RUTGERS
New Jersey Agricultural
Experiment Station

THE SOIL PROFILE

A newsletter providing information on issues relating to soils and plant nutrition in New Jersey

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International Conference on Silicon in Agriculture.

Silicon and Soil Fertility

Silicon (Si), second to oxygen, as the most abundant element in the earths crust, is seldom given much attention as a limiting factor in soil fertility and crop production. This view is about to change as agronomists become more aware of the valuable function of silicon nutrition in crops and soils and even animal life. Research conducted on New Jersey soils, and many places around the world, have shown that applying supplemental silicon can suppress plant disease, decrease injury from some insect pests, and improve crop tolerance to environmental stress.

In 1999, the first International Conference on Silicon in Agriculture was held in Florida. It was organized by Professor of Plant Pathology, Dr. Lawrence Datnoff, with the objective of bringing together scientists from around the world involved in the study of silicon nutrition. One important thing I took away from that first meeting was that silicon nutrition plays a role in suppression of powdery mildew disease. So in 2000, I began field research on silicon nutrition of crops and soils. Prior to this research venture, the majority of the silicon studies were being conducted on tropical soils and on crops such as sugarcane and rice.

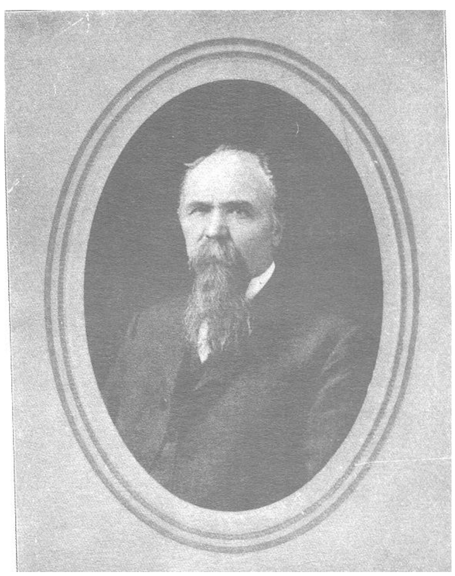
After over a decade of work on silicon soil fertility and nutrition research in New Jersey, I was a delegate to the fifth International Conference on Silicon in Agriculture that was held in Beijing, China in September 2011. At that meeting I reported on the findings from our silicon research findings.

The Soil Science Society America will be hosting a symposium on Silicon Soil Fertility and Nutrient Management at the annual ASA, CSSA, SSSA Annual Meetings October 12-24, 2012 in Cincinnati, OH. The symposium will include seven oral presentations from silicon researchers from around the world. There will also be a poster session on silicon. This symposium is especially timely since Silicon is now officially designated as a plant beneficial substance by the Association of American Plant Food Control Officials (AAPFCO). Plant available silicon may now be listed on fertilizer labels. Web link for further information about attending the meetings: https://www.soils.org/meetings

This issue of The Soil Profile newsletter will provide a summary of our research findings in New Jersey and place them in context of what we know about silicon nutrition from research around the world. The last section of this newsletter summarizes facts on silicon soil fertility and nutrition.

Silicon and Agricultural History

Before I begin discussing the specific findings from our field trials in New Jersey, I want to briefly describe something that came as a revelation to me from my trip to China. In advance of my trip I read *Farmers of Forty Centuries or Permanent Agriculture in China, Korea, and Japan*. This book originally published in 1911, details the observations of a USDA soil scientist F.H. King.



He wrote of how he witnessed farmers in the parts of Asia, habitually composting and recycling all types of organic waste materials as well as ashes to use as soil amendments on their fields. This was a method they used to maintain soil fertility and enhance crop production for centuries. In effect, this was an original form of sustainable agriculture and was foundational to the organic farming movement.

In contrast to this traditional agricultural system, modern agriculture use of commercial nitrogen-phosphorus-potassium fertilizers has largely displaced compost and other organic amendments. Additionally most commercial fertilizers contain very little if any silicon. Because uptake of silicon is comparatively large for many crops, a failure to return organic waste materials to farmland (in addition to the failure to build soil organic matter content) contributes to depletion of plant-available silicon from soil. An enhancement of biological activity in compost amended soils may also have a role in mobilizing silicon for plant uptake. As a result of these historic changes in soil fertility management, there are good reasons for a need to focus new attention on the role silicon in soil fertility.

