with magnesium or sodium, and create the water-soluble compounds magnesium sulfate or sodium sulfate. These compounds will leach into the subsoil and beyond with irrigation or rainfall, thus reducing their concentration on the clay and humus sites. The calcium in gypsum will then "attach" itself onto the clay and humus sites, thus improving the balance of the cations to the optimum levels.

Change to the cation balance will not take place overnight and you should expect a few of years of corrective to balance a soil. Bringing the cations into optimum balance greatly improves microbial activity, nutrient availability and crop growth, and is well worth the cost and effort for most crops.

The cations, and how to adjust them, are discussed in detail under their own individual headings previously in this booklet.

NITRATE NITROGEN (NO_3)

Nitrogen is an essential constituent of plant proteins, chlorophyll, enzymes, growth hormones, and comprises a significant portion of the protoplasm, or living substance, of all plant cells. Cell growth, crop yields are greatly affected by soil and crop nitrogen status. Nitrogen is commonly deficient in soils and crops, and frequently added via fertilization. Nitrate is the form of Nitrogen predominantly utilized by plants. Plants require large amounts of Nitrate Nitrogen (NO_3) for all of their growth processes.

Without an adequate supply of Nitrogen, appreciable plant growth cannot take place and plants will remain stunted and undeveloped. Common visual symptoms will be yellow leaves, initially on new growth and, if severe nitrogen deficiency, on the entire plant. A deficiency of Nitrogen will cause serious disruption to the plant's internal processes, and result in poor growth and poor yields.

Excessive Nitrogen in soil or crop results in overly lush plants that are more susceptible to sap sucking insects such as aphids, whiteflies, leafhoppers and numerous others, as well as increased problems from foliar and soil borne diseases such as powdery mildew, root rot, pythium, scab, blight and other pathogens. Plants excess in nitrogen suffer greater heat and cold stress and drought stress. Excess Nitrogen negatively affects the taste as well as the keeping quality of all crops, as the plant absorbs additional water with the excess nitrogen, thus diluting the cellular strength, nutrient and sugar concentration. Plants high in water and nitrogen taste poor and decompose rapidly. Flowers and crops such as tomatoes, grapes or berries will fail to flower or not set fruit when Nitrogen is too high.

Nitrogen does not occur in the soil in a natural mineral form, as do other plant nutrients. It occurs in the air, which contains approximately 78% Nitrogen in the gaseous form. However, plants do not make use of this gaseous N in the air until it is "fixed" into a more available form (either ammonium, NH_4, or Nitrate, NO_3), which the plant can utilize as nutrient. This process of converting gaseous Nitrogen to a mineralized, plant-available form is called Nitrogen fixation and mineralization. A healthy soil will be constantly fixing nitrogen via microbial activity,

and mineralizing the gaseous nitrogen into plant available forms.

The Nitrate (NO_3) test reading should be 40-60 PPM for gardens and most vegetable crops, the lower range for root crops and the upper level for large leaved, heavy feeders. Orchard & vineyard crops require 30-40 PPM Nitrate. Grains and pasture should be between 20-30 PPM. Lawns should be 30-40 PPM. If your soil tests below these levels it will be necessary to supplement the Nitrogen supply.

HOW TO INCREASE NITRATE

When discussing Nitrogen supplementation, a convenient way of quantifying available Nitrogen is in pounds per acre. Most garden crops require 150-250 pounds of available Nitrate Nitrogen per acre per year. Fruit trees and vines need 50-150 pounds per acre per year. With a good composting and cover crop program you can supply virtually all the needs of perennial crops; however vegetable crops nearly always benefit from supplemental N, in addition to the composts and covers.

One of the best ways to increase plant-available Nitrogen is to grow a legume cover crop. Symbiotic Rhizobium bacteria depend for their nutrients on legume plants (peas, vetches clovers, beans, alfalfa, etc.), and are able to extract Nitrogen from the air and return it to the soil in plant available form. Growing legumes in rotation (or amongst perennial crops) can increase the amount of available Nitrogen for the crop by up to 300 pounds per acre. The choice of legumes and mixtures determines the total N contribution. To learn a lot more about Cover Crops request our Cover Cropping bulletin. $10

Non-symbiotic bacteria and blue green algae also fix atmospheric Nitrogen. They live independently and without the support of higher plants. Their main food sources are Carbon, Phosphorus and Calcium. These microbes can supply as much as 100 pounds of Nitrogen per acre per year. Soils high in organic matter and phosphorus maximize these species.

