A guide to

Building Soil Health
using natural soil amendments

Find out how to test your soil, and get access to a free library of resources inside!

Featuring soil remineralization with

SoilKey® Minerals

• For Healthier Plants
• More Fertile Soil
• Enhanced Food Flavors

Including:

Portions from best selling authors
Steve Solomon
Jeff Lowenfels
One Company, One Call:
A complete garden line for landless gardeners.

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How to Use this Manual

As gardeners ourselves, we understand the difficulties of gardening. Our years of experience combined with other expert gardeners and research will help you grow successfully. This guide lays out our process for building a healthier soil to provide your plants with the best chance of success. We’ve organized it to provide information specifically for container gardeners but processes and information described can also be applied broadly for non-container gardening.
Healthy Soil for Healthy Life

Life depends on soil, and soil changes depending on how it is managed. Choices in organic matter, structure, depth, watering, and nutrient availability affect how well your soil can support life.

Understanding soil health means assessing and managing soil for optimum and sustainable use. With our methods of managing your soil health, you can improve your gardening, get more out of your garden, and reduce your impact on the environment.

Understanding Soil Health

Soil health refers to the quality of the ecosystem that sustains plants, animals, and humans. Managing it properly can improve your gardening success long-term. To do this, we need to remember that soil contains living organisms, that when provided the basic necessities of life - food, shelter, and water – can produce healthier, more nutrient dense plants.

Our method of evaluation, and management using SoilKey natural soil amendments will provide nutrients for plant growth, retain water for use during dryer periods, filter potential pollutants, and provide habitat for soil microbes to flourish and diversify to keep the ecosystem running smoothly.

What Soil Does

Healthy soil gives us clean air, bountiful produce, diverse wildlife, and beautiful landscapes by performing essential functions:

**Regulating water** - Soil helps control moisture. Water and dissolved nutrients flow through the soil for direct access to roots.

**Sustaining plant life** - The diversity and productivity of living things in soil unlock building blocks for growth.

**Filtering and buffering pollutants** – soil is responsible for filtering, organic and inorganic materials that may be harmful to plants and humans.

**Cycling nutrients** - Carbon, nitrogen, phosphorus, and many other nutrients are stored, transformed, and cycled in the soil.

The quality of soil is measured by ability to function as an ecosystem. For example, sandy soil drains fast and deep soil has more room for roots. Managing the components of your soil can vary soil characteristics for optimum soil health.

Components of Soil

The ecosystem of soil is critical to soil health and by managing it with our methods and components you can increase the quality and ecosystem of your soil. We recommend using the following components to protect crops from pests and diseases and support vital to processes like decomposition, nutrient cycling, and plant growth.

**Minerals**

Starting with the building blocks of healthy soil, our soil management process uses minerals to provide plants and animals with the nutrients they need for growth. Our Soilkey Minerals come in various forms of rock dust for their naturally occurring minerals that improve soil structure, moisture holding properties, nutrient availability and bacterial action. Over time nutrients become stripped from soil and rock dust can easily replace those minerals that are essential for life. FOR MORE INFORMATION ON ROCK DUST SEE PAGE 8

**Organic Matter**

Organic matter includes things like Fertilizer, Compost, Mycorrhizae, and Microbes. These components break down and build up soil through processes like decomposition and transformation of minerals. Managing the organic matter within your soil makes sure that nutrients in the soil can be easily available for plants and other life. FOR MORE INFORMATION ON FERTILIZER SEE PAGE 12

**Other**

Other components of soil include things like pumice and coir. We use these components to allow air and water to pass easily through the soil. These components...
are added to improve respiration and ensure quality soil structure. FOR MORE INFORMATION ON PUMICE OR COIR SEE PAGE 10

Soil Problems

If not managed properly the soil will become depleted of vital nutrients, become a host to pests and disease, reduce it’s ability to sustain healthy plant growth. Sometimes one or more minerals are reduced to the point of imbalance.

Problems include:

Leaching of nutrients - the stripping away of essential building blocks for plant processes

Continual cultivation of the land - leads to depletion or imbalance of minerals

Drought or flood conditions - unavailable or excessive water in soils

Soil composition - affects the ability of the soil to hold oxygen, nutrients and water

Compaction - rainfall, mineral content, foot and vehicle traffic, and the ratio of soil particle sizes can cause the soil to drain too readily or retain water to the point that no air or roots can penetrate

Depletion of organic matter - exacerbates all of the issues listed above

Evaluating Your Soil

In order to improve your garden you need to properly assess its condition. Doing this will give you the understanding you need to take the steps necessary for reducing problems and promoting vitality. Quality soil is the foundation of good plant growth, health, and visual appearance. Soil quality is defined by an array of physical, chemical, and biological parameters known to be important to soil functioning as a medium for plant growth.

Soil properties vary considerably from one geographical region to another. We advocate testing your soil. There are many tests available to the home gardener that will show you the nutrient balance (or lack there of) in the soil. Basic tests are an invaluable resource of information and certainly cost less than the fertilizers applied to even small gardens.

<table>
<thead>
<tr>
<th>Chemical Indicators</th>
<th>Physical Indicators</th>
<th>Biological Indicators</th>
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<tr>
<td>Organic Matter</td>
<td>Topsoil Depth</td>
<td>Microbial Activity</td>
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<td>pH level</td>
<td>Rooting depth</td>
<td>Earthworm Numbers</td>
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<td>Salinity</td>
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<td>Nutrient Levels</td>
<td>Bulk density</td>
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<td>Heavy Metals</td>
<td>Infiltration rate</td>
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<td>Pesticide residue</td>
<td>Water-holding capacity</td>
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<td>Petroleum residue</td>
<td>Drainage</td>
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<td>Aeration (gas exchange)</td>
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<td>Construction debris</td>
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Certain soil quality parameters can be assessed through a basic soil test and consideration should be given for the plant species being grown. Many of the physical quality parameters are a result of how the soil has been handled in the past. It’s generally easier, less expensive and less frustrating to address soil quality problems before planting. You can estimate your basic soil structure using the mason jar test. This will tell you the ratio of sand, silt, and clay found in your garden and allow you to determine your soil type.

