# Pyro-Gro Rare Earth Minerals

## Silicon

Silicon is the second most abundant element on the planet. (oxygen is first and aluminum is third.) The Earth's crust consists mostly of silicone dioxide (plain sand), and silicates which vary widely in composition. Sheet silicates, compounds of silicon, oxygen, metals and carbonates are rarely consistent in elemental make up primarily because metal ions can easily substitute for each other in the crystalline lattices. The most common elements found in sheet silicates are aluminum, iron, titanium, magnesium, calcium, lithium, manganese, sodium, and potassium. Hundreds of mineral silicates occur in the Earth's crust. Silicon is readily available for plant assimilation as silicic acid. Silicic acids can be extracted from sheet silicates in the form of monosilicic acid, orthosilicic acid and metasilicic acid. Standard nutrient formulations often ignore the existence of silicon as an essential element. Silicon is the second most abundant element in soil. Soil is the mineral substrate for most of the worlds plant life. Soil water contains silicon, mainly as silicic acid ($H_4SiO_4$). Usually in concentrations ranging from 50 to 400 ppm. Silicon is readily absorbed so that terrestrial plants contain it in appreciable concentrations, ranging from a fraction of 1% of the dry matter to several percent, and in some plants up to 10% or even higher. In spite of this prominence of silicon as a mineral constituent of plants, it is not counted among the elements defined as "essential". Ample evidence is present that silicon, when readily available to plants, plays a large role in their growth, mineral nutrition, mechanical strength, and resistance to fungal diseases, herbivory, and adverse chemical conditions of the medium

## Sources of Soluble Silicon

In light of all the work that has been done, why is silicon not a standard ingredient in every formulation used around the world? The biggest problems have been in getting growers educated and finding an affordable source. Over the past decade most research into the use of silicon to prevent fungal diseases has been done using potassium silicate. The results have been so positive that many growers incorporated potassium silicate into their fertigation regimes (until the first time the pH went up and the solution turned to gel).

## Properties of Sheet Silicon Clay

A common source of silicon is clay, as growers in the early part of this century knew. Adding a pinch of clay to a soil or soil-less mix and the plants seemed to be healthier, grow better, and flowers showed better color. The word clay is generally applied to any rock or soil material having a significant percentage of very small particles and exhibiting plasticity. The clay particles contained in the soil largely determine the soils suitability for cultivation. In addition to the primary silicon/metal oxide content of the clay, most clays contain small amounts of approximately 97 elements: 5 % iron, 3 % calcium, 2 % each magnesium, sodium, and potassium and the remaining 92 trace elements present in clay are estimated to be only one percent in total. The differences in clays are attributed to the ion structure and composition of elements. Clay minerals are hydrolyzed silicates (contain hydroxyl ions) or aluminum silicates of the sheet type. For purposes of agriculture and horticulture, the sheet silicon clays are of the greatest importance. They are numerous, complex, and include a wide range of ionic sizes and charges. The most frequently found silicate clays are aluminum silicate, sodium silicate, magnesium silicate, calcium silicate and potassium silicate.

Selecting a suitable silicate clay for agricultural application is complicated not only by the fact that the specific elemental composition of each type of silicate clay is different, but the elemental composition varies even from one geological pocket to the next. This great variance in element content produces mixed results in soils and plants. Silicate clays cannot be chosen on the basis of silicic acid content only. A holistic examination of the specific elements contained in the clay determines the effects on the growing medium and the plants. For agriculture, the 3-layer non-expanding clays have exceptional properties. These sheet silicates do not absorb great amounts of water, nor do they bind up elements in the soil. The best of this group are the aluminum silicates. Toxicity is possible with the sodium silicates or the magnesium silicates. A 3-layer non-expanding aluminum silicate clay has a multi-faceted positive effect on both soil and plants. Silicates are a decisive factor in the healthy development of plants. Not only for the silicic acid content, but also for trace elements, pH buffering, and enhancement of the microbial population in the growing medium.