Plant-available Nitrogen is also supplied to the soil by manures and composts. These materials are largely insoluble in water and are broken down by biological activity and oxidation/reduction until they are mineralized into Nitrate Nitrogen for plant use. The addition of compost and manure is a very important way to increase the Nitrogen supply. Turkey and chicken manures, or composts made from these manures, contain the highest Nitrogen.

ORGANIC NITROGEN FERTILIZERS

It is usually necessary to supplement the Nitrogen levels with high nitrogen organic fertilizers when growing vegetables, particularly during the soil-building phase or when growing "heavy feeders" (Nitrogen-loving vegetables such as corn, broccoli, cabbage and leafy greens). The organic grower has a whole host of wonderful Nitrogen sources. Some of the more popular include blood meal, cottonseed meal, fishmeal, feather meal, seabird and bat guano, fish solubles, alfalfa meal, and Chilean Nitrate.

Fishmeal, feather meal, alfalfa, cottonseed and blood meal give long-term, slow-release Nitrogen for sustained plant growth and are commonly used. Seabird and bat guanos provide a mix of quick and longer lasting nitrogen sources. Fish solubles or fish powder are excellent materials for supplying an "instant" shot of Nitrogen, as they are soluble and can be watered in, for immediate plant needs. They don't last long, however, and need to be reapplied weekly in moderately to severely Nitrogen deficient soils. These are typically used in conjunction with one or more of the long lasting Nitrogen sources. They also work well as foliar feeds. Also see the Fertigation section for materials that are applied via irrigation for fast response nitrogen, if needed.

Chilean Nitrate (Allganic brand) is a fast-acting source of 17% all nitrate Nitrogen. It doesn't last long and needs to be reapplied in all but heavy clay soils. It is very useful in cold soils or for quick nitrogen increase in the plant. Its major drawback is its high level of Sodium that can be injurious, if used excessively. Do not use Chilean on soils with a Sodium level above 100PPM. Apply Chilean with care on all soils;

the fast acting, soluble N in Chilean can burn roots of plants if over applied. Organic regulations restrict its use to no more than 20% of total nitrogen applied, including composts, cover crops and other nitrogen fertilizers.

RATES TO USE

For vegetable gardens, use the lower rates below if the Nitrate level is 40 PPM or higher. Use the higher rates if the Nitrate level is 35 PPM or lower, or if the crop to be grown is a heavy feeder.

For orchards, vineyards and pastures use the lower rates if the Nitrate measures between 25-35 PPM. If below 20 PPM use the higher rates.

For lawn use the same rates as for vegetables.

For farm use on perennial crops multiply the garden rates by 150 for the per acre rate.

For vegetable production on farm scale, multiply the garden rates by 200-300.

Choose one of these:

Fish Meal: 3-5 pounds per 100 square feet
Feather Meal: 3-5 pounds per 100 sq. feet
Blood Meal: 3-5 pounds per 100 square feet
Cottonseed Meal: 5-10 pounds per 100 square feet
Alfalfa Meal: 5-10 pounds per 100 square feet
Chilean Nitrate: 1-2 pounds per 100 square feet
Seabird and Bat Guano: 3-5 pounds per 100 sq. feet

The following can be used throughout the season in addition to the above N fertilizers:

Fish Solubles: 3-10 Tbs. per gallon of water
Fish Powder: 1-3 Tbs. per gallon of water

BLENDED ORGANIC FERTILIZERS

The choice of blended, pelleted organic fertilizers has become huge, and a bit bewildering. Generally these products are easy to use, concentrated and substantially more expensive than purchasing non- pelleted individual fertilizers. If you desire the convenience of mechanical fertilizer application, pelleting is a best choice. If you are applying by hand or shovel, pelleting is an unnecessary expense.

