Nutrition for Your Cacti

March 2014. Thank you Fabrizio Barbieri! His pictures were very persuasive.

The following piece is part of a collection of writings published on the Practical Small Cacti Malaysia site.

It's Not Hype or Guesswork

In Malaysian schools, when we are really stumped at a question in an exam, we *hantam* – that is, in the case of multiple choice questions, we close our eyes and stab at the paper to pick an answer. We're not going to *hantam*[1] here. Everything will be backed by plausible science and there will be plenty of pictures that show actual results, such as the picture above.

1 Or *tembak*. Hit it or shoot it, take your pick.

Nicknames for Scientific Names

PMag = *Parodia magnifica*
PClav = *Parodia claviceps*
GBald = *Gymnocalycium baldianum*
MGeo = *Myrtillocactus geometrizans*

This naming scheme is purely for convenience. Just think of them as webchat nicknames. Other nicknames and additional notes can be found in the appendix to the third chapter.

Fabrizio Barbieri's Article in *Acta Succulenta*

First, read the source article, which can be found in the open-access periodical *Acta Succulenta*:

> Fabrizio Barbieri, **My Modest Opinion About Fertilizing Cacti and Succulents**, *Acta Succulenta* 1(1) 2013.

The third page onwards is the key. But the pictures were the real attention-grabber. The pictures showed that he wasn't kidding about his ideas. I immediately knew which specimen to try it on – the GSteno specimen (picture on previous page) that was in perpetually poor shape since I bought it in 2002. The test was simply regular very dilute sprays of magnesium sulfate. The result, after a few months, is *very healthy* new growth with a waxy skin on which water beads.

Why was this piece of the puzzle so hard to find? For me, it was a mental barrier of sorts. In my mind, I wasn't doing that badly – the picture at left is a (fat) GBald with flowers in June 2002. So I already have GBalds and *Parodia*s with the occasional flowers back then, only not very frequently.

It was the GSteno that had the most obvious colour changes – the red is in response to strong sunlight – and it was hardy and surviving, but not in the pink (or green) of health.

Prior to the test, most of my specimens were on desert-like treatment so that they grow hardy[2]. They were getting little to no fertilizer and plain water. One objective was to avoid producing big fat green stems with poor spines (see picture on the previous page.) Plants cared for like desert plants didn't die but they were not very productive.

Although the effects were less obvious, my GBald specimens that had been sprayed with magnesium sulfate also began to exhibit nice waxy skins. Before the test, the GBalds would look wet after being sprayed. But now water beaded very nicely on newer growth. It began to dawn on me that while I had some success such as the occasional flowers, *my plants were not truly healthy*. To understand what happened, I had to look into the issue of nutrition for cacti.

Magnesium and Cacti

Like the discussion on slow growth of cacti, I will present the scientific case for magnesium in simplified terms. The discussion in Barbieri's article is somewhat convoluted. For more detail, it is always easy to do some Internet research. So remember, this is just a "big picture" discussion.

Magnesium is a secondary plant nutrient. Plants need less of it than primary nutrients like nitrogen, but more of it than trace elements like cobalt. Chlorophyll contains magnesium, so plants must have magnesium in order to conduct photosynthesis. Magnesium deficiency results in chlorosis – leaves will turn yellow. Chlorosis occurs on older leaves first, because magnesium is *mobile* in plants. Magnesium is one of the nutrients that can move about in a plant. Plants deficient in magnesium will *sacrifice* older leaves in order to get enough magnesium for new growth[3].

A cactus plant does not have leaves, so magnesium is reclaimed from the lower stem, which starts to turn yellow due to loss of chlorophyll. A weak lower stem may then lead to the plant's demise. In other plants, the lower stem turns corky or woody. Providing the plant with supplementary magnesium stops the plant from snacking on its older bits and pieces. This is similar to the case of shrinking stems in GBalds, where resources in the shrinking stem is reclaimed as it turns corky.

