Super-Min®

Silica

A major mineral is missing in many soils and most soil tests do not even monitor its presence. This mineral can increase stress resistance, boost photosynthesis and chlorophyll content, improve drought resistance, salt tolerance and soil fertility and prevent lodging. It can also reduce insect pressure, frost damage and destructive disease while lowering irrigation rates, neutralising heavy metal toxicity and countering the negative effects of excess sodium. If I were to tell you that this same missing mineral can increase root growth, boost yield and enhance crop quality, you could well ask, "how could we have overlooked something so important?" and you would be correct. It has been a serious oversight. The mineral in question is **silicon**, and science is rapidly revealing the scope and scale of our silicon neglect.

Poverty in a Sea of Abundance

Silicon is not classed as an essential nutrient, but, in response to a wealth of new findings highlighting the importance of this nutrient, that status may soon change. **Silicon** is the second most abundant mineral on the planet. It is everywhere. Clays are alumina silicates and sand is largely silicon, so how could there be a shortage of silicon? The answer lies in the form of silicon that enters the plant. Plants uptake silicon as **silicic acid** and this is what is missing in the soil. Something we have done in conventional agriculture appears to have compromised the conversion of insoluble silicon into the plant available form. It may reflect a mineral imbalance, or we may have knocked out some of the soil microbe species that solubilise this mineral. It is not yet understood what drove the widespread deficiency, but we do know that a healthy, disease suppressive soil should contain **100 ppm** of monosilicic acid (as measured in a soil analysis) and very few soils come anywhere near that mark!

Little was known about the multiple roles of silicon until recently. It was known to be present in every soil, but it was only when it became less plant available that it was realised that there may be a link between this loss and a host of growing problems. During the last decade, silicon seems to have become "flavour of the month" in the soil science community. Researchers have delved more deeply and hundreds of papers have been presented at the **International Silicon Conferences** in Brazil and South Africa. This neglected mineral is now emerging as a key player in proactive pest and disease management and the production of nutrient dense food. If you are not yet aware of the silicon story then this article should serve to fill some gaps.

Cell Strength is Resilience

The cell wall in plants is a substantial barrier that must be breached to gain access to the goodies within. A fungal pathogen must drill through this wall with its hyphae to be able to tap into the nutritious cell centre. Once this goal is achieved, the pest has the food source that sponsors its spread, and a disease is born. There is an obvious opportunity here to stop the pathogen in its tracks. What happens if we strengthen that cell wall so that the hyphae buckle? It's simple – the disease cannot gain a foothold and will not spread. Similarly, why would a leaf eating insect choose to wear out his eating gear on silicon-strengthened rock cakes when it can go elsewhere for sponge?

Many published papers have now confirmed the exciting potential for increased disease and **insect resistance** through good silicon nutrition. In one paper presented at the South African conference,

soluble silicon used as a soil drench had the equivalent inhibitory effect as phosphorus acid in the management of *Phytopthora* in avocados. However, the silicon-treated plants had much more vigorous roots and canopies. In another case, silicon was shown to offer effective management of dreaded black sigatoka in bananas. Other papers reported efficacy against brown rust in sugar cane, powdery mildew in cucurbits, *Fusarium* wilt in potatoes and leaf blast in rice.

Interestingly, the plant understands the protective potential of silicon, even if we don't. When a disease begins, the plant directs all available silicon to the attack site to strengthen the surrounding cells and stop or slow the spread of the pathogen. There is a problem here, however, because silicon is immobile once incorporated into the cell wall. It must be in constant supply so that the plant can utilise it at these times. Most soils contain less than half of the soluble silicon required, so there can be significant benefits in **foliar spraying silicon** at the first sign of a disease. This can stop the spread of the disease and many growers are successfully using this strategy.

Silicon and Sun Power

Photosynthesis is the most important process on the planet. The green plant is the only source of food and the management of chlorophyll, the green pigment where all the action happens, is the chief role of the farmer. **Silicon** is a gold sponsor of the sugar factories within the plant, as it supports this process in several ways. The leaf is essentially a solar panel, the underside of which also serves to capture the CO_2 gas as it rises from the roots and soil life. The better that panel is presented, the more efficient it will prove in capturing sunlight, water and CO_2 (the three components of photosynthesis). Silicon strengthens the stem and holds that panel in perfect position. The plant is less likely to droop in warm conditions and more likely to maximise **photosynthesis.**

Minerals are the major players in the photosynthesis equation. Blotches, stripes and pale colours, from shortages of minerals, represent the mismanagement of chlorophyll. Sometimes it's not just the lack of these nutrients but their delivery into the crop that is the issue. Silicon can have a big impact upon **mineral uptake**. Phloem and xylem are the pathways that govern mineral absorption and the translocation of minerals within the plant. These nutrient highways are built from silicon and their performance will suffer in its absence.