Beware of purchasing blended fertilizers unless the soil test indicates the need for all of the nutrients in the blend. Purchasing unnecessary nutrients is expensive and can unbalance a soil, and empty your wallet!

SULFUR (S)

Sulfur is essential for the formation of amino acids, proteins, and some vitamins, and is as utilized by some soil microbes for Organic Matter decay. Legumes require large amounts of available S. Sulfur deficiencies often resemble Nitrogen deficiencies, i.e. light green new growth if deficiency is mild, all age leaves light green if severe deficiency.

N and S enter the plant together to form plant protein compounds. N & S are "brothers," and that a shortage of either will impact the availability of the other, even if the other is in adequate supply.

The soil analysis measures the SO_4, sulfate sulfur, the plant available form of Sulfur.

The soil test level of Sulfur for all crops except vegetables should be at least 20 PPM, with veggie crops requiring at least 30 PPM.

HOW TO INCREASE SULFUR

The major source of Sulfur in the soil is Organic Matter and microbial biomass. Increasing the Organic Matter will increase the available (SO_4) Sulfur. Compost and manures, as well as legume cover crops, are important sources of Organic Matter. (See first section of this booklet).

To increase Sulfur levels quickly, add compost and mined Gypsum. Gypsum contains 18% S in the SO_4 plant-available form. Gypsum is highly water-mobile and should be applied consistently in soils that are low to moderate in Organic Matter, due to leaching potential. If Gypsum has been indicated earlier in this soil analysis, those

amounts will supply adequate S. If no recommendation for Gypsum was made earlier, and the soil tests below 20 PPM, add standard grade (not solution grade) mined Gypsum at a minimum of 1# per 100 sq. ft. (400# per acre). Two applications per year may be useful in low CEC and sandy soils.

Soil Sulfur is a highly concentrated (90% $S0_4$) supplement that should not be used unless there is a very high Calcium reading *and* a pH above 8.0 on the soil test. In this case only, apply Soil Sulfur at 1,000 pounds per acre (1 pound per 40 square feet) annually until pH drops to under 7 (usually 1-2 years). Crops requiring a low pH such as blueberries will benefit from soil sulfur applications at the rates note above.

MICRONUTRIENTS

Micronutrients are essential nutrients that occur in the soil at low concentration, and are used by the plant in very small amounts. Micronutrients, despite their low concentration, are every bit as important as the macro elements N, P or K.

Good aerobic Organic Matter management is the best way to ensure adequate availability of micronutrients. The higher the Humus content, the greater quantity of available micronutrients.

The most important micros are Zinc, Iron, Manganese, Copper, Boron & Selenium, but there are many more which science hasn't yet positively identified to be necessary for plants. No doubt the list of "essentials" will grow over the next decade. Nickel has recently been added to those essential micros.

ZINC (Zn)

Zinc is essential for the transformation of carbohydrates and the regulation of sugar consumption in the plant. It forms part of the enzyme systems that regulate plant growth. A deficiency of zinc will manifest as "small leaf syndrome" in plants. The leaves will look normal, but will be 10-75% smaller than normal. The lab analysis indicates the PPM of Zinc Oxide, the plant available form of Zinc.

Optimum Zinc level is 3.5-7.0 PPM.

If a garden soil tests below 3.5 PPM add Kelp Meal or Azomite at 1 pound per 100 sq. ft. for all crops. These materials should be broadcast and worked into the soil where possible.

Farm soils testing below 3.5 PPM should broadcast apply zinc sulfate or zinc chelate @ 100 pounds per acre.

Foliar feeding with kelp extracts in combination with hydrolyzed fish solubles or fish powder will greatly assist the plant's ability to absorb micronutrients in the soil. The addition of Zinc products such as Bio Min Zinc or BioLink Zinc @ 1-2 quarts per acre are good zinc supplements for foliar feeding.

MANGANESE (Mn)

This element plays a role in many of the vital processes in a growing plant, including the enzymatic breakdown of carbohydrates, Nitrogen metabolism, disease resistance and more. The analysis indicates the PPM level of Manganese Oxide, the plant available form of Manganese.

Soil levels for Manganese should be 20-50 PPM.