The evidence that silicon is of importance to plants is found in plants themselves. They contain silicon in amounts ranging from fractions of 1% to as high as 10% depending on species. Research has clearly shown that readily available silicon plays a large role in growth, mineral nutrition, mechanical strength, resistance to fungal diseases, and adverse chemical conditions within the root zone. Plants absorb silicon in the form of silicic acid, $H_4SiO_4$. In soil environments silicon in this form is available in the same relative concentrations as K, Ca, and $SO_4$. Plants presently grown in greenhouses, evolved originally with silicon as a major constituent of their nutrition in natural soils. A review of hundreds of nutrient solutions and all greenhouse growing systems showed one thing in common, the absence of silicon and a range of other naturally occurring elements. The fact is that we attempt to grow healthy productive plants in isolation from some of the nutritional inputs they were evolved to require. It is obvious by now that silicon and other rare earth elements are of benefit as a nutrient component for greenhouse and Hydroponic growing systems. The real problem for growers has been finding a source of them in an economically and useful form. Potassium silicate is too pH sensitive and expensive, and pure silicic acid is not feasible as an additive. Pyrophyllite clay is the natural answer.

## Rare Earth Elements

The publicity from China about their claims for the effects of rare earth elements on plant growth has focused attention on this aspect of plant nutrition. In one greenhouse trial we used a broad spectrum input of "non-essential" nutrient ions. The purpose of the trial was to determine the impact of silicic acid as a fungicide on chrysanthemums. While the trial was successful in its purpose, there were additional unexplainable results. The grower noted improved color, and enhanced health and vigor. Isolating which of the 60 additional elements (other than silicon) responsible for each observation is impossible. For our purposes in nutrient formulation, it is becoming obvious that we need to include a much broader spectrum of elements in the nutrient solution.

## Pyrophyllite Clay

### Pyrophyllite Composition

$Al_2Si_4O_{10}(OH)_2$ Aluminosilicate (aluminum silicate sheet)

A comparison of two growing mediums, one sand with clay colloids, and the other a Hydroponic solution, each with an equal portion of soluble salts showed that the absorbed ions of the clay resulted in greater plant growth. Clay surfaces adsorb large amounts of plant nutrients without any appreciable change in the osmotic concentration of the growing medium or fluctuation of pH. Additionally, clays increase the cation exchange capacity of the substrate. Pyrophyllite is a relatively scarce clay, with very few deposits being commercially mined. Much more common is the montmorillonite source, which tends to bind essential enzymes. It also releases very little silicic acid due to the structure which expands rather than disintegrating when mixed with water. Growers must exercise care to ensure the product they buy is Pyrophyllite, if results are to be as research indicates they should be.

The most interesting aspect of the Pyrophyllite clay is the bond which holds it together. This clay is held together by a Van der Waal bond. This is the weakest bond which can hold elements together. The potential bonding with the water is stronger than the bond which holds the clay together. The result is that when the clay is exposed to water, it literally falls apart. The amount of clay dissolved is dependent on the potential of the water to provide H+ ions, to create silicic acid. In nutrient solutions this is both limited and controlled, so the clay becomes a slow release source of silicic acid in two forms. The monosilicic acid used by bacteria and lower order plants and the orthosilicic acid used by higher order plants.

The range of elements in the Pyrophyllite provides a naturally available source of all these elements, should they be needed by the plants. The first question we had in trials was the impact of the levels of aluminum. To date, in all trials and commercial use, there have been no negative responses as long as the roots do not grow directly into the Pyro-Gro in its dry form. When the Pyro-Gro is dissolved before it reaches the roots there is sufficient silicic acid present to neutralize the antagonistic action of the aluminum. The reduced fungal infections, resulting from the use of Pyro-Gro, are easily explained by the presence of available silicic acid. What we may never understand are the other beneficial results which have been reported by growers. There are simply too many potential inputs and synergies for clear explanations.

