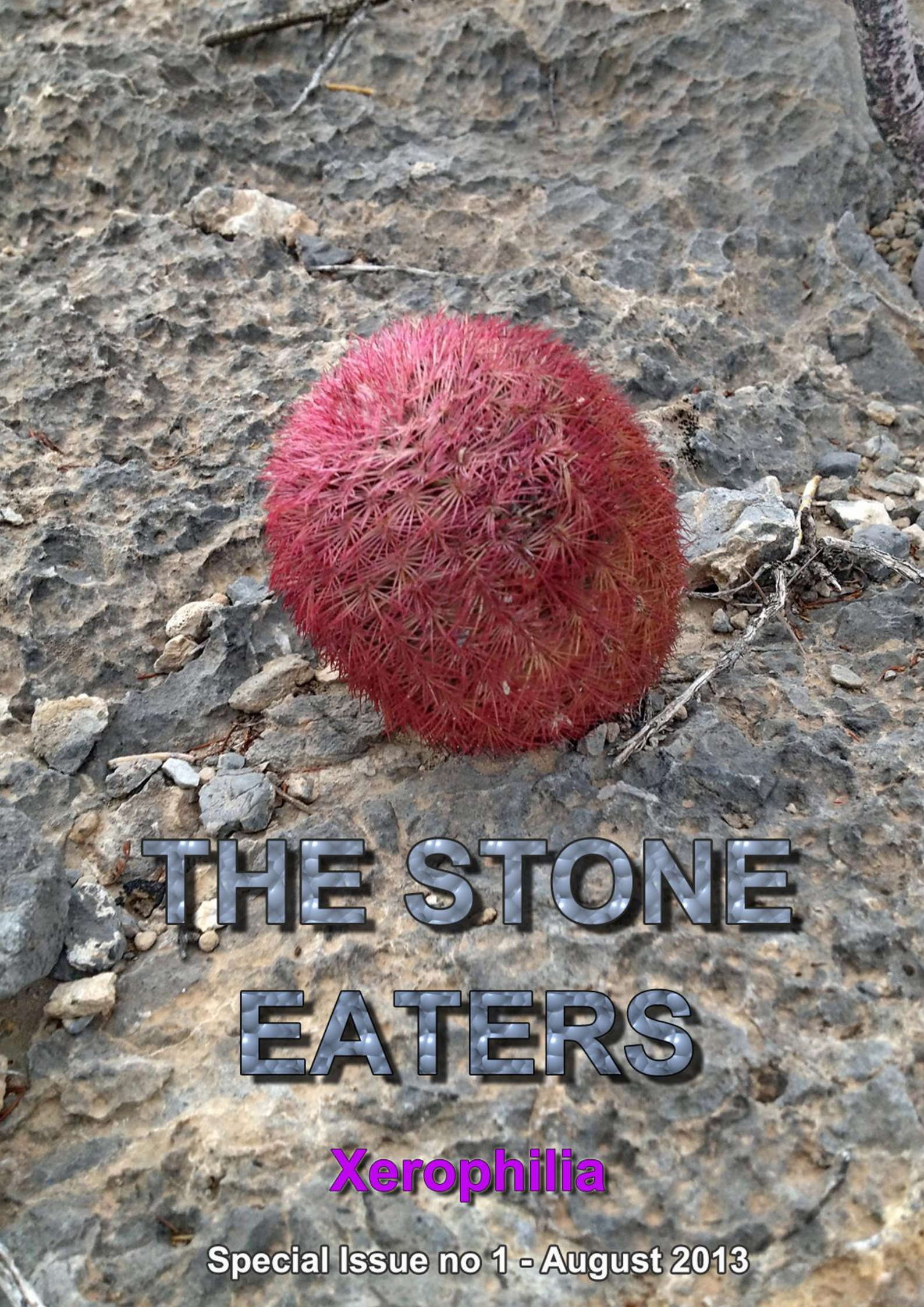
THE STONE EATERS
Xerophilia
Special Issue no 1 - August 2013

Summary

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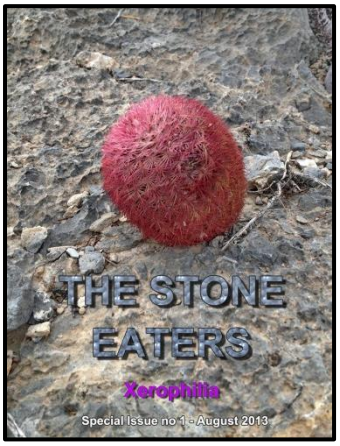

Front cover: ***Echinocereus rigidissimus* ssp. *rubispinus*** (Photo László Barta)

Back cover: ***Thelocactus heterochromus* – Minas Navidad** (Photo Grzegorz Matuszewsky)

Xerophilia

The passion for cacti and other succulents

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Articles and other contributions, photos or other materials are always welcome! Please send them to the email address below. The Editorial Team will examine them carefully and decide on publication in one of the upcoming issues. The next issue is scheduled to appear on September 30, 2013.

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***Thelocactus bicolor* ssp. *bolaensis* 'wagnerianus' - Parras, Coahuila Photo C. Perez Badillo**

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The Stone Eaters

by Dag Panco, Bucharest, Romania

Summary

Fig. 1 *Ferocactus lindsayi* – Michoacan Photo L. Barta

All truth passes through three stages:
First, it is ridiculed;
Second, it is violent opposed;
Third, it is accepted as being self-evident.
(Arthur Schopenhauer)

Reader's advisory

Due to the structure of the article, illustrations it will be concentrated in certain sections. Photos of plants in habitat that have been chosen to illustrate this work, were selected from among those species more commonly found in collections, thus avoiding intentionally, with a few exceptions, to present some plants from the genera considered difficult and which are commonly covered in books as those requiring mineralized soils. If the reading of the document will be carried out on-line, most of these photos can be seen at their maximum resolution, through a single click on the desired photo. Also, the notes in this article are built on a system of linking of the front-back type, so after reading the note that interests you, you can return to where you left.

Introduction

In December 2006, I decided to make public on the website Cactusi.Com the conclusions of several years of experiments. I relapsed in February 2008, by translating the text originally in French, and publishing it on the website Plantes Grasses. In the same era, Eduart Zimer, the Editor of ***Xerophilia***, shared the text translated into English, with various interested circles. After a while it was made available for download as a PDF document, on the website Cacti Guide. In 2011 an advanced form of the article was printed in the Hungarian magazine Debreceni Pozsgástár, illustrated with pictures by Cristian Perez Badillo and Toth Norbert, in the translation of Levai Magdolna and Levai Melchior.

Now, in 2013, after several revisions, additions, and sometimes simplifications, after adding explanations requested by readers, I publish in this first Special Issue of the magazine ***Xerophilia***, a completed form of the Soil Hexalogue. The article is aimed at all those who want to cultivate their plants, addressing the phenomenon in an entirely new manner, the only way that I have come to believe truly fair.

The starting point of this work lies in searches generated by my own concerns, from the beginner that I was in 1975 to the passionate I became several decades later that I spent among plants. The experience of the collector, synthesized in the cultivation of his plants, starts largely from their soils, since the substrate is a requisite to the great majority of the representatives of the plant world. Not being an exception, I was forced to look for soil formulas and to prepare soil mixtures. As the years passed by, seeing that I have successes, some of the collectors have begun to want to prepare their mixes following my "method", as I started once, by preparing them following or inspired by the "methods" used by others.

By giving answers, and sharing recipes as well, writing posts on forums and websites, I've found that I cannot formulate a valid concept, although I thought I master well the problem. Although the questions were punctual, I realized that my response was insufficient. And an incomplete response cannot be useful to those who seek to be guided. I started to get frustrated. Then I rebelled against myself, seeing that I fail to define in clear terms principles to believe in and to consider valid, in the light of the experience gained.

I ended up realizing that when one cannot produce a clear cut definition the concept he's presenting, it simply means that he does not know what he talks about! In other words, I understood that before giving advice to others, I have to learn myself must why I do the mixtures in a certain way and not in another, and especially to make sure that what I am doing is right.

Thus, I sought and I asked myself questions that, ultimately, have coalesced around two findings:

1. Every "cactus enthusiast" has its mixture which, always, is the best and the only one that is good, which demonstrates the inconsistency of the statement;
2. Every time I had to prepare a new batch of mixture, it was more successful than the previous one ⏩ which shows how approximate can be the approaches regarding this subject.

The two findings pushed me from the stage of interior interrogation, to the need for an experimental phase. So I went to the facts. Using plant batches and exact soil recipes, I started with the easy species, moving on to more demanding species and finishing with those seemingly "impossible" for many ⏩ the species that many grow, for safety reasons, only grafted.

Searching and searching, I have come to discover an amazing, but true response. Once found and grasped the concept, I was not surprised to see that I can now summarize premises, definitions and a number of laws: the six general basic laws of the soil for *Cactaceae*, **The Soil Hexalogue**.

Before sharing them with others, I learned two things, however. The first was that I have to forget all that I knew and all I have learned about this topic: in order to succeed I had to start from scratch.