One of barriers to the acceptance of silicon as an important nutrient for agricultural production is that it has not been classified as one of the "essential" plant nutrients. Currently there are 18 chemical elements regarded as essential. One of the several criteria used to decide if an element is essential is whether or not a plant can complete its lifecycle (reproduce) without it. The ubiquitous and abundant nature of silicon may be another reason that this nutrient lacks the stature of other nutrients in the minds of agronomists. Due to the presence of silicon in air borne dust, water, glassware, and of course soil, plants not supplemented with silicon still manage to accumulate enough silicon in their tissues, making total omission of silicon from a plant's life cycle extremely difficult. Conducting the necessary experiments to demonstrate "essential" nutrient status for silicon remains an expensive and elusive achievement. What we do know is that many plants take up silicon in large amounts and that it confers many benefits to crops. The amounts of silicon uptake often exceed the concentration levels of many essential nutrients in plants.

A recent textbook (Mineral Nutrition of Plants: Principles and Perspectives by Emanuel Epstein and Arnold J. Bloom) now classifies silicon as a quasi-essential nutrient. Perhaps because of this ambiguous classification there seems to be a mental block on focusing attention on silicon soil fertility and plant nutrition.

An important step in removal of the barriers to accepting silicon's vital role in soil fertility has been the recent classification of silicon as a "plant beneficial substance" by the Association of American Plant Food Control Officials. Plant-available silicon can now be listed on fertilizer labels.

The composition of a typical mineral soil is about 30% silicon by weight. While the amount of silicon in soil is huge, only a small fraction is soluble and available for plant uptake. On many soils there is enough available silicon in soils to grow a "satisfactory crop" without adding silicon. However, agronomists and farmers are often not aware that they may be able to grow better crops with increased stress and disease resistance by adding a source of available silicon to the soil. The benefits of silicon in crop production may be exhibited as healthier plants and higher yield with less demand for pesticides and other chemical inputs. Without an awareness of the multiple benefits associated with enhanced levels of silicon nutrition, farmers may be using more pesticide than necessary to reach their crop production goals.

Research on Silicon at Rutgers University

During silicon soil fertility research, calcium carbonate (common agricultural limestone) is often used as a control for examining crop responses to amending soils with calcium silicate as the silicon supplement. The calcium carbonate limestone, acting as a control, provides the same soil pH environment without adding any substantial amount of silicon. Calcium carbonate limestone and calcium silicate are both liming materials with approximately the same calcium carbonate equivalent (CCE). Pure calcium carbonate has by standard definition a CCE of 100%.

The calcium magnesium silicate slag used in most of our research projects were commercial products called AgrowSil™ or Excellerator™, [Excel Minerals (now called Harsco Minerals), Sarver, PA]. The parent material of this calcium magnesium silicate product is stainless steel slag. This steel-making by-product is then processed to remove metals resulting in a silicon based fertilizer product with a CCE of 93%.

Research plots to study silicon nutrition were established in 2000 on a Quakertown silt loam soil at the Rutgers Snyder Research and Extension Farm, Pittstown, NJ. A field with an initial soil pH of 5.7 was selected because this allowed for the application of liming materials.

These liming materials were each applied at 3.5 tons of CCE per acre in spring of year 2000. After application, the liming materials were incorporated into the soil with tillage. The liming materials were reapplied in spring of 2006, spring 2007, and fall 2007, at the rate of 2 tons of CCE per acre each time of application.

The calcium silicate slag product that was used contained 12% silicon (Si). This treatment application in 2000, therefore added 903 lbs Si/acre. Each subsequent application of this calcium silicate slag added another 516 lbs Si/acre. A total of 2452 lbs Si/ acre were applied during period 2000 to 2007. At this same field site, other plots in this same field never received any liming to allow for the further study of acid soil conditions on crop production.

Further details on the research methods are given in the original journal articles listed in the reference section.