LEARN MORE ABOUT THE MASON JAR TEST VISIT: SOMEWEBSITE.COM/MASONJARTEST

You’ve likely purchased our products with the intention of benefiting your garden. Without exact guidance they will typically yield quality results, but if used in extreme excess, they can result detrimental effects. Our method always works to strike balance in soil properties. Be sure to check the recommended application rate listed on the product package. For even better results, we encourage you to take the next step and learn about what your soil needs.
Included are excerpts from The Intelligent Gardener, by Steve Solomon to better describe the need for these considerations. Steve Solomon's book will give you the ability to interpret these tests or you can consult a service that can guide you. References for laboratories, consultants and places to learn more can be found in the Appendix of this manual.

**Soil Management**

Whether you grow plants in containers, on your patio or have a garden plot in your yard, your plants need air, water, nutrients, and light in the proper amounts. Air and water are intimately connected in the root zone of your soil and their balance is essential. Their movement is dictated by the porosity or space contained within it.

SoilKey products can help you manage the needs in the soil to achieve the balance for optimum plant health.

Adding pumice increases this porosity, giving space for water and air and a home for the smaller members of the soil food web to live out their processes and feed your plants. Porosity also allows for excess water to drain away. FOR MORE INFORMATION ON PUMICE SEE PAGE 11

Using Coco Coir adds to the soils ability to hold and release water and nutrients. Its spongy texture allows for airspace and prevents compaction. We recommend applying or mixing in high quality composts such as vermicompost. FOR MORE INFORMATION ON COIR SEE PAGE 10

Vermicompost gives benefits similar to the Coco Coir, but also helps to invigorate the soil food web, inoculating your soil with billions of beneficial microbes per teaspoon! These beneficial microbes move throughout the soil and colonize the roots of the plant. Our SoilKey Fertilizer has been blended for the purpose of feeding this multitude. FOR MORE INFORMATION ON FERTILIZER SEE PAGE 12

You can further utilize the potential of compost by brewing an actively aerated compost tea using our SoilKey Accelerator. FOR MORE INFORMATION ON ACCELERATOR SEE PAGE 13

Mycorrhizae are a special set of specific symbiotic fungi which increase the nutrient uptake ability for most plants, in some cases by 300%! As the microbes colonize they create aggregates in the soil, binding together the minerals and organic matter and creating further porosity. FOR MORE INFORMATION ON MYCORRHIZAE SEE PAGE 13

Perhaps the most important consideration is the mineral content. Adding minerals from rock dusts gives your soil a broad spectrum of elements that will allow the plants and microbes access to virtually any component they can make use of. Adding them in the correct balance will insure that the other aspects of your management can develop or be maintained. FOR MORE INFORMATION ON MINERALS SEE PAGE 8

**Our Potting Mix**

As we continue to test, evaluate, and work toward improved balance our mix changes. Gardening is a process, not a strict formula that applies to all situations at all times. We have found our mix outperforms other commercially available potting mixes, and yet we strive to improve it further.

<table>
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<th>For 1 cubic foot:</th>
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<tr>
<td>3 Gal Organic compost</td>
<td>1.75 Gal Coco Coir</td>
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<tr>
<td>1 Gal Pumice</td>
<td>5 Cups Vermicompost</td>
</tr>
<tr>
<td>1.3 Cups Soilkey Fertilizer</td>
<td>1 Tablespoon Mycorrhizae</td>
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This mix supplies all the necessary conditions for air, water, and nutrient movement. It is fortified with readily available and slow release nutrients that can be cycled by the microbes we have incorporated. We recommend letting it sit for a few days after all the material has been mixed to allow the food web to establish. For many crops you will find no need to add anything additional. For most an application of SoilKey Fertilizer every 3-4 weeks during the growing season will sustain a long season vegetable or perennial plant. After plants are established, we mulch the top to help maintain moisture near the surface. This soil mix can be reused for multiple successions or seasons with additional applications of vermicompost.

Over time your soil may become depleted of nutrients and may need to be replaced or remineralized depending on its structure.
Remineralization

Remineralization Utilizes the Broad Elemental Spectrum Rock Dusts to Build a Foundation of Fertility Rock dusts for remineralization should contain a diversity of nutritive minerals. Naturally occurring volcanic materials and rich glacial sediments can be suitable sources of rock dust. Basalts and glacial sands and gravels are example of these types of geologic materials. Geologic materials have a long history as sources of fertilizer for growing crops. Calcium carbonate “lime” is perhaps the most famous. Granite dust is a traditional example of a rock dust used by farmers because of its known content of the nutrient potassium. Rock phosphate is another example of a mineral concentrate of phosphorus derived from ancient sediments. For remineralization the broad spectrum nutritive mineral compounds are often found in silica rich volcanic magma and ash, in sea and fresh water minerals built from remnants of living creatures such as algae, diatoms and crust oceans producing calcium and magnesium rich carbonates, in minerals derived from carbon rich humus sediments from ancient bogs, and in the natural occurring mixtures of geologic materials found in alluvial and glacial sands and gravels. The best rock dusts provide a diversity of nutritive materials derived from natural minerals freshly crushed and blended in a gradation of fine particle sizes distributed widely in growing media.