The easiest source of magnesium for use as a supplement for your plants is magnesium sulfate heptahydrate ($MgSO_4 \cdot 7H_2O$). It can be found as Epsom salt or bath salt[4] at pharmacies. These days you can get better deals at local online shopping malls from one of the many fertilizer suppliers. Even a small box of Epsom salt from a pharmacy will last you a long time. I use an amount equivalent to only 2 or 3 grains of rice in 1 litre of water. Instead of washing out nutrients with tap water or rain water, I switched to always spraying or watering my cactus plants with water enriched with magnesium sulfate – one version of the fortified water that I now use.

Agriculture websites never discusses overdose of magnesium sulfate, so plants are most likely not sensitive to an excess of the salt. If your plants are starving for magnesium, even a little bit will bring about positive change, so it is never necessary to use a lot.

2 I feel really foolish writing that now, but I suspect it is a typical strategy of many growers of cacti.

3 It's easy to see this on a basil plant. Basil likes to grow out of control and is a heavy feeder. In a pot without adequate fertilizer, its lower leaves will turn yellow quickly and begin dropping en masse.

4 Originally, I bought a box at RM5 in 2013 at the pharmacy section of a local Tesco (now Lotus's). In 2023, you can get 2 kg for the same price (agriculture grade salt). Recently, I got more, in the form of food-grade bittersalz.

What is the colour of a GSteno? **Left**: March 2014. **Right**: July 2014.

Maybe dark green, if under shelter and not starved. **Left**: Feb 2015. **Right**: Nov 2015. The optical distortion is due to the plant being near the edge of the digital picture.

Some purists will say that dark red-green is the proper colour for a GSteno (see the pictures on the previous page.) I agree, if you aim to grow natural-looking plants. But I'm a Dr Frankenstein kind of gardener and I don't care what anyone thinks – I choose to grow healthy plants in order to maximize their chances of survival in a climate that is far different from their natural habitat. If you wish to cultivate GSteno to look like a wild specimen, use lots of sunlight and maybe starve them a little.

If it is so easy for plants to be deficient of magnesium, then just what else are they missing?

Fertigation Experiments

Prior to experimenting with magnesium sulfate, I think my specimens were getting small amounts of organic fertilizer on occasion. The reason is because small pots of cacti in soil have a high rate of evaporation in the hot tropical weather, and the use of inorganic fertilizer granules too often led to unsightly salt deposits on the pot and plants.

Thinking about the positive effects of supplementary magnesium sulfate led to new experiments in 2015. I found an all-in-one fertilizer from a local online shopping mall. This is a repacked bag of a high quality agriculture fertilizer used for crop fertigation: Valagro Master 15.5.30+2. The '2' is the magnesium content and it has trace elements – altogether a good combination of nutrients for producing big cactus plants. Fertigation is the agricultural practice of irrigating crops with fertilizer-laced water. For my plants, I am instead spraying them with fertilizer-laced or fortified water – this is called foliar feeding in agriculture, only cacti have no leaves and I am spraying their stems. When repotting, a soil mix with added coco peat was used to reduce salt deposits.

For fertigation or foliar feeding, it is useful to know the concentration of the solution that you are using on your plants. You will need an EC meter (electrical conductivity meter). Once you are used to mixing soluble fertilizers, it is not necessary to always measure the resulting solution, but it is extremely useful in the beginning when you are finding your way. In 2015, boiled tap water in my area measured about 130 µS/cm, while stored rain water was about 50 µS/cm. A tiny pinch of magnesium sulfate in 1 litre of water measures perhaps 200–300 µS/cm, so it's still quite dilute.

A very cheap EC meter, converted to use one CR2032 (a lithium coin cell will not leak as easily as alkaline LR44 cells.) Good enough for non-scientific work.