Pumpkin

Once the silicon experimental plots were established, they were cropped to pumpkin in 2000 and 2001.

Half of the plots were treated weekly with fungicide targeted for powdery mildew disease control and the other plots were not sprayed.

When powdery mildew infects leaves, it causes early loss of pumpkin foliage, and reduced fruit yield. Pumpkin grown of silicon amended plots exhibited fewer powdery mildew lesions and better retention of a healthy active leaf area. This improved leaf retention was evident on the silicon amended plots and this benefit translated into a 18% increase in pumpkin fruit yield averaged over the two study years.

Fungicide sprays also improved leaf retention, and this translated into about the same level of increase in pumpkin yield. Findings indicated that amending soils with silicon can suppress powdery mildew disease or delay the onset of the disease and may reduce the number of fungicide sprays needed for pumpkin crop management. Silicon concentrations in pumpkin leaf tissue increased from 700 ppm on control soil to 3500 ppm on silicon amended soil.

Soil test results showed no significant difference in soil pH level between the calcium carbonate (pH = 6.8) and the calcium silicate (pH = 6.9) amended plots. While, these amendments appear to be about equally effective as liming materials, the calcium silicate slag provided an additional benefit by enhancing pumpkin silicon nutrition.

Field Corn

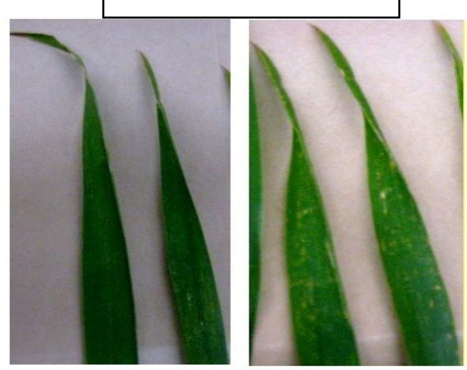
In years 2002 and 2003, the same research plots were planted to corn to investigate if the residual effects of calcium silicate slag (no additional applications since 2000) soil amendments could enhance plant silicon uptake into stem tissue and reduce injury from European corn borer.

Corn stem tissue Si concentration increased from 0.16 to 0.25 % as a result of the previous calcium silicate slag amendment. Increased silicon uptake was associated with reduced tunneling or damage to the corn stem tissue both years. However, this protection from European corn borer was not associated with a significant increase in grain yield. Grain yield averaged 168 Bu/acre on the calcium carbonate plots and 171 Bu/acre on the calcium silicate slag plots.

Winter Wheat

The same plots were next cropped to winter wheat. Additional calcium silicate slag or limestone was applied each year as previously described. In 2006, powdery mildew lesions were reduced 29% on wheat flag leaves in the silicon amended plots. In 2007, powdery mildew was not diagnosed. However, non–pathogenic Alternaria spp. leaf blotch lesions were reduced 16% on the foliage in the silicon plots. During 2008, powdery mildew lesions on wheat foliage were 44% less and yields were 10% greater in silicon amended plots.

Silicon vs Control



Calcium silcate vs. Limestone

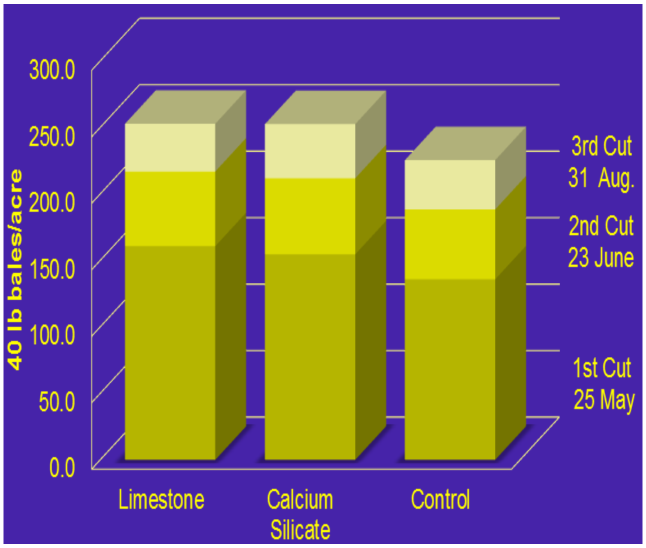
Straw removal from a field can remove substantial amounts of nutrients. In this study, silicon uptake and removal by repeated harvest of wheat straw over the three years totaled 65 lbs/acre for the calcium carbonate plots and 119 lbs/acre for the calcium silicate slag plots.