The second thing was that I entered into the world of **The Stone Eaters**!

Fig. 2, 3 *Notocactus neobuenekeri* KCS-0163, Rio Grande do Sul, Brazil. Photos C. Kádár
How many growers of this South American species would have thought that they have to face a stone eater ...?

The Laws of soil preparation

"The more northern the origin of the species, the less organic components the soil should contain."
("Coryphantha" by R. Dicht & A. Luthy)

Assumptions, definitions and rhetorical questions

The first assumption

It is considered plants are watered using only rain water, demineralized water or with the water produced by reverse osmosis, otherwise carbonates and sulfates present in hard water can intervene, through accumulation, in the sense of modifying the pH of the mixture.

NOTE ⏩ water pH **(1)** and hardness **(2)** are totally different concepts!
ATTENTION! The build-up of salts in the soil, in time, largely due to hard and/or highly mineralized water, will change the pH of the mixture, depending on the accumulated salts! ⏩ regardless of the soil components used, it will be transformed into an unusable mixture. Such undesirable water has hardness greater than 15 dGH, e.g. for Romania: tap water, spring water, or fountain water.

The second assumption

It is not the same thing, to plant a cactus in a pot or to leave it grow in natural conditions! Not only plants in pots are captive, but also their soil is captive and, therefore, you cannot compare the reactions of the soil in pots with the reactions of the "free" soil.

NOTE ⏩ by natural conditions we mean habitat conditions... or at least permanent planting conditions in the open or in a huge amount of mixture, prepared from tons of materials.

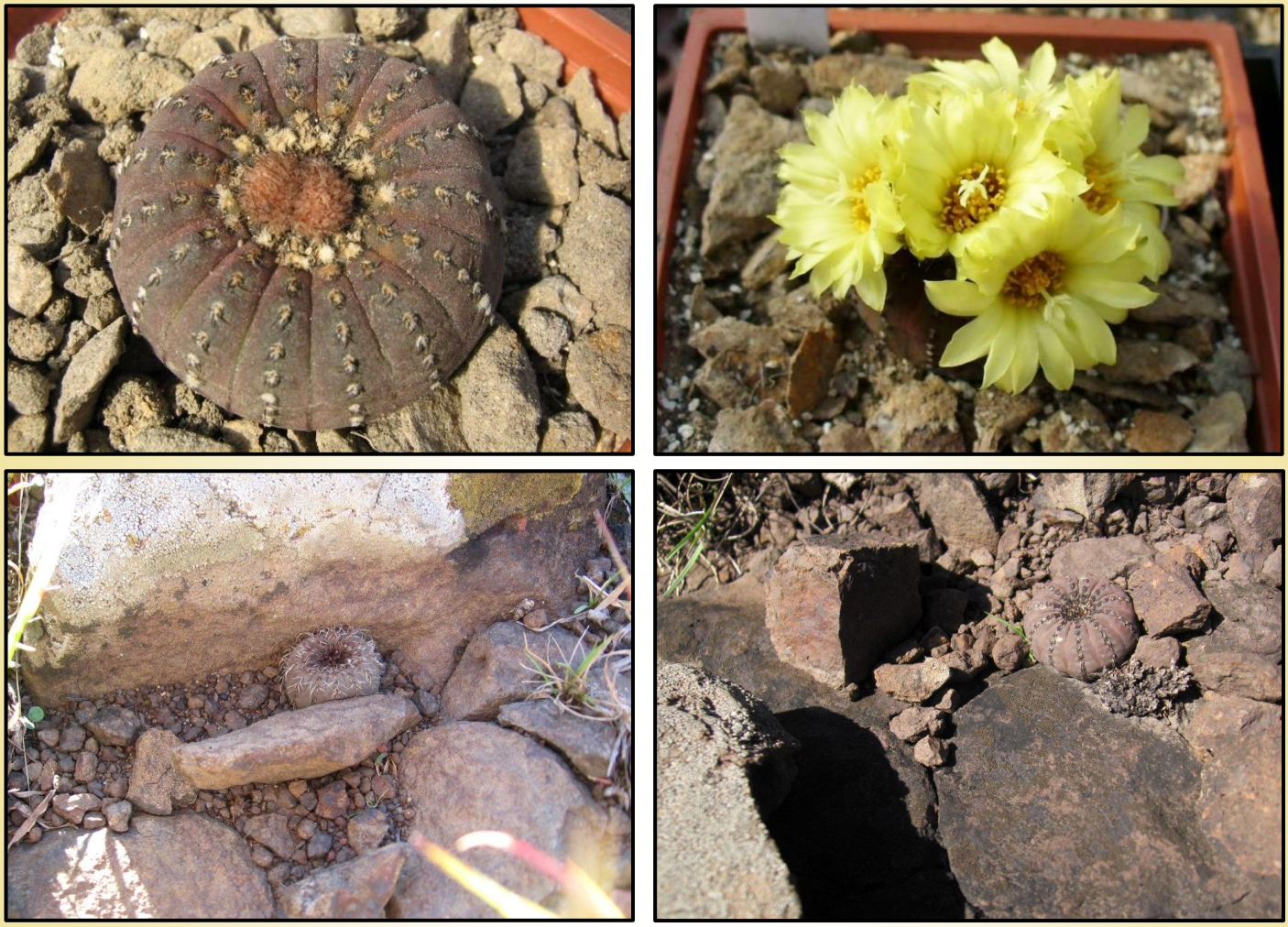


Fig. 4 - 7 *Frailea castanea*, a plant that loves to grow on mineral soil.
In cultivation - photo D. Panco and habitat - Salto and Artigas, Uruguay, on basaltic rocks - photo R. Garbarini Salgado

The first definition

In the spirit of this article, the mixture of mineral elements, of natural origin or produced by processing natural mineral components, proper to the cultivation of plants, and which exclude from its composition the elements derived from vegetable or animal breakdown, is named hereby mineral soil or mineral mixture.

NOTE ⏩ in the spirit of this article, a mixture containing at least 1% materials resulted from vegetal breakdown, is no longer a mineral soil. Therefore the use of the term "100% mineral soil" is a pleonasm.

The second definition

In the spirit of this article, the mixture of elements resulted from vegetal breakdown and mineral elements is called organic soil.

NOTE ⏩ a mixture in which the proportion of mineral components is greater than 60%, is commonly called - in the specialized literature on cacti and succulent plants cultivation – as being a mineralized mixture, dirt or soil. According to the first definition, and in the spirit of this article, it is also considered an organic soil!

COMMENT ⏩ the above two definitions were necessary, since they define concepts different to those found or defined in pedology (soil science) works. Thus, in the pedologists' (soil scientists') language, the term "mineral soil"

(3) refers to something else ⏩ the pedologic term, closest to that of the above definition, is "inorganic soil" (3). This time too, it is an approximation, to the extent that inorganic soils in pedology may still have organic components, however, as happens everywhere in nature. Equally, pedologically speaking, organic soil (4) is defined differently than in this article. After defining the terms used in this article it becomes necessary, in order to be able to understand the importance of this work, to find the answers to a set of two rhetorical questions.

Fig. 8, 9 *Mammillaria perezdelarosae* ssp. *andersoniana* - Villa Garcia, Zacatecas, Mexic and *Mammillaria theresae* – Paso de Coneto, Durango. Photos L.Barta and C. Davies. Can be compared the needs of these plants with the needs of a tulip?

The first rhetorical question

⏩ Why is it so important to *Cactaceae*, this feature in regards to the soil mixture?

The answer may seem amazing ⏩ Because the most important organ of a cactus is its root system.
Except for rare cases of sudden and fatal fungal attacks, coming from the meristems, all other serious fungal attacks resulting in the loss of our plants commence from the roots.

On the other hand, if one plant becomes very robust and vegetates correctly, having abundant flowers and during the adequate season, this largely is due to a healthy and strong root system.

The collector has, thus, the interest to foster the increase of the root system, before being concerned about the development of all other parts growing above the ground. Once the root system is well developed, the plant will operate all by itself in the direction of a necessary and sufficient development of the whole of which is formed within the limits of the living world, which means harmony. Furthermore, even this tendency of the plants to prioritize ensuring a strong root system, shows clearly that plants need it.

Fig. 10 *Echinocereus stramineus* - near Parras Junction, Coahuila, on limestone-gypsum. Photo M.A. Gonzalez Botello

Therefore, the soil being the environment of the roots it becomes one of the five crucial elements in cactus culture, along with water, light, ventilation and temperature.

Of course in the lines above, I turn to collectors, referring to plants grown in decent environmental conditions and not to plants held behind the curtain or on the desk ⏩ those being tortured and condemned to certain death, regardless of the substrate. To the same extent, this article does not address producers, for which these methods are counterproductive.

Fig. 11 *Escobaria* - Castaños, Coahuila Photo R.D. Raya Sanchez

The second rhetorical question

⏩ Why do we always have different problems with the soil mixture we plant our cacti in, always seeking a better one??

The answer is, at first glance, as simple as it is difficult to perceive ⏩ we have problems because – instinctively – we see cacti as normal plants, as are all those that surround us and which we are accustomed to. Cacti are, however, entirely different.

