

Cactus Cultivation: TRICHOCEREUS



Patrick Noll



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CACTUS CULTURE VOLUME 1: TRICHOCEREUS FIRST EDITION

Edited by Dr. Liam Engel

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This book would not have been possible without the help of all my friends, backers and members of our amazing Trichocereus Facebook group and the SAB forum. In particular, I want to thank everyone who contributed photos, information and helped spread the word about this project. These contributors and the online cactus community made both of our crowd funding campaigns a success and if you're reading this, you played an important part in this!

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FOREWORD

Despite the fact that I mostly publish printed books, I like the eBook as an art form and it was always my plan to write an eBook at some point in my life. The hard copy cactus books I've published are not cheap and it was important for me to publish something that everyone could access and afford.

There were many times in my life when I struggled financially and I know very well how it feels when you cannot afford something you'd like to have. Because of this, it is not really my plan to earn a lot of money with my TRICHOCEREUS CULTURE eBook. Right now, the plan for this eBook is to either give it away free or sell it at a price that's so minimal that everyone will be able to afford it. It really is important to me that these books get to the community and making money is not the plan here. I still need to make sure I am not going broke during all my projects and if you want to support me you can do that via Patreon.com/cactusjerk or by buying stuff from our website at Trichocereus.net. Please consider subscribing to my newsletter and engaging and sharing my content online.

It took a long time to complete this book and it will be updated on a regular basis. TRICHOCEREUS CULTURE is an extensive guide, useful for all cacti growers out there. This is not a completely and professionally published book and I want to point that out! While this eBook may not be perfect, it will help people all over the world and we will constantly edit this eBook with new stuff, photos or corrections.

After publishing this eBook, I am working on the third and final volume called **THE GENUS TRICHOCEREUS**. This book is shaping up to be massive, with over 500 pages and a complete revision of the genus. As there were some problems with American Crowdfunding services during my campaign for the second book (these service didn't like the genus *Trichocereus*), we will probably only print a very limited run via preorder and if you want to get on the preorder list, make sure to email me via EG@trichocereus.net

If you want to donate photos for the book or just share your thoughts please send me a message. I am always happy to help. So yeah, this is it! Enjoy the book!

Best wishes, Patrick Noll

You are free to share this book with your friends, but please consider making a donation via Patreon.com/cactusjerk. It costs money, time and effort to offer this eBook for free and your support means I can continue doing this work in the future.





Fat Potato.jpg



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1. Sowing out *Trichocereus* seeds

Sowing out *Trichocereus* seeds is as easy as breathing. Keeping seedlings alive afterwards is a lot more difficult though. Unless your seeds are old and have already lost their mojo over time, all *Trichocereus* seeds should germinate within one to eight weeks. The germination time and general requirements of all the different *Trichocereus* species varies greatly. As general rule of thumb, I'd recommend giving the seeds between 3 days to 8 weeks to germinate. If nothing has happened by this time, it makes very little sense to keep the seeds wet. It is very rare that more seeds will germinate after this time period and if you still have no seedlings by this time I recommend letting them dry out completely, starting a new germination cycle when water has completely evaporated. The success rates in this situation are much higher than when you keep them wet for many months.

Finding the ideal germination temperature

Trichocereus seeds start germinating between 25-30°Celsius, which translates to 77° and 86° Fahrenheit. The ideal germination temperature is 29°-C and minor spikes over 30°-C are normally not a problem for seeds.

As soon as you're having a tray full of living seedlings, the heat can be very dangerous though. With tiny seedlings, you should avoid going over temperatures of 29°-C at all costs. One of the most common reasons for sudden seedling death is heat, followed by direct sunlight. People do not always make the connection, but there's often a reason that's overlooked or misidentified as something else, for example a fungal infection. Newbies use that term a lot and not always in the right context.

When I started growing cacti, sudden or unexpected seedling deaths were common. The majority mostly looked okay, and at the time, I suspected fungal infections were a possible cause. It took me WAY too long to see the connection between overheating, drought and loss of seedlings. Seedlings killed because of heat damage open the door to mold and fungal infections in the same container. While it seemed like I was having fungal infections, these infections were only secondary and the actual problem was overheating. Experienced growers know how to spot the difference between onset of heat damage and fungal infections and in this book, I try to show you how. As with so many things in life, it is easier to prevent heat damage and fungal infections than healing the damage caused by these problem. Once the problem has started, it's often not possible to save the seedlings.



A wide variety of pathogens can attack decaying seedlings, but they are often not the actual problem. Experienced growers know how to spot the difference between heat damage and fungal infections, and in this book, I will show you how.

One thing that you should know is that it is much easier to prevent heat damage and fungal infections than healing them. Fungal infections usually take over the healthy seedlings too, and at this point it's often not possible to save the tray. A major part of a cactus breeder's job is to learn how to prevent all kinds of problems and pitfalls that might pop up along the way.

Avoiding direct sunlight while germinating

I'm always surprised by the large number of people who do not know that seeds should not be placed in direct sunlight. While you need heat and diffuse light to induce germination, direct sunlight dries out the top layer of soil very quickly, which stops the germination process. Direct sunlight is too intense and disturbs and stresses these tiny seedlings during their important first weeks. The best source of light for germination is very diffuse. You can place your seedlings beside a window or provide light using a relatively weak lamp. In nature, cactus seeds germinate on the soil surface rather than under a layer of soil. It doesn't take much and a little bit of indirect light is enough to set things in motion. I personally use weak LED panels to "wake up my seeds". These lamps are between 10 and 45 watts and are strong enough to raise cacti from seeds. That said, these lamps would not be strong enough to grow larger cacti inside. You do not need a 1000 watts pot lamp to grow cactus seedlings, but I recommend a new generation LED lamp of at least 150W if you intend to do anything apart from germinating or growing smaller seedlings with your lamp.

Finding the right amount of humidity

Cactus seeds need humidity to germinate. In the beginning, it can be difficult to find the right amount of water to put in, but it gets very easy once you know more about how these plants grow in nature. Most cacti are easy to grow from seeds and only need a little bit of moisture and condensation on the walls of the container to grow healthily. Overwatering is a very common mistake. You should never give more water than what can dry within a few hours or one day at the most. Seedling soil should never be flooded with pooling water. Too much water can wash the seeds below the surface, where they cannot germinate. Pooled water also causes other problems like rot, algae or moss. When sowing out, I usually spray inside the seed containers ONCE in the beginning before sealing them for weeks. I only open to add more water if I originally messed up and didn't spray enough water to begin with. Seedlings can stay sealed in a closed containers, but only if it doesn't look like the swamps of Dagobah.



Finding the ideal container

I am a firm supporter of the takeaway tek and was one of the first people to use it. The Takeaway Tek is basically an adapted version of the Fleischer method (a German breeder who came up with the idea to sow seeds in glass jars) and I started adapting it to little transparent Salad containers around the year 2000. Fleischer used large glass bottles with sealable lid, similar to the ones used by mushroom growers and it was so effective that the method became standard in cactus culture in in the 80s. The takeaway tek simply replaces the glass bottle with plastic boxes, such as transparent salad dishes or fast-food containers. These boxes are available in all kinds of sizes and quality grades. I personally used rectangular 200-300 ml salad containers with removable lids. If you want to use space efficiently, it is best to avoid round containers, which waste a lot of space due to their shape. A benefit of rectangular containers with fixed lids is you can stack a large number of them in front of a window or a heater, reducing space.

Sowing out cacti is a constant race against pathogens and temporary or permanent removal of the lids is a common occurrence. If you're having trouble and your container lids are not removable, you often have to cut a lid off because it's just better than having a semi-open lid dangling around. This cutting is inefficient and causes unnecessary work. All containers should be transparent and allow a sufficient supply of light for the seedlings to get through. Because the closed containers seal the humidity, you do not have to water them very often, making commercial cactus culture much easier.



This photo above shows orchids grown on an artificial medium. The containers pictured have a small air filter that lets in clean air and allows ventilation.



You can grow plants in many different growing mediums, including artificial mediums, sowing soil, cactus soil or mineral soil consisting of ingredients like Pumice. These days, I am sowing out in pumice because of its resistance against fungal infections and pests like fungus gnats. However, there are a million growth medium options and it's every grower's job to find the medium that works best for the environment they are growing in.



By sowing out directly into small square pots, you can save the time and energy that you'd otherwise spend repotting. It's also better for the environment because you cut out the fast food containers. The pots are frost and UV resistant and can be re-used very often.



Providing fresh air

Fresh air is important, which is why you should open your containers at least once a day. That's the theory, at least, but in practice people don't do this nearly as often as they should. Opening and checking containers on a regular basis drastically reduces sudden death and fungal infections, and I strongly recommend regular checking. In closed containers, fungal infections can spread rapidly; one dead seedling somewhere in the middle is enough to cause a chain reaction that leads to loss of the whole container. Opening containers to check everything is in order and to allow fresh air exchange should be a regular task.

Finding an ideal medium for sowing out

The debate over which sowing medium works best is a huge topic. You can use all kinds of soil for raising cacti, but some are more prone to causing problems than others. Due to the many different options available, this book dedicates an entire chapter to sowing mediums. There are many approaches for achieving the same or similar goals. What is most important is that you adjust your water management accordingly.

In my life, I've used almost every thinkable medium to sow out cactus seeds. These days, I am sowing out in a fine pumice mix (0-10 mm, pH 6.5) because it is a great mineral for cactus culture. I've also used commercial sowing soil and even oddities like black soil (also known as commercial grave soil).

Both these options have a tendency to be resistant against rot and mold, without turning into a clump of cement after drying out. Peat, however is famous for its inability to stay flexible after drying out, which is why I generally do not recommend peat in cactus culture unless in minimal percentages of less than 10% of your total medium. Peat can improve a medium's ability to store water, but the more peat you use the higher the risk of "bricking". If you like to neglect your cacti for a few weeks at a time, or if you just can't guarantee your medium won't dry out completely, you probably shouldn't use much peat in your soil.

In my opinion, the type of soil used is not important as long you adapt your water management. You can grow cacti in almost every medium that has the correct pH and doesn't contain toxins that kill your seedlings. Not only do you need to know when to water, you also need to know when not to water. When picking your sowing soil, the time it takes to dry is one of the most important factors to consider. It is also important to be aware of how soil reacts to being wet for prolonged periods, i.e. whether it can rot or not. Using a mineral medium has the benefit that certain pests can't infest mineral soil as easily as organic soil. To find the sowing soil that works best for you, you need to first understand the problems you personally face and adapt the soil appropriately. If your seedlings tend to develop root rot, it is likely because they get too much



water for the type of soil they are in and you can react by increasing the amount of minerals in your mix. If necessary, you can use sand to improve soil-drying time. The more sand you have, the less problems with pests like Root mealies you'll get. However, sand alone is a poor medium and I'm not a fan of using more than 10% of sand in a soil mix. If used, sand has to be mixed with other ingredients like pumice, lava, sowing soil, coir or a little bit of peat. I personally do not like to use peat because I prefer mineral soil, but there are a lot of experienced growers that get great results with relatively organic soil mixes. Again, it depends less on your medium ingredients and more on how you treat and water your soil.

I detail diverse soil ingredients in the chapter two "Cactus soil and minerals". It is important to choose the soil that works best with your personal approach to growing seedlings. If you water and fertilize your seedlings infrequently, I'd recommend choosing a soil that's more rich and organic. The higher the amount of minerals in your soil (e.g. sand, pumice), the faster it will dry. Soil high in minerals can be an advantage because it dries so fast that the roots can't rot and pests can't develop, but can cause issues if the soil dries so fast that the seedlings don't get enough water. Again, water management is the most important part of growing from seeds. Too much water will mess everything up, and too little will do just the same.

Viability of cactus seeds

Fresh *Trichocereus* seeds typically have high germination rates and take many years to become unviable. As a general rule, *Trichocereus* seeds can stay viable for 5-10 years as long as they are stored in optimal conditions. The temperature in your storage room should be as cold as possible and completely dry. I do not believe that dry seeds can get too cold, as it is a common method for seed banks to freeze them.

Humidity is one of the most important negative influences on seed viability. It is important to clean all seeds very thoroughly as remaining fruit matter can generate humidity. Fresh cactus seeds should germinate within 3 and 8 weeks. Seeds that have not germinated in this time will probably not sprout during the current germination cycle, regardless of how long you keep them wet. The cause for this is a natural barrier that keeps seeds from germinating during a long rain and flood season in which cacti might not survive. *Trichocereus* need water to germinate, but not constant rain and floods

If your seeds do not germinate in this window of time, I recommend drying the soil (including the seeds) and starting a new germination cycle afterwards. There are some cactus seeds that take much longer than 6 weeks to germinate, but these seeds are rather big compared to *Trichocereus* seeds and often require additional treatment to induce germination. For example, seeds of certain *Opuntia* species fall into this additional treatment category and it can help to carefully nick such seeds with a file to improve their ability to take in water.



Sometimes perfectly viable seeds do not germinate, even when fresh. Some seeds require a dry period after being harvested before you can start germinating them with optimal results. Seeds are living things. They are not robots which jump out of a box when you press a button. Seeds need a combination of factors to be present before they germinate, and sometimes these factors are out of our control. Things that can mess with a germination cycle are extensive heat or cold, direct sunlight, mold, insufficient water, unclean seeds etc.

While fresh seeds should always germinate reliably and without much fuss, there will always be exceptions. Refusal to germinate can be a temporary (e.g. just during the first cycle), or a permanent problem. Breeders that make hundreds of crosses have a huge task and it is hard to clean and dry so many seeds perfectly. You may get excellent results from seeds sown right from the fruit, but if you run into problems during the first cycle you should consider bolstering your cleaning and drying efforts. It should not happen often, but if you end up with a batch that produces zero germination while others have reported great germination results for the same seeds, fruit remnants or temperature issues would be my first guess. Everything takes time, and I strongly recommend letting seeds dry for a few weeks before sowing them.

If you experience germination problems with seeds that are reported as fresh, take the lid off your container, let the soil dry completely, and start again. You can restart and complete as many germination cycles as necessary, but it only makes sense to do this more than once if it's very rare seeds that you're desoeeare to germinate. Multiple germination cycles reduce your space and time, so make sure you're seeds are worth it.

Using gibberellic acid to improve germination rates

Gibberellic acid or GA³ is a chemical that can be used to improve the germination rate of seeds. Gibberellic acid can re-vitalize some very old and borderline unviable seeds, but it only works to a certain degree. As long as you don't expect any miracles from gibberellic acid you will not be disappointed.

Another plant hormone that can be used for improving the results of cactus culture is N-6-Benzylaminpourine, also known as N-6 BAP or just BAP. BAP accelerates plant cell growth and commercial breeders use it to induce pupping. My personal experiences with BAP were greatly disappointing and I could not see any effects apart from extensive scarring. I recommend approaching this with great care, especially with rare and valuable plants.

You can also use similar chemicals to speed up the time it takes for cuttings to root and I've seen incredible results in just a few weeks after application. There are various rooting hormone products on the market, e.g. Clonex.



Hardening Up your Seedlings

Hardening up your seedlings is an important step. It sucks when you spend many months and sometimes years raising little baby cacti from seeds just to kill them within a week because they weren't adequately adjusted to the elements. In this chapter, we will discuss ways how to avoid exactly this.

What does "hardening up" actually mean in this context? Seedlings are extremely vulnerable to being destroyed via sunlight, rain, high or low temperatures, dehydration, fungal infections etc. Once you start confronting your seedlings with all these natural forces, you will probably lose some along the way. How many you lose depends on your skills as a cactus grower.

Sun resistance in plants is highly variable and needs to be built up slowly over time. You do this by GRADUALLY exposing your plants to sunlight for a few hours. Seedlings that were grown in closed containers with high air humidity should not suddenly and permanently be put into a very sunny and dry environment. Instead, remove their container lids for a few hours each day until they are fully accustomed to their new environment. Adult plants do not need as much water as tiny seedlings, so you can start reducing the watering frequency when hardening up seedlings. I personally grow my seedlings in closed bags for at least 2-4 months, before I slowly start exposing them to the world.



These seedlings were grown inside for 3 months before being placed in my main greenhouse.



Once adapted to their new environment, I give my seedlings as much sun, water and fertilizer as my adult plants. During the seedling's first weeks of exposure, I cover them with gauze or cardboard for a few hours per day. At first, I remove the coverings for two hours, then four, then eight, and then I took all coverings away for good. This gradual exposure process helps seedlings get used to the new environment without getting shocked and dving in the process. For small seedlings, heat is equally as deadly as direct sunlight. Make sure to avoid cooking your little seedlings in a hot greenhouse with closed doors and windows. Adult plants are very resistant to hot temperatures, but little seedlings are not. If you expose seedlings to temperatures of more than 30° -C on a regular basis they will die. To prevent this, I always keep doors and windows open during hot days. I love giving my large plants as much sun and heat as possible, but with my seedlings, I am extremely careful and almost paranoid. If there's too much heat, the seedlings will gradually lose water and nutrients, eventually succumbing to the elements. Overheated seedlings will change their skin color to a dark red or even blackish color. If your seedlings turn red and start to shrink, you are likely exposing them to too much heat or sunlight. Change of color is a great warning your seedlings are in danger. All plants respond to stress in some way. In the case of Trichocereus seedlings, this response is often a change of skin color.

During the hardening up process, your seedlings might need more water than before. In direct sunlight, water evaporates a lot faster than in the shade. Spraying seedlings with a fine mist of water can help to cool them down and ensures that they have enough water available without getting their roots too wet. Little seedlings must be sprayed or watered very carefully or they will get washed away. Disturbing their root system during this critical time will very often result in death. If you wash a seedling out of the soil, gently reposition them. If they lose contact with the soil, seedlings will almost always die.

In the photo on the right you can see how I harden up my seedlings in direct sunlight. Take great care in avoiding shady areas, or large plants that can create too much shade. Shade often creates a humid environment and this should be avoided with cactus seedlings.







These seedlings are coming from inside my house and have just reached the size where they can tolerate full sunlight in my main greenhouses. They already get a lot of light under my LED lamp and are somewhat used to a bit of UV light.



Singling out and separating seedlings

I like sowing out a lot and I sow way more seedlings than I should. I enjoy selecting mutants, weird forms or variegates and that's why I often sow out at least 50-100 seeds per container. When doing this I have to single out or separate my seedlings. Very young seedlings enjoy being in a crowded environment surrounded by other seedlings. However, there is a point of diminishing returns and your seedlings will reach an age that they will grow better with their own space. The best time to start separating seedlings is after a year, when they are big enough to survive separation and are slowly starting to grow a bigger root stock.



These seedlings are ready to be singled out now, because they are about to start destroying each other and their pot. If I would not separate them now, little pockets of moisture and humidity would eventually lead to root rot. If there's no oxygen getting to the base of the seedlings, there is a very high risk of rot, infections and pests. Root Mealies love this kind of setting too.





Seedlings and grafting stocks ready to be singled out. The longer they are kept like this, the more likely there will be problems and fungal infections.



2. Cactus soil and minerals

There are many different recipes for cactus soil. Most recipes can produce good results as long as you have adequate water management and don't make any rookie mistakes. I must stress that once you decide to dive into cactus growing, learning about water management must become your new religion. Remember, every soil behaves differently when wet.

It's strange that an atheist like me brings up the subject of religion, but there are so many schools of thought and passionate advocates regarding different cactus soils that I may as well compare it to religions. There's lots of different approaches that lead down the same road, and an experienced grower is ready to deal with all of them.

You can grow cacti in a mineral soil or an organic one, the only question is how you treat your soil. As someone who has probably tested all possible soil types, I think it's safe to say that almost all have pros and cons. There are experienced growers who prefer organic soil and get great results, and there are others like me who believe that a mineral soil is the safer approach. Your climate affects the type of soil you should choose, the length of winter, temperatures, humidity, etc.

Another factor important to consider is the age of the cacti your soil is intended for. Seedlings are much more vulnerable to certain problems than adult plants, and adults can withstand a lot more drought than seedlings. In addition, you need to think about your feeding schedule and the nutrients you would like to feed to your cacti.