Oats

In 2009, the same plots were seeded to oats without any additional carbonate or silicate application. Oats also served as a nurse crop to under seeded red clover and orchard grass. Grain yield averaged 48 Bu/acre for the calcium carbonate plots and 50 Bu/acre for the calcium silicate slag plots.

Red Clover and Orchard Grass Hay

Hay was harvested in three cuttings from these plots in 2010 and in a single spring cutting in 2011. In addition to harvests from calcium carbonate and calcium silicate slag plots, hay was also harvested from acid soil plots that had not received any liming material. No calcium carbonate or calcium silicate slag has been applied to the research plots since fall 2007. Soil pH levels measured in 2011 averaged 5.5 for the no lime plots, 6.5 for calcium carbonate and 6.5 for the calcium silicate slag plots. Hay yields, expressed in 40 pound bales per acre shows that forage yields were increased by liming and that both types of liming material were about equally effective.



Cabbage

In July 2011, cabbage was transplanted into the plots. Since the soil pH level was 6.5 for the amended plots, no additional calcium carbonate or calcium silicate slag applied. The soil pH = 5.5 in the no lime plots. Marketable cabbage head yields in tons per acre were 30.0 from the no lime plots, 31.5 from the calcium carbonate plots and 32.8 from the calcium silicate slag plots.

Greenhouse Studies on Silicon - Kentucky Bluegrass

A collection of 18 different soils from across New Jersey was taken into the greenhouse and used to grow Kentucky bluegrass in pots. The soils naturally varied in silicon availability and soil pH. The highest pH soil received either calcium carbonate or calcium silicate for a target pH of 6.5. The remaining soils received the same rate of calcium silicate supplemented with calcium carbonate for the target pH range, or calcium carbonate only as the control. Pots were filled with the amended soils and seeded to Kentucky bluegrass prior to being placed in a greenhouse. After 42 days of growth from seed, the grass was clipped to measure yield and concentration of silicon in the plant tissue. When averaged across all soils, results showed that adding silicon increased dry matter yield.

The concentration of silicon in the plant tissue increased from 0.42% to 0.72% as a result of amending the soil with silicon. Unlike previous research indicating that silicon may reduce powdery mildew on Kentucky bluegrass on greenhouse grown turf, this response was not found in the present study. However, Kentucky bluegrass grown on soils supplemented with silicon was faster to establish and resulted in a denser turf canopy. This denser canopy was maintained under powdery mildew disease pressure with calcium silicate amendment.

Greenhouse Studies on Silicon - Dogwood

Dogwood (*C. florida*) seedlings growing in pots were placed in a greenhouse environment. The potting media, a mix of peat and pine bark, is an organic substrate that contains little silicon. A commercial liquid potassium silicate fertilizer (Dyna-Gro Pro-TeKt®, DYNA-GRO Nutrient Solutions, Richmond, CA) was applied weekly as a drench to the potting media or a foliar drench to the leaves. These treatments were compared to untreated controls. The initially disease free plants were then exposed to powdery mildew diseased plants. While the silicon fertilizer drench treatment to the soil reduced the severity of powdery mildew, the same silicon fertilizer applied to the leaf surface did not suppress disease. Dogwood trees receiving the soil silicon drench treatment also exhibited increased leaf development when compared with either the foliar spray or the controls.

Greenhouse Studies on Silicon - Pumpkin

Spring 2012, a soil (pH = 5.1) collected from a wooded site at the Rutgers Hort-3 Farm near New Brunswick, NJ was used to fill pots for a greenhouse study with pumpkin. This strongly acid soil was used in an investigation of how choice of liming material may influence susceptibility of pumpkin foliage to powdery mildew infection.

The four treatments included:
1) Unamended, control acid soil,
2) Calcium carbonate, limestone,
3) Calcium silicate slag, CSS, AgrowSil™, and
4) Wollastinite, naturally occurring calcium silicate.