Our judgment slip-up is based on the origin of the information we have received. The reverences we have for printed paper prevents us from easily understand this. For us, printed information is provided by "scientists". In fact, things are totally different: botanists, biologists, microbiologists (all scientists) do not cover plant cultivation at all, but study them from the botanical, ecological, biological, microbiological point of view, in their habitat, in greenhouses and laboratories. So, as a result, scientists write articles, but not manuals of culture.

The known cacti books have, in most cases, the cultivation advice chapters written by... professional growers: "the Gardeners".

"The Gardeners" who received or collected these plants, have introduced them first in greenhouses, as curiosities at first, and later on as potential sources of profit. They have acclimatized them harder or easier, according to the species and its origin, and then began to grow them, either directly in the ground, potted or grafted. They still grow them today, as consumer goods. Seeing that there is a market, naturally, they sought to create a phenomenon. Therefore, in order to sell better, they have written books or participated in writing books on the topic, developing in these contributions, the recipes of their own experiences, as incontrovertible and universally valid truths. Not only that these truths are not universally valid, but even – in regards to the soil mixtures – they are not true at all.

Fig. 12, 13 *Coryphantha macromeris* - Sierra Mayrán, Coahuila, on colluvial soil (5) Photo M.A. Gonzalez Botello and *Mammillaria pectinifera* - Tecamachalco, Puebla. Photo L. Barta

The Gardeners' point of view and their cultivation behaviours were transmitted from one to the other, from father to son, from generation to generation, from master to apprentice for almost two centuries. Then came hydro cultures, and with them the genial solution of the neutral and spongy substrate ⏩ peat, coconut fibre, inert granulation. The substrate is neutral and it does not generate problems. You water whenever you want, as many times as you want, adding the nourishing supplements you want. The plant grows as a Prince Charming. Since that time, the Gardeners have never had a reason why, nor how to think ahead to what a cactus actually is. And this is normal, as long as they either grow a *Melocactus*, whether it is a *Primula*, whether it is a trivial *Euphorbia pulcherrima*, the substrate no longer differs or matters! This is how it works well for them, how they produce, how they make any profit, how they continue doing it, without having reasons to change their way of cultivating cacti, although more often than not, their plants look like small melons or like cucumbers, green, very green and very fat and seemingly very, very well-fed. Mass-produced plants differ so much from those in nature, that sometimes even experienced collectors may not recognize the species.

When we grow them in pots, we all forget that they are the inhabitants of extreme environments, and they have a metabolism (CAM) which is totally different from most of the plants that surround us. Although we know that they have gas exchanges at night and not during the day, far from the burning Sun, which scorches, burns and dries out everything during the day, we want them to behave – in all other aspects – like the plants we see around us, since we were kids!

Even now, paradoxically, although cactus growing became a worldwide spread hobby, we see that the advice given now in cactus books do not differ much from what we could read in books written forty years ago.

In all books we find the same quintessence of recommendations, with small variations in form, but with an essentially unchanged content. Following this trend, we – the enthusiasts – have been taught to see xerophytes like normal plants, respecting the laws of ordinary plants, as we know them. But fact is that ordinary plants (the so-called house plants) need rich soil, fertilizer and plenty of water. Therefore, constantly, when nursing cacti in our collections, we forget what environments they live in, even though we know this, even though the weirdness of their habitat attracts us to them.

Fig. 14, 15 *Mammillaria grusonii* and *Mammillaria lasiacantha* - Sierra Mayrán, Coahuila, on limestone-gypsum. Photos M.A. Gonzalez Botello

Most of us strive to learn how to water cacti, and in this context notion like *necessary* and *sufficient* play a special role. However, with regard to xerophytes, for many collectors, water – this engine of life – remains the image of the fatal error. Partially, true. Mostly, no. In fact, this is the very first thing that we are told... almost the only thing that we are told about cactus cultivation.

As soon as you bring up the topic about cacti, the "knowledgeable" in front of you assures you that they do not need water in abundance or that they need to be watered only every now and then. And, sometimes, us being told repeatedly this absurdity, constantly, obsessively, some of us go to the other extreme – which is lethal for plants – because we've got to be convinced that we should not water them.

By simply growing them, we do not realize that we must first have to take a fight with everything we have learned before, from parents and grandparents and, later, at school, in primary school. To succeed with xerophytes, we must forget that plants need a rich and fertile soil and that they need plenty of fertilizers in order to bear fruit as more and better. The line with the rich and fertile soil that is absolutely necessary to the plant and the line with the fertilizers that also wheat and beet, and maize and soy, genetically modified or not, need, seems to us, however – unfortunately – the obvious truth ⏩ but in fact both are some heresy!

Even more, we are told to use special fertilizers, and we, in our credulous naivety, we do so. We buy, without ever asking ourselves why the recommended fertilizers do not take account of the origin of the plant, genus and species. For all cacti the same fertilizer type is advised, although, on the other hand, agricultural practices are different - it is widely known that field crops are differentiated, depending on the soil type they grow on and varieties, and looked after much more rigorously. Are cacti less demanding than wheat, corn and beet?

Fig.16,17 *Mammillaria theresae* on limestone rocks in habitat, and in culture. Photos C. Davies and M. Crisbășanu

No, of course not, just they have different demands. For example, if correct soil mixture used, fertilizers are useless, or become even harmful, because adding them to a given soil fertility represents an excess. As you will see in section "Explanations", in the living world, any excess is a risk factor, even if it seems beneficial at first glance.

From all the treaties of cacti science and from the advice received from all cacti producers, we learn that the soil for *Cactaceae* is a blend of ingredients like: 33% coarse sand (or other similar ingredients), 33% leaf mould (or peat, black coir, or equivalent ingredients), 33% garden earth (or non-essential variations on the same theme). Depending on the grower, author or country, the principle of 3/3/3, however, is universally accepted.

At the same time – and from the same kind of sources – we learn that some species, the rarest or the more difficult ones, have to be planted in a mineralized soil (see notes from 1st and 2nd definition), but we are not told either what "mineralized soil" exactly means, nor the percentages of minerals, nor any other specifics are indicated.

What I consider to be a real revelation for me – after many years of experience and experiences – is realizing that the prerequisites of the gardeners are essentially wrong ⏩ therefore all our cultivation prerequisites are also fundamentally wrong ⏩ the prerequisites we used to share with others – especially with beginners, are wrong as well. And if we assume all this was wrong, what should be done?

Fig. 18, 19 *Thelocactus leucacanthus* ssp. *leucacanthus* - Vella Vista, Queretaro and *Thelocactus hexaedrophorus* - Peotillios, San Luis Potosi. Behold species that are generally grown on humus rich soils and with plenty of fertilizers, but are living in their natural habitat, as can be seen, among the rocks. These photos of C. Perez Badillo and P. Nájera Quezada are two examples in regards of the starting point of one who wishes to grow cacti with a similar aspect to those in nature.

Cacti are not – as backyard gardeners may think – plants that grow in the ground, like... roses. They are plants that – as we can see in most of the habitat pictures – grow between rocks. Cacti are essentially not dirt eaters so to speak, but are – first of all – stone eaters!

Starting from these findings, we changed the approach on soil mixture preparation: we are no longer required to ask ourselves what organic soil components, and in what proportion etc., do we need for our cacti, but we need to ask ourselves which of them need organic soil components... and if perhaps needed.
I know, it is hard to understand and feel it, but I emphasize, once again, that we have to forget everything and start from the scratch – because what we know does not fit with what we are looking for nor with what we will learn.

Fig. 20 *Turbinicarpus hoferi* **Photo C. Perez Badillo**

The six laws ←Back to summary

The first law

Always start with a mineral blend in which you add or not, organic ingredients, only and only if the cultivated plant needs it. NEVER start from an organic mixture which is mineralized, to accommodate the species' requirements.

At first glance, it looks like being the same thing, as long as – eventually – we mix mineral and organic ingredients with each other. Well, no, it is not the same thing! Why? Because the mineral elements and the rocks in the soil – against everything that is believed and known among the collectors – **act as nutrients in cacti cultivation**. However, their role is far from being just that of loosening and fixating agent for the mixture and/or draining material. In nature, the mineral mixtures are the basic component of the soils the overwhelming majority of cacti is growing on.

As I said above, I repeat, and I say once again: the vast majority of cacti are stone eaters!

How do they eat stone? It is true that they cannot do that on their own, but with the help of symbiotic bacteria that live in their roots, nothing stands in their way ⏩ the bacteria produce enzymes that dissolve the rock, while the plant is absorbing the necessary minerals; then it metabolizes them for itself and for the bacteria as well. And so, literally, they live happily ever after, feeding, also literally ⏩ from bone-dry stone **(6)**.

Fig. 21, 22 *Coryphantha nickelsiae* and *Coryphantha werdermannii* **Photos C. Perez Badillo**

Some cacti groups – not too many – that require something else, apart from the mineral soil. And even fewer are those that do not accept it. Epiphytic species, some very large sized columnar plants - *Carnegiea gigantea* and *Pachycereus pringlei* are nevertheless stone eaters – and some prairie cacti, or forest cacti, or those that grow between mosses, are those that absolutely require the presence of the organic component in the soil.