You can literally force feed and flood your seedlings with nutrients, which is a method used to quickly get plants to a flowering size. An alternative is growing plants more naturally, at a slower pace. In the latter scenario, you will usually get plants that look closer to how they appear in habitat. Nonetheless, there are situations when a more organic and nutrient rich soil can be the better choice. In my opinion, age is the deciding factor here. Due to the high risk of sudden death, you should raise your small seedlings as fast as possible. Small seedlings can die from almost anything, including heat, pests, fungal infections, chemicals or sunlight. The point I'm making is that it's best to get plants through this crucial seedling phase as soon as possible, for their survival. For this reason, it can make sense to go with an organic-rich soil early on, and switch to a mineral approach later.



Personally, I like to use a mineral sowing soil as it is not as hard on roots as organic soil if you keep it wet for longer periods. If you want to grow your seedlings in closed containers, a mineral sowing soil consisting of pumice is probably a good choice. Pumice is very resistant against infestations with fungus gnats, which is a major sticking point for some growers.

In the following chapter, I list a few examples of classic soil additives to mineral soil recipes. Please note that it can be beneficial to add a small quantity of organic materials to a mineral medium. This is mostly to improve the soil's ability to store water, as well as to provide additional buffering to help the soil respond to changing conditions. For example, pure pumice can sometimes turn into a compact mass, which you can avoid by adding a small amount of coir, lava, or sowing soil to your mix. The example below shows one such mix consisting of pumice, lava, coir, expanded clay and charcoal.



Pumice

Pumice is a volcanic mineral and one of the main ingredients in my personal soil recipe. Pumice consists of many porous layers, which make a large part of its total volume. Because of this, pumice is very light and can store lots of water. Pumice also has a very high mineral availability, which is one important reason that pumice works so well for cacti.



In comparison, quartz sand has a fairly poor mineral availability. Because of this, quartz sand is not usable unmixed as a sole medium for cacti. When picking the right minerals for cactus soil, it is not just about the soil's mineral contents, but also about how much of this mineral content is available to plants. Pumice and lava work so well in cactus soil because they have a very high mineral availability, making them great soil additives.

Apart from mineral availability, it is also important that your soil can store and transport water. A soil is of no value if its structure cannot hold water well, or is storing water in a way that will cause rot. Chemically speaking, pumice is identical to other sorts of lava, but particularly great at absorbing water. Pumice is the lightest mineral available in gardening and helps keep root systems well ventilated, improving root formation. The structure of pumice is just perfect for little cactus roots to grow into.

Another thing to consider is the pH level of the minerals you use. The pH level of pumice is very variable. In most cases, pumice pH is neutral but this greatly depends on the country of origin and some samples I tested had a pH of up to 8.5. You can measure pH with a professional pH meter or the classic pH test strips you can get in a pharmacy or hardware store. If you intend to purchase a large amount of pumice, ask your supplier about a free sample that you can test in advance to ensure a neutral pH. Pumice can be expensive, and a high pH will slowly you're your cacti. If you keep getting the feeling that your plants do not thrive in one particular batch of pumice, the first thing to look into is the pH level. It is relatively uncommon for pumice to contain chemicals that are bad for plants, but if your plants show stunted growth or discolorations as soon as you put them in pumice, the pH level is the most likely culprit.

For sowing out, I currently use pumice with a particle size of 1-5 mm. For bigger plants, I use a particle size of 2-10 mm. Unwashed pumice contains lots of dust, which often turns sticky unless you sieve the pumice before usage. It's always best to remove dust and fine particles in advance. While sieving pumice is not essential, dust can be a real problem and may turn your seedling container first into a swamp, and then into glue, before turning your whole medium into a solid mass.



Pumice on the left, Gravel on the right.





Pumice with a particle size of 1-4 mm for sowing out. Pumice with the fine structure works great for growing seedlings in it, but you should wash it before using it in your cactus soil.



Lava

Just like pumice, lava is a volcanic mineral used in horticulture and is an excellent ingredient in cactus soil. Lava consists of molten rock full of silicate minerals like feldspars, olivine, pyroxenes, amphiboles, micas and quartz. The pH level of lava is neutral, which makes it a good medium for cacti. However, lava is much heavier and sharper than pumice, which can have some effect on roots. Lava is probably slightly worse as a medium than pumice, but it still works very well and I use it as main ingredients for my cactus soil.



This medium consists of mostly 0.5-1 cm lava, which is very fast draining. Lava is not recommend alone as a medium and should always be mixed with other minerals like pumice.



Coir aka Coconut Fiber

The name coir comes from the Malayan word for "cord" and dates back to times when cords and ropes were made from coconut fiber. Coir is a natural fiber made from the husk of coconuts. Though it is an organic material, coir works like a mineral when used in a cactus soil. This makes coir an excellent additive to soil and some of my soil mixes contain large quantities of it. Coir has a perfectly neutral pH level, which is another reason it works so well in soil.

Zeolites

Zeolites are porous minerals commonly used in industrial filters and water cleaners. They naturally form when volcanic rock and ash react with water, but most of the commercially available zeolites come from chemical production. The pH level of zeolites range between 6.5 and 7.5, which is ideal for cacti. Due to their porous structure, zeolites can absorb a fair amount of water, heavy metals and toxins. This makes zeolites a useful mineral for cactus culture.

Sand

Sand isn't clearly defined type of mineral, it's a catchall term for a variety of sandy minerals coming from all over the world. The most common type of sand is silica quartz sand, which is widely used for children's sandpits. The defining characteristic of sand is particle size, which is finer than gravel but coarser than silt. Not all types of sand are equally suitable for cactus culture, but some sands will work really well. Coarse sharp sand, for example, is an excellent addition to sowing soil.

The pH level of sand varies greatly, but most types of sand have a pH around 7. This is an ideal pH level for cacti. Due to the glass-like structure, sand can burn your seedling's roots. Sand also has terrible mineral availability and cannot store water very well. Due to this, sand is only recommend for very experienced growers and only if its structure is not fine and/or rounded. Round sand particles are constantly moving when you handle your seedlings, and cactus seedlings have a hard time digging their roots into them. As a pure medium, sand is not usable unless you water incredibly regular. I sometimes sow out in sand just to test seed viability, but only if I do not intend to raise the seedlings. Of all the mediums I've used for cactus culture, pure sand is among the worst for general health and growth speed. However, sand can be a great additive for SOME cacti as long as you stay away from very fine sand and only use small amounts. Sand can also work for people who lose many seedlings to root mealies, because these



pests do not do well in sand due to the sharp particles. Sand literally cuts these pests up and kills them!



The photo above shows very fine quartz sand. Quartz sand is usually too fine for sowing out, but it can be beneficial for rooting.

Perlite

Perlite is a type of volcanic glass made via the hydration of obsidian. Perlite is white in color with an average pH level of around 7. Perlite is able to expand greatly, which is why it is widely used for cactus culture. Perlite is widely distributed as a soil additive, but I am not a fan and have sworn that it will not get anywhere near my soil because I consider it unnecessary.

Perlite is a very light material that collects on the surface of pots, which always bothered me because it then spreads throughout the garden. If you decide to use perlite in your soil, you better get used to seeing it spread all over your yard. In addition, perlite stores a lot of water and stays wet for much longer than pumice. This means perlite attracts algae and moss, which creates lots of additional problems.

On top of all these drawbacks, there are reasons to believe that perlite might cause cancer when inhaled. There just isn't a good enough reason to add perlite to your soil when you can achieve a



better and more reliable result with pumice and lava. Don't get me wrong, perlite will definitely work as a soil additive, and there are many people that swear by it, but I do not like to use it.



Photo: Ragesoss under Creative Commons License



Expanded Clay

Expanded clay is a lightweight medium made by heating clay to 1200°-C. Expanded clay is a popular additive for cactus soil and I use it in some of my mixes at 10-15% of the total medium. Expanded clay is light and can store plenty of water. Similar soil additives are perlite, rocklite and gravelite.

The pH level of most expanded clay products is around 7, while the ideal pH level for cacti is 5.5-6.5. There are expanded clay products on the market that have an unsuitable pH level for growing cacti, which is why you should request and test a sample beforehand.



Commercially available expanded clay © Trichocereus.net



Sowing out with topping layers

The mineral quartz mostly consists of silica and shows potential as both a soil additive and topping layer in cactus culture. Quartz is not usable as general soil medium, but I use it to keep moss and algae from overgrowing the surface of my soil. For smaller seedlings, algae and mosses can become a real problem and these are easier to avoid than get rid of. Due to the coarse structure of the quartz particles, algae and mosses cannot grow on quartz easily. Some people use a topping layer of quartz sand to avoid weed formation on the surface. Unlike the larger quartz particles, very fine sand particles can still be overgrown if they form a closed mass throughout the container.





The container on the photo above is completely overgrown with moss, greatly increasing the risk for fungal infections. Moss traps humidity and eats away much needed sunlight. I had to transplant all these seedlings into another container. Not all species of moss and/algae are problematic and some even show positive effects on the general health of nearby plants, but in general I would recommend avoiding them. Some moss and algae can grow very fast and overgrow cactus seedlings effortlessly.

This takes away sun and nutrients from seedlings, and the only way to respond is either by removing all weeds from every single one of your containers, or by transplanting the seedlings in a clean container. Moss and algae will cost you a lot of time, especially if you sow large quantities of seed. You can also use other minerals as topping layers. The main factor in determining which mineral is usually particle size. The bigger the particles, the less likely the risk of attracting weeds that can overgrow everything. Usable minerals include but are not limited to

lava, pumice, split, asphalt, basalt and marble.

The big problem with topping layers is that it makes it very difficult for you to estimate how wet the soil below the topping layer is. You can certainly see how much water you have in the topping layer, but not what's below. Cacti (especially seedlings) are very sensitive to both overwatering and drought, which is why every cactus grower should be one hundred percent aware of the humidity level of the soil they're using.

Topping layers can be great, as long as everything goes according to plan. However, I've seen cases where very rare seedlings were lost because the soil seemed dry but was a rotten swamp below the topping layer. Obviously, choosing organic soil to sow out makes this problem even worse.





Growing seedlings in high humidity

Cacti are hardy plants that can withstand drought, cold weather and rain. Yet, as seedlings, cacti are particularly vulnerable to drying out. For seedlings, it can be helpful to germinate and grow in a permanently enclosed environment. A salad container or pot sealed with a transparent plastic bag can be used to grow cactus seedlings, but there are some important considerations when doing this.

1. When growing in enclosed containers, you need a soil that does not rot when it holds water for weeks or months. The soil must also be able to dry very fast, to allow you to respond to infection. A typical response to infection in an enclosed growing container involves unsealing the container and removing infected soil and seedlings. The container is only resealed after it has dried and the infection has stopped spreading.

I cannot recommend sowing in pure coir or other absorbent mediums unless you are sowing out in summer. Mineral soil mixes consisting of pumice and lava are perfect for sowing out and are my personal preference. You could add perhaps 10-15% coir to improve stability of the soil mix, but it's not necessary.

- 2. When keeping cacti in enclosed containers, you must keep close control of temperature to avoid infections. While cactus seeds and mature plants can tolerate higher temperatures, cactus seedlings tolerate a maximum of 30°-C. Heat is a particular concern when seedlings are in enclosed containers under grow lights, because they retain more heat than open containers. It is difficult to distinguish seedling cause of death and high temperatures is a culprit often overlooked. It is part of life to lose a seedling here or there, but a risk of enclosed containers is that one dead seedling can turn into an entire dead container of seedlings, within just a week or two.
- 3. Checking containers on a weekly basis is essential. Seedlings require fresh air and dead seedlings should be removed. Use a little piece of plastic for fishing out dead seedlings before they turn into a fungal infection. It should be very difficult for fungal infections to return after removal of dead tissue. They may return, but it's unlikely.
- 4. Be careful with fertilizers, carbohydrates and extracts. Adult plants and seedlings love seaweed extract, but if you put it into a closed container, seaweed extract will turn your soil into an algae nightmare. Fertilizer can cause burns that kill seedlings and give pests or algae a major growth boost. It's not only seedlings that love nutrients, but other living things love them too. In contrast, if you use a purely mineral soil, you will need to add fertilizer right away. If you're using a mineral soil, I recommend a very mild



concentration of a specialized fertilizer for sensitive plants. I personally use a fertilizer called Wuxal Super.

- 5. Particle size matters. Ideally, you would use a mineral soil with a slightly bigger particle size to create obstacles to infection spreading. I personally use pumice and lava in a particle size between 5-10 mm. This gives your seedlings strong attachment to the medium, while keeping algae and lichens in check.
- 6. Do not sow out too many seeds per container! The more seeds you sow into a small container, the higher the risk that one of them kickstarts a full-blown infection. Cacti like to grow in a crowd, but there are limits.

Examples of poor soil

If your soil looks like some of the examples in this chapter, then you should change it. Old soil can sometimes turn into one big brick and completely block plants from taking in any nutrients. This is especially problematic when the soil is high in peat. Cactus soil needs to possess a structure that allows the roots to dig themselves in, which may not be possible when soil is too firm.





3. Growing adult *Trichocereus* and similar columnar cacti





The genus *Trichocereus* is very hardy and one of the easiest genera to grow. However, frost is a major killer that can destroy entire collections in just a few days. As someone who once lost an entire greenhouse full of plants while spending a record winter in a hospital, I can't stress the need to respect cold damage enough. Most commercial sellers do not ship during the winter months, and it's best not to buy sensitive plants during winter either.

When it's cold, avoiding overly wet soil is particularly important. In summer, *Trichocereus* can take large amounts of water. However, when temperatures drop below 10°-C you really want to avoid them getting wet. *Trichocereus* roots can easily rot from a combination of cold and wet weather, so ensure to keep your plants completely dry during the cold winter months. Colder temperatures around -5°-C are usually not a problem. In my greenhouse, I overwinter my plants at 0° Celsius. I live in an area with a relatively mild winter, and between October and March it's mostly between 0-10°-C. I use heaters to avoid frost, but as long as temperatures are in the lower range, my heaters do not kick in. During milder weeks, I do nothing for my plants besides providing fresh air. Because I grow my plants in a mineral soil, they are a lot hardier against cold weather than they would be if they were in a mostly organic medium. While some people swear on organic soil, I personally cannot recommend using an organic medium for cacti, unless sowing out. Seedlings start as tiny blobs of life that are very prone to drying out, root rot and overheating. I highly recommend using mineral soil as a general culture medium, and most commercial breeders would probably agree.

It's best to sow seed in late winter or early spring. By doing this, you can get the most out of the coming season and get your seedlings to a size where they can better survive the following winter. If you sow out inside or keep tiny seedlings at room temperatures, they have very different water, light and nutrient needs. When kept at lower temperatures, cacti do not use up a lot of water and it is often unnecessary or even unsafe to water them during the winter. However, by growing in a heated room you emulate a natural spring or summer for your seedlings. If you put your plants into a heated room in winter you will also need to provide a powerful source of light to keep the seedlings from etiolating, as well as water and nutrients to keep them from drying out.

Watering your plants

All cacti have different water requirements. Species from the genus *Trichocereus* can often tolerate plenty of water, and I water my plants almost every day during the summertime. This only works because I use a mineral soil that dries out very fast, combating root rot. Both pumice and lava can store water in a way that does not cause the roots to rot as easily as they would do in organics. Pumice is probably a little bit better than lava due to the effect of pumice on the roots, but I use both ingredients regularly.


In horticulture, it is often recommend not to water your plants in the evening. Too much water in the evening increases the risk of fungal infections. At night, temperatures are lower and the risk of your plants getting overly wet is much larger than when you're watering during the early morning, or during a hot summer's day. There are countries where it never gets particularly cold, but watering in the evenings can still cause issues in these places, particularly during colder nights. In months of extreme heat or during abnormal heatwaves, watering in the evening is perfectly fine.

Finding the right amount of water

As a rule of thumb, it's best to water on the side of caution and only water what can safely evaporate during the rest of the day. The exact amount of water you can safely give varies from soil to soil and from species to species. You can always decide to give more water, but you can't give less. Once the soil looks like a stinky swamp landscape, it is much more difficult to get the water out again. If you use a 100% mineral soil mix consisting of volcanic minerals like lava, the water will dry so quickly you can watch it happen. Mineral soil dries so fast that it can sometimes be a problem for drought sensitive cacti and seedlings, which is why I sometimes use organic additives in my mixes. Good organic additives include coir, black/grave soil and sowing soil. These additives are resistant to mold and bacterial rot. Keep in mind that the more organic additives, the higher the risk for mold, root rot or pests like fungus gnats though. Try to get the best of both worlds by using a mostly mineral soil with 10-30% organic additives. This is sufficient for improving your soil's ability to store water and nutrients while retaining the benefits of a mineral mix.

Pots – plastic or clay?

Everyone has their own opinion about the ideal cactus pot. Personally, I like pots made of plastic. Plastic pots are very light and easy to handle. They do not store much water and often dry out faster than clay pots. Plastic pots are often smaller, and smaller pots dry out faster. Your plants don't need a huge root system to be healthy, and this is something I took some time to learn. When I started, I was a big fan of clay pots, simply because they looked great. However, this great aesthetic comes at a cost. Clay pots are heavy and when you are dealing with a spiny 2-meter tall *Trichocereus* in a mineral medium you are already in hazardous weight-lifting terrain. I hurt myself trying to move large and spiny cacti quite often, and once I stopped dragging around heavy pots injuries occurred much less regularly. Weight is an issue and I like that plastic pots that are more mobile. You can also ditch plastic pots easily when you catch something like root mealies, and it is affordable to buy new pots. Army of cacti goes BRRR. If you think of the cost of 1000 clay pots it becomes clear why almost every commercial breeder I know uses plastic. Clay pots need to be cleaned, especially after infestations with pests, and it is



very difficult to do this cleaning reliably. Root mealies are very hardy, and their eggs are even hardier.

Weeding your pots

I consider the removal of weeds from pots an absolute necessity. If left unchecked, grass and similar other weeds will eventually cover the lower part of your plants and trap humidity in that area. This humidity increases the risk of root rot and other infections in the lower area of your cactus. Weeds prevent a crucial supply of oxygen for cacti. They also decrease your plants' ability to flower.





Weeds are a major problem for seedlings. They can create a humid microclimate around the roots and cause rot. Weeds also make it easier for pests to take over otherwise healthy plants. Clover is particularly problematic because of its invasiveness. The fruits explode and catapult the seeds through the whole greenhouse. I hate it with a passion and consider its invasiveness a huge deal breaker, even though it has positive effects on the quality of the soil. Clover will very fast outgrow most seedlings and take away all the light. For cacti, this is a major problem. I can only recommend fighting clover very aggressively.

Larger weeds need consequent removal too. Otherwise, you will have constant problems with little micro-jungles around your plants, which causes all of the problems mentioned before. Plants will not flower as readily, rot will appear on a regular basis and your plants will just have a higher risk of skin problems.



Clover is the devil. Best make a habit out of removing it once a month.



4. Pests and annoying insects



Mealy Bugs and Ants - Copyright: Vijay Cavale under CC



Root mealies / mealy bugs



Mealy Bug – Copyright: Gailhampshire under CC



Root mealies or mealy bugs are a species of fluffy lice. They are white in color and mostly attack the roots of your cactus, but can also cause problems on cactus bodies. Plants infected by root mealies often suffer from poor health and secondary infections that are the result of microscopic wounds left by these lice, and the lice's constant sucking. Rot mealies resemble aphids that are covered with a grainy or mealy substance. The appearance of this substance is where root mealies got their name. They commonly leave cotton-like remnants on the base of shoots, areoles or roots. If you see root mealies freely moving around on your plants, one of them freely moving around on your plants, it is very likely that you have a bigger infestation somewhere else.

Root mealies are a very common problem for cactus breeders. Once you have them in your collection, they spread to other plants very fast. Unless taken care of, mealy bugs will keep spreading until you use a treatment strategy. They are quite hard to kill and for this reason I recommend you throw away all pots and containers that are or have been infected by root mealies. If you use clay pots and don't want to throw them away, make sure to use disinfectants and hot water to kill all remaining eggs.