Differences Among Rock Dusts

Over 30 years ago one of the founding fathers of remineralization, John Hamaker, promoted the use of glacial and alluvial rock dust sediments for remineralization. This choice was based on his objective of emulating glacial forces in revitalizing the planet through remineralization. However, volcanic geologic types such as the basalts and the complex metamorphic and sedimentary hard rocks and clays have been found to serve as well as the best regional glacial and alluvial sands and gravels. Quality of all rock dust materials should be quantified by purity, geochemical analysis, mineralogy and particle size. Glacial sediments often contain a higher percentage of hard minerals such as quartzite. As the glacial and alluvial sediments are transported from their original location over eons many of the softer minerals weather away, leaving a greater proportion of the harder, less nutritive materials in tact. The unweathered magmas such as the basalt and other hard rock sediments derived from regional volcanism, ancient oceans, lagoons or inland bogs often retain rich mineral diversity and nutritive properties. Seen in this light both the single broad elemental spectrum hard rock or clay geology as well as the higher value glacial or alluvial sediments can serve Hamaker’s objective of emulating natural forces to regenerate and revitalize the earth through remineralization.

Rock Dust Analysis: Fundamentals of Mineralogy and Geochemistry

A fully vetted rock dust will have both geochemical analysis and a basic petrology describing the classification of rock type if not the specific mineralogy. The best rock dusts will generally be those with good proportion and relative abundance of the major nutritive elements, an abundance of nutritive trace elements and very low concentrations of arsenic, lead and the natural radioactive heavy elements, the latter at levels near or below natural concentrations found in native soils. Silicate rock types below approximately 50% Silicon dioxide will often have a good concentration of nutritive minerals.

Nutrients in Rock Dusts Become Available to Plants Through the Action of “Weathering” which is Mechanical, Chemical and Biological

Unlike soluble chemical fertilizers, rock dusts for mineralization are largely insoluble silica rich minerals that become reactive in soils through a process called “weathering” produced by changes in pH, mechanical breakdown resulting from abrasion, changes in temperature such as freeze-thaw cycling, and the action of beneficial organisms both large and small. Examples of these beneficial organisms existing in healthy soils are earth worms and microorganisms such as bacteria and fungi.

What is the Differences Between Synthetic Fertilizers and Naturally Occurring “Rock Dust” Minerals?

Many synthetic fertilizers are acid salts or soluble sulfates of a very narrow elemental spectrum, often containing a single elemental nutrient in combination with Chlorine or Sulfur. Chemical fertilizers are usually
a combination of three elements; N, P, and K (Nitrogen, Phosphorus and Potassium) delivered in soluble form. In contrast, the broad elemental spectrum rock dusts contain a naturally occurring distribution of dozens of macro and micro nutrients delivered in mineral form. There is little or no nitrogen in most rock dust materials although essential elements for fixing nitrogen in soils such as Molybdenum and Vanadium are present in many high quality rock dusts. The use of fixed carbon and humus with rock dusts is encouraged to help build soil biology and regulate the uptake of essential nutrients in plants. Soil remineralization is a method of encouraging a natural, resilient and self regulating growing environment which promotes long term sustainable fertility.

**Working Seasonally with Rock Dust**

Spring tillage is traditional. Apply rock dust powders with other soil amendments to new or established planting beds at the same time. Fall tillage or top dressing applications are extremely valuable. Rock dust incorporated in the fall assimilates over the winter and is available during the spring growing season. Apply with planting of overwintering tubers such as garlic, broadcast over hayland or pasture. Apply whenever cover crops are tilled in preparation for new planting. The charge of micronized minerals will stimulate microbial populations and make the nutrients more available to the new crop. Micronized rock powders can be suspended in water for “fertigation” and then use any time during the growing season. Top dressing or side dressing can be done during the season at any time. Adding a fine covering of stone flour gradations of rock dust to the soil surface of potted plants and watering in every month is good practice, especially during seasons of vigorous growth.

**Measuring the Benefits**

Annual soil testing should show improvements in both available nutrients and overall nutrient density in soils. Overall improvement in plant vigor should follow the assimilation of minerals in the rock dust. Brix refractometer readings should improve, indicating higher sugar and mineral content in plant sap. Higher sugar and mineral content will improve disease and insect resistance as well as drought and frost resistance.

Tissue analysis of produce and forage should indicate increased mineral and nutrient value. Produce tastes better. Herd health of livestock fed remineralized forage and feeds will improve, reducing vet bills, reducing mortality and increasing profitability. Remineralizing soils is the first step to remineralizing living things, whether they be microflora in soils, animals or human beings. Remineralization is a foundational practice of nutrient dense food production. The benefits can be measurable and cumulative.

**Global Reach of the Local Practice of Soil Remineralization**

Scientific studies have shown that remineralized soils capture carbon and nitrogen (Tang, Goreau et.al 2012) and fix them in soil as carbonates and complex organic compounds created by microorganisms through biologic activity. Remineralization with naturally occurring and readily available rock dusts in combination with fixed carbon sources such as biochar provide an immediate and workable solution to the immediate problem of reducing atmospheric greenhouse gases such as CO2 by building fixed carbon in soils. Reducing atmospheric carbon and building fertility in soils serves to stabilize regional and global climate through the revitalization of the temperate zone, with measurable benefits locally and globally. Carbon capture through sustainable farming practices such as remineralization and sustainable biologic growing techniques using living soil and fixed carbon has long term world wide benefits, one acre at a time.
SoilKey® Minerals

ABOUT SOILKEY MINERALS
Our minerals are various forms of rock dusts that have been deposited over many thousands of years in the earth’s crust. These deposits are mined, dried and screened for agricultural and horticultural re-mineralization. Rock Dust can replace key elements that have been depleted from the soil over the years in a form readily used by soil microbes to create healthy soil. When added to the soil, the soil recreate the colloids (minerals and humus) which are needed to improve soil structure, moisture holding properties, nutrient availability and bacterial action. With the correct balance the soil becomes a favorable environment for a host of beneficial molds, fungi, bacteria and earthworms that support plant life.