This organic component can be as low as only 10-15% (as with *Mammillaria senilis* – that, without humus into the soil mixture, does not bloom), to 60-80% the (as with *Stenocereus thurberi*) becoming therefore a major component of the soil mixture. Otherwise, most of the species grow on a mineral soil within the pedologic meaning of the word, i.e. having, in the habitat, traces of organic component of up to 5-10%.

Some cacti species thrive, however, incredibly well, on mineral soils, while others – strictly specialized – cannot live in captivity, on a different type soil other than mineral.

Do not confuse a mineral mixture with a well-drained mixture!!

The confusion between mineral /mineralized soil and well-drained soil, started also from books. This distinction between the two is rarely explained, although it is of absolute importance in the cultivation of *Cactaceae*. A minimal excess of water in the soil, can kill for sure a cactus, by rot rather than tearing it in two. Stem pieces can be rooted, rot can't!


Fig. 23, 24 *Thelocactus conothelos* ssp. *argenteus* and *Thelocactus multicephalus* - Aramberri, Nuevo León, on limestone. Photos M.A. Gonzalez Botello

As I have said, the mineral mixture – the one used in pots – has no components of plant breakdown. This does not mean that a mineral mixture is automatically a well-drained mix. Clay – for example – is a mineral element, but completely prevents a good drainage. Therefore, applicable to the conditions that a pot provides, a mineral soil with clay becomes, in time, lethal for a cactus. A well-drained mixture can have elements of vegetal breakdown or may consist of only such components. We can thus say that:

The third definition

The well-drained mixture is a mixture which has the capacity to let the water pass through easily – regardless of whether it consists exclusively of mineral components, of exclusively organic ingredients or from a mixture thereof.
NOTE ⏩ the drainage quality of potting mixtures depends only on the physical characteristics of the components used and the way they react in the mixture, whether they are resulting from vegetal breakdown, or are minerals.
This definition allows us to state the second law:

The second law

Mineral or organic, a potting mixture must be as well-drained as possible. Components like clay and structured soil (e.g. garden earth) impede the draining capabilities proportional with their weight in the mixture.

From these first two laws derives in a third one, with immediate practical effect:

The third law

If you do not know what type of potting mix your cactus needs, choose, above everything, a well-drained mineral mixture!


Fig. 25, 26 *Echinocereus stramineus* and *Epithelantha greggii* - Sierra Mayrán, Coahuila on limestone-gypsum. Photos M.A. Gonzalez Botello

Of course that the exceptions I have mentioned above will need to be considered: epiphyte cacti and those whose photos in the habitat show them growing in forests or surrounded by thick vegetation - for all these the soil mixture will include the necessary organic ingredients without any doubt. However, regardless of the cactus species, all soil mixtures we use will need to be well draining mixtures. And, in order to easily clarify the type of mixture assortment we have to choose for our plant, here is a fourth law that establishes this:

The fourth law

To know how to understand the best mixture for a plant, you need to know, at least from the pictures if not first-hand, its habitat.


Fig. 27, 28 *Echinocereus engelmannii*, Mojave Desert, South California Photos E. Roberts

We have to keep in mind, always, another particularly which is important for understanding xerophytes. These specialized land dwellers are found on a wide range of soil types, from wastelands to completely eroded surfaces, and are encountered even in extreme pedologic conditions, such as excessively calcareous soils. We will call the latter calcicole plants.

The fourth definition

Calcicole plants are plants "liking" limestone and support a basic pH of the soil from 7.2 to 8.8, produced by the presence of limestone.

NOTE ⏩ Bear in mind the term "to support" and that it describes a basic pH produced by limestone and not of other chemical compounds.

The fifth definition

Plants that do not support a basic pH of the soil from 7.2 to 8.8, produced by the presence of limestone, are called calcophobe plants.

Most *Cactaceae* accept a neutral pH, but prefer a more acid one, from 6.0 to 6.8, making it desirable not to fall below a minimum 5.8 for most species. The presence of limestone in the soil, depending on the amount, tends to drastically alter the pH, giving the mixture an alkaline pH, especially in confined environments like pots.

Another extreme environment is where soil salinity takes over. Some cacti live in the proximity of somewhat saline environments. However, in nature, when cacti are confronted with such influences, the amounts of salt in the solution that they are obliged to endure are relatively small, compared to the normal values supported by truly halophyte plants **(7)**. Some cacti, such as *Turbinicarpus lophophoroides*, are forced to stand floods with brackish water **(8)**. Other species grow on beaches or on the sand dunes still under the influence of sea water mist. However, these are exceptions and it doesn't mean that there are cactus species requiring salt for a proper cultivation! So, the use of salt (NaCl / KCl) – and not of salts generally speaking – is completely contraindicated. That is why using sand from the shores of the seas and oceans, can be dangerous especially for potted plants, by the fact that this sand can contain salt and, even worse, we may not know how much, because not everyone can afford special lab equipment to analyse the stuff. There are however solutions: people collecting sand from the banks nearby brackish, salted and very salty waters can remove the sodium, potassium and magnesium salts from those sands, by repeatedly rinsing with fresh water. There will be more washing cycles needed as the water has a reputation of being more salty.

Fig. 29 *Turbinicarpus lophophoroides* Two plants growing on saline soil, and other two on soil considered 'normal'... the difference is obvious – text and photo D. Rubbo

The first rule

In culture, cacti have not halophyte behaviour – they CANNOT develop properly in a salty environment! The use of salt can be only a practice for the purpose of research/experimentation and God forbid using it in cultivation!
I was saying the sand from the sea side is salty. However, most often it also consists of sharp split of shells or coral grinded in the waters, which means not only salt, but also calcareous materials will be added.

However, informed collectors, who have carried out experiments, are able to use with a great deal of success for their plants these rich in mineral salts "spices" – however, being and still remaining not recommended for beginners... especially since they are not really necessary.

As I was saying above, not all plants support limestone. Adaptation to limestone is an extreme specialization, sometimes even fascinating. But like any extreme, it can cause problems. Therefore, in order to avoid surprises, here is the fifth law of soils:

Fig. 30, 31 *Turbinicarpus krainzianus* ssp. *krainzianus* - La Ventana and *Turbinicarpus krainzianus* ssp. *minimus* - San Andres Deboxtha Photos G. Matuszewsky

The fifth law

No plant requires limestone in the soil! The grower may, however, need – sometimes – to add limestone in the mixture.

I will expand a bit the subject, not only because it is interesting, but also because it is very controversial, even among people who have a great experience in the cultivation of exquisite specimen cacti.

Plants that grow on limestone or calcareous soils are plants with a high degree of specialization, they gained a specific adaptation – they are resistant to the high alkaline pH of the soil. This specialization has helped them to gain an ecological niche, where they cannot be followed and fought by too many competitors. However, by becoming specialized, they have lost the ability to endure in a competitive battle – in common environments – with plants that do not have gained this specialization and, therefore, they do not have to compete with outside the areas they have conquered, i.e. in places they originated from.

When competing with other plants, there are of course species exhibiting a higher tolerance to limestone and a greater adaptability than others. The *Thelocactus* species are an interesting example in this regard, as they are found in various habitats, reaching from some extreme, to some more lenient and seeming that they grow equally well in all of these situations.