Due to their cotton-like protection layer, it is hard to combat these pests. You may have to resort to serious pesticides to get rid of mealy bugs.

Mealy Bugs: Treatment, prevention and pesticides:

Neem oil and white oil can kill root mealies, but it can take quite a number of treatments. Some of the commercially available pesticides last longer than neem and white oil. Imidacloprid, sold under the brand name Confidor, is one of the most effective pesticides against mealies. Other neonicotinoids and the bacterial byproduct Spinosad are also effective solutions. However, not all pesticides are approved for cactus gardening and the regulations on pesticides vary from country to country. The list of countries that limits the use of certain pesticides gets longer every year, and you should certainly check with your country's regulations before ordering pesticides online. Due to the resilience of wild insect populations, it has become more difficult to obtain pesticides that can reliably kill root mealies, and many plants on the commercial market are already infected. If you buy plants online, you should check all root stocks and plants carefully before they get into your collection.

Make sure to isolate infested plants as soon as possible. Problems with mealy bugs often happen with plants that are kept inside that do not experience a normal winter. Cold temperatures often kill or reduce mealy populations. Very often, a treatment with pesticides may be necessary. In order to be effective, mealy treatment needs to be done repeatedly over the course of months. There are various chemicals or treatments that can reduce the presence of root mealies, but most will not work permanently because they do not kill their eggs. To reduce populations, it can be enough to spray your plants with a water sprayer every now and then. This disturbs root mealies and keeps them from getting too comfortable. Water is really not comparable to a pesticide, but



it's a start. If you want more impact, you can also spray ethanol or methanol. This comes with risks and methanol and ethanol should not be applied in bright sun, but it's very often not a problem for cacti and instantly combats root mealies. Sulfur is another useful chemical that reduces populations of root mealies and organic gardeners use sulfur in large amounts. Sulfur can also reduce the risk of fungal infections, so it's a helpful tool.

Biological treatments for root mealies include ladybugs and predator mites.



On the photo above you can see a very bad mealy bug infestation on seedlings. Mealy bugs can cause terrible damage on cactus seedlings, especially when the seedlings are grown in an organic soil.





The photo above shows a friendly visitor on a *Trichocereus*. Very few insects can pose a threat for plants from this genus, so I recommend not hurting them unless they become a systemic problem.



Scale insects

Scale insects or scale, is a catchall term for a group of insects that are very common in cactus culture. Scale insects are round and look like little brown spots on your plants. Some species of scale have a protective layer that can shield them from pesticides and scale often scars plants permanently. Many plants on the commercial market suffer from scale, and cactus growers may fail to recognize them as an infestation. Because there are so many different species, even capable long-term growers and experienced people have trouble recognizing scale. They can look very similar to scars or blemishes, especially because they cause constant scarring.

Distinguishing different species of scale is rather difficult. In the grand scheme of cactus culture, scale species does not really matter because all scale causes similar damage and hence require extermination. To be effective, scale treatments require numerous applications and a systemic pesticide is usually necessary. Scale causes extreme scars that can kill a plant via secondary infections.

Treatment, Prevention and Pesticides:

Personally, I like to use regular ethanol treatments for scale population control, followed by use of a pesticide. Ethanol treatments are not as effective as a systemic pesticide. but if done repeatedly, often kill the current generation of scale insects. Methanol and ethanol treatments have a slightly lower risk of causing scars and chemical burns than oil-based pesticides like neem oil. Systemic pesticides like imidacloprid or other neonicotinoids are effective. Spinosad can be used to treat scale as well.













On the previous photos there are some extreme examples for scarring after a scale infestation. The skin abnormalities on these photos are not caused by a primary fungal infection, but they can turn into one because of the scarring. Constant micro-injuries often cause secondary fungal infections that appear like they are the actual problem. In reality, they are only a symptom.

In my personal opinion, scale is a terrible threat to collections and should be treated very aggressively. Some of the pesticides are effective are bendiocarb, bifenthrin, oils like paraffin, imidacloprid, malathion, etc. Please keep in mind that all of these have side effects and can be highly toxic or scar inducing.





Example for a mild scale infestation.







Thrips

Thrips are slender insects that can cause substantial damage to cacti. Thrips are tiny, reach a size of up to 2mm and often attack new growth at a cactus tip. Thrips are very difficult to get rid of and strongly scarred plants should be considered a thrips red flag. Due to their small size, scars are a primary indicator of thrips. On online marketplaces, there's always a risk of receiving infected plants. For this reason, it can make sense to treat new plants proactively.

In some stages of the thrip lifecycle, thrips have wings, while in others, they do not. This makes it easy to overlook or mistake thrips for friendly insects that are just passing by. I really recommend that every cactus grower that buys outside plants take a close look at thrips and become familiar with their appearance during different development stages. Thrips are tiny and very easy to overlook. A magnifying glass may be needed to spot them. Of all the pests that attack cacti, thrips cause the worst scarring. It takes a very long time for plants infected by thrips to outgrow their damage.





Thrips thrive in collections grown in warmer temperatures, such as amongst indoor plants. Controlling humidity, rain and sunlight can reduce thrip problems tremendously. Some pesticides are not effective against thrips, and the ones that are effective are often unavailable or unapproved for hobby gardening. Imidacloprid is very effective against thrips. Spinosad is quite effective as well. Ethanol treatment can work for thrips, but must be repeated multiple times. Oil treatment with neem or white oil will kill thrips, but poses the significant risk of chemical burns.







This image shows a plant with the classic thrips damage at the tip. After application of a pesticide, new growth looks somewhat normal again, but constant treatment will be necessary to get this plant back to health, and the scars will not disappear. You can also see spots where the thrips sucked out the chlorophyll, leaving an appearance similar to virus infections or sunburn.





The plant above has suffered from a thrips infestation. The plant received few treatments with a systemic pesticide, and now there is fresher, greener growth coming through at the tip. You can still see how much damage the thrips have caused on this plant, including a secondary infection, evidenced by the dark spots below the areoles in the center. If you use an oily pesticide, the risk of such secondary infections gets even higher. In some cases, secondary infections progress and turn into serious rot. In others, secondary infections heal up again.





Classic V-shaped damage caused by thrips. The infection is over, but it will take years until this damage is no longer visible.





This *Lophophora* specimen shows classic signs of Thrips damage as well. They often cause classic V-patterns, which is normally followed by healthier fresh growth. The skin starts blistering and secondary infections are very common.



Spider mites and red spiders



Spidermites – Copyright: Lucis via CC

Spider mites and red spiders on your cacti are typically from the *Acari* family *Tetranychidae*. These are usually less than 1mm in size and can cause extreme problems, especially when plants are being grown inside. There are various *Tetranychidae* species and some of them are able to spin very fine webs similar to spider webs. Due to the small size of spider mites, these fine webs can sometimes be the only thing alerting growers to the presence of this pest.



Indoor plants can suffer pretty badly from spider mites, simply because the plants are not exposed to the element. Rain, humidity, strong winds and cold weather can greatly reduce spider mite populations. Spider mites on over-fertilized plants are most vulnerable to spider mite damage and reducing the nutrients can already be effective.

In nature, the cold temperatures of winter reduce mite populations before they can turn into a serious problem. When growing plants in a heated greenhouse, this natural process of spider mite elimination does not take place. Due to the constantly warm climate and dry air of a heated greenhouse, pest populations can get out of control very fast. This is especially so with spider mites. If spider mites find themselves in ideal conditions, they can produce many generations of offspring in a very short time and cause substantial damage to the infested plants. Typical spider mite damage changes the cacti's green skin color to a grayish brown. Spider mites suck chlorophyll out of cactus skin, which causes lots of tiny wounds and secondary infections. Spider mite damage often goes hand in hand with orange rot or other fungal infections, and these conditions frequently confused with one another.

Treatment, Prevention and Pesticides:

When plants get too many nutrients, they are more likely to develop spider mite infestations than hard grown plants. Winter and bad weather often reduce spider mite populations, and some steady rainfall is sometimes enough to wash them away. For plants that are only watered from the bottom, spider mite populations can grow very fast. By misting and spraying your plants on a regular basis, you are taking the first step to ensure spider mites don't turn into a problem.

Another thing you can do to prevent spider mite infections is to keep your plants perfectly healthy. While over fertilization is something that should be avoided, under fertilization is just as dangerous. Weak and malnourished plants are vulnerable to fungal infections and all kinds of pests, including spider mites. Providing a balanced fertilizer containing all the necessary micronutrients is a good way to keep infection rates low. A cold winter period helps to keep spider mites in check. I overwinter my plants in a greenhouse with an interior temperature of 0° Celsius between December and March. Because of the cold temperature during this time, spider mite populations have a hard time growing. In addition, I use garlic extract to deter spider mites. It might be unnecessary, or overkill, but the garlic extract also keeps the plants healthy and in combination with regular misting the extract reduces spider mite problems to very small number.

Cacti can tolerate both cold or hot temperatures, but some pests that cannot. Cacti are very hardy and sometimes it can be beneficial not to spoil them. There is a saying that translates to "hard times make strong men" and this is also true for cacti. Don't get me wrong, neglecting your plants usually kills your cacti, sissifying them is not the answer. A mixture of great care, sufficient nutrients and tough love is what makes the magic happen. Remind your plants that life



isn't easy and they need to flower on a regular basis if they do not want to die. It also keeps pests like mites to an absolute minimum.

If all else fails, there are special miticides to kill spider mites. For example, there's Fenpyroximate, Abamectin, insecticidal soap, Bifenazate, horticultural oil, etc. All of these have side effects and you have to make sure to look into the safety instructions to avoid health problems when applying them. I am not a fan of pesticides and I do not endorse ANY of them. I just want to list them for informative reasons.



The photo above shows a spidermite infestation, in combination with a secondary fungal infection.



Centipedes

Though centipedes are rarely a problem for cactus growers, we sometimes cross paths. Centipedes tend to ignore larger cacti, but they won't say no to a bunch of small seedlings or older cacti already wounded by other insects. It is important to remember that centipedes are not always a problem. Centipede management is only necessary if you see continuous damage or have a full-blown infestation in your garden/collection.





Ants

Ants are very annoying and best kept away from your collection. I personally do not advise anyone to kill ants, but if you find a nest in your collection, it is best to move it elsewhere if it's legal to do so in your country. Some ant species are protected, and damaging the nest of a protected species could land you in trouble. If not removed you might end up with an antautobahn inside your greenhouse. Ants steal seeds and can even carry pathogens and pests from one plant to another. I want to stress that I do not believe in killing ants because there are much bigger fish to fry (I'm looking at you, mealy bugs!), but you should definitely remove an ant nest if you find one your greenhouse. And again, legal limitations might apply.



Copyright: Richard Bartz, Munich Makro Freak Under CC



Fungus gnats

Fungus gnats are a common problem in cactus culture and the biggest related concern is dead seedlings. Poor water management and/or choice of soil is one of the most common causes of fungus gnat infestations. Fungus gnats have a very hard time with most mineral soil mixes, which is why they mostly occur in organic soil mixes using peat. They can also live very well in pure coir, which is another reason why coir is not an ideal medium in winter. During summer, mediums dry out much faster, making fungus gnats less of a concern during this time.

Fungus gnat larvae are tiny transparent worms that crawl around on top of the soil. Adult fungus gnats are little black flies that can be confused with fruit flies. Many cactus breeders use glue traps to reduce fungus gnat populations. Personally, I find these traps exceptionally cruel and believe that breeders should improve their water management and soil choice instead.



James Lindsey at Ecology of Commanster



Nematodes

Nematodes or roundworms are very small worms often found in soil. Nematodes are not always a bad thing. Some species can be beneficial for plants and attack pests, but there are also parasitic species that are total nightmares for cactus breeders. Personally, I am very careful about nematode infestations because I know how hard it is to get rid of them. To deal with nematodes, plants must often be cut from their entire root system. The roots, including the soil, should then be thrown away. Nematodes can cause substantial plant losses and every cactus breeder should teach themselves how to recognize nematode infestations.

The most reliable way to spot infestations is to inspect roots for little round tumors on the roots. These tumors form nodules that are clearly visible and filled with nematodes. It is vital to check the roots of any new plant to protect your collection from nematode infestation. Personally, the presence of little tumors on the root system is already enough for me to pack the whole plant including the pot into a bag and shoot it into space.

I would love to share some photos here, but nematodes are so rare that I have only seen very few infestations my whole life. People in our cactus groups posted some of those infestations. All infected plants all had swollen nodes at the roots in common. Nematodes themselves are so small that it is difficult to photograph them. In my opinion, there are probably many more nematode infestations than what's publically known and I will update this chapter in the next editions of this eBook. Anyone with photos is invited to send them over for the later editions.



Worms

Worms can be beneficial and rarely cause problems for cactus growers. They improve the quality of soil and are a strong ally for every gardener. With that being said, worms should definitely not live inside your plant's pot. Worms can and will weaken the general health of a plant if they are given the chance to dig endless circles within the plant's roots on a regular basis. Because of this, I recommend using a soil that is mostly mineral and thus less inviting to worms. You can often spot the occurrence of worms via secretions on top of the soil. If you find worms in your cactus medium, it would probably a good idea to repot.



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Caterpillars / grubs

Caterpillars can cause substantial damage to both plants and their roots. Grubs are famous for chewing on root systems, which often leads to total loss of the affected plants. If you planted your cacti in a garden, digging up and removing grubs might not be a bad idea. You can also use a pesticide, but I personally stay away from these because pesticides may prevent beneficial insects. Caterpillars often take out bigger bites of cacti and poop all over them. If you see little bits of poop remnants and it looks like something has munched on your plant, a caterpillar is a likely culprit.

However, caterpillars usually have a very limited window of time where they can cause damage and I personally don't consider them a huge threat. They can and will definitely cause a little bit of damage, but it's usually not so bad that it kills a plant. If you find caterpillars, collect them and throw them in a grassy area far from your plants. Some caterpillars turn into very beautiful insects later on and I always prefer to spare life unless it's an invasive species.





Moths

Moths are often not a real problem for cactus breeders, but they can do some damage. There are countries where very aggressive cactus moths exist and if this is your situation, it will require a strategic response. Here in Germany, I barely have any problems with moths, but I do see them sometimes in the greenhouse and there have been a handful of cases where moths have eaten a hole into one of my plants and laid some eggs inside.



On top of this plant is a moth cocoon. The cocoon is not a direct problem, and moths are important pollinators for the genus *Trichocereus*, but I would still recommend removing this cocoon.





Cactoblastis_cactorum_moth_female Peggy Greb, USDA ARS



Earwigs

I personally do not consider earwigs a real problem in cactus culture. Earwigs have many benefits, so I like keeping them around. They attack and eat pests like thrips and mites, which are much more dangerous to cacti. Earwigs might take bites from a cactus here and there, but they pose a minimal risk relative to other pests.

Healthy plants are part of the ecosystem, which is why there are insects present on a regular basis. Insect presence is not a problem unless you have a systemic insect infestation. In case of mealy bugs or thrips, one insect is already too much though.



Dermaptera (Earwig) / Copyright: Vengolis under CC



Snails and slugs

Snail and slug damage is very common in cactus culture and I personally consider it a major problem. Snails and slugs can and will munch away seedlings and damage adult plants to the point where the vascular bundle is so damaged that the plants can no longer pup. Despite this, I don't kill slugs and snails because I consider them to be an important part of the ecosystem. I am growing cacti in the middle of a forest, surrounded by trees, other plants and wildlife. I don't think it's fair to punish these amazing animals for just following their nature and doing what they normally do.

A slug will not understand why you're killing it and I prefer to value all life where possible. Don't get me wrong, when I have an infestation of mealy bugs on my plants I go nuclear on them, but I still go out of my way to leave all life unharmed. In my opinion the key is to keep snails and slugs from getting to your plants. Strategies to keep them away include keeping the doors closed during times when slugs and snails are most active, removing them from your growing area or providing them with alternative foods that they like better. Garlic extracts can also be used as an effective snail and slug deterrent.



Snail - Copyright: Macrophile via CC





Slug – Copyright: Fufusiainfjeijc Via CC











5. Infections and other health problems

Fungal and bacterial infections are very common problems in cactus culture. Infections happen during all stages of cactus development, and the list of things that can infect your plants is long. Seedlings are much more vulnerable than adult plants.

Preventing infections is much easier than fighting infections once they have started. Always ensure to provide sufficient airflow and fresh air to your plants, and to have a well-draining soil and quality fertilizer. Applying the right amount of fertilizer and micronutrients can also help prevent infection, but how you apply these depends on the product, so it's best to follow the recommendations on the label. There are various fungicides that work against fungal infections, but once you are able to see the infection, damage is already considerably advanced.

Orange rot

Orange rot is a term for a group of pathogens that can pose danger to some cacti, such as plants from the genus *Lophophora*. Columnar cacti are much less vulnerable to orange rot. It is very rare that orange rot is able to infect healthy *Trichocereus*, and in most such cases infection stems from a poor immune system resulting from poor care. The best way to prevent orange rot is to have healthy plants that get enough nutrients and fertilizer, and to provide plenty of oxygen, particularly when there is high humidity, such as in a greenhouse. I've heard about minor problems with orange rot on fresh cuts and grafts that were made too late in the season. When humidity is high, I recommend avoiding cutting your plants. I only graft until the end of summer, and I cannot recommend cutting any later than this.

Treatment of orange rot is difficult and may require a good quality fungicide. Fresh air should be the first step. If dealing with a minor infection, fresh air alone can resolve the problem. Sulfur is also often applied to fungal infections and there are fungicides consisting of copper that can be used to combat infections. Copper should never be used when you are sowing out because it greatly reduces the seed viability. It is possible that sulfur affects the viability of seeds as well, but I have never tested this.

Orange rot is often caused by rusts. Rusts are diseases caused by pathogenic fungi of the order *Pucciniales*. There are more than 150 genera that can be a problem, which is why it rarely happens that you can identify the actual species infecting your plants.












Orange rot infection in combination with spider mite damage.





This variegated *Trichocereus validus* has suffered through winter. The discolorations appear fungal.





On this photo you see a superficial infection on a cutting that was not properly calloused. Due to the fact that the wound did not get enough time to heal, the superficial infection got worse and turned into a systemic infection afterwards.

After removing the top it became obvious that this plant was beyond saving. The infection had already spread straight through the bundle. vascular Without a healthy piece of vascular bundle it becomes very difficult to save the plant.



Benign black rot

Benign black rot is a group of diseases caused by fungi or bacteria. They produce black or dark brown discolorations and leave plants with bad scars. Once again, there are all kinds of pathogens that can cause benign black rot and exact identification is often not possible without access to a laboratory.

Treatment of benign black rot is often unnecessary. It almost always heals up by itself, if you provide enough fresh air. Infections relating to benign black rot usually stem from high humidity. Some *Trichocereus* species are particularly vulnerable to benign black rot, such as *Trichocereus bridgesii*. This rot also seems to happen very often with the PC clone. While benign black rot is not a life-threatening infection and plants almost always survive and heal after their experience of this condition, the resulting scars are often unsightly and permanent.

Witch's broom disease

Witches' broom disease, also known as witch's broom, is a deformity in a plant where the structure of growth is changed or mutated.

There are various reasons for witches' broom. In most cases, it is the result of an infection with pathogens such as phytoplasms, but there are also other causes including spider mite infection, insect damage, fungal, viral and bacterial infection, plant hormones like cytokinin, coconut water and nematodes.

There are constant online arguments about witches' broom and whether or not it is pathological or desirable. Due to the large number of potential causes, the arguments cannot be settled. Infection



with witch's broom disease is rarely beneficial and I have seen large and ancient cactus gardens killed by these infections.

Witches' broom in cacti usually causes plants to pup repeatedly, but without growing normal shoots. Infected plant's ability to grow is often completely out of control, resulting in plants covered with many small pups. Infected plants usually stop growing right away, pupping incessantly instead. In many cases, these pups are hairy and have an abnormal felt covering them.













Unlike plants infected by witch's broom, this plant displays a genuine genetic mutation without pathological habit.