## Documented Results

To date growers around the world have benefited from using Pyro-Gro. In water culture we have found that 0.5 mmol (approx. 300 ppm) of silicon is the target level in the root zone for most plants. The target is the same for drain to waste and recycling media systems. The application of 25-50 grams of Pyro-Gro on top of the transplant block, under the drip line, after planting out, seems to work very well.

Pyro-Gro has been beneficially used on a range of crops including; tomatoes, cucumbers, peppers, lettuce, chrysanthemums, African violets, basil, rosemary, bedding plants, poinsettias, aquatic plants, alstromeria, roses, tree seedlings, rice, golf courses, plus a host of others. It has been used in nutrient solutions, both drain to waste and recycling, and incorporated into all types of grow media. Also as a foliar dust or spray, or as a topical media dressing.

The range of trials we have supervised with greenhouse growers is extensive. In no case has a negative response on yield been experienced. A tomato grower who lost 30% of his crop to botrytis last year, used Pyro-Gro as a dusting once a week the next year. His loses to botrytis were zero. Other growers, in the same area, who were not using the Pyro-Gro, experienced the same loses as the previous year. A cucumber grower, who was using potassium silicate in his irrigation program, put 50 grams of Pyro-Gro on top of each transplant block, in several bays of the range. The treated plants were the earliest to produce, the highest producers, and resisted powdery mildew in spite of the fact the rest of the range became heavily infected. A grower with phytophthora in his water supply, introduced Pyro-Gro into his storage reservoir. Within days, there was no evidence of phytophthora in the growing system. Reports from a range of growers detailed improved plant health on a range of crops. There are currently hundreds of growers incorporating Pyro-Gro into their nutrition programs, and the number is increasing rapidly as growers share their experiences.

Field Applications

For field growers there is an application for Pyro-Gro, in the remediation of dead soils. Bringing soils back to long term health, is a slow process as long as there is little food for the bacteria. Rock dust is commonly used, but it is a slow response application, taking up to a year to show results. Mixing Pyro-Gro with the rock dust, yields an immediate source of silicic acid, and over 60 other elements. This kick starts the bacterial population, which is so essential to the activation of the elements contained in the rock dust. In lab experiments, done with bacteria and Pyro-Gro, it was found that the reproduction time for the bacteria was instantly reduced by 25%, and enzyme production increased exponentially.

--------------------------------------------------------------------------------

Pyro-Gro Quick Reference

Use & Application Chart

Propagation

A light dusting of Pyro-Gro over the media after seeding, will provide fungicidal protection. For optimum results, water in with a NutriBoost (plant enzyme rooting initiator) amended solution.

## Transplants

Sprinkle a few grams of Pyro-Gro on top of the media after transplanting. In drain to waste, or drip return systems, we have found the best results comes with the placement of the Pyro-Gro, on top of the transplant block, under the dripper. For all single year crops, 25 grams of Pyro-Gro will provide slow release of silicon throughout the growing season. For multi-year crops such as roses, add additional Pyro-Gro each year.

## Recycling including NFT

For recycling water culture, including NFT, there is the consideration of the additional nutrient elements, which are added when Pyro-Gro is dissolved in the reservoir. We recommend that Pyro-Gro be added to maintain silicon levels at 14 ppm. At this concentration you are also adding: Fe-1 ppm; Al-5.4 ppm; K-0.5 ppm; Ca-0.5 ppm; Mg-0.6 ppm; S-0.5 ppm; Na-0.3 ppm in addition to the rare earth elements at levels in parts per billion, similar to that found in soils. The addition of 23.5 grams of Pyro-Gro per 1,000 liters (265 US gallons) of solution will provide silicon concentrations of 14 ppm at 0.5 mmol (mS).

Greens & Golf Courses

Mix Pyro-Gro with the top 6 inches of soil/sand at the rate of 50 lbs./ton of media at initial construction.
Top dress with 100 lbs./acre of Pyro-Gro each spring and fall. Application can also be done through the irrigation system.