ADVANTAGES
- Raises pH in acidic soils.
- Increases phosphorus availability
- Corrects mineral balance in the soil
- Provides an excellent source of macro and micro nutrients.
- Increases moisture holding properties in the soil.
- Improves the cation exchange capacity.
- Improves soil structure and drainage.

GLACIAL
Glacial Rock Dust can increase phosphorous availability, provide an excellent source of calcium, iron, magnesium, and potassium and supply trace elements and micro nutrients. It can also increase moisture-holding properties in the soil, improve the cation exchange capacity and improve soil structure and drainage.

OLIVINE
Olivine is a Magnesium and Iron rich mineral material. It’s weathering process has the unique ability to fix atmospheric CO2, increase plant health and vigor. It can also increase moisture-holding properties in the soil, improve the cation exchange capacity and improve soil structure and drainage.

BASALT
One of the widest range of macro and micro nutrients available in any geologic material. It can also increase moisture-holding properties in the soil, improve the cation exchange capacity and improve soil structure and drainage.
Glacial

**USES & APPLICATION**


**GUARANTEED ANALYSIS**

- Total Nitrogen (N) .................................. 4.00%
- Available Phosphate (P2O5) ...................... 2.00%
- Soluble Potash (K2O) .............................. 3.00%
- Calcium (Ca) ......................................... 3.7%
- Sulfur (S) ............................................... 1.8%
- Iron (Fe) ............................................... 0.7%
- Manganese (Mn) ...................................... 0.1%
- Sodium (Na) .......................................... 0.2%

Olivine

**USES & APPLICATION**


**GUARANTEED ANALYSIS**

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Basalt

**USES & APPLICATION**


**GUARANTEED ANALYSIS**

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ABOUT SOILKEY COIR

Coir is a by-product of coconut harvesting. This fibrous material is obtained by husking or breaking up the hard coconut shell, then soaking it in water to soften the fibers. These fibers make up about one third of the husks with the remaining two thirds consisting of pith or dust which previously was discarded as waste. Not until the 1980’s, did horticulturists begin studying Coconut Coir dust as a substitute for sphagnum peat moss.

About 60% of the world’s Coir fiber is produced in the state of Kerala on the western coast of India. Sri Lanka and India together produce 90% of the annual coir production world wide.

Usually coconut husks are processed in water-filled pits of sea water. We take care to make sure our Coconut Coir is washed and free of any salt that could be harmful to your soil.

USES & APPLICATION:

As a growing medium

Compost and Coir have many of the same characteristics, such as a spongy texture, expanding air space, and high moisture holding capability.

Backyard/garden compost breaks down rapidly in the soil and must be re-applied annually. Coconut Coir, on the other hand, will last in soil for years.

As a seed starter

For many gardeners starting seeds is a challenge prone to failure. Coconut coir works great for two main reasons:
- Being a disease free growing medium.
- Retaining moisture without being oversaturated

In worm composters

A handful or two of Coir to each new tray will speed up the composting process and produce higher quality finished worm compost for your garden.

ADVANTAGES

High water holding capacity
Retains and releases nutrients
Naturally weed free
Disease resistant
Spongy texture
Excellent air space & drainage
Develops elaborate root systems
Neutral to slightly acidic pH
Soil amendment & conditioner
ABOUT SOILKEY PUMICE

Pumice is a type of igneous rock which is formed from molten or partially molten material. Providing excellent aeration to the soil, pumice loosens heavy clay soil and retains moisture well.

With the addition of as little as 10% pumice in potting media and garden soils, you will significantly improve your soil. The porous nature of pumice allows it to hold vital nutrients in surface pores, which helps regulate fertilizer release.

Pumice is a great bedding additive to worm composters, adding air space, preventing matting, and helping to control moisture.

ADVANTAGES

Increases bulk density of potting mixes.
Regulate fertilizer release
Increased aeration and drainage.
Loosens the density of heavy soils
Reducing watering requirements by as much as 35%.
Long lasting and can be recycled and reused.
Does not attract or host fungi, nematodes, or insects. Pumice is pH neutral.

USES & APPLICATION:

As a soil amendment
Use when transplanting plants or when mixing potting soil for container gardens or potted plants

For composting
Pumice is a great bedding additive to your worm composter. It adds additional air space, prevents matting, and helps to control moisture. Use 1-2 cups per tray or as needed.

As a mulch
Coarse-grind pumice makes an excellent, and attractive mulch for flower and shrubbery beds, container gardens and potted plants. The soil beneath the mulch stays moist longer and is less likely to compact from watering. Weed problems are minimized with a couple of inches of pumice mulch. It’s very durable so it will last much longer than fibrous mulches.
SoilKey® Fertilizer

ABOUT SOILKEY FERTILIZER
This blend increases the biological activity in soil, compost and vermicompost. It enhances the natural biological process by supplying a more complete variety of nutrients and minerals feeding microbes in the soil, allowing the microbes to unlock the nutrients vital to increased plant vitality.

By incorporating glacial dust, our mix provides the plant nutrients required to build healthy soil and grow healthy plants.

GUARANTEED ANALYSIS
Total Nitrogen (N) ..............................................4.00%
Available Phosphate (P2O5) ....................... 2.00%
Soluble Potash (K2O) ............................... 3.00%
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Iron (Fe) ....................................................... 0.7%
Manganese (Mn) ......................................... 0.1%
Sodium (Na) .................................................. 0.2%

ADVANTAGES
Contains a complex mix of nutrients
Certified for organic food production
Alternative to synthetic fertilizer
Enhances natural biological plant process
Enhances root fertility

USES & APPLICATION:
For composting
Compost and Coir have many of the same characteristics, such as a spongy texture, expanding air space, and high moisture holding capability.