Plants got fertilizer water with a concentration of about 500–1000 µS/cm regularly, plus regular spraying with magnesium sulfate water. The results were somewhat successful: some plants grew very fast and produced many flowers but the experiment cannot be called a total success because I am not a huge fan of fat stems with poor spines.

How do we get healthy specimens with better spines? The obvious reason for the "fat stems" issue is the primary nutrients in fertilizers, namely their NPK content. So fertigation with an all-in-one fertilizer is not a magical solution for cacti[5]. In fact, there were quite a bit of flowers with added magnesium alone, even before the fertigation experiment. Back to the drawing board – it was time to start taking *The Stone Eaters* more seriously.

GBald specimens in February 2016. So it is possible to grow a very long GBald using fertigation methods. But the base of the long specimen was turning yellow, so it was never going to go on forever. Eventually things started to get complicated and the specimen had to be cut up. The long specimen is resting on a pot that has another specimen that got a turbo-boost from fertigation.

At the 5 o'clock position is a GBald with shiny new growth. This is the kind of waxy water-repelling skin that you can get by feeding them additional magnesium. Compare this to the long specimen's skin – the latter does not really have healthy skin, though most of the stem is still green. The long specimen is probably too unnaturally shaped for a GBald. At the upper right corner are stomach-shaped *Gasteria* flowers on their flower stalk.

5 But it may be acceptable to some growers if they don't mind the risks of cultivating cacti with fat stems.

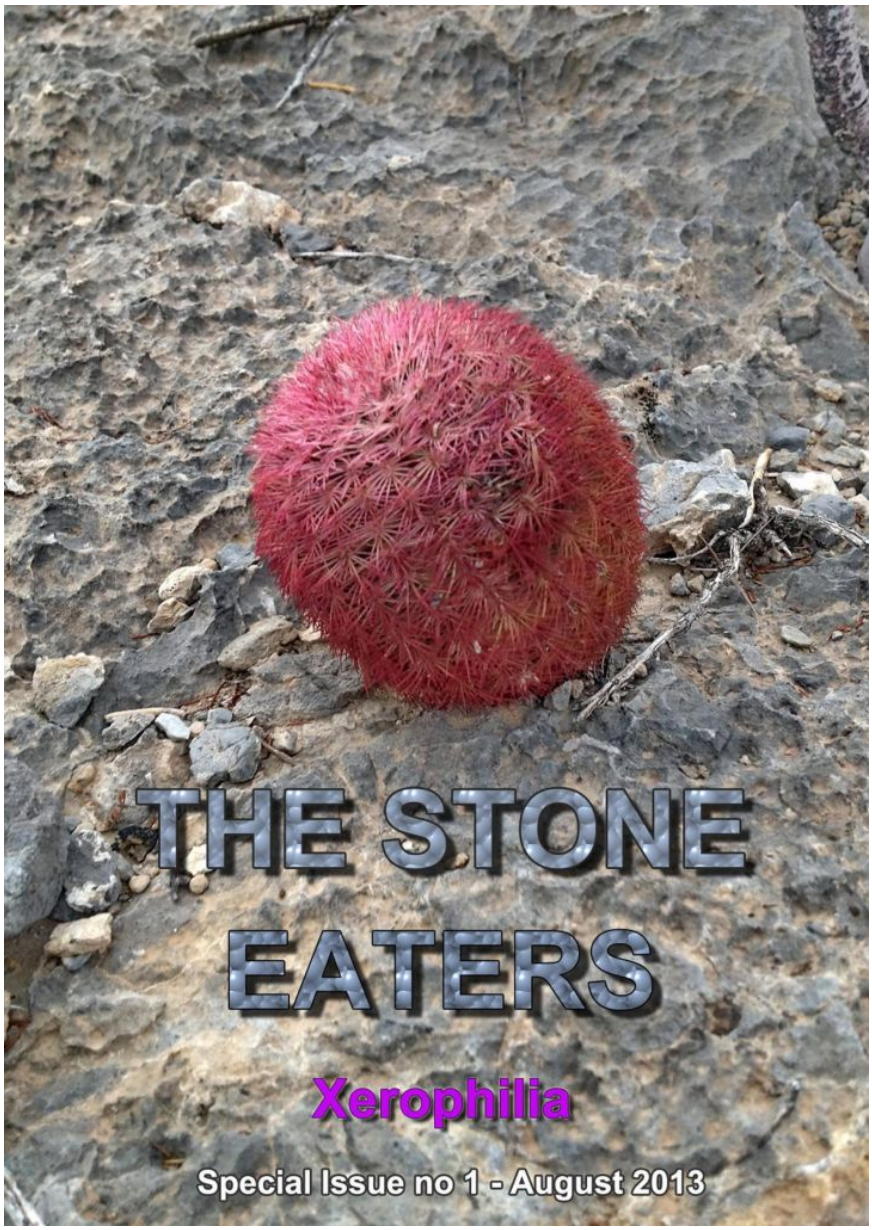
Another illustration of issues with primary nutrients. A PClav pictured in December 2018. This specimen had been repotted some months back, and near the bottom of the pot, a few pellets of goat manure were deliberately added. Too much nitrogen apparently. This made the plant produce offsets instead of flowers.