The photo above shows a plant that I suspected to be infected by witch's broom disease at first, but which turned out to be perfectly healthy. A good way to distinguish witch's broom disease from normal growth is by looking at the general health of the pups. Pups on infected plants rarely grow healthily like the pups on this photo.



Mildew

Mildew is a fungus that can infect many plants, including cacti. Mildew infected plants are often covered with a sticky, powdery substance that's usually white in color. There are also molds related to Mildew which can have a yellow, beige or dark color. Mildew requires a certain degree of humidity (over 60-93%) to be present in order to actively grow and infect other plants. Fresh air is one of the best ways to prevent mildew and I rarely find Mildew on my cacti because I open the windows and doors of my greenhouse on a regular basis. Mildew infection is often caused by a water condensation on your plant, combined with lack of fresh air and presence of pathogens. Preventing condensation can be as easy as opening greenhouse windows once a day. Automatic window openers can make this job very easy.

Plants that are infected with mildew should be cleaned very well. Apply a mild, natural soap solution, using a brush to remove the sticky substance left by this fungus. The application of a fungicide like sulfur or a systemic fungicide may be necessary to heal very bad infect

Tobacco mosaic and similar viruses

Tobacco mosaic virus is often discussed in cactus culture. This is mostly due to a combination of paranoia and difficulty distinguishing viral discoloration from normal sunburn. The only way to actually show that a discoloration is caused by a virus is by test a specimen into the lab. This costs money and most hobbyist growers don't have access to the equipment necessary to run these tests.

The underlying principle, the destruction of chlorophyll, looks almost identical in both sunburned plants and plants infected by tobacco mosaic virus. Even professionals have a hard time telling the difference between these two conditions. Skin discolorations is a very normal thing in cactus culture and many things can cause this. While viral infections are widespread throughout the cactus family, viral infections are often not the reason for discolorations in this particular genus. While tobacco mosaic virus can be common in certain genera, it only rarely jumps to *Trichocereus* or *Echinopsis*. It is certainly possible to infect a *Trichocereus* or *Echinopsis* with tobacco mosaic virus, the most common method being via mechanical inoculation, also known as cactus grafting. You can infect a plant by grafting it onto another, already infected plant. There are also many horror stories about ants spreading tobacco mosaic virus (and many other viruses) are spread through grafting.





The plant above is suspected to suffer from tobacco mosaic virus or a comparable virus that increases vulnerability to sunburn. The yellow spots showed up as a result of sunburn during the first sunny days in spring, but the pattern is so typical that it is likely that there's an underlying viral infection decreasing the plant's ability to withstand sunlight. Very few sunburns have a virus as the underlying cause.











Other fungal infections

Fungal infections are big enemies of the cactus breeder. Fungi are opportunists and use every little mistake we make as an opportunity to attack our beloved plants. Seedlings are the most vulnerable to fungal infections, but they can also kill adult plants that are perfectly healthy. Fungal infections are more often a problem with neglected plants that don't receive proper care and/or nutrients.



A superficial fungal infection without pathological effects. This is very common with plants in nature, and it never seems to bother them. I've seen this particularly often on *T.bridgesii*.





The photo above shows a superficial fungal infection. The growth below is completely healthy and the superficial infection eventually stopped after a few hot months. Not all fungal infections require mechanical removal. The photo below shows a systemic infection that killed the plant.







This infection spread from the scion to the grafting stock within just a few days. The stock was saved, but there is still a risk of infection reoccurrence.



Potential causes of fungal infections:

- Lack of fresh air. Every cactus breeder should make sure to provide fresh air for their plants daily. Fresh air is one of the best and easiest ways to prevent fungal infections.
- High air humidity, especially in combination with high temperatures. Late autumn and early spring are the most dangerous times for high humidity.
- Dryness without rain or mist. Constant rain might dramatically increase the risk of fungal infections, but the opposite can be just as bad. Plants need water and rain to stay clean and develop a healthy skin.
- Lack of nutrients and water. Plants that don't get enough nutrients and fertilizer are more prone to fall victim to fungal infections.
- Too much fertilizer, especially when the fertilizer contains too much nitrogen.
- Fresh, unhealed injuries. Plants that are cut in winter have a much higher risk of suffering from fungal infection, especially when kept in a high humidity environment.
- Wrong temperature range. Temperatures that are too high or too low can be equally problematic. High temperatures during winter are as much of a risk as low temperatures. In my greenhouse, I keep plants between 0°-10°-C during winter.
- Dead fruits, weeds and organic matter left in the pots. This material retains unwanted moisture.







These plants suffered from a fungal infection caused mild scale before winter. I removed the infected parts, but they were so weakened that the infection came back as temperatures increased. Most of these seedlings are beyond saving and should be thrown in the trash. You should not put infected plants in your compost lest you risk your compost infecting other plants.





















The scion on top of the stock pictured above developed a fungal infection following sunburn. The top was removed and left in full sun until the infection stopped spreading. However, you can still see visible signs of infection, such as wrinkled and discolored skin. This is not necessarily a sign the fungal infection is returning. It can be, but it was not in the case above.





This plant suffered a major fungal infection because of a scale infestation. There is often an underlying cause that kickstarts infections. If you have plants that show major damage it can be easier to discard them, or harvest new pups than to deal with the infection. Having sick plants can pose a serious threat for healthy plants nearby and I always recommend quarantining sick plants.





This plant has two problems. Sudden onset of strong sunlight caused many micro-sunburns has opened the door to a mild fungal infection. You can spot the orange discolorations on top of the burns. The fungal infection is a secondary infection caused by the decay of burnt skin. It is very likely that this plant will outgrow the damage and fungal infection, but there's always a risk it won't. Sometimes an infection can lay dormant for many years, returning with a vengeance as soon as the plant is weakened. This happens often during winter, with less light, lower temperatures and higher air humidity during this time.









One of the worst fungal infections I have ever seen. The underlying cause was scale infestation.









This large column had to be cut because it developed an infection. The infection came back after cutting because the bottom was not hardened up properly. After cutting, it is important to wait a month or two before you start the rooting process to avoid encountering trouble with a similar infection. Fresh cuts can be hardened or calloused in full sun or under a grow lamp.



Partial removal of infected ribs

Plants from the genus *Trichocereus* do not necessarily need all their ribs to grow healthily and if one of my plants suffers from a sudden infection that requires removal, I often remove the infected parts and keep the rest of the plant intact. This may not look nice, but it has practical benefits. Sunburns and secondary infections are extremely common at the beginning of the growing season, and when they occur it usually means the end of the flowering season for the affected plants. Leaving the infection in place until after the flowering season is very risky and usually not an option. So you are faced with the decision to either cut the whole plant down, or simply to remove the small infected area.



This plant developed an infection after sunburn. This infection went undetected and removal of a few centimeters of the ribs helped me ensure the plant would continue to flower this season.





I had to remove half of this grafted pup because it developed a bad infection following sunburn. Removal of the infected flesh saved the scion, which will eventually outgrow the damage, as the center and core remain intact.



6. Fertilizer, nutrients and additional products





Getting a quality fertilizer is crucial. There are all kinds of different fertilizers and the choice of which one to use really depends on personal preference. There are many different types of fertilizers, nitrogen fertilizer, phosphate fertilizer, potassium fertilizer, organic fertilizer, the list goes on. The main macronutrients of fertilizers are nitrogen, phosphorous and potassium. There are also some secondary macronutrients including calcium, magnesium and sulfur. In addition, there are also micronutrients, such as copper, iron, zinc, boron, molybdenum, silicon, cobalt.

Nitrogen produces plant growth, while phosphorous enhances flowering, root formation, fruit and seed formation. Potassium is responsible for inducing flowering and fruiting in plants as well as healthy, thick and vigorous plant growth.

NPK fertilizers

NPK fertilizers contain nitrogen, phosphorous and potassium and are the most important fertilizers for cactus growers. The NPK system consists of three numbers divided by a dash which quantifies the part of each of these elements in a particular fertilizer. Some fertilizers put the focus on the Nitrogen, while others are higher in phosphorous or potassium. For example, a 10 kg bag of fertilizer labeled 10-10-6 would contain 1 kg nitrogen, 1 kg phosphorous and 6 kg potassium.







This plant is getting a good amount of fertilizer with every watering, giving the epidermis a beautiful, dark blue color. This is a normal color for certain *Trichocereus* species and a great fertilizer will help bringing this color out. I personally avoid fertilizers that are high in nitrogen and instead focus on providing a high amount of phosphorous and potassium.



Micronutrients

The most important micronutrients are molybdenum, zinc and copper. In a fertilizer, these micronutrients are usually present as salts. Iron is another micronutrient that is important, but it's administration is problematic because iron is usually unavailable in soil. In response, EDTA can be used as a chelating agent to make iron more available.



A healthy and well fed Trichocereus validus. Note the bright green color of the new growth.

Phosphate fertilizers

Phosphate fertilizers are usually obtained through natural extraction and mining of minerals. As there are also impurities contained in natural rocks, phosphate fertilizers are sometimes polluted with radioactive elements like polonium. Phosphate fertilizers are great for flowering and most professional breeders I know use these on top of a normal NPK fertilizer to improve a



plant's ability to flower. However, potential radioactivity bothers me and I feel it should be a legal requirement to test and regulate fertilizer radioactivity.

Coconut water

Coconut water is an organic liquid that is heavily used in tissue and orchid culture. More recently, cactus breeders have started using coconut water too. There are many coconut water brands, and the manufacturer is not very important, as long as you get yourself pure coconut water and not a diluted beverage containing only some coconut water, or something like coconut milk. These undesirable products have additives that can cause problems if used on plants. Coconut water is simply the liquid that's inside coconuts, and it contains all kinds of carbohydrates and beneficial plant hormones.

Because coconut water contains lots of sugar, it is recommended to dilute it down before usage on your plants. Personally, I only use 50 ml of coconut water per liter of water, and I only apply this mixture in combination with a pH buffer. Coconut water is known to reduce soil pH to a value that's no longer healthy for cacti, and this can cause substantial problems. I've seen coconut water reduce medium pH to 4, which is quite unhealthy for cactus.

Another potential problem pertaining to coconut water usage are pests like root mealies or thrips. This is because coconut water is so nutritional and rich in carbohydrates, providing pests with a lot of food and nutrients and allowing pests to reproduce very quickly.






This plant grew 20 cm within just a couple of months, which is the result of a well thought out nutrient strategy. Note the healthy color of new growth at the tip.



Effects of coconut water:

- Induces pupping, and can be used to mass propagate. It is common for plants to pup abundantly when treated with coconut water, with fewer side effects than synthetic hormones such as BAP.
- Strengthens the overall growth via nutrient provision.
- Prevents fungal or bacterial infections by strengthening plant immune systems.
- Lowers pH, which can be undesirable in cactus culture.
- Can cause abnormal growth that looks similar to witch's broom. This growth is not permanent and plants should continue to grow normally once treatment with coconut water has ended mutations grow out.
- Acts as a booster for pests and insects, dilute accordingly.
- A natural fertilizer that can be used in organic farming. It is unknown how the treated plants change in regard to food safety. While it is highly unlikely that something negative happens inside treated plants, but more research on this topic is required.
- Can be used to get seedlings to a safe size quickly.



This photo shows unnatural pupping behavior after an infection with witch's broom disease. Coconut water can cause almost identical pupping behavior to witch's broom disease.



Overfertilization





Plants love fertilizer...until they suddenly don't. There are many signs of over fertilization, and the most important signs are swollen and bloated growth. The photo above is a perfect example of this swelling. It's normally not a problem and will grow itself out, but I consider it a warning that a plant has had enough. The more fertilizer you use, the more vulnerable plants are to fungal infections. This vulnerability is one of the biggest dangers with overfertilized plants. It is disappointing to spend three months pumping your seedlings with fertilizer only to have the whole tray quickly melt in a sea of mold.

Another problem is that plants that get too much nitrogen can suddenly lose their stability and structure, making it easy for the plant to fall over or break. Giving your plants a lot of fertilizer at once is basically the opposite of hardening up your seedlings, so you should probably stop fertilizing your columnar cacti if are shaking around the greenhouse like a pool noodle.

7. Light, sun and forces of nature

Without light, all attempts to grow cacti are doomed to failure. Inappropriate light is one of the most common failures in cactus culture. If you use a greenhouse with a large rack, make sure that the rack lets enough light through to the plants on the lower levels. When my father helped build my first greenhouse, he organized a huge shelf with lots of shelves that I could use to store my cacti on. It was great in theory, but the structure of the shelf ate up all the light and the plants couldn't thrive. It took me years to understand that light deficiency was preventing my cacti from reaching their potential.

Long story short, light is fucking important and without it your cacti will be weak and sick. It's your job to find out how much light your cacti will need. Most plants from the genus *Trichocereus* like to get full sun all summer long, provided they are incrementally acclimatized to sun exposure. Shade cloth can be useful for this acclimatization. –If they aren't ready for it, your plants can get sunburnt easily. Small seedlings are at the greatest risk of being killed by sun light, but older plants that weren't hardened up properly may suffer too. Strong sunlight also reduces the viability and the germination rate of seeds. Germinating in direct sunlight should be avoided.





With the right nutrient strategy, plants can't help but flower at some point.











Natural sunlight

Compared to all grow lamps, the sun is ridiculously powerful. No plant lamp can replace the sun. Sunlight will always be the best for cacti. Ideally, you want to leave your plants in a spot that provides enough light to let them grow healthily, without causing any sunburns. As mentioned previously, sunburn is mostly an issue for younger plants or plants in a new environment. When you buy a plant on eBay that has spent its life in total darkness and you put it in full sun, it will most likely get sunburn. Buying new plants is always a risk. They can bring pathogens and pests and you are never sure how they were treated before. Because of this uncertainty, it's best to slowly and incrementally harden up new plants. Once plants are used to it, you can move them to a spot where they get at least 12-16 hours of light a day. The more sun your cacti get, the more likely they are to flower and set fruit. Plants that are grown in full sun are usually healthy and flower prolifically. On the other hand, plants that are grown in the shade can be of poor health and struggle to flower.

For a cactus, flowering and fruit production are tools of ensuring survival of the species. If plants don't flower they are at risk of becoming extinct, which is why it's more likely that they will flower when they are stressed. When dealing with plants, stress is not always a bad thing. Plants that are hit by regular winds produce stronger shoots, and plants that have a cold winter will flower a lot more than plants without one. Cacti will flower more abundantly when they get maximum sunlight during the summer. The amount of light that a plant receives in nature is very variable. An adult plant can take more light than a young one, and a seedling is more likely to die from sun exposure than an adult.







Avoid creating shadowy areas with minimal sunlight! If you're putting a lot of plants close to each other, you can accidentally create little pockets that trap humidity and block sunlight. In this photo you see a good example of what I mean. There's a combination of larger and smaller plants, which isn't optimal for light distribution or airflow.

This kind of stuff happens often because growing space is a luxury that many growers do not have. Wherever possible, leave space between your plants to provide sufficient ventilation and sunlight for ALL plants, not just the tallest ones. It can be a good idea to arrange plants by their size, placing plants of a similar size beside each other and put plants beside each other that are similarly tall.





Artificial lights and growlamps

There are all kinds of growlamps that you can use to grow cacti and none of them will ever be as good as the sun. That doesn't mean you shouldn't use them, many grow lamps can be used effectively. These lamps are sold in a very competitive market and there are improvements being made every year. In general, I'd recommend buying new and recently released lamps, and this is especially true if you are buying an LED lamp. Other popular choices are HPS (high pressure sodium) lamps and metal halogen lamps. In terms of efficiency, there probably isn't anything better than a HPS lamp. That said, LEDs are picking up speed dramatically and the quality on the market is excellent. I personally like LEDs because they don't use lots of electricity. When I was younger, I was very poor and paying for the electricity bills was a constant struggle. Because of this, I've learned to avoid machines or tools that use up too much electricity and appreciate a cheap, good quality grow lamp. Newer LED grow lights are affordable and good quality. Cheap HP-LED lamps cost between 20 and 100 Euro, while high-end lamps cost between 300 and 1000 Euro.



Red LED lamps can temporarily cause reddish discolorations.





What to consider when buying a lamp?

PAR means photosynthetically active radiation and is one of the most helpful numbers you can use to compare grow lamps. PAR can be used to measure how much light a lamp emits. The region of the electromagnetic spectrum that a grow lamp should emit is 400-700 nm. The science behind grow lamps is very complicated, and producers use that to their advantage to overhype poor lamps.

Don't use total lamp wattage for comparisons!

The most important principle to remember is that wattage should NEVER be used to compare grow lamps. It is notoriously unreliable and does not tell you anything about the quality of the lamp you are using, but it will tell you how much it costs to run it. With poor quality LEDs or chips, a 300 watt lamp can be terrible for growing cacti. That's why wattage is only important if you want to know if you can afford to run the lamp.



Don't use lamp lumens for comparisons

Lumens measure of how bright a light looks to the human eye, but it really doesn't say anything about plants or how well a light works for photosynthesis. I would be very wary of lights marketed based on their lumens alone.

Do not use Wattage of the LEDS for comparisons either

As mentioned previously, wattage is a very unreliable metric for light quality. Just because an LED lamp uses a lot of watts doesn't mean that it's efficient or that it produces a great light for growing plants. The number of LEDs, their color and total wattage should always be taken into consideration when buying an LED lamp, but it is difficult to use this information to compare lamps.

Be wary of marketing claims

The LED market is very competitive, and lots of sellers are unethical. Many sellers measure the quality of light directly at the lamp instead of near the plants, as the quality of light drops substantially the further away you get from a lamp. To compare how strong of a lamp your new LED lamp is actually able to replace, you need to know how much light actually reaches the plants. An ethical seller will provide this kind of information and if a seller doesn't it says a lot. The seller is either incompetent or intentionally hiding it.

What really matters?

When purchasing a grow lamp I recommend choosing a reputable brand and avoiding UFO lamps at all costs.

The most important things to know about a grow lamp are 1) how much light reaches your plant and 2) the light distribution. It's also useful to know how much it costs to power a lamp, the color and chips that LEDs use, lamp shape, cooling system, life span, PPF, input watts and PPFD maps for your intended grow area.



Sowing out with cheap LED panels

I like to sow out seeds below relatively weak LED grow panels. These panels are completely unusable for larger plants, but they work great for tiny seedlings. As you are able to bring seedlings very close to the panels, this can be very efficient. Small seedlings do not need lots of light and because the panels do not produce a lot of heat, you can place them very close to the light and produce excellent plant growth.

Cheap LED panels are also great to induce germination. Cacti need a weak light source to germinate. These panels are just strong enough to wake seeds up, but not so strong that they burn the seeds.





Hail damage and resulting infections

Unfortunately, hail damage is a common problem for cactus growers that leave their plants outside. Hail can cause substantial damage to greenhouses, windows and plants. Hail causes damage by blunt force trauma and can lead to terrible follow-up infections afterwards. This is especially true when wounds do not have time to dry and stay wet for prolonged periods. The best way to deal with this is by removing all smashed plant matter in a clean cut, and then bring the plant somewhere to dry. For plants that are firmly planted in the ground you will need to become a little inventive and build something that keep the wound from getting wet. Putting a plastic bag over the wounds is no viable option because high air humidity will eventually lead to secondary fungal infections.



Hail damage on Trichocereus peruvianus - Copyright: Tony Davey



















Water management





Water management is one of the most important things when growing cacti. There are people who soak their plants in water, and there are people who forget to water their cacti until they turn into a dehydrated crisp. Both of these examples are less than ideal, and the secret is to water somewhere in between. Too much water will kill your plants, but so will too little water. My plants are kept dry throughout the winter, but get a lot of water and fertilizer between spring and summer.

Cacti should only be watered when it's warm. I'm from Europe where we can get some very cold winters with temperatures down to -20°C, and I can assure you it's a bad idea to water your plants when it's really cold outside. Dangerous temperatures vary greatly between plants, species, genera and geographies. Some *Trichocereus* species can survive temperatures of -4 °C when they are dry, while others can survive at -9°C or even lower. Some cactus genera like *Opuntia* have extremely frost hardy plants that can take temperatures of -20°C and below. It's important that your plants are dry when it's cold and don't have"wet feet". The term "wet feet" refers to a problem that is extremely common among cactus growers, when cacti are overwatered in the cold. There's a reason we don't go outside at freezing temperatures with wet clothes on. We don't want to freeze, and neither do cactus roots.