As a soil amendment
Backyard/garden compost breaks down rapidly in the soil and must be re-applied annually. Coconut Coir, on the other hand, will last in soil for years.
SoilKey® Accelerator

Kick Start Compost Activity
This natural catalyst increases biological activity in compost including compost tea. SoilKey™ Accelerator provides complete variety of nutrients for enhanced microbial activity.

ADVANTAGES
Contains complete mix of macro and micro nutrients
Certified for organic food production
Speeds up decomposition of raw organic materials
Increases biological activity

SoilKey® Mycorrhizae

Enhance Root Structure
Mycorrhizae are fungi that unlock nutrients and make them available for growing plants. SoilKey™ Mycorrhizae builds a healthy root structure for increased plant vitality.

ADVANTAGES
Reduces Drought Stress
Reduces Watering
Reduces Transplant Shock
Increases Yields
Increases Overall Plant Hardiness
Promotes Rooting
Promotes Nutrient Uptake
About the Author

Steve Solomon is the founder of Territorial Seed Company. He has been growing most of his family’s food for over 35 years, and is the author of several landmark gardening books including Gardening When it Counts and Growing Vegetables West of the Cascades. A lifelong advocate for the value of self-sufficiency, his writing, lectures, and classes are focused on helping people become financially independent through producing their own necessities. He currently homesteads in Tasmania.

Praise for The Intelligent Gardener

“This is an excellent book which concentrates on the mineral content of soils. In it the author makes the case for growing nutrient dense food, critiques compost only growing strategy, describes what different minerals do for plants, and then explains how to bring the minerals in your soil into optimum balance. The explanation includes how to send a soil sample for testing, how to analyze the result and then using worksheets and information that he provides how to formulate a soil amendment strategy that is specific to your soil. For those who don’t want to test their soil there is a recipe for a Complete Organic Fertilizer that will help to provide a full range of minerals.

This is a real working book. The information provided is useful, practical, and aimed at growers rather than students. Even when looking at the science behind soil mineral balancing, the explanations are easy to understand.

Perhaps more important than a list of what the book contains is what it does. For me it opened up a ‘Pandora’s Box’ of questions. What minerals are in my soil, in what ratio, and if there are deficiencies, how do I correct that? Finally, what are the consequences to my health of not doing so? I have since had my soil tested and using the worksheets provided, am now amending my soil with exactly the minerals that it needs to bring it to an optimum balance. I also have a soil test report to use as a check to see how successful I have been when I next test my soil.

For some time the Organic Gardening movement, has concentrated almost exclusively on compost as the solution to gardening problems. Including soil mineral balancing as part of your food growing strategy, will complement the use of organic matter, and should improve the nutrient content of your food. This book is the ideal guide to doing so.” - Deano Martin from www.permaculture.co.uk
Selections from The Intelligent Gardener

“If your intention is to produce nutrient-dense food on a scale that means a great deal to the family economy, do a soil test, and amend the soil in the direction that maximizes nutritional outcomes. That’s the best way. Thinking just in terms of money, if you’re growing a large-enough garden that its output makes a financial difference, and if its fertilization requires the purchase of anything at all, why not add another $20 to your annual cost and do a soil test first? Then you can buy only what the garden really needs. The test could save you more than its cost. And if you think of it in terms of your family’s health, there is no choice at all.” (pg. 83)

“Better-mineralized vegetables … gently improved our health a few notches, with one slight drawback: Annie and I started gaining weight even though we were consuming costly vegetables; we hadn’t yet learned to adjust our intake down to match the increase in how much we were eating because the vegetables all tasted so great!

After remineralizing, we had even less interest in buying treats, meats, cheese and other things from the supermarket. In other words, homegrown veggies became a larger fraction of our total intake than they already had been. This shift was effortless; we’re eating what we enjoy most. I think improved vegetable nutrition has enabled me to mostly give up our excellent Tasmanian cheeses (much of the time); consequently, I am not having as much discomfort at night. I also have more energy – important when a bloke gets to age 70.

The English language has few words to accurately describe flavor. But how about this attempt: we have long enjoyed eating zucchini splosh. To make splosh, you steam or simmer chunks of zucchini until they are soft enough to mash. Then you mash. While mashing, add a big pat of butter and a little black pepper. Salt if you must. That’s it. This year, our splosh tastes nearly as rich as a savory pumpkin soup. It’s incredible. We want to eat a big bowl of zucchini splosh every night. We were sad last autumn when we ate the last serving the garden would provide until the next summer.

And our sweet corn! I hadn’t tasted corn that good since coming to Australia. I’d been complaining about the lack of good flavored sweet corn varieties in Australia. I discovered that one reason was a quarantine restriction on corn seed imports. The main result of this restriction has been to create a protected market in which our domestic seed producers can charge several times the price Americans have to pay; to add insult to injury, we home gardeners are offered only a handful of second- or third-rate varieties. While in Australia, I’ve done trials that included every corn variety legally available, but remembering the corn trials I did when I had Territorial Seed Company, I would say that in Australia I have never tasted a variety I would have scored over 7.5 out of 10 because I still remember the flavor of Jubilee, or Sugar Dots, which I generally awarded a 9.5. After remineralization, a variety I scored 7.0 last year tastes like an 8.0 this year. And I’m expecting 8.5 next summer as more nutrients leach into the subsoil. Remineralized soil!” (pg. 81-82)

“I wrote this book to function like “Analysis for Dummies.” I will tell you only what you absolutely need to know – in the simplest possible terms. I cover only the bare essentials, leaving out all that fascinating (or boring) background information enthusiastic writers usually can’t keep to themselves. For me, personally, the study of soil chemistry and the contemplation of what might constitute the ideal soil and how one can create it is a marvelous puzzle that can endlessly occupy my thoughts. It’s possible you don’t feel the same way.
about it.

However I’m pretty certain that when you taste the result, you will be inspired to learn more. And that’s why I include mentions of some of the other interesting books out there as often as I think I can get away with it. For me, there’s always endless heaps of fascination to delve into. But learning that much is entirely unnecessary if all you want to do is successfully produce nutrient-dense food.”