Studying *The Stone Eaters*

The Stone Eaters is a special issue of the Romanian open-access (free to read) C&S periodical *Xerophilia*, in fact it was the first special issue, published in August 2013. The primary feature article, "The Stone Eaters" by Dag Panco of Romania is an updated version of his famous online publication that was widely shared from 2006, titled "The Soil Hexalogue" or simply *Hexalogue* for short. Since I seldom frequent online C&S forums and I rarely check European C&S sites, I have never read *Hexalogue*, so I will discuss *The Stone Eaters* instead of *Hexalogue*.

In *The Stone Eaters*, the author is obviously very passionate about growing cacti in a certain way. Specimens that look like their natural counterparts in habitat are preferred over big 'domesticated' specimens. The key to *The Stone Eaters* is planting cacti in mixtures of rock with little or no organic matter – mineral soil. Rocks break down over time to provide minerals to the plants. It's not far different from the rocky landscapes inhabited by cacti in the wild, so there is a strong appeal of authenticity. It is a way of "growing cacti like the real thing", so to speak.

The other articles in the special issue are practitioners' stories. Two growers, Demeter Zsolt Mihail and Laszlo Ambrusz, uses deep square pots. The other grower, Basarab Popa, also uses deep square pots, but more impressive are the large elevated planter boxes and their tons of mineral soil. Large or tall specimens are grown in the ground, still in mineral soil.



Xerophilia Special Issue no 1 – August 2013, *The Stone Eaters* (cover screenshot).

The mineral soil technique, as shown by the many pictures in *The Stone Eaters*, obviously works. Many cultivation pictures show old plants that are not big and bloated. They look very healthy. The cultivated plants compare very favourably to wild plants that mostly live in rocky habitats. So yes, it is a great way to grow cacti. The question is whether it translates well to a tropical climate.

Now, the problems. First is the footprint of needing to keep stocks of rocks and the weight of deep square pots. After killing plenty of specimens over the years, I do not want my collection to grow out of control – it has to be of maintainable size. A heavy mineral soil mix would have a significant footprint. Of course, as of 2018 I do have scoria and pumice in stock, but I do not use a full mineral soil mix. Scoria and pumice are also lighter than normal rock, so pots are only slightly heavier.

The large planter boxes of Basarab Popa are out of the question for typical Malaysian urban houses. His collection is inside a large greenhouse – realistically this would be out of reach of almost all Malaysian growers[6]. Also a large planter box in the humid tropical climate would probably develop algae and much more – just wait for a week or two of rainy weather and you'll have new plants in your planter box: weeds, algae, moss, and fern gametophyte[7]. The weeds you can easily pull out, the others stick fast onto surfaces of rocks.