The genus *Trichocereus* grows all over South America, and there are many different species that all have different requirements. Plants in the Peruvian and Ecuadorian San Pedro group are known to tolerate high humidity and lots of water during the summer months, while the Bolivian species like *Trichocereus bridgesii* are more vulnerable to humidity. These species regularly develop infections with benign black rot, and I would recommend giving them a slightly different treatment than Peruvian species.

How often should you water?

This question is hard to answer. How often should a person eat? It depends on what you're doing, your metabolism and what you're eating. More organic soil will be able to retain water and humidity longer. Avoid watering already wet rootstock and adapt your watering management to your soil. Mineral soil dries fast and plants in mineral might need constant watering. I personally like a cactus soil that mostly consists of minerals, but which also contains organic material able to hold some water. In my case, I use coir as the main organic additive in my soil. During the hot summer season, I need to water my plants AT LEAST once a week, sometimes even more often. If my soil contained a higher percentage of organics, I might only have to water every other week. Personally I feel, the more often I can water and fertilize the better. When I water my plants, I also often add natural extracts like garlic, valerian flower, horsetail, a pH buffer and a



commercial fertilizer for sensitive plants. The faster the soil dries, the faster I can water again with another additive.

I am not suggesting you flood your plants with nitrogen or anything like that, rather I advocate for healthy additives on a regular basis, much like any healthy diet. A balanced fertilization strategy is just as important as remembering to water your plants.

How many waterings per week?

Watering frequency depends on your soil. I water my soil once a week, sometimes twice a week. However, I only water between March and October, and my plants are completely dry for the rest of the year. During the hot summer months, plants from the genus *Trichocereus* like to get a lot of water and rarely suffer from overwatering during that time. If temperatures are cold or if you have a sudden and unexpected frost period, you should not water at all. If your soil takes weeks until it gets dry, you should probably use a different soil. Most cactus soils on the market are not ideal, and contain too much organic materials. I have never understood the reason for this, but

you can often get some great cactus soil from smaller specialty nurseries or semiprofessional cactus breeders. Generally, the bigger the garden store, the worse the quality of their soil. I have seen commercial plants grown in sawdust, bonsai soil or mulched wood bark... The list of terrible cactus soil mixes is endless. I recommend that people use the soil recipes in this book to mix their own soil. These recipes produce soil that stays wet long enough for the plants to take in some water, but not so long they get wet feet. Remember...if the soil is dry again and the weather is warm, it's probably safe to watering. get

Me after a long day of watering and fertilizing. The photo says it all...fertilizing is unavoidable hard work. During the first months of the growing season, water and nutrients are my main priorities. The process of flowering is





hardcoded into these plants and it's important to use their inner clock to your advantage. In Europe, the time between April and June is extremely important for flowering and your plants should get plenty of water during this time. People from other continents will have to adapt this to the requirements of their own growing season.



European Trichocereus macrogonus clone, aerial roots © Trichocereus.net

This *Trichocereus* has produced some aerial roots. These roots often develop on plants that are thirsty, or which are endemic to drier areas and rely on humidity for water. These European



Trichocereus macrogonus clones are very similar to *Trichocereus bridgesii*, both produce aerial roots at a much higher rate than some of the Peruvian species. These plants often come from dry environments, producing aerial roots, even when at peak health.



Grafts and seedlings should get prioritized when it's about water management. They are the first to be watered at the start of the season and they can die off very easily. Small grafts need a lot of water to keep both the stock and the scion alive and you should not let them getting too dehydrated. In addition, they can suffer from wound infections very easily and it's important to keep them at a great health all the time. Seedlings and grafts can die off at any time and many things can kill them. Large plants on their own roots are a lot less difficult. In addition, you should also remove all pups that emerge on the grafting stocks because they will literally suck the water out of the scion.



The problem with shelves

Some breeders keep telling me I should put many shelves in my greenhouse, but I won't. Every shelf absorbs and blocks light from plants, greatly reducing the plant's ability to flower and increasing the chance of infections. Yes, it can be great to have additional grow space, but I keep greenhouses relatively shelf-free because the flowering of my adult plants is my main priority as a cactus breeder. Take a critical look at your greenhouse or growth area and analyze which objects reduce the availability of light. Perhaps this will lead you to remove trees shading your greenhouses, unnecessary shelves, arranging your plants by height, etc.



On the above image, I have placed my flowering sized mother plants on the left. This ensures maximum sunlight, which is why I intentionally avoided using a shelf on the left.

I also place the large columnar *Trichocereus* species in a spot where they get plenty of sunlight, but do not cast shadows on other plants. The small shelf on the right is only used because there is relatively little sunlight coming from that side of the greenhouse.







8. Why is fresh air so important?

Oxygen is life. This truth applies for much of our earthly experience, and this includes cacti. Though cacti do not breathe as humans do, they still run into big problems if there's no fresh air available. The availability of fresh air combats fungal and bacterial infections and reduces the air humidity in your greenhouse. If there's already high air humidity outside, greenhouse humidity

will often be much higher. This will eventually lead to problems with mold and similar pathogens, which is why it's generally recommended to keep your greenhouse windows and doors open during humidity.

I experience this in my own greenhouses in early spring. This is the time when the risk for fungal infection is highest. The plants are still in a partial dormancy after the end of winter and thus the immune system is notoriously vulnerable to infections. In the spring sun, greenhouse temperatures can get up to 30°C, despite the fact that it's being relatively cold outside. A lack of ventilation can cause disastrous losses stemming from fungal infections.





Flowering



Flowering Trichocereus arboricola © Trichocereus.net

There are various stages of flower development, demonstrated in the photos below. In my greenhouse, *Trichocereus* flowers start forming between March and September. It usually takes a couple of months from the first signs of flower buds to bloom.





It is important to give your plants a normal winter, similar to what they would experience in nature. Plants that are kept inside the house during winter will often not be able to flower. The reason for this is that they have not experienced a normal winter. During my early years of cactus cultivation, I never got many flowers on my plants. I spent lots of money buying huge mother plants, but messed them up by overwintering them in my cellar. As a result, I am not a fan of indoor overwintering.

Indoor overwintering increases the risk of fungal infections. Such plants will not be as healthy as they would have been in a greenhouse, and may not flower well after overwintering. Don't get me wrong, there are definitely a handful of semi-professional breeders who overwinter their plants inside with success, but it is difficult and- requires purchase of quality hotbeds or mini-greenhouses. This can permit you keep the plants inside between November and March and still give them a winter experience by moving them to the hotbeds around January or February. In this way you can avoid the worst frost, but still have a winter period for your plants.

Personally, I keep my plants outside in my greenhouses all year round, their winter temperatures usually reaching around 0° C. I should add a warning this is NOT a perfectly safe temperature and you may lose a plant here and there as a result; but it is very close to natural winter



temperatures in habitat and hardier *Trichocereus* hybrids or species will respond to this experience by producing many flowers in summer. These cold temperatures trigger your plants' survival instincts, and encourage them to flower. If you want to play it safe, you should probably aim for warmer temperatures somewhere in the 5-10°C range, but a little bit of stress can bring you more flowers. Like with everything, there is a limit and eventually your plants will respond

negatively to stress but it is your job to find out exactly where that limit is. The genus *Trichocereus* is big and some species are more cold hardy than others. In my collection, the hard limit is -5° C and I never allow my plants to get colder than this. They might make it, but beneath this temperature starts to get really dangerous.

Don't forget, there's always a risk of pushing your plants too hard and you may end up with a frozen plant here and there. I own something like 10.000 plants and every year there's a few plants and seedlings that don't make it. The only way to be completely safe is to always keep the temperatures in the greenhouse above 5°C, but I'm happy to risk it in exchange for extra flowers.











A large *Trichocereus* in the earliest stage of flower development. Note the white fluff forming above the areoles. © Trichocereus.net





Early stages of development on a Trichocereus flower © Trichocereus.net

In the photo above you can see a *Trichocereus* flower in an early stage of development. The flowers usually start off as little dots of hair or fluff at the top of areoles. Over weeks to months the hair or fluff will grow into buds before blooming as flowers.

In the earliest stages, flower buds are very vulnerable and can die off at any time. Avoid moving a plant during this time or risk aborting flowers. It is risky to ship a flowering plant or cutting once the process of flowering has already begun. The inner clock of cacti is completely confused by the darkness of shipping and packaging. Flowers can delay development for months or drop off completely. Flower buds stuck in earlier phases of development may eventually continue to grow, so do not remove aborted flower buds until the end of flowering season. Unfortunately, in most instances where flowers stop they will not continue to grow again.









The top photo above shows an early stage of flower development. The fluff that's emerging from the areoles will turn into flowers within a few months. In the other photos above you can see the remnants of mature flowers and fruits.

Trichocereus, Lobivia and *Echinopsis* flowers: Differences and commonalities

The two genera *Trichocereus* and *Echinopsis* are very similar, and were combined into one large catch-all genus under the name *Echinopsis* around 1974. Nomenclature and taxonomy is constantly in motion and undoubtedly there will be more changes to both of these genera in the next 50 to 100 years. Since this is mostly a practical eBook I do not want to delve into this taxonomical debate too deeply. However, I want to give you a short overview of *Trichocereus* and *Echinopsis* for the sake of purposes of breeding. Some parents will not match due to important differences in flower structure, meaning crosses between these plants often fail.Let's have a look at the genus *Echinopsis sensu stricto* (in the strict, narrrow sense!) and consider what their flowers actually look like.

Echinopsis

Plants from the genus Echinopsis are often smaller than plants in the genus Trichocereus. While Trichocereus have columnar growth habits and grow very tall, Echinopsis stay small but clump heavily. Echinopsis form little side-pups that are connected very loosely and easily knocked off the mother plant. The type species of the genus *Echinopsis* is Echinopsis eyriesii. Plants from this genus have a high rib count and a round shape. Their flowers emerge from the upper part, the apex. They have a relatively long flower tube, much longer than the flower tube on Trichocereus. Much like the flowers on *Trichocereus*, Echinopsis flowers are covered with black or white hairs and scales. Some species are diurnal and some are nocturnal. Due to the longer shape of the





flower tube, it is very difficult to pollinate *Echinopsis* with pollen that did not evolve to fit their particular type of tube.*Trichocereus* pollen is often can't make the long way through an *Echinopsis* pollen tube and literally expires on the journey. The opposite is perfectly possible though, meaning it's not a problem to pollinate a *Trichocereus* (with a shorter flower tube) with the pollen of an *Echinopsis* (with a longer tube). In this case, *Echinopsis* pollen does not have to reach a part of the *Trichocereus* flower that it's not anatomically made for and this is the reason why the cross *Trichocereus* scopulicola x *Echinopsis subdenudata* often succeeds, while the reverse cross *Echinopsis subdenudata* x *Trichocereus scopulicola* often fails. It is not impossible to successfully use short tube pollen in a long tube flower, but the success rates are very low, with a failure rate of at least 70 or 80%.







Early flower buds on two different $\mathit{Echinopsis}$ species $\ensuremath{\mathbb{O}}$ Trichocereus.net




A unique and beautiful flower of an *Echinopsis* hybrid from my collection.







Trichocereus

The flowers on *Trichocereus* are larger than *Echinopsis* flowers, which is one of the key differences between these two genera. Both have hairy flowers, with scales on the flowers or flower tubes. On *Trichocereus*, you can find species with a flower diameter of up to 25 cm, while *Echinopsis* flowers are usually within the 10-15 cm range. *Echinopsis* flowers are substantially smaller but the flower tubes on *Trichocereus* are much shorter, which is another useful means of distinguishing the two genera. That being said, there are *Trichocereus* species with a fairly long flower tube such as *Trichocereus strigonus* and *Trichocereus strigosus*.



This hybrid is one of my strongest flowering *Trichocereus* hybrids. It always pushes out lots of flowers simulatenously.









Early stage of flower development on Trichocereus arboricola.





Greenhouse full of Trichocereus flowers, May 2019.





Flowering *Trichocereus validus*. Their green throat is absolutely amazing.









This plant is an intergeneric hybrid between *Trichocereus macrogonus* and *Echinopsis obrepanda*. It has traits of both genera and a flower tube that's a lot longer and more slender than the tubes of most Trichocereus species. Pollinating this plant with pollen from a species that has a short flower tube would be difficult.





Aporocandicans (Aporocactus x T. candicans) hybrid 'PAUL EHRLICH'.





These two photos are included here demonstrate different length floral tubes on *Trichocereus* and *Echinopsis*. The upper photo shows many *Trichocereus* hybrids with short tubes. The lower photo shows *Echinopsis subdenudata*, which has rather long flower tubes.





The flower bud of a $\mathit{Trichocereus fulvilanus}$ in an early stage ${}^{\odot}$ Trichocereus.net





© Trichocereus.net

Trichocereus arboricola is a *Trichocereus* species that flowers abundantly, at a relatively small size and with a breathakingly beautiful flower. This makes *Trichocereus arboricola* a perfect species for hybridization, and many people use it in hybrid culture. The plant pictured above is roughly 30 cm tall, and pushes out a good 5-10 flowers per season.

Other *Trichocereus* species like *Trichocereus peruvianus* and its relatives are much harder to get to flower, and often only flower when taller than 50-80 cm. Certain Andean *Trichocereus* species like *Trichocereus terscheckii* need to get even bigger before they flower. For this reason, there are fewer *Trichocereus* hybrids involving Andean species.





Trichocereus fulvilanus in an advanced stage of flower development © Trichocereus.net





Trichocereus fulvilanus in an advanced stage of flower development © Trichocereus.net





These flowers had opened a few days before capturing this image. All but one pollinations had failed at this point. In this image you can see that the ovum (the base of the flowers) has already swollen on the successfully pollinated flower.



In this photo you can see the successfully pollinated flower on the left side. The right flower later dropped, only the left flower produced viable seeds.













Flowering Trichocereus arboricola. © Trichocereus.net











The photo above shows a multihybrid with a ragged flower. Ragged cactus flowers are very rare and sought after.





Hildewintera Hybrid





On the photo above you can see a flower that emerged from a pup.





Trichocereus lamprochlorus flower buds







9. Crossing, fruit formation and seeds

Where I live, my main flowering season is between May and September. During this time, my greenhouse is full of all kinds of flowering plants and it is a gorgeous sight. I live in an area with very cold winters and I let my plants hibernate between October and March to April. As soon as I feel like ending hibernation, I start watering and fertilizing like mad. I try to water at least twice a week, and I know breeders that have their plants potted up in a purely mineral soil mix that water EVERY day during this time. I usually mix it up, fertilizing first and spraying them with plant extracts as soon as the soil has dried. When the soil dries a second time, I do another round of fertilization. I should emphasize that not all plants can take tolerate this approach, especially not plants in organic soil mixes. It works for me because I use fast draining soil mixes that are high in pumice and lava and gentle on the roots. If you fertilized plants in a cheap potting mix using this approach, you are at serious risk of losing plants to root rot. If you decide to increase watering, make sure to use the right soil and be careful about splitting.















The hybrid in the top photo above is a cross between a *Trichocereus* and an *Echinopsis* species, which is the reason it has a longer flower tube than the flowers on the *Trichocereus* in the lower photo above.













Approximately 8-14 days after pollination, flowers will either drop or enter the early stages of fruit development. The ovum stays on the plant and ripens into a fully formed fruit within ROUGHLY two months.





A Gräser *Trichocereus* hybrid shortly after pollination. Both crosses succeeded and produced viable seeds.





Flower buds of a Trichocereus arboricola in their earliest stage.





There are situations when flowers do not open correctly. For example, heat or pest damage can prevent a flower from opening correctly. When this happens, you can cut away the damaged petals to access to the stigma. Then you can pollinate as you would with a normal flower. Pollinating damaged flowers does have a lower success rate, but sometimes it works and it's definitely better than wasting the flower. In many cases, damaged flowers will not open normally and are prone to rot.



Make sure to remove old fruit remnants. These remnants can provide opportunities for fungal infections and other pathogens. Rotting fruit can also attract mold and insects, which is even more risky if fruit isn't removed correctly and there is areole damage. I always cut away fruit at the fruit's base.





Different stages of fruit development.




These fruits are already beyond the point where they should be harvested. As soon as the fruit color changes to red or yellow, the fruit is most likely ripe. There are exceptions but in most cases you can get viable seeds from fruit that is older than 8 weeks.





A freak flower on a *Trichocereus arboricola*. The flower was basically a pup that turned into a flower. The top of the plant fell off once the flower had aborted and the plant continued to grow from the base.





Trichocereus arboricola with freak flower, now in the opening stage.







Fruit removal prevents infection

Fruits can be a major cause of infections. Fruit are full of sugar and carbohydrates, attract insects and may be difficult to remove. If you remove fruit in a way that damages an areole you can create an entry door for fungal infections. A fruit left to rot on the plant may cause the same problem. Personally, I remove all fruits by cutting them off at their base, avoiding injury the plant itself.



The fruit on this plant was cut directly at its base, which is the best way to prevent infections.





The upper photo shows a flower of *Trichocereus validus*. The bottom photo shows a mutant *Echinopsis* flower with two flower tubes grown into one. This mutation is very rare.



Ripe versus unripe seeds

Fresh seeds are black or gray, round or kidney shaped and are heavier than unripe seeds. Unripe seeds are often brown, reddish, beige and/or comparably flat. I recommend removing seeds that float or otherwise appear improperly developed. Having too many of improperly developed seeds in your seed container can attract mold because they are basically dead tissue.



This is how ripe seeds appear.







10. Overwintering in a cold climate

This is a huge subject I will try to condense as much as I can. I've been growing cacti in a very cold European environment for decades. Everything I know I learned by making mistakes and trying not to repeat them. In the following chapter, I list some of the most problematic mistakes and explain strategies for avoiding them.





1. Wet soil and cold temperatures.

Wet soil and cold temperatures do not mix well. Cactus roots are very sensitive and rot very easily. During summer, this is not as problematic as it is in winter. Cold temperatures and moisture are a deadly combination for cactus roots, so I always overwinter my plants in completely dry soil. I stop watering towards the end of the growing season, keeping the plants in bone-dry mineral soil until spring. Between October and March, my plants do not get any water. There are certain cacti that would not tolerate this treatment, but plants from the genus *Trichocereus* are hardy as hell and usually don't mind. It is important that your plants are well fed BEFORE winter comes, because at this point you can no longer safely water and fertilize them and the plants need energy reserves sufficient for hibernation. The temperatures in my greenhouse reach 0° C, which is survivable for plants from the genus *Trichocereus* as long as they are in a dry mineral soil and are used to this kind of winter storage. I'll expand on this point later.

2. High air humidity and high temperatures

Winter is not always cold and dry. Some winter days are very sunny, increasing greenhouse temperatures substantially, and potentiating fungal infections. The simplest way to deal with this problem is to open the windows of the greenhouse, doors too, if necessary. The higher the temperatures in a closed greenhouse are, the higher the risk of fungal infections. I recommend using a good thermostat to track and react to greenhouse temperatures. I personally use digital thermostats in all of my greenhouses and have a wireless weather station that I can check from inside the house. If I notice high air humidity and sudden temperature spikes, I open greenhouse windows or doors right away. As a cactus grower it is your job to always be aware of temperatures and conditions in your greenhouse or grow room. There are no excuses not to be on top of this and if you don't pay attention you will lose plants to fungal infections on a regular basis.

I also get weeks where it rains like crazy, which also causes air humidity to spike. The temperatures during these rainy periods are often warmer than the temperatures during the frosty periods. As long as temperatures are over 0° C, I try to provide plenty of fresh air. This helps to prevent fungal infections and is probably the most important tool for combatting outbreaks during rainy periods. Fresh air can help prevent most fungal problems that could hit your collection.