If a garden soil tests below 20 PPM add Kelp Meal or Azomite at 1 pound per 100 sq. ft. These materials should be broadcast and worked into the soil where possible.

Farm fields testing below 20 PPM should apply Manganese Sulfate at 50 pounds per acre, broadcast and worked in.

Foliar feeding with kelp extracts in combination with Hydrolyzed Fish Solubles or Fish Powder will greatly assist the plant's ability to absorb micronutrients from the soil. The addition of Manganese products such as Bio Min Mn or BioLink Mn @ 1-2 quarts per acre are good manganese supplements for foliar feeding.

IRON (Fe)

Iron is essential for the formation of chlorophyll and for photosynthesis. It is the activating element in several enzyme systems and

important in respiration and other oxidation systems of plants and is a vital part of the oxygen carrying system. Lab results indicate the PPM of Iron Oxide, the plant available form of Iron.

Soil Iron levels should be 20-50 PPM for most crops.

Levels above 50 PPM indicate a leached, acid soil. See recommendations for Calcium if the soil tests above 50 PPM Iron *and* has a medium to low Calcium level.

If a garden soil tests below 20 PPM add Kelp Meal or Azomite at 1 pound per 100 sq. ft. These materials should be broadcast and worked into the soil where possible.

Farm fields testing below 20 PPM should apply Iron Sulfate at 100 pounds per acre, broadcast and worked in.

Foliar feeding with kelp extracts in combination with Hydrolyzed Fish Solubles or Fish Powder will greatly assist the plant's ability to absorb micronutrients from the soil. The addition of Iron products such as Bio Min Iron or BioLink Iron @ 1-2 quarts per acre are good iron supplements for foliar feeding.

If the soil tests below 10 PPM, a one time application of Iron Sulfate at 100 pounds per acre (1 pound per 400 square feet) should bring the level up to a point where it can be maintained using the above methods. Use Zinc Chelates, instead of Zinc sulfate, at the same rate if the soil is sandy and has Organic Matter below 2%.

COPPER (Cu)

Copper plays an important role in plant growth as an enzyme activator and as a part of certain enzymes which function in plant respiration. It is very important in the plant's reproductive stage of growth and plays an indirect role in chlorophyll production. Lab results indicate the PPM of copper oxide, the plant available form of Copper.

Soil Copper levels should be 1.0-3.0 PPM.

If a garden soil tests below 1.0 PPM Copper, add Kelp Meal or Azomite at 1 pound per 100 sq. ft. These materials should be broadcast and worked into the soil where possible.

Farm fields testing below 1 PPM should apply Copper Sulfate at 25 pounds per acre, broadcast and worked in.

Foliar feeding with kelp extracts in combination with Hydrolyzed Fish Solubles or Fish Powder will greatly assist the plant's ability to absorb micronutrients from the soil. The addition of Copper products such as Bio Min Copper or BioLink Copper @ 1-2 quarts per acre are good copper supplements for foliar feeding.

It is easy to get above the optimum level if the crop is sprayed with Copper compounds for disease control. Growers of peaches, nectarines, walnuts, almonds and grapes should test their soil, to avoid reaching high levels of Copper. Levels above
5.0 PPM can be toxic to plant and soil fungi. If the soil exceeds 5 PPM copper consider changing to a non-copper based fungicide. Use gypsum, compost and cover crops to leach copper from a soil that has too much.

BORON (B)

Boron is essential in protein synthesis, which has a dramatic impact on plant sap sucking insects such as mites, aphids, leafminers, whiteflies, etc. It is associated with the increased cellular activity that promotes maturity, with increased set of flowers and fruit, and with yield and quality. Boron also affects Nitrogen and carbohydrate metabolism, and water relations in the plant. Optimum boron levels increase crop yields. The lab results indicate PPM Boron oxide, the plant available form of Boron.

The optimum level for Boron is 1.0-2.0 PPM.

If a garden soil tests below 0.5 PPM Boron, add Kelp Meal or Azomite at 1 pound per 100 sq. ft. These materials should be broadcast and worked into the soil where possible.