More serious is my avoidance of the usual contact insecticides and systemic insecticides. Bug control means spraying stems to wash off dust, and occasionally spraying mild household insecticides or natural insecticides or repellents. One must be able to reach and manually clean the entire stem of a specimen when there is an outbreak – the plant has to be in a pot that you can move. Since no contact insecticides or systemic insecticides are used, you can bet the winds will eventually be successful in bringing over some bugs to start an infestation, perhaps once a year on average. This kind of bug control may be impossible with big planter boxes. Inspections of deep pots full of heavy mineral soil also means heavier workloads. And unless you have a very clean and isolated environment, there will still be root mealybugs, even with zero organic matter.

The underside of the tray of GStella grown in pure red volcanic scoria (March 2019). Note the powder at the bottom of the tray, the result of scoria breaking down. In the beginning, the tray was clean with just 3–5 mm sized red scoria. Even with pure scoria, I have seen small numbers of root mealybugs clinging to roots of the cacti.

6 Oh, I know in Malaysia people use corrugated plastic sheets or plastic film on some sort of framework to shelter plants. Most plant nurseries use something like that. It will protect plants from the weather, but not from bugs. A friendly warning: If you want to put up a large shelter in your garden, remember to consider the possibility that it may be blown off. In my area there are occasional very strong winds. Uncommon gusts of wind that are of maybe once-in-10-years strength have blown down medium-sized trees.

7 In housing areas where ferns are popular, fern gametophyte can be easily found in shaded areas, including on rocks. Search the Internet for the "lifecycle of ferns" if you don't know what fern gametophyte is.

Less serious is the issue of sourcing rocks suitable for a mineral soil mix. Now, let me be perfectly clear here: **As a Malaysian, I am wholly and totally opposed to collecting or mining rocks from public lands**. Let's face it, large scale collection of rocks is mining. Malaysia has enough problems with sand mining due to people crazed with greed. Just Say No. Peninsular Malaysia is just a small bit of land when viewed from space, there is no need for any urban cactus gardener to exploit public lands for rocks. Volcanic scoria works fine. You can easily buy scoria from online suppliers in Malaysia. I also buy a bit of larger-sized pumice for bigger plants – I suppose it's a bit more nutritious for the plants compared to LECA balls. But I still use LECA balls here and there:

Repotting MGeos, June 2018. I don't provide them with very good care, and they usually get tap water instead of fortified water or fertilizer. These were grown in plain soil, perhaps even in soil recycled from a regular houseplant pot. But let me point out the pot with the very dense root system: the bottom specimen in the left picture, and same plant with some soil removed, leftmost in the right picture.

This plant was grown in plain soil, *plus a few large LECA balls*. The better root system may be due to better aeration or air exchange in the soil, *or* it may be due to the MGeo roots responding to the hard rock-like clay balls in a cramped or packed space – a kind of mechanical feedback thing. After all, many cacti grow in crevices between rocks in their natural habitat.

I'm not blindly following the precepts of *The Stone Eaters*. Instead, I am trying to derive useful information from many cause-and-effect observations. For example, LECA balls have a surprising effect on MGeo roots. This may be due to MGeo's aggressive anchor roots. But this may not work with GBalds, whose root systems are weak and finicky. I do not believe a "master formula for success" in cactus cultivation exists. I'm rather more interested in species-specific details that can lead to better understanding about cacti behaviour and their successful cultivation.

Finally repotting two GStella specimens, September 2019. Here you can see the mat of roots of one of the specimens. The LECA balls and white pumice were added later as a top layer to help hold some smaller specimens in place. The GStella roots were growing in the older scoria layer, mainly along the bottom where there is scoria powder. Half an inch of pure scoria with a boom-bust watering cycle worked pretty well. As for the two *P. leninghausii* specimens, I swear I didn't mean to buy them[8].