3. Heavy Frost and Cold Damage

Heavy night frosts should be avoided at all costs. Every species has a different temperature tolerance. Large and massive *Helianthocereus*-like *Trichocereus* species (e.g. *Trichocereus terscheckii*) are more frost resistant than the Peruvian and Ecuadorian



Trichocereus species. If grown in a mineral soil, most *Trichocereus* species should tolerate at least 0° Celsius. Many of those will even be able to take short night frosts of -4° C, but lower temperatures are extremely dangerous. That being said, as with everything in life there are no guarantees. A sick or roughed up plant might not even survive light frost. Don't push it! If necessary, get yourself a heater with a digital thermostat or cover your plants with blankets or bubble wrap during the coldest nights.

4. Be careful during Springtime

In my opinion, spring is just as dangerous for your plants as winter. Winter is cold, but often dry. During spring you can suddenly get very sunny days that push greenhouse temperatures to 20° C and above. If you are too slow to provide fresh air, this can cause a sudden onset of fungal infections and sunburns. The latter is often followed by secondary fungal infections.

5. Dripwater can kill

Very often, there is condensation building up on greenhouse windows and ceilings. During winter, this water can be extremely cold and cause fungal infections or cold damage. This is especially a problem for seedlings that are more prone to infection due to wet feet.

6. Heaters and digital thermostats

I use electric heaters by the manufacturer Bio Green, the model is called Palma. In addition, I use one digital thermostat per greenhouse. The models I am using are TERMO 1 and TERMO 2. Both are very similar, but the second one also has a cooling function. During winter, this is unnecessary, but it can work as a fan to move the air a little bit. Using a digital thermostat in combination with an electric heater reduces the costs of electricity needed to heat a greenhouse. You set a certain temperature range (in my case I set it at 1° C) and as soon as the temperature goes below the range, the heater will kick in until the temperature is within the range again. Never use a heater at full capacity. Heat in combination with high air humidity can kill plants via heat damage or fungal infections. I learnt this the hard way when I put a gas heater in a greenhouse and cooked everything inside within a day or two. No matter what heater you use, it has to be possible to set their temperature. Many cheaper heaters only have higher minimum temperatures (e.g. 10° C), which uses up a lot more electricity and creates more heat than is necessary.





Digital heater PALMA by BIO GREEN. I use it in connection with a digital thermostat.



7. Sunburns can occur, even in winter too

I recently heard the claim that sunburns cannot take place during winter. Obviously, this is ridiculous. On a very sunny day, you can suddenly get temperatures above 20° C in a closed greenhouse and this poses a substantial risk to plants that have not accustomed themselves to stronger sunlight. Even outside you can suddenly get sunburn - plants need time to build up a natural resistance to sunlight and significant weather changes happen too quickly.

8. Check your plants daily

I know that it's often not possible to check your plants every day, but this is the best-case scenario. During winter, all your plants should be checked at least once a week. Get yourself a little mirror to check your plants from all sides, keeping an eye out for anything that is not normal like evidence of sunburn, fungal infections, other discoloration, and extreme dehydration. I always bring plants with problems inside the house. Inside, the risk for fungal infections goes down substantially. Something I very often do is checkgrafts or plants for minor fungal infections. By catching infections early you can protect the plant by removing just the little piece of infected flesh. The longer you wait to remove an infection the more flesh you will have to remove and the greater the risk of plant death.

9. Check grafts and seedlings

Grafts and seedlings need more care than adult plants. Seedlings can die within one day and grafts can dry out almost just as easily. Grafts need more water than plants on their own roots and I usually begin watering my grafts and seedlings first. Weak or infected grafts and seedlings may have to be brought inside. I usually start watering my larger plants around April, but give grafts and seedlings some water in March. Grafts and seedlings are smaller plants, have a smaller root system and just can't hold out as long as larger plants. So, I start watering them first.

10. Cold winter periods and flowering

Winter is a completely normal thing and plants need winter to flower properly. In all the years, I overwintered my plants inside my house, not one of them flowered in the following summer. Providing your plants with a cold and dry winter is healthy and it helps remind them that they should procreate or risk going extinct. It is unknown how cold temperatures should be, but I like to have my winter temperatures around 1° C. Almost all plants in my greenhouses flower abundantly and a cold winter period plays a major part in this.



11. Remove rotten plants

For most people this should sound completely self-evident, but I want to say it nonetheless. Every rotten or dead plant will lead to more pathogens being present in your greenhouse, and this can cause other infections that you would not have gotten if you'd removed the casualties. Everything that's dead or decaying needs to be removed as soon as possible, and this includes dead rodents. I once had a mouse expire in a greenhouse, which stunk the place out for weeks.

12. Make use of greenhouses or hotbeds

The reason for using greenhouses or hotbeds this is simple. They extend the growing season dramatically. My greenhouses are the reason I can leave my plants out for two more months before winter, and I bring them out two months earlier again in spring. I now keep my plants in greenhouses all year round, but I could definitely bring them out sooner if I still kept them in the house. It's a completely different ball game to bringing plants out in late spring. One of the best breeders I have ever met doesn't even own a greenhouse, and grows all of his hybrids in hotbeds.

13. Don't cut during winter

Winter is the most dangerous time to cut. I only graft during the hot months of summer, and I only cut in winter when I have absolutely no alternative. When I cut in winter, I usually bring my plants into the house until the wounds have healed. During winter, the risk for fungal infections on cuts and grafts is much higher than during other times of year. High air humidity sustains wounds that would otherwise heal with no problems. Only cut in winter if you absolutely must, such as to remove an active infection or clean up slug bites.

14. Slug bites

During winter, there will always be warmer weeks when slugs suddenly become active. This is most dangerous for seedlings, although slugs can also damage larger plants. While it is important to provide fresh air on a regular basis, keep in mind that slugs and snails can and will come into a greenhouse if temperatures allow it.





The image above shows one of my greenhouses in Europe. My plants must survive very cold winters and it took many years to learn everything necessary to keep my plants alive. I originally started overwintering my plants inside the house and brought them out to the garden in late spring. This caused many problems like sunburn in the early months of summer, lost plants due to lack of oxygen, etiolation, and many other things. Another problem with overwintering inside was that my plants never flowered. Eventually I realized that there's no way around getting a greenhouse if you are living in a colder environment. Electric or gas-powered heaters and digital thermostats are necessary here and really help me get all my plants through the winter.





My plants during a very cold January. In extremely cold temperatures, I sometimes use candles in addition to my electric heaters.





Seedlings and grafts in winter. All of them need to be completely dry or they will start rotting. It is sometimes necessary to use a cover to control rain and humidity. Avoid putting seedlings and grafts in closed containers. What works in summer can be deadly in winter.



A candle can help to protect your seedlings from frost. Make sure to follow all safety regulations and avoid burning down your greenhouse.





On the photo above you can see an electric greenhouse heater manufactured by a company called BIO GREEN, and the digital thermostat THERMO 2. The temperature can be adjusted and I normally set the temperature at 1°C.



11.Skin discolorations, nutrient deficiencies and other blemishes





Sun burn and chemical burns

Sunburn is a real threat and can often cause secondary infections. These secondary infections may be misidentified as the actual problem while, in reality, are the result of older sun damage. Like all wounds, sunburn can open the door for other infections. In this chapter, I will show you the many faces of sunburn. Please note that there are infections that can increase the sensitivity to sunlight. Viral infections can be an attributing factor to sunburn cases.





How to differentiate viral infections and sunburn

Every time I see skin discoloration, I try to understand the environment the discoloration first occurred in. I try to take a close look at where, how and when the discoloration appeared and try to figure it out from there. For example, sunburn often happens on the most exposed parts of a plant. In most cases, discolorations caused by sunburn can be found on the ribs or the apex. Discolorations caused by virus infections such as tobacco mosaic virus can be found all over the plant. There are limitations to this approach but the relationship between discoloration and environment is a useful diagnostic starting point.



Sunburn often manifests itself on the most sun-exposed parts of a plant. In most cases, this means the ribs and/or the tip.





Mild case of sunburn on a *Trichocereus* 'Yellow California'. These kinds of burns are often not dangerous and can occur at the beginning of a growing season. Unless there are secondary fungal infections that sit on top of a burn, these burns are nothing to worry about and will vanish over time.





Two different chemical burns are pictured above. The upper photo shows a dry rot that occurred because of neem oil treatment, which required the cacti to be completely cut. The lower photo shows a mild fertilizer burn that didn't cause further problems.





Extreme sunburn on an *Echinopsis* hybrid. The plant is slightly variegated, which makes it more vulnerable to sunburn.





Old sunburn that was very substantial, but healed well. These old scars may still cause an infection at some point in the future.





A combination of sunburn and fertilizer burn. Use of fertilizer can increase the risk for sunburn dramatically, which is why fertilizer should not be applied in full sun.





Sunburn on a variegated scion. Some variegates are a lot more vulnerable to sunburn and have a harder time recovering. I recommend hardening variegates up very carefully, only increasing sun exposure when you're sure they are used to it.





Combination of sunburn and chemical burn following excess fertilization.





A massive sunburn on an older plant. Surprisingly, this sunburn has never caused serious problems for the plant and the main column grows normally. It does present a risk for infections, however.





This plant was badly burned by sunlight during a terrible heat wave in 2020. It was so bad that I worried about losing the whole plant, but to my joy it recovered and a wound infection did not follow. Sunburns of this size need to be observed closely and afflicted plants must be kept in a dry environment. I know it seems ironic but providing a healthy amount of sunlight can also be beneficial too. If a plant with bad sunburn experiences high air humidity, fungal infections are likely. A sufficient supply of oxygen provides some protection.







Insufficient light and etiolation

Lack of light can cause discolorations like discolorations caused by malnutrition. Plants need sunlight for chlorophyll production and when plants are grown in shade or in darkness, this production may not take place. Below you can see examples of plants that received insufficient sun light.



The plant above was shipped in a closed package and spent weeks in total darkness. This caused a minor skin discoloration at the tip and a few other spots and blemishes. Fresh cuttings often suffer from these things because they do not have a root system yet. With a good and healthy root system, discolorations are a lot less likely.





The thin area on the lower part of the plant above is the result of a period where this plant did not get as much light. These thin parts on otherwise massive plants are usually permanent and do not grow out. The best way to deal with them is by prevention.





Another plant that slightly etiolated during shipping. The new growth will almost certainly be very thick, making the plant look disproportionate.





Plants or pups that are covered by soil or other plants can develop discolorations that resemble nutrient deficiencies.





This pup was entirely covered by soil and took a very long time to produce sufficient chlorophyll. It has improved, but years later, you can still see the discoloration. The main column is also blocking light, which doesn't help the situation.




Sufficient grow space is something that many cactus breeders do not have, which is why it is common for breeders to pack their plants tightly. However, this can create shady areas and block most light from smaller plants, increasing the risk of fungal infections and spine injuries. Crowding also traps a lot of water and moisture, which can be dangerous for grafts or seedlings.

I recommend sorting your plants by size. Place small plants on the sunny side and bigger ones on the more shady side. In my greenhouse, I try to place the seedling shelves on the shadier side too. Everything that you put in your greenhouse will eat away at the available light.





This *Trichocereus cuzcoensis* KK242 experienced a short period where it was left in the shade while a new greenhouse was built and you can see the resulting etiolation very well. After leaving the shade, growth continued as it had previously.





This plant had a bad nutrient deficiency when I got it, and it took a while until it was fully rooted. During rooting it developed a partial etiolation at the top.





Classic discoloration from lack of light.





This plant has a true variegation and died shortly after this photo from its inability to produce chlorophyll. I generally do not keep plants alive that can't even produce their own Chlorophyll. It's a waste of perfectly good grow space. I am a big fan of partial variegates though.



Nutrient deficiencies

Discolorations from nutrient deficiencies are very common. Many people confuse these discolorations with true variegation or viral infections, and it requires a lot of practice to spot the difference. If a plant changes its color to yellow or beige, nutrient deficiencies should always be considered. Please note that it takes many months or even years for some discolorations to disappear, which is why you must be patient when tackling this problem. Make sure to get a high-quality fertilizer that doesn't only provide nitrogen, but also phosphorous, potassium and trace elements that are often not included in cheaper fertilizers. It can make sense to use magnesium and calcium supplements to rule out all potential nutrient deficiencies. The most common nutrient deficiency is caused by lack of nitrogen and leads to a yellow discoloration of the skin. If plant skin turns yellow, nitrogen deficiency is the most likely culprit.



Malnutrition. Potentially potassium deficiency, iron deficiency, nitrogen deficiency etc.





Nitrogen deficiency. The yellow discoloration is very typical and looks like discolorations resulting from lack of light.





The hybrid "Amun-Re" is known to occasionally develop nutrient related discolorations.









Malnutrition on an intergeneric hybrid involving *Trichocereus* and *Echinopsis*. After giving additional nutrients the skin color normalized, although it took many years. It can take a long time for plants to return to normal after suffering from malnutrition.





Substantial nutrient deficiency due to an overly mineral, fast draining soil.









Another example of malnutrition





In comparison, here is a true and genetic variegation. It looks nothing like the previous discolorations.





Classic nutrient deficiency on a hybrid between *Trichocereus pachanoi* and *Echinopsis obrepanda*.





Likely a calcium deficiency.













Malnutrition and nutrient deficiencies often manifest themselves on ribs first. Ribs are often sun exposed and are more likely to develop abnormalities than the rest of the plant. This "Aporocandicans Schigra F2" hybrid produced these discolorations after a change of fertilizer. I bought this plant from another breeder, and once I switched to a fertilizer with a different NPK ratio this coloration returned to normal. Please note that sun damage can also play a role in this process, but it's not the same as classic sunburn.















Frost and cold damage

Frost damage will normally change cacti skin color and it is common for frozen plants to turn black. Once plants show visible signs of cold damage, it is often too late to save them. Dark coloration tends to be the start of the decay process and will progress until the plant is dead. It is possible to save plants that suffered from frost damage, but it is very difficult and you must remove dark flesh immedietly and put cuts under a strong grow lamp to stop secondary infection and decay. In general, most plants that change their color to black, dark gray or brown as result of frost damage will not survive. Another strong indicator of frost damage is when a plant's skin becomes very glassy or white. It's basically a similar process to sun burn, but in this case it's cold that's damaging the skin. I'm sure you have heard of fristbite experience by people, spending time in cold environments. Just like people, plants can suffer from frostbite too.



A frozen *Hildewintera* hybrid. *Hildewintera* hybrids usually tolerate a lot of frost, but for this one the cold was too much. Note the dark and bright spots on the skin, demonstrating both types of damage that you can encounter. The skin looks glassy too, another indicator of frost damage.





The *Trichocereus* plant in the left photo has suffered from bad frost damage of the tip. It had previously suffered from a scale infestation, which might have increased the plants sensitivity to cold. By cutting away the black tip, I might be able to save the rest of the plant. You can see that the black frost damage only progressed to a certain point, which often happens during short night frosts. The tips are the most exposed during these sudden frost attacks and are often the first thing damaged.

The plant in the right photo above is a *Lobivia winteriana*, which is a notoriously cold sensitive species with quite an ironic name. I own a few larger plants of *Lobivia winteriana* that can withstand my cold winter temperatures, but there are many that cannot.









These plants and seedlings were lost after a surprising wave of frost very late in winter. They didn't freeze because of cold temperatures the greenhouse, but rather in because they were pressed too close to the windows. Window contact can be deadly for both seedlings and larger plants, but smaller plants are the most vulnerable. If you find frozen seedlings in your sowing container, remove them as soon as possible to avoid attracting mold that might kill other seedlings in the container.





A frozen *Trichocereus* plant from my greenhouse. This frost damage occurred during the last cold days of winter when I was getting started for the new season. Sometimes, late and sudden frosts are the most dangerous.





A grafted Echinopsis pup that was getting too close to the windows. Note that the damage is only on the side that was in front of the window. Windows be can extremely dangerous for plants and seedlings during the cold months of winter. Make sure plants are dry and protected from drip water and condensation. There is often a lot of condensation on windows and this can cause frost burns when temperatures get low.

Echinopsis are slightly more sensitive to cold damage, which is why I reduce the number of *Echinopsis* hybrids in my collection to an absolute minimum. *Trichocereus* do a lot better with the climate that I have here in Europe.







Frost damage on a plant that was pressed against a frozen window.







Frost damage and a secondary infection on Trichocereus





The photo above shows a *Trichocereus* tip with a piece of Styrofoam as frost protection.







Scarring and corking

Corking involves excessive development of scar tissue. Very often, scarring is the result of an underlying problem, such as scale, thrips, mealy bugs or mites. The micro-injuries made by these pests can change the appearance and texture of an epidermis to make it cork-like. While corking is not a problem in itself, corking can be the sign of an underlying issue. For some cacti, corking is part of their natural development cycle. It is your job to find out if corking in your plants is natural or the result of stress and injury. There is no cure for corking and it often cannot be reversed.



Scarring on two different *Trichocereus* species. While the scarring is not reversible, the new growth was completely healthy once the underlying problem was solved.





The plant above has both corking and mild sunburn, suggesting suboptimal conditions.





Massive scarring following scale. This is not an active infection, but the plant is at increased risk.












Scarring resulting from scale infection.





Healed sunburn that occurred during a massive heatwave.



Mechanical injuries and spine wounds

Almost every cactus breeder I know suffers from a lack of sufficient growing space. It is common for breeders to pack plants tightly in small spaces, which can cause spine injuries and secondary infections due to insufficient oxygen supply.



A bigger *Trichocereus* hit this plant very bad, which resulted in a tear of the skin. These wounds can sometimes be the cause of serious secondary infections.





This plant suffered from a little spine injury during shipping and it ended up becoming really infected. Though this is benign black rot that healed by itself, smaller wounds can be a real problem for breeders that put of plants in a small area. The plant also suffered minor sunburn.











Slug injury on a Trichocereus arboricola



Slug and snail damage

Snails and slugs can be a major problem for people who do not have a way to protect their plants. As a breeder who works with a greenhouse, this isn't a terrible problem for me, but snails and slugs definitely take a bite here and there. Bigger plants are much more resistant to attacks than seedlings and I have lost quite many to slugs and snails. In this chapter, I want to show you some examples of snail and slug damage.







This flower was completely messed up by a nightly slug attack. As a result, the flower was unable to open properly and the cross failed. Slug attacks are very dangerous for flower buds and flowers.



Splitting

As a response to extensive watering after a drought, plants can and will split up sometimes. This splitting of the skin is usually not a big problem, but it is aesthetically unpleasant and can work as an entry door for fungal and bacterial infections. Every wound is a risk factor that can lead to infection, especially because the plants often split in areas that are particularly moist.





Water spots and mineral deposits

Depending on how many minerals are contained in your water, there may be mineral deposits on your plants or in your soil. These are not a problem initially, but if you see bigger mineral deposits, it might be a good idea to repot. In the photos below, you can see some mineral deposits that remained on plants after water evaporated. This is normally not a problem, but adding a pH buffer to the water when watering might be useful in these situations. Please note that the symptoms of minor cases of root mealies can look like mineral deposits, too.



Trichocereus.net





These photos above show examples of mineral deposits. These deposits usually do not have any negative impact on the general health and I personally ignore them. I often see these deposits after using a mineral fertilizer.



Condensation on two different *Trichocereus* species. After evaporation of the water, the mineral deposits are what's left on the plants.



Neglect

Neglect is very common in cactus culture and plant culture in general. Plants can stand too close to each other, lack of nutrients or water, or be overdue for repotting. People that encounter health problems may struggle to care for large plant collections amassed in healthier years. Cacti are very hardy and neglected plants tend to survive relatively long, although neglect is usually visible in a plant's appearance.

Neglect can cause fungal and bacterial infections result in a reduced ability to survive cold or wet periods and ability to flower and create a higher risk for sunburn and other health conditions. Neglected plants are at a much higher risk of infections, simply because they often don't get everything they need. Neglect is caused or worsened by lack of fertilizer, micronutrients, fresh air, root space, sun, exposure to pests, infections, inappropriate pH levels and other environmental factors.

Growers normally don't choose to neglect their plants. It is rather easy to start a large collection, but it takes a lot of work to properly CARE for a large collection.