Calcium is an example of a poorly translocated mineral that will be utilised more efficiently when the nutrient highways are broad and true. **Boron** is a calcium synergist, which can improve the performance of calcium, but it has recently been recognized that boron also boosts silicon uptake. Boron solubilises insoluble silicon and it is a good idea to combine boron, calcium and silicon in your program to maximise the synergistic potential of the trio. One popular strategy involves the application of boron to the soil in late winter to trigger the release of silicon. The soluble silicon will be used to build the super highways that will improve the sluggish uptake of **calcium** (needed for cell division during the spring flush).

Super-Min®

Silicon – The Stress Saviour

There are two types of stress that affect production negatively. **A biotic** stress involves the negative impact of environmental factors upon living organisms and **biotic** stress is about pest pressure. A biotic stress is the single most harmful factor impacting crop growth and productivity on the planet and it can only have more impact as global warming progresses. However, biotic stress is not far behind.

Every year since we began "the chemical experiment" in agriculture, there has been an increase in the total amount of chemicals applied on a global scale and every year there has also been a marked increase in pest pressure. The current path is not sustainable; in fact it is not working!

There is an obvious relationship between abiotic stress and biotic stress in that environmental factors will increase pest pressure. We are seeing this in all of the countries in which we work. Even in the local ginger industry, right on our doorstep, growers are experiencing *Pythium* pressure unlike anything they have previously experienced. This destructive fungus has found a new niche in the wettest growing season ever. This does not represent a deficiency of fungicides, but rather highlights the desperate need for a more holistic approach that will offer a greater level of inherent protection during times of stress.

Silicon can reduce the impact of both **abiotic** and **biotic** stressors and it represents an essential component of a program designed to create a disease-suppressive soil and stress-resistant plants. The stronger the cell wall, the more stress-resistant the plant, whether that stress is from pathogens or non-living factors.

Part of the **climate change** forecast is an increase in extreme weather events. Wind can be particularly destructive in that it can promote lodging, which can render the crop un harvestable. At the most recent silicon conference, Iranian researcher, A. Fallah, presented a paper reporting a reduction of silicon within the plant associated with high nitrogen usage. It is already understood that over application of nitrogen has a nutrient diluting effect and that the mineral most affected is potassium. Now we understand that mismanagement of nitrogen can also impact silicon nutrition and the associated protective effect of this mineral. In this instance, weaker stem strength and increased susceptibility to lodging were noted in the rice crop studied. Fallah reported much stronger stems and resistance to lodging in silicon treated crops.

One of the stressors that is becoming more of an issue in many soils is the oversupply of heavy metals, salts and some trace minerals. In all cases, silicon has been shown to mitigate the stress. Copper (Cu) can build up in the soil due to the overuse of fungicides. We have found humates a valuable tool to neutralise the negatives associated with this excess. Silica has been effective in mitigating the effect of a variety of heavy metals but recent US research suggests that silicon may be a viable management tool in high copper soils. J. Li, J. Frankz and S. Leisner working in flower crops in Ohio, found that silicon could very effectively mitigate **Cu toxicity** stress and the improvement was measured on multiple levels.

Swedish researchers working in cadmium contaminated soils found that the higher the silicon level in the plant, the lower the cadmium level. In fact, there was 60% less cadmium in the silica treated food grains.

Super-Min®

In some exciting Russian research involving wheat, silica was shown to alleviate **salt stress** quite dramatically. Wheat is notoriously sensitive to high salinity and the salt created a major decrease in photosynthesis. The addition of silicon to the soil resulted in increases in photosynthesis ranging from 158% to 520% depending upon the salt concentration in the soil. This is one of several studies highlighting the silicon link to salt management. We always recommend the inclusion of small amounts of humic acid and potassium silicate with every irrigation, to manage saline irrigation water.

A South Australian study reported reduced **drought stress** and an associated reduction in pest pressure following silicon treatment. This study found that applied silicon mitigated the increased insect pressure that was a direct effect of high levels of nitrogen. Not only does high N shut down silica uptake but applied silica can also compensate for this nitrogen mismanagement.

Cold stress can even be addressed with silicon. South African scientists working with bananas have shown that silicon protected the plants from cold damage and that an associated increase in vigour decreased the banana's susceptibility to *Fusarium* wilt.

This enhanced **protection from disease** has been well researched. A recent Japanese study entitled "Silicon in the Control of Diseases in Rice, Sorghum and Soybean", found reductions in brown spot pressure that varied between 35% and 75% in rice studies. They found significant reductions in anthracnose in silicon-treated sorghum and the results were quite dramatic when foliar applying potassium silicate to manage soybean rust. They concluded their paper with the following words; "The results of these studies underscore the importance of Si to increase plant resistance to foliar disease".

This increase in disease resistance was originally thought to be related to the "barrier effect" linked to increased cell strength, but it is now understood to be also related to increased plant immunity.