There are other differences. For example: plant selection. *Gymnocalycium* and *Notocactus* (now in *Parodia*) were in the minority in *The Stone Eaters*. Most of the species pictured were North American or Mexican cacti or uncommon types such as *Turbinicarpus*, *Ariocarpus*, *Aztekium*, *Obregonia* or *Blossfeldia*. Well, I don't care about rare cacti anymore – I have zero interest in them these days and I am unlikely to be ever tempted again to buy one if seen on sale. Instead I work with a small subset that do well in a hot and humid urban tropical climate – the practical approach. I just want to grow PMag, PClav and GBald. Anything else that works is a bonus.

So the main theme of *The Stone Eaters* is rocks or mineral soils. The challenge to the urban grower in the tropics is to adapt the ideas in *The Stone Eaters* in a manner that is sustainable in the long term. In landscaping, it is easy to build something very nice on a turnkey contract basis. But can you maintain it? For example, you may end up having to pay a gardener to maintain the landscape. As a cactus grower who wants to reap rewards in the form of healthy plants and flowers, it is important for you to be able to properly maintain and sustain your collection over many years.

8 See the next page for pictures of how the plants looked when purchased and how their appearance changed.

Two commodity cacti just after purchase, September 2018. These two are some kind of *Parodia* or *Notocactus*. Sure...

The same two specimens, just after being moved into the scoria tray, April 2019. New growth is beginning to look like *P. leninghausii*. But the appearance of *P. leninghausii* is very different from how these plants looked when purchased. Most of the time, it is easy to find regular *P. leninghausii* at retail. So why this disguise? What exactly happened? A lack of minerals? Was it a deliberate horticultural technique to produce plants for sale with different spine colour? (They look bloated too.) An “engineered product” that looks good on sale but is really a different plant? It all looked *very* suspicious to me, because I saw these types on sale often around 2019.

Minerals and Cacti

If you cast your net wider, you will find that the principles of mineral nutrition is both pretty common and pretty ancient. Volcanic soils have been exploited by farmers since time immemorial. In modern organic farming, rock dust is used as a type of slow release fertilizer. Often this rock dust is manufactured from volcanic basalt, so it's simply a modern form of volcanic soil that you can add to your garden. Partial use of minerals (picture below) may give good results too.

If there is too little emphasis on the use of minerals in the cultivation of cacti, perhaps it is because of the reputation of cacti as hardy plants that can survive and thrive in difficult conditions. Perhaps we have been a little too quick to admire their ability to survive; we are slow to realize that in their rocky natural habitats they get minerals all the time, moreso when their roots can explore unimpeded. We may also have been unintentionally misled by the mass producers of cacti, who usually use soilless mixes of peat or coco peat with perlite. Oh wait. Those fellas grow cacti successfully too. What?!!

Seven flowers on a GBald, posed, March 2014. If magnesium sulfate, regular fertilizer, plus regular care is already producing this, you would be slow in trying out the mineral soil ideas in *The Stone Eaters* too. Also during this time, I used a heterogeneous soil-based mix with a lot of added stuff: sphagnum moss, LECA balls, small rocks, aquarium coral, etc. The flowers were great; the spines were poor.

I'd say more experimentation is needed for (a) sphagnum moss, (b) coral.

If the mass producers of cacti are able to mass-produce plants in a soilless mix, they must be doing something right. The simplest explanation: they must be using enough micronutrients in their fertilization scheme. Bear in mind they can control conditions and fertilization to produce millions of pots for sale each year, all which are of a uniform size and high quality. Also, remember that a lot of production is located in places where it is always very sunny with near-ideal weather for cacti, such as Canary Islands. As such, they are getting a very good balance of growth speed and spine quality.