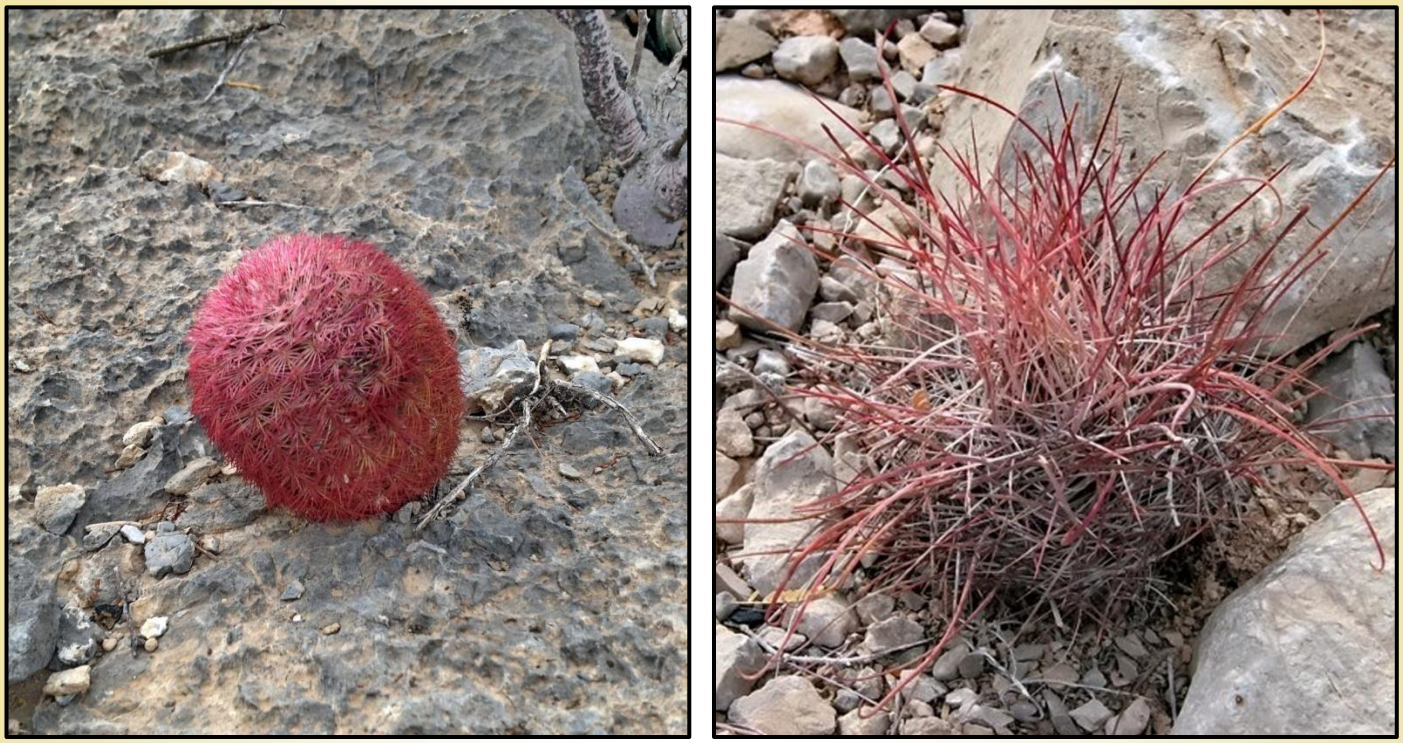


Fig. 32, 33 *Echinocereus rigidissimus* ssp. *rubispinus* and *Ferocactus hamathacanthus* Photos L. Barta

But the fact alone that certain plants feature such adaptability to alkaline pH, does not mean they do not feel great – on short and medium term – on rich soils having an acid pH. The problem that arises, however, is the aberrant growth that such a plant achieves in such circumstances. Why this growth? Simply because in the presence of an alkaline pH, conferred by limestone, this acts as a growth inhibitor.

Thus, no longer controlled by an inhibitor, the plant develops to its potential size rather to its natural one. Excessive growth – as though they were pumped up – leads not only to the loss of the specific appearance of the plants, but especially contributes towards their weakening in front of biotic and abiotic factors with which plants are in constant competition. This phenomenon of competition is more apparent in our pots, than in the wilderness which the species comes from. Under such conditions, the plants become unrecognizable, losing their compact form, the specific colours of the epidermis, the particular spination, etc. An injury heals much harder and infestation occurs more quickly. A mite or insect attack is more harmful, the epidermis being thinner and the cells more “fragile”. A

sudden and accidental drop in temperature is more unbearable, the cells of the plant being – even at rest – too turgid. An excess of water is more difficult to bear, because the root system is not properly developed. Sun exposure is harder to tolerate, because of the hypertrophied cellular mass and the sensitive epidermis. And examples may continue, being multiple.

Fig.34, 35 *Echinomastus mariposensis* and *Escobaria tuberculosa* - Coahuila Photos R.D. Raya Sanchez

Few growers say that plants need limestone. Most say that adding limestone into the mixture plant is stupid and – in an absolute sense – they seem to be right.

As living beings, it is true that the poor plants do not need – in any way – the presence of these limestone rocks, since they can absorb the necessary calcium supply from various other minerals. And yet… lime is recommended and is required, in the case of calcophile plants, so that plants do not look "skewed". Plants that grow in limestone areas are like natural "bonsai". Lacking in limestone, they become again what they could have been, and not what they supposed to be. They become plants with a spectacular development. However, for too many tens of thousands of generations, they are struggling with limestone in their environment and are, genetically, trained to grow in a certain way. If their environmental conditions are too lenient, growth becomes too quick and unhealthy, so the plant is becoming – and I say again – very sensitive and, as such, likely to be put down at first disease or parasite attack. You can easily make a parallel between these plants and farm chickens raised with hormones, so that in six weeks to be sacrificed. Those fowls would not be expected live another year if they continued the regime in which they are bred for consumption only, and therefore, breeders fowls are kept in different conditions and being fed completely different.

Fig. 36 *Echinocereus pectinatus* - Castaños, Coahuila Photo R.D. Raya Sanchez

Reassessing

For long-term wellbeing of the calcophile plants, the grower is required to inhibit their development, by adding limestone.

NOTE ⏩ largely, and without becoming a generalizing statement, South American plants are calcophobe, while North American plants are calcophile; of the North American plants, there are some of them that grow in near-pristine limestone substrates.

REMARK ⏩ in the author's opinion, plants in a cactus collection should look as close to their appearance in the habitat, which is a standard that has resulted from the identification and diagnose of a new taxon and then has been passed on to collected plants.

The above compels me to make an amendment to the third law, whose complete representation can be understood only now:

The third law rephrased

If you do not know what your cactus needs, choose, above everything else, a well-drained and limestone free mineral mixture!

a) If the plant "yearns", adds humus into the mixture!

b) If the plant "swells" too much – add limestone!

Fig. 37, 38 *Thelocactus hastifer* - Sierra del Doctor, Queretaro and *Thelocactus multicephalus* - Doctor Arroyo, Nuevo León
Photos C. Perez Badillo

The sixth law

The balance of a soil mixture is delivered both by the weights of the main mineral components – with or without limestone – and respectively of the organic ingredients added, and by the porosity of the whole, as well.

The elements of the mixture ←Back to summary

In order to be consistent with the sixth law, the mineral mixture must have components that make possible, on the one hand, to have a pH ranging from neutral to acid, and on the other hand, to assure a certain porosity of the mixture. We list the main rock types that can be either used or avoided. Artificial materials are also presented as they can be found on the market. Mineral soil components have been grouped into two indicative lists, taking into account their origin.

In many countries it is prohibited to collect soil, rocks and other soil components from the wild. Therefore, for every soil ingredient presented below, I will add info regarding the sources and where it can be purchased from by those who want to prepare their own mixture, being already obvious at this point of the work that the specialized soils in shops (the generic "Cacti and Succulents Potting Mix") is completely contraindicated. Due to both the diversity of the countries of origin of those who will read, and the laws and regulations that govern them, sometimes the sources are indicated in a suggestive way, such as deposits of construction materials or aggregate stations, which are likely to be the sought source. Where possible, I will provide commercial alternatives, these being, however, always very expensive and therefore prohibitive in the case of collections that surpass one hundred liters.

In regards to the organic material, I recommend – to those who cannot collect – to read carefully the article dealing with compost making, a compost specially designed for cacti and other succulent plants, written by E. Zimer – this being the optimal solution of replacing the natural soil elements, for those who have a backyard.

In line with this discussion, each rock presented here is understood as crushed – this being the optimal solution, taking into accounts the fact that the roots attach more easily to a rough surface with crazing, than to a smooth and polished one. Alluvial gravel type materials will be also listed and explained, but although they are useful to a certain extent, they must be always regarded as a last resort solution and only as a substitute for other desired materials. That is why all the soil descriptions which will follow tin the lists below are based only on crushed granularities. Chemical elements which are included in the composition of classic fertilizers, commonly known as NPK, will be put in brackets with their symbol.

Natural mineral elements

Andesite ⏩ is an extrusive igneous eruptive rock, which contains plagioclases (calcio-sodium) and ferro-magnesium compounds. The colour and texture may vary according to the deposit. Some collectors use it as main ingredient in soil mixtures. From my point of view, it is not an absolutely necessary, but surely it augments the mixture; however, if left out no soil deficiencies will emerge. The recommended granulation is between 2 mm and 8 mm. It can be found in aggregates used for roads construction or in quarries where crushed rock sorts are prepared on site. Fig. 39 photo C. Cristian.

Clay ⏩ is a sedimentary rock composed of silicates, mica and fine quartz sands. Clay is found almost everywhere and is very prevalent and comes in various colours. The best for our intended purpose is quarry clay. It contains a multitude of micronutrients and compounds needed for our plants. Clay is, however, an impermeable element that cannot be used other than in a dry granular form or half-burnt (calcined). In form of powder or crushed, clay is extremely dangerous and leads to the clogging of the soil, obstructing its permeability. However, if we want to use this mineral component, and to preserve the draining quality of the mixture at the same time, depending on the specific requirements, we will add clay only in proportions ranging from 5% to 10% of the mixture. This percentage is directly proportional to the amount of organic component of the soil. Clay can be found in nearby quarries and cement factories or in specialized horticultural shops. Fig. 40 photo C. Cristian.

Fig. 41 *Escobaria abdita* - plant whose soil is in habitat composed exclusively of clay. For potted plants we will retain the need for mineral soil, but we avoid using clay. It can be successfully replaced mine score. Photo C. Perez Badillo

Limestone ⏩ is calcium carbonate in the form of sedimentary rock, often of an organic origin (organogenic). Limestone contains many other minerals such as: clay (aluminium, magnesium, iron, calcium, potassium and sodium compounds), dolomites, and quartz sands. The recommended granulation is between 3 mm and 8 mm. Limestone is found in quarries near cement factories.