(merge pg. 93-94)

“An archery target usually consists of concentric rings with a bull’s-eye in the center. When balancing soil, the target is the relationships among six elements: Calcium, magnesium, potassium, sodium, sulfur, and phosphorus. The other plant nutrients – boron, iron, copper, zinc and manganese – are equally important, although they are not added in large quantities, and we are not as certain about where their bull’s-eye are.

There are a handful (or maybe a hatful) of other elements that plants don’t seem to absolutely require but do pick up in tiny traces; and there are a few elements plants do absolutely require for their own internal chemistry, but only in the slightest of traces, like molybdenum and cobalt. Rest assured, I don’t overlook any of these elements, because even if the plants don’t seem to require them, your body does.

Growing nutrient-dense food requires bringing nutrients in soil to target levels that are in balance with other nutrients, while at the same time making sure there is a healthy soil ecology helping the process along. Creating maximum soil fertility is not necessarily about having more; it is about achieving balance; often, it is about having less. My underlying strategy is to present both the plants and the soil ecology with a luxurious abundance of everything they can use…” (merge pg. 96-97)

“When assaying soil, a sample is soaked in an extractant solution; then, the elements removed from the soil by the extractant are analyzed. This book focuses on a type of soil test that uses Mehlich 3 (M3) extractant. A standard soil test using the M3 method accurately measures the availability quantity of 11 essential plant nutrients. To adjust for differences from spot to spot in any field or garden, several samples are thoroughly blended before the extraction is done. The test result will be accurate only if each soil sample going into the blend is the same size. For gardening purposes, we usually analyze the top six inches of topsoil because that is where most of the biological activity happens. It’s where the crop does the majority of its feeding, and it’s also where we can conveniently mix in fertilizer with a shovel, fork or tiller… Soil varies from spot to spot, so you need to take several samples and blend them to determine average values. An established home garden will have different fertility profiles from bed to bed…” (merge pg. 97)
About the Author

Jeff Lowenfels is the former president of the Garden Writers of America, a Garden Writer’s Fellow and was inducted into the GWA Hall of Fame. He is founder of Plant A Row for The Hungry, a national program that encourages gardeners to plant one row in their gardens dedicated to feed the hungry. Jeff hosted a popular statewide TV gardening show, for Alaska and gardeners above the Arctic Circle. Today, Jeff has a popular radio show where he plays The Germinator. He now lectures around the world, explaining the science behind organics and how plants grow.

About Teaming with Nutrients

In Jeff’s new book Teaming with Nutrients, he writes for the gardener who is fascinated by plants and wants better understanding and visualization of the world of soil nutrients, molecules, and root hairs, of hydrogen ions, covalent bonds, and nutrient movement through the phloem. His explanations are clear, accompanied by abundant illustrations from over twenty contributors. His motivation is to bring the average gardener into the world of plant chemistry and nutrient bio-availability.

The first chapters, which profile all of the nutrients and their function in plant growth, provide the basis for the next chapters that describe soil test results, how to interpret them, and how to acknowledge and troubleshoot visual nutrient deficiency symptoms. Teaming with Nutrients adjusts our lens to the microscopic level, giving us a tour of the unseen system of plants and soil.
Selections from Teaming With Nutrients

“Unless you’re a scientist who deals with Mycorrhizae, you’ve probably never given much thought to how plants eat. Most gardeners think that growing a good tomato is all about photosynthesis and mixing in some nitrogen, phosphorus, and potassium (N-P-K). Jeff Lowenfels shows how wrong this assumption is. Jeff’s book is timely as it is informative. Too many gardeners think they are taking the modern path by blindly pouring on synthetic N-P-K fertilizer in accordance with a picture on the label or an ad on television. We let chemistry take over. We know little about what we’re doing, but we do it anyway. The result has been an alarming spike in phosphorus and nitrogen pollution.”

“How do plants eat? I am pretty sure this is an age-old question. It probably came up 10,000 years ago after some early gardener noticed that rotting fish did wonders for plants. The observation that one’s urine had a beneficial impact on plants could not be missed, either. These and other natural fertilizers not mentioned in public helped trigger the Neolithic Revolution, the transition from hunter-gatherer to farmer-gardener. Even in ancient times, feeding an ever-growing population required horticultural advances. The Aztecs and Mayan civilizations, for example, were all about growing food to support burgeoning populations. They offered their gods sacrificial blood to ensure a good harvest. Perhaps this practice arose from their observation that soil bloodied from butchering an animal or as a result of some mortal blow during a heated battle grew better plants. I come from a long line of natural fertilizer users. My grandfather and dad taught me to bury the uneatable bony fish we used to catch every summer under roses and tomatoes. We had a horse for a while, too, and chickens, geese, ducks, and rabbits. We knew about the wonders of manure. I won’t go into my use of urine as a fertilizer, but with three boys growing up on eight acres, you can bet it was applied liberally, with varying impacts on the plants. We let nature take its course.”

Most gardeners can name many of the essential nutrients. The macro nutrients are the ones required in the greatest quantities. Three of these are always represented on fertilizer packages as the N-P-K trilogy: nitrogen (N), phosphorus (P), and potassium (K). Because it often comes up, the symbol K is used for potassium not because the letter P was already taken, by phosphorus, but because it comes from the Latin name kalium. Beyond this trilogy, some gardeners are familiar with other macro nutrients, such as sulfur, calcium, and magnesium. These are also used by plants in large amounts. Carbon, hydrogen, and oxygen are also macro nutrients.