For growers like you and me, we cannot give our specimens the perfect, computer-controlled care that the commodity cacti are getting. In tropical climates, we cannot maintain that soilless mix properly. Whether small pots or big pots, the hot tropical weather will quickly dry out the top portion of the soilless mix, and you will have trouble getting it wet again. To solve that problem, one can use a layer of scoria as a mulch to prevent the mix from drying out too quickly – this is another reason why I use a layered mix with scoria or pumice as the top layer.

The GSteno with its first flowers, April 2017. Thanks to better nutrition.

As a grower who is incessantly experimenting, I don't see mineral soil as the only solution. I have no interest in formulating 'laws' of soil mixes. I'm a Dr Frankenstein kind of gardener and I like to experiment on my cactus plants.

As of 2019 and later, I am increasingly leaning towards a two-pronged mineral nutrition strategy. First, minerals in the form of scoria or pumice is usually used as part of the soil mix, either layered or mixed. They also serve as mulch and may help the growth of roots. Second, regular applications of mineral nutrition in the form of both magnesium sulfate sprays and micronutrient sprays. This ensures that plants have access to some minerals all of the time. Nutrients are not washed out by tap water or rain water. Mulching plus dilute feedings means that no salt deposits will form on the pots. For micronutrient sprays, I found an online supplier selling a soluble microgranule formulation used in agriculture. All of this will be discussed in detail later. The micronutrient water turned some algae in a spray bottle *bright green* – they were the healthiest algae that I have ever seen.

We all want our cactus plants to do well. But all of us also have our own personal preferences. Thus, no cultivation method will fit everyone perfectly. It is better for us to understand *why* we cultivate in this way or that way. Usually we cannot have what's perfect for our plants because we have limited time and resources that we can expend on their care. With knowledge and understanding, you can make your own choices and strike a balance that works for both you and your plants.

Here are some yellow flowers for a change. Two PMags in bloom, November 2019. PMag and PClav specimens also responded positively to better nutrition. Those that flowered occasionally became more willing to flower. Eventually, I got the big PMag and the big PClav to flower regularly nearly every month for multiple years.

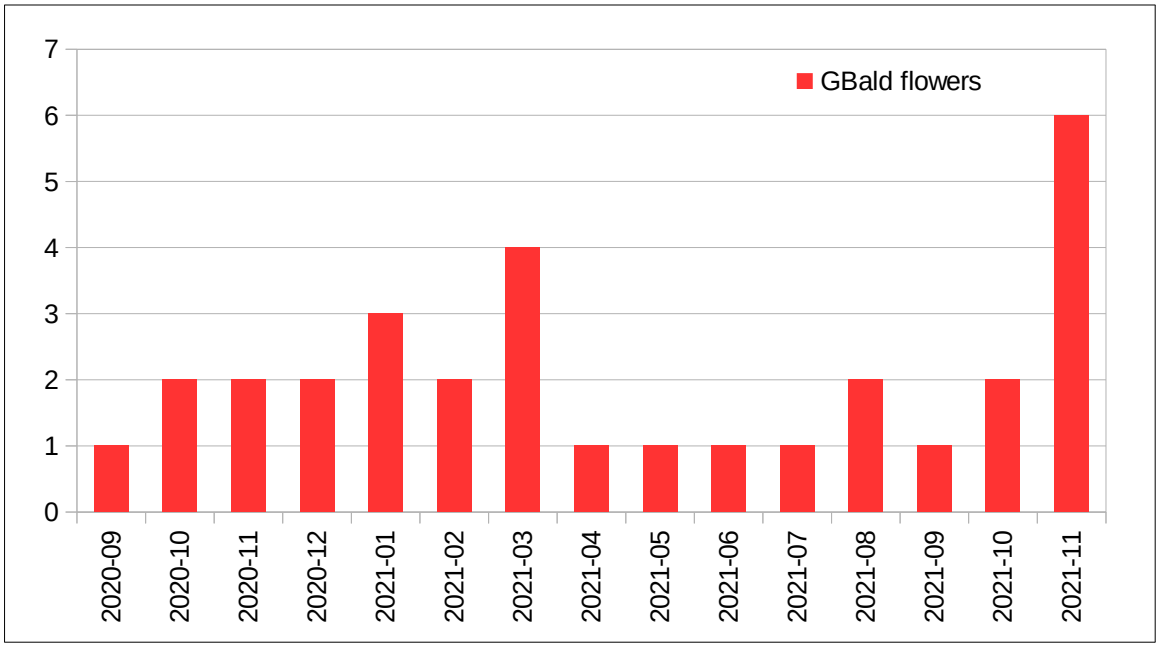
Experimenting with a Silicon Nanopowder Fertilizer