These liming materials and were each added to the soil at the rate of 4000 lbs/acre. Several weeks after seeding the pumpkin, the leaves of the plants provided with supplemental silicon in the soil as either calcium silicate slag or Wollastinite exhibited marked suppression of powdery mildew disease compared to the unamended control or the limestone treatment. The treatment effects are exhibited in the photos on page 7.

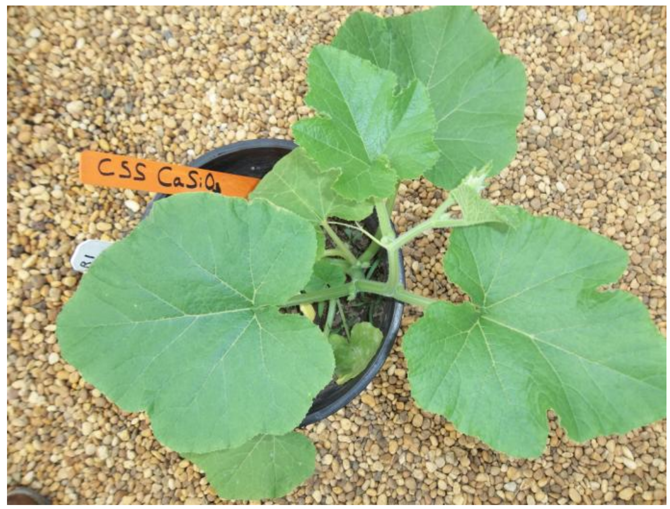
Silicon Research Summary

Findings from over a decade of field trials conducted on the silicon research plots at Rutgers University, New Jersey Agriculture Experiment Station show that calcium silicate slag is an effective liming material and silicon fertilizer. Plants grown on calcium silicate slag amended soil exhibited increased silicon uptake. Pumpkin fruit and wheat grain yields were increased in some years in association with suppression of powdery mildew disease on calcium silicate slag amended soil. Corn plants grown on soil previously amended with calcium silicate slag exhibited less injury to the stem tissue from European corn borer. Forage yields were improved by liming low pH soil with either calcium carbonate or calcium silicate slag 3 and 4 years after the last application. Cabbage yields were improved by liming low pH soil but calcium silicate slag increased yield more than calcium carbonate The residual benefits of calcium silicate slag applications were evident in crops produced 3 to 4 years after the last application.

The field research conducted over the last 12 years using calcium silicate slag shows enhanced levels of silicon uptake which sometimes imparts crop production benefits beyond its service as a liming material.

A substantial body of local and international research trials shows that enhanced silicon soil fertility and nutrition helps to control powdery mildew disease on a wide variety of crops. The photos of pumpkin below illustrate the value of adding silicon to soil for suppression of powdery mildew disease.

Unamended, control acid soil



Calcium silicate slag, CSS, AgrowSil™


Calcium carbonate, limestone


Wollastinite, natural calcium silicate

Facts about Silicon in Agriculture

Chemical Names and Terminology

Silicon or Si is elemental silicon also known as the chemical element Silica, silicon dioxide, or SiO_2, are compounds with silicon and oxygen. Silicate refers to silicon compounds such as $CaSiO_3$, $MgSiO_3$, or K_2SiO_3. Silicic acid or mono silicic acid ($Si(OH)_4$, or H_4SiO_4) refers to the soluble, plant available form of silicon in soils. Silicone refers to R_2SiO, where R is an organic group such as methyl, ethyl, or phenyl

Function of Silicon in Plants

Silicon (Si) is a beneficial nutrient in plant biology. Although the element is classified as essential for only a few plant species, many crops respond positively to supplemental silicon. Plants, especially grasses, can take up large amounts of silicon and this contributes to their mechanical strength. Besides a structural role, silicon helps to protect plants from insect attack, disease, and environmental stress. For some crops, silicon fertilization of soils increases crop yield even under favorable growing conditions and in the absence of disease.