The second category is micro nutrients, which are sometimes called trace minerals. The lack of iron, manganese, zinc, copper, molybdenum, boron, chlorine, or nickel can cause plants to do poorly. Although the name micro nutrient might suggest they are less important than the macro nutrients, they have the same degree of importance. They are essential but only tiny amounts are required. The micro nutrients are present in most soils and don’t have to be added very often unless there is something way off balance. But they have to be there or the plant will not survive and reproduce.

The list of essential plant nutrients is not a very long one, and most should be familiar to you because they are in your own daily diet (just check your vitamin and mineral supplements bottle). If you’re going to be a really good gardener, though, you need to really understand a lot more about them.”

(pg. 7-12)
“If simply ensuring there was a sufficient and continuing supply of the essential nutrients to plants was all there was to gardening, we could all be prizewinners. Unfortunately, even if all the right plant nutrients are present in unlimited quantities, there are other factors that affect their availability to plants.

What makes a gardener a good one is understanding how plant nutrients work and how to supply them. However, what makes a better gardener is also being able to identify and deal with the special conditions required to ensure the essential plant nutrients are most efficiently taken up by plants.

“The ability of your soil to maintain aerobic (oxygen-rich) conditions is another major factor that affects plant nutrients. Well-aerated soils have lots of microscopic pore spaces that allow for air and water exchange. This water replenishes the supply of nutrients to depleted root zones, and it carries nutrients up into plant roots. If soils are not well aerated, there can be less water and consequently lower root pressure and less mass flow and nutrient uptake. In addition, carbon dioxide produced by cellular respiration in roots can build up in poorly aerated soils. Carbon dioxide chemically reacts with water to form an acid, and it often combines with organic matter to form cell-killing alcohols and fermented products that are not good for plant roots or some of the beneficial members of the soil food web. Well-aerated soils can absorb and then help release the carbon dioxide produced by cellular respiration in roots into the atmosphere. These soils also contain oxygen, which mixes with water and enters roots. When soils are anaerobic (oxygen-poor), microbes that require oxygen often replace this element and use other nutrients instead. Thus, soil compaction affects the availability of iron, sulfur, and manganese because microbes use these nutrients, reducing amounts available for uptake by plants.

And, of course, soils need to have ample oxygen to sustain the free-living microbes that fix nitrogen, as well as the plants that house many of them. Moreover, the microbes that like anaerobic conditions include many that unfix nitrogen at the plant’s (and gardener’s) expense. Finally, mycorrhizal fungi, which are important for the uptake of phosphorus, nitrogen, copper, and other essential nutrients, require aerobic conditions.

Aside from oxygen, the uptake of potassium is the nutrient most affected by compacted soils. A whopping 50 percent reduction can occur in compacted soils. Because potassium is required for the regulation of carbon dioxide and water levels, which are both important for photosynthesis, it is no wonder plants become stunted in anaerobic soils.” (pg. 187)

“The ability of nutrients to move through soil to roots depends on the characteristics of the soil. Organic and clay particles in the soil have lots of negative charges on their surfaces that hold positively charged mineral nutrients. These nutrient cations can be exchanged with plant produced cations. The number of cations that soil is capable of holding is the cation exchange capacity (CEC)

Clay is made up of sheets of molecules, and some molecules hidden in the layers hold positive charges. When these become exposed, they attract anions that are exchanged with hydroxyl ions (OH-) in the water solution. Likewise, the number of anions that a soil is capable of holding is its anion exchange capacity. Because most anions are already in the water solution and available to plants, however, this is not as important as the CEC.

Soils with a low CEC won’t hold nutrients well, so the gardener needs to mete out nutrients over an extended period of time so they won’t all leach away. If your soil has a good CEC, then you can dump in large amounts of nutrients and expect them to be held. If your soil is sandy, you may need to add compost full of organic matter and clay to increase the CEC of your soil. CEC may also influence the timing of fertilizer application. For example, you wouldn’t want to put fertilizers down in the autumn with low CEC soils, because there would be nothing left by spring due to runoff. However, if your soil has a high CEC, amending it in autumn might be a good practice.

In short, CEC has a lot to do with the mobility of nutrients in soil. Assuming an adequate CEC, the anions chlorine, nitrate, molybdenum, and sulfur are mobile in soil. In contrast, the cations ammonium, calcium, copper, iron, magnesium, and manganese are much less mobile, depending on the amount of organic matter and clay, which increase CEC and decreases their mobility. Nickel, phosphorus, potassium, and zinc are
relatively immobile in soils. Mobile elements have to be replaced more frequently than the immobile ones because they are both readily taken up by plants and more quickly leached out of the soil.

Obviously, the amount of water in the soil can have the ultimate impact on the availability of nutrients. Water influences pH, mass flow, and root pressure, all of which affect nutrient uptake. As water moves out of the soil, it leaches away the nutrients dissolved in it. It can also wash away soil that contains nutrients, which is a major source of phosphorus loss. Of course, water can also increase nutrient availability by releasing nutrients, both chemically and by weathering. Once again, too little or too much water has a direct impact on populations of microbial symbionts. If there is too much water and anaerobic conditions develop, our Rhizobia and Frankia bacterial friends won’t produce nitrogen. This can cause a decrease in the production of sugars in leaves and reduce the numbers of soil food web organisms that rely on exudates, including mycorrhizal fungi. The result is little or no nitrogen, Phosphorus, copper, and other nutrients being delivered biologically to the plant.