Around mid-October 2021, I started adding small amounts of a silicon nanopowder fertilizer in the usual fortified water sprays. The primary objective was to test whether silicon as a plant nutrient can help with disease control for cacti, with emphasis on protection against fungi attack.

The silicon fertilizer is a nanopowder formulation (supposedly). It is slightly acidic – a pinch mixed into a cup of water gives a pH of 4 – and it probably has a weak acid and a chelator to help make the silicon soluble. Silicon fertilizers are usually of a silicate formulation, while nanopowders are less common. I bought this nanopowder fertilizer because it is more easily stored compared to liquids. The fertilizer is hygroscopic (water-absorbing), because it looks like some kind of wet salt.

The initial test subjects were several GBald-on-MGeo grafts done in 2019[9]. A few of these specimens were suffering from black patches which appear on areoles from which flowers have recently detached. I suspect the problem is the result of fungi attack, and the silicon fertilizer is one potential solution that I had identified for experimentation.

As of November 2021, silicon appears to have a positive disease-resisting effect – this will be discussed in the next chapter on Battling Bugs. But there was also an unexpected short-term effect: Some of the grafted specimens started to put out flower buds with renewed vigour. One of the grafted GBalds, 2019B, has never produced more than 3 flowers in one flush (see the table below), but it suddenly managed *6 flowers* in November 2021. Now, each time I sprayed the plants, I used very little of it – about 3 grains of rice worth in 1 litre of water. So the effect was rather dramatic.



Flowers produced by one GBald-on-MGeo graft, 2019B, from its first flower in September 2020 to six in November 2021. One of the four flowers in March 2021 actually belongs to the flush of flowers in the previous month.

9 You can read all about these plants in the chapters on grafting. See the chapters on the 2019 specimens.

Two views of a GBald-on-MGeo graft, 2019B. **Left:** 2019B in late October 2021, about 2 weeks after silicon fertilizer was first applied. **Right:** In November 2021, eleven days later. The flower buds were starting to open. The smallest bud was eventually aborted, so 2019B produced a flush of 6 flowers. (I will provide more pictures in the relevant chapter on grafting at a later date.)

I don't think a sudden jump to 6 flowers in a single flush is due to anything that I have been doing normally. The only change was in the feeding of silicon fertilizer. Perhaps there was an element of luck in the timing – the GBald got the fertilizer boost as it was gearing up to produce a flush of flower buds. It may have been the action of the acid or the chelator, but unlikely I think.

While here have been no negative effects from spraying fortified water with soluble silicon on cacti, HLimi and *Gasteria* have reacted somewhat negatively, perhaps to acidity. For now, I limit the occasional silicon sprays to cacti. In 2023, I have turned to growing new roots to get strong and healthy stem growth (see the chapter on stalled growth) and so silicon sprays are currently on hold.

It looks like proper nutrition for cacti is much more than simply feeding them with basic NPK stuff. And more than giving them basic TE (trace elements). As such, I have started to look into other supplements. These days, I don't really believe the calcium in the tap water is enough[10], so for my next experiment I will be adding powdered eggshell to some pots of cacti. ♦

10 It depends. Tap water at my locality is around 100 µS/cm or less – good for flushing nutrients out of pots, ha ha.

Version Information

This is the December 2023 Edition of this document.

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Colophon

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