Marble ⏩ the solubility of a soluble mineral, in this case calcium carbonate, is directly proportional to the surface area being in contact with the solvent, and hence with the porosity of the particles in the mixture; the marble chips, with their more compact crystalline structure, almost lacking porosity, are less soluble in water as other minerals containing limestone, influencing therefore less the pH of the mixture. However, marble still reacts in soil mixtures, but largely depending on the plant, and in a patchy way. Therefore, its action cannot be determined and anticipated correctly when added in order to inhibit excessive growth. However, it is attacked by acid substances added to the water, as well as by the acid environment that forms in some soil mixtures. It also may be dissolved by the roots that work together, in symbiosis, with the bacteria for the production of necessary dissolution enzymes. I do not dispute its usefulness. I have used it only for a short period of time, later on showing a preference for limestone of marine sedimentary origin, rich in salts and microelements or for dolomite. Fig. 42 photo C. Cristian (limestone).

Dolomite ⏩ is a sedimentary rock, improperly called sometimes limestone, being a calcium and magnesium carbonate, sometimes also called dolomite limestone. Dolomite is very interesting in soil for plants, in particular for calcicole plants, whereas they contain magnesium.

ATTENTION!! As it has an increased solubility! **(9)** – this is why it will be added in smaller amounts than limestone, the effects being similar to those obtained with a larger amount of the latter. If you add dolomites to the mixture, do NOT add limestone at the same time! The recommended granulation is between 3 mm and 8 mm. You can buy it from specialized stores, as it is a construction material used for various types of finishes,

but it also can be sold as food additives for poultry or livestock, or used for land improvements. Attention! In these latter cases it is in the form of powder and – as such it is contraindicated, its solubility increasing along with its surface of contact with water. In such cases it can be mixed into clay, and once turned manually into granules, it can be dried in the oven (not the microwave oven!) and later incorporated into the mixture. Fig. 43 photo C. Cristian.

Calcareous tuff ⏩ is a natural rock of chemical precipitation which forms following limestone deposit – in the waters saturated with dissolved calcium carbonate – especially on active supports such as stones, shells, twigs, or certain species of aquatic mosses (*Fontinalis antipyretica*).
ATTENTION!! Looking – as chips – similar to volcanic tuff, calcareous tuff is extremely dangerous for potted plants, being almost pure calcium carbonate with an extremely high porosity (thus the dissolving surface). Therefore, in pots, it shall not be used, not even in calcicole plants!! It should be noted, however, that on large pieces of this kind of rock – turned into micro-biotopes – by watering with soft and acid pH water, can be obtained very spectacular arrangements of calcicole plants sown and grown directly into the cracks and gaps of the rock. Such rocks do not react in the same way as the chips added to a mixture in a pot. It cannot be found on the market. What you can buy are only the processed forms of a deposit tuff, called travertine. It is totally useless and not recommended. Fig. 44 photo C. Cristian.

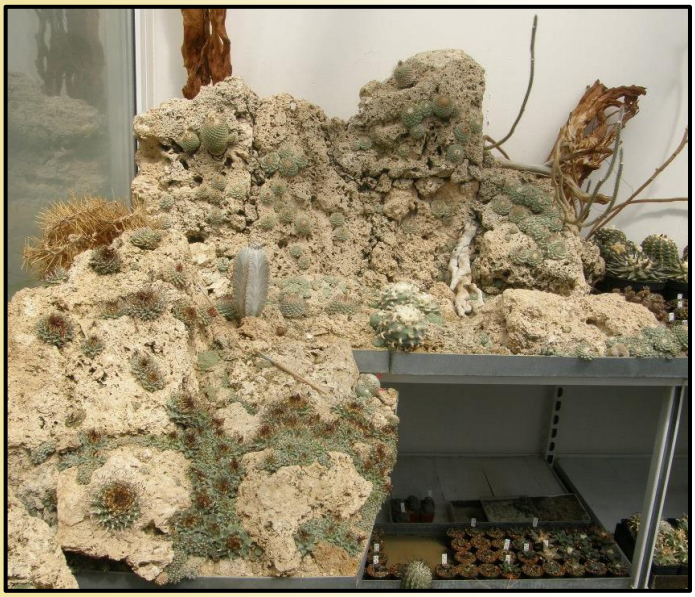


Fig. 45, 46 Planting in calcareous tuff. In the photo on the right, in the top left corner you can still see well plant traces in the underlying rock, now covered by limestone. Collection J. Pavlíka, photos O. Novák

Quartz ⏩ is a natural glass. As far as I know no cactus associated with symbiotic bacteria can consume it. For the cultivation of cacti and succulent plants, the artisanal or industrial cracking is producing very sharp and dangerous chips. Even in the form of sand, quartz does not operate as a mineral feeding substrate. If necessary, it can be used as a support for sensitive roots, but it is mostly used in very specific and purposeful cases. I know only two categories of Brazilian plants that grow on blunt chips (eroded by rolling) or in coarse quartz sand: several species of *Discocactus* (especially *Discocactus horstii* that grows in a mixture of eroded quartz chips and lichen humus), *Uebelmannia buiningii* and *Uebelmannia meninensis*. I do NOT recommend this product, its main disadvantage is that it is inert, being likely to be replaced with other active components with nutritional value that, from a physical point of view, have the same properties. Fig. 47 photo C. Cristian.

Dacite ⏩ is an igneous rock containing silicates and feldspar, and is in my experience an excellent substrate – the best for the growing conditions in Romania – and it can make up to 65-80% of the mixture (when other ingredients are missing). The recommended granulation is between 0.2 mm and 8 mm. It can be found in aggregates used for roads construction or in quarries where crushed rock sorts are prepared on site. It is a highly recommended soil base. Note ⏩ the best chips, as in the case of granite, come from area of the deposit, where the rock is denaturated. The best soil base combination is a mixture of equal parts of dacite, granite and mica-schist. Fig. 48 photo C. Cristian (denaturated dacite).

Gypsum [(10)] ⏩ is a hydrated calcium sulphate, found in nature in the form of sedimentary rock of evaporation. Gypsum is more soluble in water than marble, dolomite or calcite, being one of the most soluble of the minerals containing calcium (Ca). The rock has a low hardness, being slightly crumbly, occurring as a result of sedimentation following the evaporation of marine waters. The rock called gypsum does not have a homogeneous structure and contains various other chemical compounds, and many trace elements that are beneficial to gypsum loving plants. The granulation must be bigger, between 5 mm and 8 mm. It can be found in horticultural stores, being designed to improve soils. Fig. 49 photo Z.M. Demeter.

Fig. 50 *Aztekium hintonii* on denaturated gypsum, along with crystalline parts of the cliff. Photo L. Barta

ATTENTION!!! Gypsum is a crystalline substance that does not absorb water. But larger slabs of this rock have, however, a heterogeneous structure. Thus the rock which is homonym to the chemical compound, gypsum, can retain water in areas where porous structures have been formed, as shown in the above photo, and are clearly differentiated from the crystalline portions. In these heterogeneous formations, clogged gaps and/or gaps filled with clay particles may occur. Sometimes, small crystals debris, mixed with various other deposits and inclusions, can create a kind of slime or suspension, giving the impression that the rock is a great water-absorber. That is why gypsum chips should be well washed. Otherwise, we must take care not to over-water the plants growing in heavy mixtures containing gypsum, these species being typically sensitive or very sensitive to excess moisture. I recommend to beginners to use this rock, only and only if they are well informed.

WARNING!!! Do not use the construction or medical materials, known under the same name (or known as plaster) – you have all chances to kill everything you plant in it!! The industrial materials referred with this name contain or may contain additives that are toxic to the plant.

Granite ⏩ is an acidic igneous rock. In addition to feldspar and mica, granite has a high content of trace elements and compounds favourable for lithophagous plants: calcium, iron, potassium (K), magnesium, manganese, sodium, potassium, rubidium, strontium, and titan. The recommended granulation is between 0.2 mm and 8 mm.

Note ⏩ this rock is a recommended soil base, as good as dacite. The highest quality granulations for mixtures can also be found in areas where the rock deposit is distorted. It can be obtained from the same sources as dacite, i.e. from the crushing quarries or from aggregate warehouses for road construction. Fig. 51 photo C. Cristian.

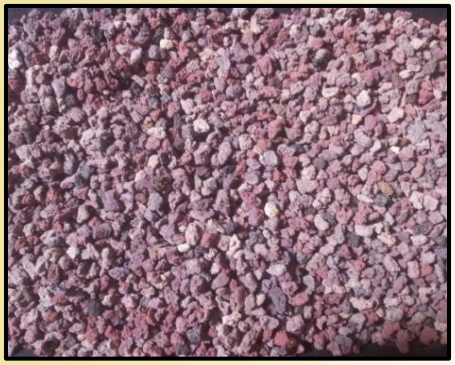
Sandstone ⏩ is a sedimentary rock formed by the cementing of sands, under the pressure of the layers. Depending on the structure, it may be harder or more friable. It is an excellent root support of plants and can be used to stimulate the development of the root system of some smaller plants in larger pots. It is used in plates arranged obliquely or vertically in pots or in the form of larger pieces and chips. The recommended granulation varies largely, ranging, depending on the purpose, from 5 mm to 25 mm. It is a very valuable component for the heterogeneous elements contained. Unfortunately, it is almost impossible to obtain it, where its collection from nature is prohibited, as there are no industrial or commercial sources for it – except for decorative landscaping materials, but to truly prohibitive costs. Fig. 52 photo C. Cristian.