If a farm soil tests below 0.5 PPM Boron apply 10 pounds Granubor per acre. Boron is toxic to plants and soil microlife if over-applied. Never apply more than 20 pounds per acre. Do not use in a garden.

Foliar feeding with kelp extracts in combination with Hydrolyzed Fish Solubles or Fish Powder will greatly assist the plant's ability to absorb micronutrients from the soil. The addition of Solubor @ 1 quart per acre is a good boron supplement for foliar feeding.

Many Western soils have boron levels above 2.0 PPM. At high levels Boron will be toxic to soil microflora as well as plants. Boron toxicity can kill plants. If the soil tests above 2.0 PPM Boron, it will be necessary to take corrective action. The best method is to apply Gypsum and quality compost 2 to 4 times per year in combination with low salt water. Adding calcium from gypsum buffers the toxic effect of Boron, and the sulfur in gypsum leaches out excess Boron. See Calcium section for more info.

Many water sources in the arid regions of the West, especially wells, contain excess Boron. If you have a high Boron soil test it is worthwhile to check the water source for Boron contamination.

EXCESS LIME RATE

This is a visual rating of free lime (Calcium Carbonate) present in the soil sample. Soils that contain levels above Medium will have problems in the availability of major and minor elements to the plant, as excess lime interferes with soil microbial activity and the release of essential plant nutrients.

The soil test should read L or M for optimum results.

If the soil contains (H) High or (VH) Very High levels of Lime, it will be necessary to take corrective action:

1) Do not add any limestone.

2) Add large quantities of Organic Matter in the form of compost and cover crops.

3) Add Humates at 400 pounds per acre (1# per 100 sq. ft.)

4) Add Mined Soil Sulfur at 1,000 pounds per acre (3# per 100 sq. ft.), and leach the sulfur into the soil with low salt water.

5) It may be necessary to repeat the Sulfur application 1-2 times to achieve optimum results.

SOLUBLE SALTS

This reading indicates the level of potentially harmful soluble salts including Sodium, Chloride, Boron, Magnesium and others. It is desirable to maintain levels of .5-1.0. When these levels exceed 1.0 there is risk of plant damage and reduced microbial activity. When levels get above 2.0 some plant damage nearly always occurs.

Levels between 0.2 and 1.0 are optimum for most crops

When the tests show levels above 1.5, leach the soil with Gypsum and low salt water, and increase the Organic Matter. Changing the water source may have the biggest long-term impact. See previous instructions for more information on Gypsum and Organic Matter.

FOLIAR FEEDING

Foliar feeding is the technique of spraying soluble nutrients, microbiology and water onto the leaf and branch surface of active growing plants. All plants absorb nutrients through their leaves and stems using stomata, little openings similar to the pores of our skin. On most plants the majority of the stomata are on the underneath side of the leaf. A foliar application will provide the applied materials in direct contact with these stomata, which will "drink" the materials into the plant. This provides a near immediate source of nutrition, and coating of the leaf with beneficial microflora that help protect against foliar pathogens. Foliar feeding has been shown to be up to 20 times more efficient than

soil-applied nutrients. Properly formulated foliars can increase crop growth and yields, increase Brix content which includes sugars, minerals and vitamins, improve cold resistance, heat resistance, storage qualities and more. For complete details on foliars feeding, with numerous formulations, application rates and recommendations for applying foliars for the largest benefit, please request our Foliar Feeding booklet. $10

Foliars help the plant when it may not be getting enough nutrition from the soil, as in low fertility or cold soils, or soils in some type of stress such as low pH or high salts. Most plants also respond when foliar feeding is timed to coincide with seedling emergence, stress caused by drought, heat, cold, mechanical or insect damage, the beginning of flowering, or the onset of disease susceptible periods. Foliars can be timed to induce rapid growth phases or to encourage flowering, fruiting or seed formation. Many crops benefit from 6-8 foliar applications per season. Some growers apply weekly or bi weekly foliars at low concentrations to improve nutrient balance, stimulate flower or fruit production, or fight disease and insects.