“Unlike chemical fertilizers, natural fertilizers foster the health of the soil food web which builds all important soil structure. Biofertilizers are living organisms that are added to the soil to promote plant health. These include nitrogen-fixing bacteria, phosphate-solubilizing bacteria and fungi, and mycorrhizal fungi.” (pg. 194)
Appendix

Resources

Online

Print

Media

Soil Testing

Notes

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Soil Health Worksheet

### Soil Respiration Worksheet

<table>
<thead>
<tr>
<th>Rep. No.</th>
<th>Ring H (cm)</th>
<th>Start Time</th>
<th>Soil Temp. (Celcius)</th>
<th>Pressure Factor (assume 1.0008)</th>
<th>Carbon Dioxide (%)</th>
<th>Soil Surface Moisture (%)</th>
<th>Respiration (tests CO2)</th>
<th>Respiration (tests CO2, acid)</th>
<th>Respiration (tests CO2, acid)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5.88</td>
<td>1.8</td>
<td>calculation</td>
<td>calculation</td>
<td>calculation</td>
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</tr>
<tr>
<td>2</td>
<td>5.88</td>
<td>1.8</td>
<td>calculation</td>
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<td>calculation</td>
<td>calculation</td>
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</tr>
<tr>
<td>3</td>
<td>5.88</td>
<td>1.8</td>
<td>calculation</td>
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<td>calculation</td>
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<tr>
<td>4</td>
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</table>

### Soil Solution pH Worksheet

<table>
<thead>
<tr>
<th>Rep. No.</th>
<th>1st Inch of Water</th>
<th>2nd Inch of Water</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Start Time</td>
<td>End Time</td>
</tr>
<tr>
<td>1</td>
<td>calculation</td>
<td>calculation</td>
</tr>
<tr>
<td>2</td>
<td>calculation</td>
<td>calculation</td>
</tr>
<tr>
<td>3</td>
<td>calculation</td>
<td>calculation</td>
</tr>
<tr>
<td>4</td>
<td>calculation</td>
<td>calculation</td>
</tr>
</tbody>
</table>

### Soil Density Worksheet

<table>
<thead>
<tr>
<th>Rep. No.</th>
<th>1st Inch of Water</th>
<th>2nd Inch of Water</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Weight of dry soil (g)</td>
<td>Weight of water (g)</td>
</tr>
<tr>
<td>1</td>
<td>calculation</td>
<td>calculation</td>
</tr>
<tr>
<td>2</td>
<td>calculation</td>
<td>calculation</td>
</tr>
<tr>
<td>3</td>
<td>calculation</td>
<td>calculation</td>
</tr>
<tr>
<td>4</td>
<td>calculation</td>
<td>calculation</td>
</tr>
</tbody>
</table>

### Electrical Conductivity Worksheet

<table>
<thead>
<tr>
<th>Rep. No.</th>
<th>1st Inch of Water</th>
<th>2nd Inch of Water</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimated Soil N/C</td>
<td>Estimated Soil N/C</td>
</tr>
<tr>
<td>1</td>
<td>calculation</td>
<td>calculation</td>
</tr>
<tr>
<td>2</td>
<td>calculation</td>
<td>calculation</td>
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<tr>
<td>3</td>
<td>calculation</td>
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<tr>
<td>4</td>
<td>calculation</td>
<td>calculation</td>
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</tbody>
</table>

### Aggregate Stability Worksheet

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<tr>
<th>Rep. No.</th>
<th>Weight of sand (%)</th>
<th>Weight of silt + clay (%)</th>
<th>Weight of silt + clay (%)</th>
<th>Weight of silt + clay (%)</th>
<th>Weight of silt + clay (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>calculation</td>
<td>calculation</td>
<td>calculation</td>
<td>calculation</td>
<td>calculation</td>
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<tr>
<td>2</td>
<td>calculation</td>
<td>calculation</td>
<td>calculation</td>
<td>calculation</td>
<td>calculation</td>
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<tr>
<td>3</td>
<td>calculation</td>
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<td>calculation</td>
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<tr>
<td>5</td>
<td>calculation</td>
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</tr>
</tbody>
</table>
**Extend Plant Life**

*for both Indoor and Outdoor Container Plants*

Just push down! Automatically conforms to containers with inside bottom diameters of 5 to 7”.

---

**ROCKS...**

“Conventional wisdom” says ROCKS IN A POT will improve drainage. The truth is, overtime rocks do just the opposite and make drainage worse! The Smart Soil Separator permanently solves the problem of drainage and many other not so obvious problems.

---

**IF PLANTS...**

Your plants can’t take up nutrients without AIR around the root. Air and water combined pass nutrients to the plants root.”

- Ed Smith, *The Vegetable Gardeners Bible*

---

**Circling Roots**

Circling roots occur in nearly all potted plants and is a major problem in house plants that spend their entire life in the same pot. Circling roots are large and easy to spot when a plant is removed from its container. Circling roots can be avoided by using a Smart Soil Separator.

“Standard pots encourage the development of roots that grow around the container in a constricted pattern,” state gardening experts at the University of Washington.

“Highly Branched Roots”

“When plant roots are exposed to AIR, the plant will constantly produce new and highly branched roots,” Washington State University emphasized.

“These highly branched root structures allow a plant to more efficiently uptake water and nutrients while increasing the growth and overall plant health,” according to University of Washington.

---

**Improved air flow in the root zone improves Plant Performance**

- AIR supports photosynthesis
- AIR enables roots to extract more water and nutrients
- AIR protects roots from pathogen attacks
- AIR below the root zone “burns off” circling roots
- A permanent airspace extends plants life.
Worm Factory®
Kitchen Waste Recycler

FEATURES:
• 5 year extended warranty
• High Quality Food Grade Plastic
• Thermo-siphon Technology

ADVANTAGES:
• Reduce Household Waste
• Create Nutrient-Rich Compost
• Save Money by Recycling

PERFECT FOR...
✓ Gardening
✓ Recycling
✓ Organic Produce
✓ Confined Spaces
✓ Learning

HOW DOES IT WORK?
Americans throw away 34 million tons of food waste into landfills each year, more than any other type of waste. (www.EPA.gov) Waste can be effortlessly and efficiently recycled using worms. This process creates rich compost packed with beneficial soil microbes and soluble nutrients.

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At maximum efficiency, a Worm Factory® can house thousands of worms and process about five pounds of waste per week.