Fig. 53 – 55 *Ariocarpus scaphirostris* - Rayones, Nuevo León - adult plant completely hidden by sandstone debris;
***Coryphantha poselgeriana* - near Parras Junction, Coahuila, growing in sandstone rubble;**
***Ariocarpus scaphirostris* and its natural environment. Photos 53, 54 M.A. Gonzalez Botello, 55 - C. Perez Badillo**

Various volcanic chips and rubble

Lapilli/Lapillo (11) ⏩ is a form of tephra, a volcanic eruptive rock of the pyroclastic class, having a similar composition to pumice stone – rhyolite, dacite and andesite. When it is compacted by time and pressure, it becomes lapilli tuff, which is a heterogeneous tuff, which contains particles larger in structure. It is a very good rock in its composition, but which may well be replaced by tuff and should not replace the dacite/granite/mica-schist chips, as recommended on forums where cactus cultivation is not dissociated from artificial feeding of plants. It can be found in the specialized trade, but it is a relatively expensive horticultural material, if used it as a base when preparing large amounts of mixture. Fig. 56 photo D. Rubbo.

Lava ⏩ is magma that reached the surface through volcanic eruptions. A series of rocks covered in this sub-section are the result of these eruptions, such as andesite and lapilli; often in gardening, lava is also called pozzolana (v. pozzolana). Depending on the volcano, lava can be a valuable component of the mixture or a nearly inert one. In all cases, however, it represents a material favouring improved drainage. In countries where there are active volcanoes, lava or an entire series of elements associated or confused with it, are used for a long time in horticulture. Therefore, lava or other similar materials can be bought from horticultural shops. Fig. 57 photo E. Zimer.



Pozzolana ⏩ is an igneous rock, consisting of volcanic ashes and slags. It is used for its drainage qualities and its porosity, but is in exchange poor in micronutrients. It is not a mineral component with potential for the nutrition of cacti. Being anything but nutritive, I do not recommend using it, except if the collector has no nutritious minerals at its disposal, in order to assure also an improved drainage of its mixtures. The use of this material is a waste of space with nutritive potential for the roots. It can be found in specialized horticulture stores. Fig. 58 photo F. Adriaenssens.

Pumice stone /Pumice ⏩ is an eruptive volcanic rock formed from fragments of expanded rhyolite (it is the eruptive equivalent of granite, containing dacite, andesite, feldspar, and other elements important for life, such as iron and magnesium). It is characterized by a high porosity. It is recommended for mixtures, having the qualities of granite, but also the advantage of being a less compact rock and with increased porosity. It is becoming more and more used in the culture of bonsai and it gives results in a series of *Aizoaceae*. Recommended granulation is 3-8 mm. It can be found in horticulture stores. Fig. 59 photo D. Rubbo.

Volcanic Scoria ⏩ I have not used this component, which is actually a form of pozzolana with a stronger expansion that generates large vacuoles, communicating with each other. It is a material with properties similar to pozzolana, but with an almost total permeability, which from the standpoint of the cactus cultivation is not a quality, but on the contrary, it is rather an inconvenience. When preparing soil mixtures for cacti, we need to include various types of granulations that favour a good drainage, but also, equally, absorb water in their porous structure only to be able to make it slowly, slowly, over time, available to the roots, while remaining constantly aerated. Fig. 60 photo V. Posea.

Marl ⏩ are layered, sedimentary rocks, composed of **clay** and **limestone** (calcium carbonate), containing sometimes **gypsum** or salt. Using marls is indicated only in case of mixtures for calcicole plants and only if you completely eliminate limestone from the mixture it has been added to! Do not forget that you will have to prepare potting mixtures! You do not want to overdo with adding limestone compounds that can totally inhibit growth or even kill the plants. If marl becomes a component with strictly controlled weight into mixtures, it will bring a welcomed addition of micro-elements. Recommended granulation is 5-8 mm. Fig. 61 photo C. Cristian.

Mica-schist ⏩ is a metamorphic rock, containing lots of mica and a number of elements important for plants. Mica-schist contains titanium, iron, manganese, magnesium, calcium, sodium, potassium (K). The amount of micro-elements in the composition added to its physical properties that favour some absorption of liquids, recommends mica-schist as one of the very important mixing elements. The recommended granulation is between 0.2 mm and 8 mm. Even less than the sandstone, mica and mica-schist cannot be found where the law prohibits the collection of mineral elements from nature. Fig. 62 photo C. Cristian.

Mica ⏩ is a widespread crystalline silicate. In its composition there is a whole series of chemical elements necessary for formation of chemical compounds beneficial for lithophagous plants, such as: potassium (K), sodium, calcium, magnesium, iron, lithium, etc. Mica is dubbed according to its basic compound. White-silver ⏩ muscovite, with potassium and aluminium. Greenish ⏩ phlogopite with magnesium and aluminium. Smoky black ⏩ biotite, predominantly with iron and aluminium, etc. Mica is added to the mixture either with mica-schist, in native form or as chips. Fig. 63 photo C. Cristian (biotite).

Fig. 64 - 66 *Mammillaria magnimamma* - La Ventura, Coahuila on quartz-syenite. Photo M.A. Gonzalez Botello; *Coryphantha kracikii* - Buen Dia, Durango and *Coryphantha poselgeriana* - El Hundido, Coahuila. Photos L. Barta

Sand ⏩ is – in general - a natural broken rock of alluvial origin, and having exclusively tiny grains. Throughout this article I advocate the use of crushed rocks and not alluvial rocks. However – despite being difficult to control its effects and its behaviour in relation to permeability in a mixture - sand remains the most widely used material for improve draining of organic mixtures. Note, however, that – used in larger quantity - especially in mineral mixtures, it can become a water retainer, through a phenomenon of capillary action, which prevents drainage and/or easy evaporation. There are several types of sand:

River sand ⏩ depending on the river path, the sand may contain many interesting elements collected on the way, or may be an almost inert material in terms of nutrient intake, i.e. the sand is composed mostly of quartz. It can be purchased from building materials warehouses. It can be

easy distinguished from the quarry sand by the grey colour, compared to the yellow-reddish one, of the other; more, the whiter it is, the more quartz or limestone it has. Fig. 67 photo D. Panco.

Quarry sand ⏩ is at the origin river sand that – through sedimentation – became part of the underground layers. This sand carries with it fragments of loess, which results in a particular fertilizer mixture... but both river and quarry sand less permeable, and the bears the risk of sudden and unexpected clogging of the mixture; as a result it becomes necessary to wash it, if used in mineral soils. Soils mixtures containing organic ingredients – as in the case of clay – reduce the degree or the risk of clogging. . It can be purchased from building materials warehouses. Fig. 68 photo C. Cristian.

The so-called *"marine" sand* ⏩ whether produced by crushing and grinding of shells, or it is the result of coral grinding – it is an organogenous sand composed of limestone. Organic limestone contains, in addition to calcium carbonate, a series of other compounds and interesting trace elements, but – for pot cultivation – it should be regarded as a dangerous limestone compound. There is also marine sand produced by the erosion of escarpments and cliff faces, being in these circumstances, similar in texture with river sand, only the quartz content is lower, and mostly consisting of volcanic rocks or limestone. Regardless of the type, marine sand collected from beaches, must be very well rinsed to remove any salt deposits. Marine sands are found in specialized aquarium stores, but the high price paid for such products (sold as "living" sand), does not justify anyway their use.

Other sands ⏩ see especially Quartz.

Gravel (pearl) ⏩ is a particular category of sand with a granulation greater than 3-8 mm. Gravel may be used in mixtures, as well as sand, if there is no alternative, replacing rock chips. It can be used for plants that grow among rocks in alluvial organic soils – however, organic ingredients are not really necessary in our prepared mixture, if we have at hand the right rock chips selection. For example, for cacti of the subgenus *Coryphantha* of the homonymous genus, it goes well – in general – with alluvial granulations (however, with quite a few exceptions). On the contrary, for cacti of the subgenus *Lepidocoryphantha*, of the same genus *Coryphantha*, crushed rocks and chips are required and not granulations of alluvial origin. Gravel can be purchased from building materials warehouses. Fig. 69 photo C. Cristian.

Fig. 70 *Echinopsis leucantha* KFF 1256 - Estancia La Alfara RUTA 40, at 1445 m altitude, Catamarca, Argentina
Photo P. Kupčák

Mine scoria ⏩ is a natural "brick" formed underground, by exposing two layers of clay at high temperatures, as a result of the combustion of a lignite layer between them. In the form of crushed rock, it is a component with exceptional qualities for the mixture that can successfully replace, in any mineral soil mixture, artisanal crushed brick and clay. The recommended granulation is between 2 mm and 8 mm. Fig. 71 photo E. Zimer.