Both of the plants pictured were neglected for some time. The left plant responded to neglect by growing very slowly, while the right plant responded with discolorations and scars.





This column had to be cut because it reached the roof of the greenhouse. During the rooting process, the plant developed some skin discolorations due to sudden absence of water.





This plant suffers from many problems, including neglect. At some point there must have been a change in environment and reduction in light, which caused the thin growth and various skin discolorations above it. The new growth appears healthy, evidenced by the sudden color change to a healthy dark blue with a glaucous layer. The thin column will take many years to grow out though, and may be permanent.





This plant is a grafted scion of the hybrid 'Mamacita'. The bright and yellowish skin color at the tip is the result of insufficient light. The discoloration is mostly reversible, and you can combat this easily by giving the plant more sunlight. Such discoloration can also be caused or worsened by nutrient deficiencies. However, insufficient light also causes etiolation, which is a harder problem to solve. It is much easier to prevent etiolation than healing etiolation after it occurs.





This plant has numerous problems. It should have been repotted years ago, and has not received enough light or nutrients. Neglect has caused the skin problems pictured.





Two badly neglected plants. They are covered in spiderwebs, were grown in the shade and have have much discoloration. At this point it's best to use the columns for harvesting pups.





Spiderwebs and dirt should always be removed from the plants. Get yourself a fine brush and GENTLY clean them up every now and then. Also ensure to regularly spray sheltered plants with water to imitate the cleaning process caused by rain in nature.



Sudden environmental changes

When plants are introduced into a new environment, the transition can be difficult. Don't buy a plant that has been overwintering in a hothouse that's heated all year long and put it straight into a cold greenhouse.

Plants need to be hardened up until they reach their full potential and if this process does not occur you can lose them. The best way to prevent this is to ask every seller you buy from how they have grown their plants. Sudden changes in environmental conditions can cause sudden death, skin discolorations and fungal infection.



This *Trichocereus thelegonoides* hybrid did not like the cold temperatures in my greenhouse and took many months to show new and healthy growth.



Terminated growth and pupping

If stressed or injured, plants from the genus *Trichocereus* may terminate their growth. Healthy plants will eventually pup again after a healing period, but the scarred tissue might never look the same. Scarred tissue has a different structure and plants are a lot less likely to pup from scars and damaged areas.



The TPM pictured above was injured after a slug attacked the main tip, effectively terminating growth on this column. The plant pupped from a lower area and now continues to grow from there.





Terminated growth on a small seedling following snail damage. The seedling will probably cease to grow from the tip, pup and grow from there.



12.Pesticides, chemicals and treating illness

There are various pesticides and chemicals that can be used to treat infections, pests or blemishes. In this chapter, I will list treatments I consider somewhat interesting and noteworthy.

Neem and neem oil

Neem is an Indian tree from the *Mahogany* family that has many medicinal properties and can also be used as a pesticide. The scientific name is *Azadirachta indica* and the most common way this tree is applied as a pesticide in the form of neem oil. Neem oil is pressed from the tree's fruits and seeds. It usually takes a couple of weeks until neem starts killing pests, but it works reliably. Neem oil is a good repellant and works similarly to other oily plant treatments such as white oil, having a suffocating effect.

Neem would be the perfect pesticide if it did not cause occasional chemical burns. These burns worses if treated plants are left in the sun, which is why I recommend keeping plants treated with neem in complete darkness for a week or two. However, I have still seen many situations where neem still caused extreme chemical burns despite these precautionary measures. Neem oil burns are unpredictable, and I personally do not like any oil-based pesticides. I currently have a large plant in my greenhouse that looks as if it has leprosy because I decided to give neem another try, and I regret this fifth attempt. If you'd ask me about the frequency of these burns, I'd say that approximately 8 out of 10 treated plants will be perfectly fine. The odds are good but it's not worth risking turning your most precious plant into goo. I would not use any oil pesticide on a rare plant. There are neem pesticides with the active agent Azadirachtin that may not have the same side effects of oily neem products. There are also other chemicals in neem that may contribute to pest deterrence, including meliantriol, salannin, nimbin and nimbidin.

White oil

White oil is a natural, homemade pesticide that is often recommended against certain pests. Everything I have written above about neem oil also applies to white oil. If you decide to use white oil, take great care to avoid strong sun light after treatment. White oil can be made with all kinds of cooking oils and below you will find a white oil recipe. I do not take any responsibility for damages caused by this recipe if you decide to use it.



Recipe for white oil: two cups vegetable oil, one cup dishwasher detergent or soap. Put ingredients in a bottle and shake contents until white. Add one tablespoon of your white oil mixture per liter water and apply to your plants.

Please note that there are some brands of dishwasher detergent that include chemicals that are bad for plants and unsuitable to use in white oil. White oil should never be applied in direct sun light or during high temperatures $(25^{\circ}C+)$.



The photo above shows a chemical burn from an oily pesticide. Chemical burns from oily pesticides usually linger for a very long time, and kill the plant in most cases.



Sulfur

Sulfur is a chemical element that is abundantly available and can be used as a natural pesticide. Sulfur is often permitted under organic farming regulations, and you can get it relatively cheap. A kilogram of sulfur is commonly priced \$20 online and this amount would last the regular *Trichocereus* grower many years. Contrary to the legal limitations that apply for the sale of many pesticides, there are hardly any limitations on the sale of sulfur. Sulfur is a mild pesticide as well as a fungicide. Though sulfur is often not enough to kill complete populations of hardy pests such as root mealies or thrips, it is enough to weaken or reduce these populations tremendously. Commercial cactus breeders often use sulfur to spray seedlings to prevent or treat damping off, and sulfur can also be used to treat active fungal infections. Sulfur is not as toxic as other pesticides or fungicides, which is why it's one of the first chemicals widely recommended in cactus guides and online forums. Sulfur dosage varies greatly and there are many different recipes involving it.

Powdering cacti with sulfur

Powdering cacti with sulfur is one of the most common methods of sulfur application. I personally do not like powdering because it reduces visibility of the wound or infection, but it still works. When you are dealing with infected wounds there are two things that matter. The first thing is fresh air, and the second is your ability to determine whether you need to cut the plant or not. When dealing with infected wounds you need to be experienced enough to classify and understand the cause of the symptom. If you don't cut, the plant might not survive. When dealing with fungal infections, time really matters. Making the right call at the right time can save an extremely rare cactus and you just don't want to make these decisions when you can hardly see a wound because of all the yellow frigging powder that is covering it. In addition to oxygen, a fair amount of sun light is great and healthy for most infected wounds. You should avoid preventing a wound from getting light. In addition, powdered sulfur can create am outer layer that traps humidity below the wound, adding fuel to the fire. Rather than applying powder, I usually dissolve sulfur in water and use it as a spray.

Sulfur is also a necessary nutrient for cacti and works as a general immune booster. Sulfur is very common. Organic apples are often treated or washed with a sulfur solution and if you pay attention, you can often smell it.



13. Grafting

Grafting is one of the most common methods of cacti propagation. By using strong growing cacti as grafting stock, you can make cacti grow substantially faster than they would on their own roots. I will produce a complete grafting guide at some point, but this chapter gives a basic introduction into the process.



A small *Lobivia* pup grafted onto a massive *Trichocereus*. Every year, this plant pushes out dozens of flowers. You would only get a small number of these flowers if the *Lobivia* were on its own roots.





A grafted seedling from a cross between *Trichocereus validus* and the *Trichocereus* hybrid 'Schick Pink'. This seedling is three times as big as the seedlings that I grew on their own roots. Grafting gives you a substantial time advantage.



The first series of grafts I made in 2021. They are placed under a strong lamp to get started.





On the photo above, you can see the inside of a cut *Trichocereus*. The round circle in the middle is the vascular bundle and all your scions have to be connected with it in order to survive long term. The vascular bundle is the only way that a grafted scion can take in nutrients, which is why it is so important to place the scions on top of it.



Rubber bands

Rubber bands are an essential part of my grafting process. Picking the right bands is just as important as picking a good growing stock. With rubber bands you can put a lot of pressure on the scion, but without having to spend a lot of money on stuff like stockings or other grafting equipment. I bought a few thousand strong rubber bands for 7 bucks. Get yourself a few packets of rubber bands in different sizes and strengths and you're set for a few years of grafting.



On this larger graft I used extra strong rubber bands.









Hybrid seedling grafted on Trichocereus © Trichocereus.net





The plant in the photo above has been used as grafting stock. I used a combination of rubber bands and painter's tape to apply pressure to the scion. Make sure to keep insects away from taped grafts because they can get stuck on the tape, and this is unusually cruel.



Choosing grafting stocks?

You can graft on almost any cactus there is. As long as you follow the basic principles of grafting, your grafted cactus will grow much faster compared to growth on their own roots.



Seedling graft at 6 months old © Trichocereus.net

In the above image, I flattened the stock ribs in order to prevent pupping from the areoles. It is rare that cacti pup from scar tissue, so flattening can keep new pups from pushing the scion off the grafting stock. Because the seedling get energy from the stock, it grew extremely fast and pupped vigorously. This is normal and not a sign of an infection like witch's broom disease or anything like that. There is just a lot of energy available to the scion, leading to explosive



growth. It is not uncommon that such grafts grow substantially within just one year and flowering on grafted plants often begins faster than it does on plants on their own roots.



The seedlings above were grafted as seedlings on actively growing *Pereskiopsis* cuttings. *Pereskiopsis* are ancient plants that are closely related to other types of plants and grow much faster than most other cacti. *Pereskiopsis* still have leaves, but are actually cacti and can be used as grafting stock. *Pereskiopsis* are most effective as stock for seedlings and you often don't even



need pressure to connect a small scion. All you need is a sharp razorblade to cut the seedling in half, a warm environment with high air humidity and a plant lamp. You usually keep fresh small seedling grafts or "micrografts" for a week or two in a humidity chamber to prevent tiny scions from drying out.



A grafted seedling with variegation.









I often graft little pups and seedlings on rooted *Echinopsis* pups. This genus pups like crazy and you can easily remove every single pup, root them and use them as grafting stocks. *Echinopsis* works great as a grafting stock for smaller cacti. *Echinopsis* does not produce growth as vigorous as *Trichocereus*. However, *Echinopsis* are still great to get little seedlings through the difficult early phases. *Echinopsis* can also be used as stock for slab grafts and can be used to continuously harvest new pups for grafting. Make sure to cut away edges from discouraging the plant from wasting energy on pupping. You can cut away all the skin on the upper part of an *Echinopsis* pup and it should not affect the general health of the plant.




Grafted variegated Gräser hybrid. Variegates tend to sunburn easily, so be careful when introducing them to direct sunlight.





A grafted pup of *Trichocereus narvaecensis*. This graft is approximately one year old and is growing a lot faster than it would on its own roots. By using a fast-growing species with an already established root system as stock, you can save yourself a lot of time. If done properly, grafting protects your plants because you get them bigger faster. The smaller a seedling, the higher the risk of sudden death.





A grafted *Trichocereus validus*. It is so thick is that it is grafted on a large *Trichocereus*. If grown on its own roots, it would take much longer to reach this size. Grafting brings you enormous time advantage.

Grafting growth rates depends on the type of stock. I personally recommend using somewhat spineless and fast-growing species like *Trichocereus pachanoi* and *Trichocereus scopulicola*. You can also use species like Trichocereus candicans, *Trichocereus spachianus*, *Trichocereus peruvianus* and anything that isn't too fat. *Trichocereus terscheckii* and similar species aren't as suitable for grafting because of their massive diameter and tough core. It can be very hard to cut *Trichocereus terscheckii* and this may require a tool as strong as a katana or a machete.





This variegated seedling is from a cross between *Trichocereus peruvianus* and a Gräser hybrid. The seedling was grafted on a rather valuable hybrid called 'Amun-Re' and I intentionally left one pup on the stock to harvest it at a later time. If you cut away all the edges on the grafting stock, it will probably not pup. If you graft on rare grafting stocks it can make sense not to remove the edges, but new pups should be removed right away.





A grafted variegate from a cross between *Trichocereus peruvianus* and a Gräser hybrid with growth sped immensely via grafting.



Types of grafting

There are various ways to graft. Below you can see a variety of grafting techniques.



Wedge grafting

The grafting method in the left image above is called "wedge grafting". You cut out a wedge-like piece from your grafting stock and fill it with a similarly cut piece from the scion you want to graft. When making wedge grafts you must be extremely careful that the piece you cut fits perfectly into the wedge you created. It takes a lot of pressure from rubber bands or similar things to make the wedge fit perfectly into the wedge-shaped hole you cut into your stock.



It is equally important that no dirt gets in between the scion and the stock. Otherwise, it will greatly increase your risk of fungal infections.

Cutting stock edges

Cactus grafting uses up many resources, don't waste them. You give grafting stocks water, fertilizer, a place to grow and your precious time. You have to pay for the scions and risk losing them with a sloppy graft. Some scions are irreplaceable. If you take the effort to graft, please go the extra mile and do it right. So many amazing plants haven't made it into cultivation because their grafter did a poor job.



On this graft, I used a powerful *Trichocereus* as grafting stock and the scion has since tripled in size! I cut away the edges to prevent new pups from pushing the scion off from below.

Cutting stock edges also prevents skin from shrinking up, which is another way fresh scions can be pushed off their stock. Cutting edges keeps the stock from putting energy into new pups that



would normally come up from the edges. If you cut a stock and put a graft on it, it does not automatically put all the energy into the scion. A graft may take, but be unable to get enough nutrients and water because the plant prioritized pushing out another pup. By removing parts of a stock likely to pup, you increase the energy that can be made available to the scion. Personally, I have occasionally kept the edges on valuable stock. I know it sounds snobbish, but people who raise very rare cacti sometimes get into a position where they use rare cacti as grafting stock and collect pups that come up on the edges. However, I really can't recommend this as it eats up lots of energy during the important first months after grafting.



This stock has gotten so much power that it started pupping like crazy and didn't put energy into the scion. After re-cutting the edges, the stock will push more energy into the scion.





This graft is growing well, despite uncut edges, new pups and flower buds. However, the scion would probably be twice the size if the edges had been cut. It takes energy for the plant to produce pups, and you can save this energy and your time by removing the edges and the opportunity for the chance to pup.









Another example of poorly cut edges. If a new pup can grow anywhere near the scion you have not cut the edges properly.



In order to prepare your stock for grafting, you first make a horizontal cut to remove the tip. This can be a perfectly straight cut, or at an angle. Personally, I like straight cuts because it makes it easier to position the scion. After cutting away the tip, you make a few downwards cuts on the edges, cutting away the top few centimeters of the ribs, including the area beside the ribs. It doesn't look pretty, but this keeps pups from coming up from the edges between the ribs. You should use a very sharp knife that has small, sharp ridges on the blade. These ridges make it easier for you to cut cacti skin. Sharp blades without ridges can cut the inner core of a cactus without problems, but tear up the skin later on. I have used many different knives for grafting and prefer large bread knives or something similar. It is important to avoid tearing skin off, which can and leave large wounds on cacti.

Grafting on clumping Echinopsis



A large number of *Echinopsis* pups that were rooted separately to graft on them.





I love grafting on *Echinopsis. Echinopsis* are readily available because they pup, and with a few large mother plants you can harvest hundreds of pups every season. At the beginning of every growing season I go around remove pups from my plants, put them into sand and wait until they have roots. Then I graft on these rooted pups all summer long. Unlike what many people think,



Echinopsis can make amazing grafting stocks if they are used correctly. Compared to *Trichocereus, Echinopsis* produce less explosive and furious growth, but they are reliable, easy to graft on and relatively hardy. It is extra important to remove the edges and/or scar the *Echinopsis* before grafting on them. As stock, *Echinopsis* can put too much energy into pupping, so you should work to counteract this.



I like splitting little *Echinopsis* or *Trichocereus* pups in half and grafting both sides to two different stocks. In the photo above you can see the bottom part of an *Echinopsis* that I grafted onto a *Trichocereus* and the scion has now pupped. I use these grafts for harvesting pups that will be grafted onto other stocks.











Failed grafts

This chapter illustrates failed grafts and will help you learn to differentiate graft inactivity from graft failure.



The scion in the photo above looks dehydrated and does not show a lot of active growth, which is usually an indicator that a scion has failed to take. If the scion produces tiny roots, failure is even more likely. Grafts that look like this should not be grafted again right away because they are already dehydrated. The solution is to root these failed scions in sandy soil, water them regularly and regraft when they return to health.





No apparent scion growth, probably due to the uncut edges. A new pup is about to emerge on the stoc



14. Inducing pupping

Pupping is a natural process in cacti and often happens spontaously. However, there are ways to induce or improve pupping and I will list some of them here.

Cutting

Cutting cacti is one of the most common causes of pupping. It may be seen strange that cutting or hurting a plant can cause new growth, but it is a protective mechanism responding to damages of active growth. The removal of an actively growing column will often be followed by new pups on the healed wounds or at the base of the plant. The bigger the remaining plant, the more likely will it pup.



The birth of a pup on a *Trichocereus*. The little 'horns' at the top are vestigial leaves; a remnant from a time when cacti still had leaves.





Pupping on a freshly cut plant. © Trichocereus.net

Coconut water

Coconut water is a commonly used additive for tissue culture media and is extremely beneficial for plants. Coconut water is regularly used as a natural fertilizer for cacti and I can't recommend it enough. Coconut water is full of carbohydrates and plant hormones like cytokinines, which will GREATLY improve a plant's ability to flower and pup. When I use coconut water, I always dilute it down to avoid providing too many nutrients at once. The reason for this is that coconut water and similar chemicals aren't only great growth boosters for your plants, they can also attract pests and pathogens. Imagine what might happen when you soak your plants with a solution of sugar and water and you get an idea why it's a good idea to dilute coconut water when fertilizing. I personally use 50 ml of coconut water per liter of water, but there are other recipes that work just as well. I wouldn't recommend using more than 500 ml of coconut water per liter of water and if I used it in such a high concentration, I'd only apply it to adult plants that are in great health and growing in a mineral soil medium such as pumice. Coconut water can cause



abnormal growth and that looks very much like witch's broom disease. This growth is usually a direct response to plant hormones contained in coconut water and it is unclear if there is any pathological context.

Fertilizer, phytohormones and cytokinines

The more nutrients you provide, the higher the chance of your plants pupping. This applies to all kinds of fertilizers and includes plant additives like seaweed extract and kelp, carbohydrate extracts, products like Vitanal and other plant extracts. I recommend that you fertilize your plants regularly. Plants that are fertilized adequately are much more likely to pup. In addition to normal fertilizers, you can also use chemicals like BAP (6-benzylaminopurine) or GA3 (gibberellic acid) to induce pupping.

Personally, I like to provide a wide range of nutrients to make sure plants are healthy. A healthy plant will eventually pup and if you provide appropriate care you don't need to use fancy chemicals. Cytokinines are best applied as a last resort method. Some species rarely pup and in these cases it might make more sense to use chemicals. On my plants I use valerian extract, garlic extract, horsetail extract, nettle extract and they pup like crazy.

Removing pups

Personally, I like to leave pups on a plant until they reach a size of 15-30 cm. Plants that I really care about are usually left alone until they are too big to fail. Pups grow much faster when left on a plant, and the risk of smaller pups expiring is very high. If you want to remove pups from an infected main column, I recommend waiting until you know for certain that the main column is going to die. Even though pups are connected to the main column, infections rarely spread to separate pups. If I am using very rare plants as grafting stock, I wait until their pups are a size that can survive the rooting process, even though it takes nutrients away from the scion. Normally, I remove any pups on grafting stocks immediately.





The grafting stock I used on this graft is red flowering *E.macrogona* hybrid 'Amun-Re'. In this instance, I intentionally left the stock edges uncut because I wanted to both graft and get pups from the stock at the same time. This was not ideal, but I had no other grafting stocks and urgently needed to graft.







The image above shows one of my propagation stations. I first root the plants by putting them in propagation sand, before cutting off the tip to graft. I then give the cut trunks as much light, water and fertilizer as possible without causing an infection. A high amount of nutrients means plants will soon pup again, which I then graft. This method ensures that I always have plenty of pups available for propagation and helps rapidly produce a large number of bigger plants.