MATERIALS FOR FOLIAR FEEDING

Gardeners should use a combination of hydrolyzed liquid fish and kelp extracts as regular foliar nutrition. Compost tea will increase beneficial microbes on the leaf surface, as well as provide nutrients and plant stimulants. To encourage flowering rather than vegetative growth, hold back the fish fertilizer, continue with kelp and add a high phosphorus fertilizers such as high P seabird or bat guano, or liquid organic phosphorus mix.

Farmers should use plant tissue testing, as well as sampling with Refractometers and Nitrate meters to determine foliar needs and responses. Materials that have good success as foliars on farms include:

Low temperature extracted liquid kelp extracts, such as Algrow or Sea Cream, are important base materials for all foliars due to their concentration of many trace minerals, plant growth promoters, auxins and hormones. Some of these benefits are also contained in kelp powders, but at lower concentrations.

Compost tea is an excellent all purpose nutrient, plant stimulant and beneficial microbe source that is added to nearly all foliars. Complete directions for the manufacturing and use of compost teas, including plans for top quality low cost farm built compost tea makers are available for $10.

To stimulate growth phases use a combination of hydrolyzed fish solubles, corn steep liquor or high N seabird guano in combination with kelp concentrates.

To enhance flowering, seed formation and fruiting, or to hasten maturity, replace the fish with High Phosphorus Seabird or Bat Guano, or micronized rock phosphate.

When Calcium is needed to build insect and disease immunity add solution grade gypsum, Bio Min Calcium, Calcium 6% Liquid, Calcium 25, Mora Leaf, or other high quality organic calcium source.

To increase Potassium for disease resistance or cold hardiness, add solution grade Sulfate of Potash.

For a concentrated source of trace minerals growers include Bio Min Booster, Green Cypress Crops Mix, Mefzer, Phyto-Plus Micros Plenty, Ruffin Tuff Micros, or other high quality organic micronutrient product.

For additional sulfur micronized wettable sulfur or liquid sulfur products are good to increase protein formation.

A FEW TIPS FOR FOLIAR FEEDING

Foliar feeding should not be done in the heat of the day. The best time to spray is at dawn or dusk.

Apply thorough coverage to the entire plant, particularly the underneath side of the leaves. Apply in as fine of particle size as possible, using just enough pressure to fully wet the leaves. Typical ground sprayer application rates

are 25-50 GPA of water and additives. Foliars can be applied with most pesticide or fungicide materials. Check compatibility prior to application.

It is important to use a spreader sticker with all foliar sprays. Quality compost teas act as a good spreader. Therm X70 yucca extract and Oroboost orange oil are very good spreaders. Check the pH of the spray mixture and adjust to 5.5 to 6.0 for maximum effect. Vinegar or citric acid is used for lowering a high pH mixture. Baking soda will increase pH. pH adjuster products are available

Measure the Oxygen content of the foliar solution with an ORP meter and add 35% food grade Hydrogen Peroxide if the ORP reading is below 150. Optimum is 250-350 ORPS. This increases plant uptake of the applied nutrients.

FERTIGATION

Fertigation is the practice of applying soluble fertilizers and additional nutrients with irrigation water. This is a convenient and quick way to provide short-term fertility via irrigation. The impact is slower than foliar feeding, but faster than standard soil applications. Typically, dry materials are injected into the irrigation after first mixing with water in a tank. Liquid fertilizers can be injected directly into the irrigation using a siphon mixer or mechanical pump such as a Dosatron. It is important to filter the fertilizer/water mixture prior to injection if using drip or micro sprinklers.

Some materials used in fertigation include:

For nitrogen: fish solubles, corn steep liquor, Chilean Nitrate, liquid organic fertilizer mixes

For phosphorus: micronized rock phosphate, high P bat or seabird guano, bird manures

For potassium: solution grade sulfate of potash

For calcium: Marblewhite solution grade limestone

For calcium and sulfur: solution grade gypsum

For sulfur: micronized wettable sulfur

For micros: liquid or dry kelp powder

General purpose nutrient and microbes: compost tea

Microbial stimulation & nutrient release: humic acids

Note: Mixtures of the above materials are commonly combined for fertigation. Also there are numerous products on the market that contain these ingredients mixed together. Rates of use should be determined by crop need, crop growth stage and the recommended application rate for the material.