Field Crops

Top dress fields with 300 lbs./acre after harvest in the fall or between harvests on multiple cropping.

Soil Remediation

Mix 1 part Pyro-Gro with 200 parts rock dust and incorporate into the soil at the rate of 3 tons per acre with any bacterial inoculation being done.

----------------------------------------------------------------------------

Concentrated Stock Solution

For Foliar and Irrigation Applications

Every liter of concentrate produced is sufficient to treat 100 liters of water at 50 ppm of silicic acid.

The water used to create the concentrate should be demineralized and deionized. Use 28 grams of Pyro-Gro for every liter of concentrate required. For small volumes of concentrate (20 liters or less) two containers should be used. For larger volumes use a single container and an external pump. Treat the Pyro-Gro in a microwave for 2 minutes at the highest setting. Spread the heat treated clay onto a tray with a very fine screen bottom, which will fit over the containers you are using. Leach the water to be treated through the Pyro-Gro until the water has a concentration of 10,000 ppm.

--------------------------------------------------------------------------------

Culture Stress

Harvest & Pruning Stress

Cover all pruning and harvest wounds with Pyro-Gro dry or as a paste. It may also be applied through a duster or fogger at the end of the day, at the rate of 10 lbs./acre (10 kg/hectare). Any dusts or fogs can be irritants. Use of masks or respirators is recommended. All other personnel should temporarily vacate the area.

## Crown & Stem Rot

Mix 50 grams of Rovril with 2000 grams of Pyro-Gro, and add water to make a thick paste. Apply a thick coat to all visible lesions. Place 15 grams of Pyro-Gro around the root crown of all plants in the affected growing area.

## Fungal infections

Top dress with 400 lbs./acre of Pyro-Gro as soon as the fungus is noticed.

## Fungus or Pathogen Contaminated Water Supplies

Add 20 grams of Pyro-Gro to each 1000 liters of water storage and ensure maximum aeration. Repeat each time reservoir is refilled.

Foliar Application for Powdery Mildew

Add 250 grams of Pyro-Gro to every 1,000 liters of water. Agitate at 3,000 rpm for 20 minutes. Apply through pressure sprayer or overhead misting.

--------------------------------------------------------------------------------

Typical Mineral Analysis

Silicon as Silicate Salts 59.6%

Aluminum 22.9%

Iron 4.7%

Magnesium 2.5%

Potassium 2.5%

Calcium 2.2%

Sulfur 2.0%

Sodium 1.2%

Titanium 0.5%

Phosphorus 0.1%

Strontium 0.1%

Gadolinium 2 ppm

Holmium 2 ppm

Barium 969 ppm

Fluorine 500 ppm
Copper 327 ppm

Vanadium 156 ppm

Zirconium 144 ppm

Manganese 119 ppm

Zinc 78 ppm

Cerium 68 ppm

Rubidium 42 ppm

Chlorine 40 ppm

Lanthanum 33 ppm

Nickel 30 ppm

Neodymium 21 ppm

Praseodymium 20 ppm

Gallium 17 ppm
Cadmium 17 ppm
Lithium 15 ppm

Molybdenum 13 ppm

Boron 10 ppm

Scandium 10 ppm

Lead 10 ppm

Chromium 9 ppm

Cobalt 8 ppm

Niobium 6 ppm

Arsenic 6 ppm

Samarium 5 ppm

Thorium 4 ppm

Hafnium 3 ppm

Cesium 2 ppm

1 ppm; Tin; iodine; Selenium; Uranium; Dysprosium; Bromine; Erbium; Beryllium; Thallium;

Trace Amounts: Antimony; Ytterbium; Terbium; Tungsten; Mercury; Silver; Tellurium; Thulium; Lutetium; Indium; Rhenium; Bismuth; Germanium; Iridium;

Information provided by Green Future Management, Princeton B.C. an Ed Muckle publication