Specific benefits observed due to silicon nutrition is extensive:

- Direct stimulation of growth and yield
- Counteracts negative effects of excess N nutrition
- Suppression of plant diseases caused by bacteria and fungi (Powdery mildew on cucumber, pumpkin, wheat, barley, Gray leaf spot on perennial ryegrass, leaf spot on Bermuda grass)
- Suppression of stem borers, leaf spider mites, and various hoppers
- Alleviates various abiotic stresses including lodging, drought, temperature extremes, freezing, UV irradiation and chemical stresses including salt, heavy metals, and nutrient imbalances

Function of Silicon in Animals

In animals, silicon is regarded as an essential element. Silicon strengthens bones and connective tissue. Vegetables, grains, fermented grain products such as beer, and possibly bone broth are sources of silicon in human nutrition.

Silicon-Deficiency Symptoms

Symptoms of silicon deficiency are generally not visually apparent in an obvious way in the field.

Indirectly silicon deficiency may be exhibited as an increase in susceptibility to certain plant diseases. Crops, such as pumpkin, cucumber, wheat, and Kentucky bluegrass, are susceptible to powdery mildew disease. Providing enhanced levels of silicon nutrition for these crops can suppress or delay the onset of the disease.

As a result of increasing silicon concentrations in plant tissues the mechanical strength may be improved. Grain crops lacking adequate silicon may be more susceptible to lodging.

The amount of insect attack on plant tissues may be inversely related to the silicon concentration.

Plant Tissue Analysis

It is not unusual to find silicon concentrations in plants at levels comparable to or above those for macronutrients nitrogen, phosphorus, or potassium.

Concentrations of silicon in plant tissue can vary widely depending on plant species and silicon availability from the soil. Grasses and monocots in general tend to accumulate silicon. Concentrations as high as 10% silicon are possible in some plant species such as *Equisetum*.

Dicotyledonous plants in general have fewer tendencies to accumulate silicon and some species may grow adequately with levels at about 0.1% Si in plant tissue.

Optimum silicon concentration levels have not been established for many crops grown in New Jersey. However, research conducted on local soils and crops indicates concentration ranges that may occur for some crops. For example, supplying supplemental silicon to a Quakertown soil used to grow pumpkin, corn, and wheat resulted in remarkable increases in concentrations of silicon in the plant tissue.

Silicon concentrations in pumpkin leaf tissue increased from 700 ppm to 3,500 ppm, in corn stem tissue from 1,300 ppm to 3,300 ppm, wheat flag leaves from 1,530 ppm to 11,750 ppm, and Kentucky bluegrass leaves from 4,200 ppm to 7,200 ppm.

For optimum disease suppression and grain yield of wheat, a silicon concentration of 1% (10,000 ppm) or more in the flag leaf is recommended.

Soil Analysis

Silicon is the second most abundant element in the Earth's crust after oxygen. Soils contain on average 30% silicon by weight, but most of it resides in minerals that are only sparingly soluble. With such abundance of silicon in nature, the economic value of this element in agronomy and horticulture is sometimes not been fully appreciated.

In general, older and more highly weathered soils are more depleted of silicon than geologically young soils. Many of New Jersey's soils are classified as Ultisols. These soils, which have been subjected to continuous leaching in a humid environment for a very long time, tend to have little remaining weatherable minerals. Consequently, Ultisols tend to be relatively depleted of silicon.

Although soil testing for silicon availability is not a routine part of soil fertility testing, some laboratories offer an acetic acid soil-extractable soil silicon analysis. At present the data base is very limited in correlating silicon soil test levels with plant silicon uptake. Research is needed to find better soil test methods to predict silicon availability.

Interpretation of any soil test requires years of field research experience to provide a meaningful data base. At present the data base is very limited for interpretation of silicon soil test levels.

When eighteen New Jersey soils were collected and tested using the acetic acid soil extraction method (Logan Labs) they exhibited ranges of soil test silicon from 4 to 35 mg/L. The average soil test silicon level was 14 mg/L.

Occurrences of Silicon Deficiency

Field trials conducted on a Quakertown silt loam soil have shown that several important New Jersey crops can benefit from supplemental silicon. Pumpkin benefited from supplemental silicon when the acetic acid soil test levels were 40 ppm and winter wheat benefited when the soil test level was 33 ppm. In summary, field trials suggest that some New Jersey soils have less than optimum levels of available silicon for crop production.

