Is ortho-silicic acid worth the additional expense in hydroponics?

Silicon is all the rage right now and different silicon product manufacturers are racing to produce commercial products that contain more and more biologically active silicon. The idea is mainly that potassium silicate – the most commonly used form of silicon in hydroponics – has some problems maintaining high bioavailability at the pH levels used in hydroponics and therefore more stable silicon sources are needed to meet plant needs. However we need to ask ourselves if this is actually true and whether it is actually worth it to go to much more expensive Si sources when supplementing plants with silicon products. Today I want to talk about the Si research up until now and what it tells us about silicon and stabilized silicon products.

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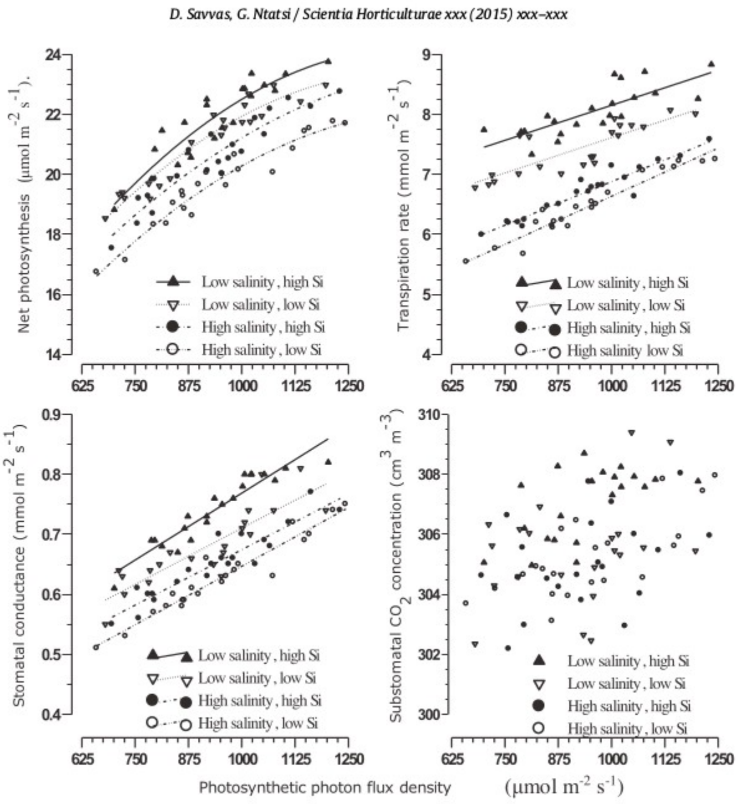

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Without a doubt there are some proven benefits to using silicon supplementation. As explained within [this recent literature review]() from 2015 about silicon's role in plants the benefits from silicon application include increased photosynthesis, resistance to abiotic stress as well as increased resistance to several fungal pathogens. It is also clear that foliar application of Silicon does not lead to large increases in tissue concentration and root applications tend to yield the biggest benefits. The above image shows some of the benefits of high (1mM) and low Si (0.1mM) treatments under different conditions for hydroponically grown Zucchini plants. The review also mentions the exploration of stabilized silicon forms and the current lack of scientific evidence regarding their efficacy when compared with traditional non-stabilized forms of silicon.

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So if silicon from potassium silicate can show benefits why may we need a better form of silicon? The problem with silicates is that under low pH values the silicate ion gets protonated and converted into silicic acid but silicic acid is unstable and will tend to polymerize and form molecules with limited bioavailability under these conditions. If we use a form of silicon that does not suffer from this problem then we might be able to get some additional benefits. There are indeed a few studies in lettuce and tomatoes showing that choline stabilize orthosilicic acid (ch-OSA) can indeed improve plant responses under Mn stress and even a study about the use of ch-OSA improving seedling growth but these results lack controls against potassium silicate so we don't know if the response would simply be equal than that of a traditional silicate application. Below you can see a graphical representation of a choline molecule's structure, choline is basically a beta aminoacid that is able to stabilize silicic acid by binding to its oxygen atoms through the positive trimethyl amine group, inhibiting polymerization.

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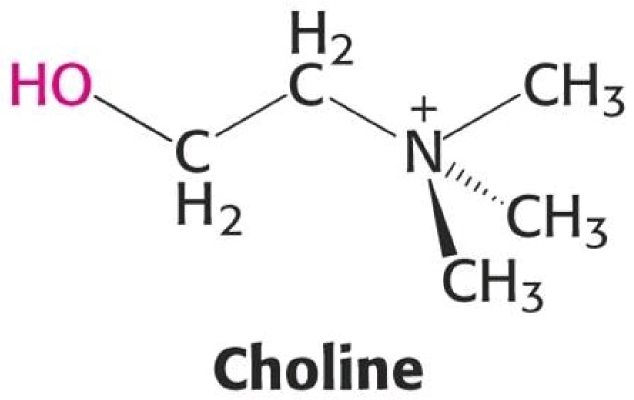

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We know however that not all forms of stabilized silicon sources would work well. For example there is a study involving alkyl silicic acids (another form to stabilize silicon) that shows that the application of these compounds produces even worse results than controls with no silicon supplementation. Plants do not seem to deal well with this type of stabilized compounds, where the silicon is stabilized by the introduction of simple alkyl groups. Some of these forms of silicon – dimethyl silicic acid – were even highly toxic to plants at low concentrations.