Sudden rib growth

Plants from the genus *Trichocereus* will often grow new ribs and this sudden appearance of additional ribs can look like monstrose growth. The following images depict examples of normal rib growth, demonstrating some common changes you might see in your own plants.



New rib growth on a grafted *Trichocereus tulhuayacensis*. New rib growth can suddenly appear and even disappear again. The number of ribs is not constant and can change over the life span of a plant.





Trichocereus thelegonus x Echinopsis eyriesii v.grandiflora hybrid growing a new rib.





This beautiful *Trichocereus* just developed a new rib. It is not a monstrose mutation, just a temporary rib change.





A normal day during flowering season. During this time, it is very important to keep insects out of your grow room. If not they might accidentally pollinate your flowers, and this should be avoided.



15. Treatment and prevention of infections

It is easier to prevent an infection than heal one. Prevention should be your first and foremost aim when growing cacti. Make sure to fertilize cacti as often as possible without turning them into distorted steroid monsters, use a good quality soil that is mostly mineral and give your plants plenty of sun light, water and fresh air. If you follow these easy rules, you can prevent the vast majority of infections and I'd go so far to say that almost all infections are preventable. However, there are always cases that you don't anticipate. The following list contains some common techniques for for battling hardy infections.

Aluminium / silver spray

These sprays are not very good for the environment, but work great against infections. Aluminium and silver sprays helped me get some extremely hardy infections under control, and are products barely used by people other than veterinarians. You can usually get these sprays in apothecaries or online for about \$10 per spray can. They are a gray liquid that you can apply to plant wounds, creating a protective layer against infections while leaving the skin's ability to breathe intact. This function is important to understand because there are similar products that restrict airflow and cause fungal infections. Tree grafting wax is an example of a product that restricts airflow. Aluminium spray should NEVER be inhaled, so wear a mask when you apply it. I sometimes spray aluminium on sensitive cuts AFTER they've had a day to callous. Very rarely have I had an infection return after this treatment.

Tree grafting wax

Tree grafting wax can be used in a similar way to aluminium spray. I've often gotten fresh cuts treated with wax that looked great, but I have never managed to use tree grafting wax in a way that didn't end with an infection below the surface. The wax creates a closed environment and prevents fresh air from getting to the wound. Grafting wax might work if you let fresh wounds heal for a few weeks before application, but by this time, most wounds will be fine, even without a protective layer, making wax unnecessary. Aluminium spray is a much better product because it allows the fresh wound to breathe and heal.





Top: aluminium spray / bottom: tree grafting wax © Trichocereus.net



Heat treatment

Heat is a risky way to treat infections. Almost all pathogens and infections are vulnerable to heat, but there's a limit to what a plant can take and infected plants are already weak. The higher the temperature the higher the risk for the return of fungal infections, but this is only a problem if there is enough humidity for fungi to grow. If you reduce the air humidity substantially in combination with providing heat (a dry heat, like that of an air dryer, electronic heater or food dehydrator) you can cause a wound to heal before an infection comes back.

LED lamp treatment

I use a cheap 45W LED panel placed directly onto freshly cut wounds. The combination of bright light and heat will usually burn away any pathogens present on the skin. It can also be used to stop infections that were going on for quite some time. As someone who sometimes buys cuttings in late summer or early autumn, I am very happy that I came up with this technique.

Please note that there are lamps (like HPS lamps for example) that get too hot for this treatment, but most cheaper LED panels will work. The strength of these LED panels is just enough to place them directly above the plants without causing burns, while still cooking pathogens. I use this for extremely rare plants or plants where an infection occurred after cutting or grafting, and this is the first time I'm sharing this method. I know there are a lot of haters out there, but this seriously works and I wouldn't use it if it didn't. LED lamp treatment also works with plants that suffer from repeated infections.

Safety note: This is an experimental technique. All safety regulations need to be followed, and under no condition should you leave the lamps unsupervised because the heat generated in this technique may constitute a fire hazard.

Fresh air

Fresh air has already been mentioned as a strategy to avoid infections, but fresh air is also crucial to promoting a healthy wound-healing process. Every cactus grower needs to watch the environmental conditions in their greenhouse or grow room like a hawk, and be in total control of the environment. If you get an infection inside, the first thing to do is provide fresh air.



Sunlight

Just like fresh air, the sun is a healer. Sun dries infected wounds and kills pathogens before they can take hold. When I have a fresh cutting that is infected, I place it in the sun to make sure it gets lots of light and dry heat and will avoid getting it wet. If you have an infection inside a sowing container, take off the lid and put it into the sun. The fresh air and sunlight should kill the pathogens inside the container.



This plant is getting full sun all day long, and loves it. Plants from the genus *Trichocereus* provided they have time to acclimatize.



Fungicides

There are many different fungicides that can be used to control infections. More details are provided in the chapter on fungicides.

Hydrogen peroxide

Hydrogen peroxide works just like a classic fungicide, and it's a great tool to kill pathogens and disinfect sowing soil, water or your plants. If used in concentrations of 1.5-3% hydrogen peroxide should not cause any adverse effects.

A growlamp directed at the wound

Just like the beneficial effects of sun light, you can use a strong growlamp or UV lamp to get infections under control. Just place the lamp above the infected wound and allow it to heat for a few hours. Be careful not to cause sunburn. On the photo below, you can see a wound treated via a 40W LED lamp pointed right onto the wound and it stopped the infection instantly.



This *Trichocereus* suffered from an aggressive infection and it took various weeks to end it via the LED tek.



16. Rooting

I've heard all kinds of things about rooting and people are usually very quick to recommend their own rooting medium. I think it's important to have tried rooting in various types of soil before judging a medium. It can take years of experience and a long list of both failures and successes to find the formula that suits the climate you are working in. Sometimes, a certain soil works very well in an extremely dry or hot climate, but is too organic to be used in a humid and colder climate. Where I live, very coarse sand has proven to be most reliable for kickstarting root formation, avoiding fungal infections and resisting pests like root mealies. Very fine sand is not perfect for rooting because it does not provide enough stability. Fine sand will work as a short-term medium and is probably even better than peat-rich mixes, but it just isn't ideal. Coarse sharp sand outperformed finer particle size in every single one of my tests.

In my opinion, coarse sharp sand is the gold standard for rooting and there are many situations where it brings the best results with a very low failure rate. Sand dries extremely fast and can rarely be overgrown by moss unless it's excessively wet. This is a major plus because moss and algae trap humidity below the surface, which can then lead to fungal infections. Fungal and

bacterial infections are the main enemies of a cactus breeder trying to root plants and it is best avoid them like the plague!

You can also root in lava or pumice, and they are second and third on my list of great minerals to root in. I've also seen people use commercial mineral mixes sold for birdcages as rooting medium. These products often include crushed mussel shells and which is mildly anise. antibacterial and antifungal. Both of these additives can help prevent infections in your rooted plants.







A large *Trichocereus terscheckii* rooting in very fine quartz sand. These giant cacti often take years to root.







Species that root poorly

There are certain species that are extremely difficult to root, especially when it's a mid-cut instead of a tip. *Trichocereus terscheckii* is one such species and I recommend using a rooting hormone to encourage them to produce roots. Species closely related to *Trichocereus terscheckii* like *Trichocereus pasacana* and *Trichocereus werdermannianus* can be equally problematic. However, there are some slender forms belonging to these two species that are easier to root. If something does not produce some roots within one year, using a hormonal product is highly recommended. Some such products are called Clonex and Rhizopone.

Problems during rooting

Many things can go wrong during the rooting process. The following list describes issues that can occur during rooting and accompanying strategies.

- Infection, bacterial or fungal. Checking fresh cuts regularly is a must. Don't disturb them
 regularly as this keeps plants from rooting properly, but if you see discolorations
 emerging from below you need to remove the plants and inspect the problem ASAP.
 Superficial infections that don't weaken the skin are not something I personally care
 about. Strategies for differentiating superficial forms of systemic infections were shown
 earlier in this book.
- Plants not rooting. Rooting often takes time and I usually wait at least a year until I intervene in the rooting process. If there are still no roots showing after this time you can either graft the piece on a very strong growing stock, apply rooting hormones, wait another year or throw the plant into the trash. It really depends on the plant and how much time and work you think it deserves.
- Visible signs of dehydration. This could be a big problem because it means that the clock is running against you. You should not cut dehydrated plants, and even for well-hydrated cuttings there's only a certain period they can survive without ingesting water and nutrients. Once you go substantially past that window, you can lose the cuts at any time. They get more and more dehydrated, change their color to a pale yellow and die off. The more dehydrated your cuttings are, the more dangerous it gets. Treatment is simple. Slowly but steadily water and fertilize the plants, even if they do not have roots. Just make sure that the soil does not stay wet all the time and has time to dry up in between watering cycles. It is best to use a fertilizer that makes it through the skin, as done in foliar feeding. Never graft an already dehydrated cutting unless you see no other way. Dehydrated plants have a much higher risk of death during grafting. A better approach is to rehydrate them over time and graft them later.


- Sunburn. Tough shit. Better luck next time! Jokes aside, all you can do is hope it heals as it grows out over the course of the following months. Very badly sunburned plants don't make it, so better to avoid a sunburn before it happens.
- Frost damage. Better luck next time. Frost damage is very dangerous and once you can see the cuts changing their color to black, there's no coming back.
- Overwatering. This one is easy. Take your cacti out of wherever it is and put it somewhere well-draining, like you should've done earlier. If you root in sand, overwatering should rarely be a problem. If you are rooting your plants in peat or pumice...don't. I explained why not to root in peat and pumice in the previous chapter. Anything that takes time to dry invites rot. This is especially problematic when you run into an unforeseen problem and want the soil to dry up NOW. The only real reason for using peat or coir as a rooting medium is when you live in a super-hot and aggressive climate where rooting in sand causes dehydration. If I lived in such a climate, I would still use pumice and lava. Both can store nutrients and water, without being hard on the roots, while also drying incredibly quickly.





Preparing a rooting field

In this chapter, I discuss establishing a very basic rooting field. I use fields to root a larger number of grafting stocks at once without having to pot them all up before grafting. Doing a few hundred grafts a year in a greenhouse requires too much space and work. The natural sandstone sand in my area works great for rooting cuttings and I will never use anything else for rooting again. It really depends on the type of soil that you have, but most types of coarse sand will work for rooting. The medium can't be too organic because organics trap water for longer than the unrooted cuts can take. The area of your rooting field should be completely devoid of weeds and receive sun all summer long.



This is a basic rooting field in front of my greenhouse. It gets full sun all day and is completely exposed to the elements. This field works great because the sand does not stay wet long.





Cuts need roughly two months to develop roots, so be prepared.





Make sure to take straight cuts that are easy to graft on. If the cut surface isn't flat, it will not be easy to use as a grafting stock. Balance, contact and pressure are very important when grafting.



19. Useful tools and little helpers



I use the grabbers pictured in these photos to handle my cacti. The grabbers are sold as mason jar holders, but they are a great help for handling cacti without ruining my hands and are irreplaceable in my garden.





Potting up, pots and soil

Potting cacti is a complex skill. First, you need to find the right soil. I personally like using pumice for my cactus soil and you could use it right out the box, if you have nothing else. I like adding coir and lava, but the latter is only usable as an additive because its sharp structure is bad for roots. No matter what you use, make sure your medium has the right pH level. Some pumice has completely the wrong pH and growing in it would probably work out very poorly. The pH of the soil should be between 5.5 and 6.5 and everything outside this range will produce suboptimal results. Particle size is equally important and it's best to sieve out fine dust to prevent clumping. The perfect particle size is somewhere between very small (0.5-1 cm) and large (2-3 cm). Larger particles can be placed at the bottom to provide drainage, but I really try to provide an even and balanced mix between medium sized pumice, coir for structure and a bunch of larger particles for drainage.

Make sure to get yourself a grabber tool or something you can use to hold or move spiny plants. It is helpful to get yourself something you can use to lean the plants against, such as a wall or a large heavy flowerpot. Old soil and dead roots should be carefully removed. If you cannot get root stock out of a pot it can be necessary to destroy the pot. This is obviously more affordable if you are using plastic pots, but sometimes it is necessary to go full hammer time on a clay or porcelain pot. Then you get a bigger pot with a layer of larger sized particles at the bottom, put in some of your medium, put the root stock on top and fill the remaining space up with more medium. Make sure that the plant is straight and doesn't fall over the first time you're watering. Very often, a stick or metal rod can be helpful to stabilize a large plant that was just repotted. After a year or so, you can then remove the stick again.

I will stress again that it is important that soil has neither too much nor too little drainage. If the water runs right through your soil it is unsuitable, and the same if soil stays wet for too long. In my greenhouse I have a few potted plants that are in extremely fast draining soil, and they are a lot less likely to flower than the others. Plants need a little time to take in water and nutrients and if it's gone too fast they stay hungry and thirsty. Plants from the genus *Trichocereus* will probably survive and even grow healthily, but will not thrive as they would have in better soil with a smaller particle size. Again, it really helps with flowering if your plants have a day to take in the water you provide. If it's gone within an hour your soil is draining too fast.

The following chapter outlines how I am potting my cacti and provides some tips for potting efficiently.



20. Soil recipes

In this chapter you find a selection of soil recipes from members of our Facebook group at <u>https://facebook.com/groups/trichocereus</u>.



- Marvin Eckhardt

Two parts horticultural soil (largely bark compost, this has to be aged or stored for a prolonged period so fermentation is already finished) one part sand, one part loam or garden soil, one part perlite (all by volume)

- Ron Hobbs

Two parts organic soil with worm casting, one part turface, one part Perlite, one part sand. I live in Missouri so we have hot humid summers, my cactus thrive outside during those periods. Our winters are cold and frigid, so I bring all in around Oct 15. I make sure that dry out completely before bringing inside, then only water 1-2X they out winter.

-Rosh Austin

40% fox farm ocean forest 60% chicken grit for tractor supply.

-Jasper Peeters

- 15% lightweight vulcanic rocks In Example: Pumice 0-16mm

- 15% heavyweight vulcanic rocks I.E.: regular 'vulcanic rocks' 0-16mm

- 5% crushed/partially powdered eggshells or other calcium rich shells (Musselshell, Oystershell, etc.)



- 5% ashes, I use a mix of woodashes, weedashes, incense ashes and charcoal ashes, but any ash you happen to have should do, as long as it's not from toxic materials such as painted wood

- 30% Compost, preferably home made from a mix of plant material and manure/poop (either from 'big' animals like chicken or rabbit or cow or horse, or small insects such as compostworms, mealworms, or escargot snails, any should work, really)

- And to finish it off, 30% organic rich potting soil

To add new nutrients next season or later (shouldn't be needed earlier if you used decent size pot):

add fresh homemade compost, crushed eggshells and some ashes

(and diluted urine for extra nitrogen, urine causes pups thanks to the Urea, dilute with coconut water to boost the amount of pups thanks to the cytokinesis)

and every few years some new Vulcanic POWDER

Greenhouse, The Netherlands, Europe. Full ground (removed the top 30cm soil inside greenhouse and replaced with this mix) & pots

Start keeping dry/stop watering in October. If grown in pots outside greenhouse, move inside greenhouse in October.

Keep dry throughout winter, start watering (while they're inside the greenhouse) around the end of March again

Optional; cover pots with Diachomaceus Earth

Recommended: put a tiny little bit of mycorhiza in with each plant's roots when potting them up into the new soil mix

-Edoardo Mng

70% pumice, 30% lightmix (zone 8b)

-Jordan Maddox

25% regular potting soil, 25% perlite, 20% gypsum, 5% dolomite lime, 15% pea rocks, 10% blood meal, plant tone and fish emulsion.

Heavy top coat of gypsum.



It's very humid in north carolina, and with this mix I usually water 2+ times a week and they LOVE it along with mother nature's showers.

-Matt Flamang

50% Fox Farm Happy Frog 50% pumice or perlite. A handful of worm castings and a couple handfuls of Dr. Earth 5-5-5 granules. Mix well. This has worked in Northern California, Southern California, and Arizona.

-Graciano Cruz Arauz

30% river sand, 30% forest black soil, 25% bokashi (I make this myself and will share the recepie is someone is interested), 5 to 10% micelium colonized oak leaves from the same forest I get the soil, 10% worm castings. Climate= Central America highlands, summer between 16C to 30C, a lot of rain and humidity. Winter 3C to 18C, dry and cold. 2200 meters altitude

-John Jaquez

6 part ocean forest, 3 part perlite, 3 part pumice, 1 part worm compost, 1 part horticultural sand

2 tbsp azomite(rock dust)

Sand and worm castings optional and pumice is substitutable with perlite if not accessable.

Zone 9b East Bay, Bay Area, California

-Travis Bryant

Melbourne Australia, temperate oceanic climate. low humidity, hot dry summer

Tried many and the best and easiest has been:

3 parts good qual potting mix

1 part Medium/coarse grade perlite

1 part fine scoria (or other finer minerals 5-7mm)

handful of worm castings

-Patrick Noll

My personal soil mix consists of consists of 80% pumice (0.2-1 cm) and 20% coir or sowing soil. The latter make the mix more stable and improve root formation. Some ingredients for cactus soil have a roundish structure, and this can be problematic for little seedlings. I have also added lava to my mixes from time to time, but I stopped doing it lately because pumice is just so much better



than lava. My climate is very cold with minimum winter temperatures down to -15°C. Using pumice as main ingredient has proven to be most reliable in a climate this cold.

I will update this chapter with additional recipes from time to time.





21. Liam Engel's Coke bottle tek

The coke bottle tek is an adaptation of the takeaway tek. Coke bottle tek was originally developed by Halcyon, authored by Liam Engel and published by Entheogenesis Australis. The strategic use of double flanged plastic bottles offers a number of advantages over takeaway tek, including increased space above soil level, increased soil depth, a pre-set reservoir depth for wicking as well as improved access and recyclability.

Equipment

- Two identical, double flanged, PET plastic bottles
- Soil or growing medium
- Mulch or wood-based potting mix
- Scissors
- Metal skewer, knife or other sharp poking implement
- Seeds
- Spray bottle
- Rinsed sand or zeolite (optional)

Method

1. Use your scissors to cut the labels off the bottles. Discard the labels.

2. Pierce small 2-4 mm drainage holes ~4-5 cm above each indent at the bottom of one bottle (5 holes total).

3. Pierce the bottle used in the previous step \sim 9 cm from the top (just above the top flange).

4. Pierce the other bottle ~12.5 cm from the bottom (just above the bottom flange).

5. Cut around each bottle in line with the piercings you made in steps 3 and 4. When cutting a bottle, cut the lower side of the bottle using the top blade of the scissors, rotating the bottle with your other hand to keep your cutting hand stationary.

6. Place mulch or wood-based potting mix in the bottom of the bottle so it fills to just above the drainage holes, aiding the wicking effect.

7. Fill the plastic bottle with your growing medium to 12-15 cm from the base. Rinse deeply to saturate the potting mix and fill the reservoir, in preparation for sowing.

8. Place a top layer (~1 cm) of rinsed sand or zeolite on your growing medium if you have some. This provides an additional barrier to infection.



9. Place seeds on the top layer of your growing medium.

10. Thoroughly spray seeds with water.

11. Attach the terrarium lid by inserting the lip of the smaller bottle half inside the lip of the bottle you just filled with water.

12. Place under shade cloth, filtered lighting or other appropriate light source. Use of a box is recommended for multiple terrariums.







All photos and text in this chapter © Liam Engel





THE GENUS TRICHOCEREUS

This book is the result of my ongoing work as a botanist and cactus grower and focuses on the genus *Trichocereus*. It has been a work in progress for five years and will be published in the coming years. The book offers descriptions, photos and information concerning the genus *Trichocereus*. I have included never before seen pictures of rare plants and the book represents a perfect mix between classic descriptions and new high-quality pictures.

Preorder THE GENUS TRICHOCEREUS via <u>EG@trichocereus.net</u>. We're seriously thinking about only printing as many books as are preordered, due to the extensive printing costs of this massive book. Get in touch if you want to be put on the preorder list.



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