Soil Factors affecting Silicon Availability

Soil texture refers to percent sand, silt, and clay particles in a soil. Silicon is a component of these mineral particles of varying size. Although sand is largely composed of silicon dioxide, this material provides very little soluble or plant available silicon. Thus, it is not unusual for crops grown on sandy soils to benefit from applications of soluble silicon.

Silicon is not a major component of soil organic matter. Soils composed almost entirely of humus and organic matter, are called muck soils or Histosols. Because the substrate of such soils contains little silicon, certain crops grown on these soils may benefit from silicon application.

The use of soilless mixes in greenhouse production means that very little silicon is being supplied from the growth medium. Greenhouse production systems have also been shown to benefit from silicon fertilization.

Silicon availability does not change markedly across the soil pH spectrum used to grow crops. However, the application of acidifying fertilizers, such as ammonium sulfate, may enhance silicon uptake by crops. Repeated use of these fertilizers may contribute to depletion of silicon from agricultural soils. Many of the commonly used silicon fertilizer materials also serve as liming agents and their application results in neutralization of soil acidity.

Crops Responsiveness to Silicon

Crops may benefit from supplemental silicon as disease suppression, reduced injury from insect pests, stronger stems, tolerance to stress, or direct stimulation of yield.

Around the world, rice and sugarcane are the crops that very often exhibit beneficial responses to silicon fertilization. Of crops commonly grown in New Jersey, pumpkin, corn, wheat, oats, Kentucky bluegrass, and cabbage, have exhibited positive responses to silicon.

Crop groups that are considered good candidates for silicon fertilization include cucurbits, grasses, and small grains. Any crops susceptible to powdery mildew disease and/or grey leaf spot would appear to be good candidates for field trials with silicon.

Silicon Sources

Crop residues, manures, and compost are sources of silicon. Straw from wheat and other small grain crops may contain valuable amounts of silicon. Wheat straw silicon concentrations may range from 0.15 to 1.2% Si depending on the silicon fertility level of the soil on which it is produced. Demand for silicon by crops on some soils may exceed the ability of plant residues and compost to supply available silicon. Increased soil biological activity associated with organic matter may improve to solubility of silicon from soils. Additionally, it may take several years for silicon from crop residues to become available for plant uptake.

Some of the silicon in plant residues occurs in the form of “plant stones” or phytoliths. These silicon structures are very resistant to decomposition and many persist in soils for very long periods. Phytoliths provide a kind of durable “plant fossil” useful in archaeological and paleoecological research.

To be an effective source for crops, a silicon fertilizer should provide a high percentage of silicon in soluble form. Other characteristics to consider are cost of material, physical properties, ease of application, and ability to raise soil pH. Because silicon in nature is always combined with other chemical elements, the agronomic value of the other elements that accompany the product should also be considered. Some of these elements may be valuable plant macro and micronutrients.

Commercial silicon products are marketed as either solids or liquids. In the case of solid silicon sources, plant available silicon increases as particle size decreases.

Calcium silicate products are the most commonly applied silicon fertilizers for field application. Steel mill slags are a rich source of calcium silicate. Because they neutralize soil acidity and supply calcium, they are commonly applied to soil as an alternative liming agent in much the same way as agricultural limestone or calcium carbonate. Slags vary in purity, silicon availability, and liming ability (rated as calcium carbonate equivalent or CCE). A fine particle size, purity, and a high percent concentration of soluble silicon, are desirable properties of a calcium silicate slag product.

Agrowsil® is a commercially available silicon product for agronomic and vegetable crops. It is made from stainless steel slag that has been subjected to processing to remove metals resulting in a calcium and magnesium silicate product that typically contains 30% Ca, 7% Mg, and 12% Si. With a calcium carbonate equivalent value of 93%, Agrowsil® can be used as a liming material at about the same application rate as would be recommended for calcium carbonate or dolomite liming materials. A calcium and magnesium silicate fertilizer with added micronutrients called Excellerator® is also available from the same manufacture designed mainly for the turf industry.