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Up until this point there is basically no scientific evidence that shows how stabilized silicon sources like ch-OSA may provide a benefit over using a simpler and cheaper source of silicon like potassium silicate in higher plants. If potassium silicate is dissolved at the appropriate concentration and in an adequate manner then there is no doubt that it can provide significant benefits at a fraction of the cost. Companies producing ch-OSA and similar silicon stabilized sources generally say that they contain "more bioavailable silicon" and while it may be true that they may allow for the larger abundance of some silicon species in solution, what they should show is an increase in benefits when compared with a potassium silicate control since this is in the end what interests most hydroponic growers. While this evidence is lacking it is certainly not worth it to pay the extra cost, given that benefits using potassium silicate have been proven while benefits using ch-OSA haven't been proven to be greater than those obtained with these cheaper Si sources.

Silicon in Hydroponics : What

Silicon is Good For and How it Should be Used

Certainly if you have been involved with hydroponics for a while or even if you have just started to research this awesome field you might already know that science has only discovered a handful of elements to be necessary for plant growth. From the first 92 elements of the periodic table, plants have only been proved to require C, H, O, N, K, P, S, Mg, Ca, Fe, B, Cu, Mo, Zn and Mn for their adequate growth. However it is certainly true that some other elements have proved to be beneficial – in certain quantities – for the development of several different crops. Such elements include Co, Si and Na. On today's article I am going to introduce you to Si, the way in which plants absorb it, how it should be administrated and the positive effects it is bound to have on your hydroponics plants.

Silicon is definitely one of the most abundant elements on the Earth's crust, forming – with aluminium – a very large portion of the earth's heavier elements. Silicon is mainly present in nature as the silicate ion (SiO_3^{2-}) forming solids with different degrees of polymerization known in the geological world as silicates. From these silicates we have a very large variety of minerals, from the aluminosilicates formed with aluminium to the very fine quartz particles (white sand) making up some of the most beautiful beaches throughout the world.

However when thinking about silicon and our plants we need to think about the way in which plants would be able to absorb this element. The minerals in which silicon is found are quite insoluble at room temperature and for this reason they cannot be absorbed efficiently by plants. If we want our plants to get some silicon we need to provide it in a form which is soluble and readily available for absorption. Such a form is sodium silicate (Na_2SiO_3) usually available as a pure solid or a solution in water called "liquid glass".

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Studies in the field of hydroponics have shown that different types of cultivars such as wheat, tomatoes and cucumbers react positively to a moderate addition of silicate ions. When water glass is applied at a concentration of around 100pm (measured as $SiO2$), positive effects are found including increased weights of fruits, increased nutritional composition and – most importantly – a very important increase in the resistance to bacterial and fungal diseases. It seems to be that plants use the silicate ions to "line-up" their cell-walls offering a strong additional mineral resistance to any incoming pathogens that would want to get into their cells. Since plants lack and active immunological system, passive measurements like this which increase cell-wall strength are likely to be key to increase disease resistance for many crops.

However most people are quite careless about the way in which they apply this "liquid glass" since they are mostly unaware of the very sensitive equilibrium that takes place to maintain silicate ions in solution. Silicates are by definition very insoluble and the acidic pH in hydroponics is bound to cause some precipitation of different reaction products of this ion with other ionic species present within the hydroponics solution. The silicate ions can also form silicic acid and start to polymerize into complex macromolecular constructs. As a matter of fact, several studies do include information about the problems with drip systems, sprinklers, nozzles, etc, when using silicate ions since they tend to precipitate easily outside the hydroponic solution.

I would suggest – and so I have done with my own systems –

that it is better to apply small quantities of silicate ions every 2-3 days, instead of applying a large amount during the beginning process. Applying a large amount of “liquid glass” (the 100ppm for example) would most likely end in most silicate falling out of solution and only a small part becoming available for plant absorption. I believe that the best thing to do is apply about 5ppm (measured as SiO_2) every 2-3 days until the solution needs to be changed. This provides both higher stability and a better control over the solubility of this tricky ion within the hydroponic solution. Of course this is purely anecdotal evidence and no controlled study has yet shown this to be better. If you want to obtain results as those of the scientific literature available then applying the 100ppm on every reservoir change might be the wisest thing to do.