Silicon-Based Immunity

One of the most dynamic research streams in agricultural science relates to the investigation of plant immunity and the triggers that activates the plant to fight its own battles. It is now understood that the plant has an immune system, which can be both monitored and magnified. Salicylic acid, for example, the biochemical upon which aspirin is based, activates the plant's **immune system**. *Aloe vera* is the richest natural source of this compound and many of our growers benefit from the inclusion of this plant extract in their programs.

Recently, silicon has been found to trigger the production of a suite of compounds that fuel immunity. This mineral is now seen as an integral tool in proactive pest management as it offers both protective cell strength while also fuelling a robust defence system.

Phenolic compounds are one of the biochemical's that are part of this defence system and these compounds are now recognised as key players in the protection of avocado trees from *Phytopthora cinnamoni*. T.F Bekker, et al, from the University of Pretoria, conducted research which demonstrated that soil applications of potassium silicate to soils affected by this disease increased the total phenolic content of the avocado root tissue.

It is interesting to note that this silicon-based immune response is most pronounced when there is existing disease pressure. It is almost like the plant calls in the heavy artillery when the going gets tough! A Canadian paper presented at the South African conference involved the study of 30,000 genes. The researchers reported that unstressed plants appeared to be minimally affected by silicon feeding with the associated up regulating of only two genes. (Note: up regulation is the process by which a cell increases the quantity of a cellular component such as RNA or protein in response to an external variable.) However, in stressed plants (affected by powdery mildew) there was an up regulation of a number of genes. A Spanish paper also covered the **Powdery Mildew** control potential of silicon and they found that the inclusion of amino acids with the silicon fertiliser enhanced the response.

Russian researchers have hypothesised that the plant immune system requires mobile silica compounds and if there is luxury levels of silica available to the plant there will be additional synthesis of stress protection molecules. A co-operative research effort between American and Japanese scientists showed that silica related resistance involves multiple pathways and that silica amendment clearly alters plant defence signalling, increasing the plant's disease resistance.

But There's More

Not only does silicon offer increased pest and stress resistance. It can also provide a major fertilising response and substantial **yield increases**. In a paper by J. Bernal, involving research with rice and sugarcane in Columbia, just 100 – 200 kg of magnesium silicate per hectare achieved yield increases of **14.63%**in sugarcane and the increases in rice ranged from **21%** to **33%** (depending upon the application rate). Iranian research with rice mirrored the South American findings, but in this case, the yield increase was **22%** after applications of 500 kg of silicon. Rice and sugarcane have been most researched, as they are recognised silicon accumulators. In fact, rice has the highest levels of silicon of any crop. However, we have found that most crops respond to silica and research is now quantifying our infield experience. Brazilian researcher's trialled six different application rates of potassium silicate on potatoes and found that the**1%** rate was most effective. In fact, 6 litres of potassium silicate in 600 litres of water, sprayed each week during the crop cycle, produced an impressive yield increase of **22.4%**.

Australian, M. Lynch, a champion of silica fertilisers for over a decade, presented a paper at the SA conference where he suggests that silica fertilisers have consistently outperformed high analysis fertilisers in cereal production. This has included increased protein levels, increased yields, decreased screenings and increased grains/heads. He contends that silica fertilised grapes have superior skin quality, higher brix values, uniform bunch size and a virtual absence of fungal diseases.

At NTS, we have often found unexpected benefits when including silicon in programs. An avocado grower from North Queensland found that he no longer lost up to 15% of his crop to wind abrasion. The increased skin strength created fruit that did not mark when the fruit rubbed against the branches in windy conditions. Golf courses often report that the greens are wearing better following applications of liquid, micronized diatomaceous earth (a rich silicon source).

Super-Min®

Silicon and You

If plants respond so favourably to silicon,what about humans? One could assume that if most plants are silica deficient then most people would also suffer from a shortage of this mineral. The Japanese Government has certainly recognised this problem and have strongly encouraged the use of soluble silica on rice crops.

H. M. Laane from the Netherlands presented a research summary of **human health** research into silicon. The human body contains 7 grams of silicon, which is more than all the other trace minerals put together. High levels of this mineral are deposited in bones, nails, tendons and the walls of the aorta and substantial amounts are found in the kidneys, liver and lungs. Silica interacts with several minerals but important research has highlighted the use of silicon as a means of inhibiting aluminium toxicity.

Silicon is also a **calcium synergist** and should be included in all good calcium supplements. Laane concluded that dietary levels in Western diets are too low and there is a coincidence with increased skin, hair and nail problems, osteoporosis and Alzheimer's disease. There are also obvious benefits in silicon-strengthened arteries.

Fertiliser Sources of Silicon

Silica fertilisers are available in liquid and solid form and the liquids offer the most rapid response. Silicon is found in good levels in Super-Min and in rock phosphate and guano products. However, this is not the plant available form of the mineral and, depending on the particle size, it may take many years for the mineral to become available. This is not the case if the fertiliser is a calcium silicate or magnesium silicate but you need to ask about the solubility of any silica fertiliser you may be considering. This is also not the case if these materials are **micronized**.