Wollastonite is naturally occurring mined calcium silicate. Mined minerals are usually permitted for use in organic farming. Finely ground wollastonite is a good source of plant available silicon. However, organic farmers should check with their certifier to be sure that a particular source of silicon fertilizer it is permitted for use in organic farming.

Potassium silicate and sodium silicate are more commonly used for horticultural or greenhouse crop applications. They are soluble products that can be added to nutrient solutions or used as foliar sprays. However, plants generally respond better from soil rather foliar applications of silicon.

Contaminates in Fertilizers

Some fertilizer sources are by-products that may contain high levels of heavy metals. Such materials if used in agriculture would contaminate soils. Materials, containing heavy metal concentrations greater than allowed by regulators or believed to be unsafe relative to other soil amendments should not be used in agriculture. Samples of questionable products can be collected and tested by the New Jersey Department of Agriculture, P.O. Box 330, Trenton, NJ 08625. Phone: 609-984-2222. In Washington State, all commercial fertilizer products must be tested and the results posted on the web: http://agr.wa.gov/PestFert/Fertilizers/default.aspx

Because many of the fertilizers listed are national brands, New Jersey growers can use this information for selecting products with low heavy metal content.

Silicon Fertilizer Practice and Rates of Application

In general, silicon fertilizers should be applied to the soil, soilless mixes, or added to nutrient solutions. Spraying silicon fertilizers on plant foliage is generally not as effective.

The need for silicon fertilizer is not easily predicted by currently available soil tests for extractable silicon. But soil testing for soil pH and need for liming can be very useful in determining the proper application rates for calcium silicate sources.

A practical approach to managing soil fertility for enhanced silicon nutrition of crops is to use calcium silicate products as liming materials. Application rates can be determined by the need for soil pH adjustment or lime requirement of the soil. The greater the lime requirement of the soil, the higher the application rate possible for calcium silicate.

Another soil test factor to consider is the percent saturation of the soil colloids with calcium, magnesium, and potassium. Silicate products containing these cations can be used to supplement the balance of soil fertility on the cation exchange complex (CEC).

Over-application of silicon to soil from calcium silicate is generally not a concern because soil pH elevation would limit how much can be applied. Thus, application rates for calcium silicate may range from 1 to 4 tons per acre depending on the initial soil pH level and the target soil pH range for the crop to be grown.

Experience suggests that for encouraging plant uptake of silicon, it may be better to apply calcium silicate supplements yearly at lower application rates to maintain a satisfactory soil pH and calcium saturation of the soil CEC. This approach may provide a continuous supply of readily available silicon for crop uptake. If heavier application rates are to be applied, direct it to the crop fields most likely to benefit from the silicon application. For example, fields to be planted to pumpkin, wheat, or other crops know to be more responsive to silicon.

When crops need nitrogen, applying the fertilizer N as ammonium sulfate may help enhance silicon availability and plant uptake from silicon fertilizers.

High value horticultural crops may benefit for soluble silicon fertilizers, such as potassium silicate or sodium silicate, applied through drip irrigation systems or through calcium silicate additions to soilless mixes.

References

Provance-Bowley, M., J.R. Heckman, and E.F. Durner. 2010. Calcium Silicate Suppresses Powdery Mildew and Increases Yield of Field Grown Wheat. Soil Science Society America Journal. 74:1652-1661.

Heckman, J.R., S. Johnston, and W. Cowgill. 2003. Pumpkin Yield and Disease Response to Amending Soil with Silicon. HortScience. 38(4):552-554.

Heckman, J.R. and M. Provance-Bowley. 2011. Silicon in Soil Fertility and Crop Production; Ten years of Research. Northeast Branch Crops, Soils and Agronomy Meeting Abstracts.

Hamel, S.C., and J.R. Heckman. 1999. Impact of Mineral Silicon Products on Powdery Mildew in Greenhouse Grown Turf. Rutgers Turfgrass Proceedings. 31:215-220.

Heckman, J.R. 2006. A History of Organic Farming: Transitions from Sir Albert Howard's War in the Soil to USDA National Organic Program. Renewable Agriculture and Food Systems. 21:143-150.

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