ATTENTION!! Scoria dust is dangerous, leading to the clogging of the mixture! In Romania it is found as an approved material used for tennis courts covered with slag – so it can be purchased from such a supplier. I do not know – depending on the country – where it can be purchased from. Normally scoria crushing stations must be in the vicinity of the lignite loading terminals, where coal is separated from sterile.

Schist ⏩ is a sedimentary argillaceous rock which, as a result of geological processes, has become a metamorphic rock. Some slates are metamorphosed schist. Sedimentary schist is an excellent support device for rooting (see **sandstone**). Schist is used either in the form of chips with 5-8 mm granulation, either in the form of sheets arranged vertically into the mixture. It is unlikely to find it from the trade. Fig. 72 photo C. Cristian.

Volcanic tuff ⏩ is a consolidated pyroclastic rock, formed from particles of smaller sizes, particularly from volcanic ashes. Tuff is highly porous mixing material. It is particularly necessary for the improvement of mixtures, but it cannot be used as the base material of it. The recommended granulation is between 2 mm and 8 mm. Fig. 73 photo V. Posea.

ATTENTION!! Not to be confused with calcareous tuff (see above limestone)! It is found in horticultural shops and/or as material for the maintenance of artificial ponds or in aquarium shops.

Zeolite ⏩ is a mineral composed of hydrated, natural calcium-aluminium-silicates. It contains sodium, potassium (K), barium, magnesium, and strontium. Zeolite is an important ion-exchange agent and a natural filter, having also the capacity to release over time, constantly, potassium (K), a very important macro element for plants. If zeolites are saturated with micro-elements purchased from the trade, they will release them slowly and gradually in the cultivation medium. Fig. 74 photo V. Posea.

ATTENTION!! It is found as a horticultural product, but it can be either non-enhanced or saturated with fertilizers. Be careful what you order – buy zeolite that does not contain added fertilizers! (see further below Chabasai).

ATTENTIONS! There are various forms of artificial zeolite with industrial destination – they are already treated with various chemicals. Do NOT use them, they can kill plants!

NOTE ⏩ all crushed components, whether natural or of artificial/industrial origin, and like most sands, contain micro particles resulting from crushing or, in the case of sands, as a result of the retention of various particles suspended in water. These micro particles, with slimy appearance, when grit and sand are wet, have the consistency of dust when the materials are dry. This dust, which becomes ooze, after watering, is an extremely dangerous clogging material, when the mixture is free of organic ingredients. That is why all these materials should be sieved and sorted through successive sieves up to the lower limit of granulation that we want to keep. The last two varieties will have to be washed very well several times. The larger grained sorts will still have traces of dust, but after shaking in the sieve, these remnants will be harmless for any clogging, but will be necessary, however, in order to help the absorbent hairs of the roots to stick to these larger sized grains. Especially do not neglect washing any granulations!

Fig. 75 – 80 Various crushed minerals: andesite, dacite, gypsum, marl, mine scoria and volcanic scoria.
Photos C. Cristian, V. Plăcintar, Z.M. Demeter, D. Rubbo, D. Panco, V. Posea

Industrial mineral elements

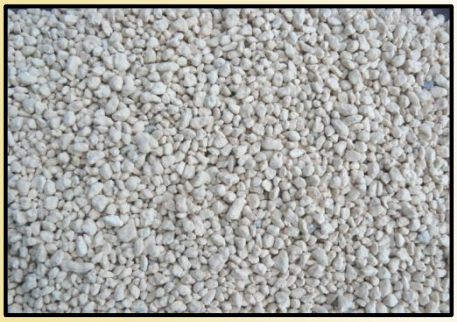
Akadama ⏩ is a semi-clayish ash rock, with the appearance of granules, specific for Japan. In a general way it is a professional florist product, designed for bonsai cultivation. Due to its capacity to maintain the soil very well drained but moist and plus, due to its ability to slowly release trace elements dissolved by symbiotic bacteria, akadama can be used successfully in cactus cultivation. Akadama changes its colour depending on the hydration level. For bonsai cultivation, the colour is an indicator for watering. After several years, however, it must be changed, because it begins to become rather compacted, losing its qualities as a well-draining component. If it is not used as substrate on its own, but as a mixing element, it can remain in the soil mixture for an indefinite time. It is a very good product, in the absence of other components that can serve as base component, but relatively expensive, especially if used in larger quantities. It can be found in horticultural shops. Fig. 81 photo F. Adriaenssens.

Chabasai ⏩ is a zeolite in the category of chabazites, a mineral occurring in glassy rhombohedral crystals. I included it into the industrial products category, because Chabasai is a registered trademark, the product being a process of several kinds of chabazite, following a recipe which is the subject of a patent, even though originally it was natural crushed rock, blended and delivered as such or treated with macro and micro-elements. Like zeolite, Chabasai is a substrate which has absolutely remarkable properties in terms of water absorption due to the porosity of its granules, while leaving the soil well-aired. This component of mineral soil retains a neutral pH and, and especially, does not compact. It is a professional product for bonsai, increasingly used as a mineral substrate for various rare xerophytes or sensitive to uncontrolled watering. The product can be ordered from the manufacturer or it can be purchased from specialized stores. It is relatively expensive. Fig. 82 photo F. Adriaenssens.

Artisanal brick ⏩ is a product resulting from the burning of clays at high temperatures. As this material is very porous and very favourable for plants that can extract "on the dry" substrate the moisture retained and can consume thus trace elements of its composition. The recommended granulation is between 2 mm and 8 mm (see also above – Scoria). Fig. 83 photo D. Panco.

ATTENTION!! 1. I must specify that I recommend only artisanal brick and not the industrial one, which contains or may contain additives toxic to the plant. 2. Crushed brick shall be washed well before being introduced into the mixture, brick dust being as dangerous as clay. It is best to be collected from old buildings under demolition, especially in the rural areas.

Fig. 84 *Echinocereus pentalophus* ssp. *leonensis* - García, Nuevo León on limestone. Photo M.A. Gonzalez Botello



Kanuma ⏩ is a type of mineral substrate similar to akadama (see above). It is a professional florist product used for cultivation of certain plants, which prefer well-drained and predominantly acidic soils. It is recommended in the mix for cacti with similar affinities (especially for South American species). Widely used, both by bonsai enthusiasts, and Asian cactus collectors, this product can be easily found in nearly all specialized stores. It is a relatively expensive product. Fig. 85 photo F. Adriaenssens.

Perlite ⏩ is a hydrated volcanic glass expanded industrially at high temperatures. It is used in horticulture and contains: sodium, potassium (K), iron, magnesium, calcium. It produced in different granulations. It has low density, which makes it float on the surface of the dish and cling to the body of the plants. However, in larger granulations, it is beneficial to any mixture, blending all three major qualities required from a mineral soil component: it contains various nutrients; it is an excellent draining element and retains water in its porosity, releasing it slowly. Fig. 86 photo. V. Posea.

Sepiolite ⏩ is a magnesium silicate complex that represents a class of clays with fibrous structure. It is used commercially as cat litter, the acidity of cat urine being neutralized by the alkalinity of the composition, with a pH that ranges from 9.5 down to 8.2. I have never used this soil component, however I must mention it, bearing in mind that on many forums or sites there or have been reports on its successful use for sowing substrates. The article "Sowing on Sepiolith" was published in the second issue of 1998 of *Kakteen und andere Suculenten* journal. I do not know if there was a follow up on the consequences of this experiment. It is sometimes sold in pet shops. However, I draw the attention that the product may contain asbestos, which is considered a carcinogenic substance.

Seramis ⏩ is the name given (adopted from company name the producing it) for a professional florist product, designed for exotic plants types grown in pots. It consists of expanded clays with the property to store water, and to preserve the necessary aeration of the roots. Among some cactus growers it has a reputation of being a very good rooting substrate. It can be purchased in specialized stores for horticultural products.

Vermiculite ⏩ is a natural hydrated basaltic rock, expanded artificially by exposing it to high temperatures, for use in industrial and agricultural purposes. It contains magnesium, iron and aluminium. It is used in coarse granulation and presents the same advantages as perlite: it contains various mineral nutrients. It is an excellent draining element that retains water in its porosity, releasing it slowly. We add thereto the quality of a specific density, preventing it float. It can be obtained from the specialized trade. Fig. 87 photo V. Posea.

Various organic elements

Unlike mineral soils that never deplete their nutritional qualities, organic soils lose them over time, depending on the percentage in the mixture, pot size and plant size. Thus, the majority of the organic soil mixtures need to be changed between two years and four years. As we are approaching a deadline, a fact that plant is signalling to us by both appearance and flowering, the need for additional chemical fertilization becomes imperative... just that, similar to drugs, fertilizers cause addiction and readapting issues when not supplied anymore. We will clarify this aspect in a different section of this paper.

Fig. 88 *Mammillaria senilis* is a plant considered to be more difficult, but still needs an addition of 10% organic soil. Photo B. Popa

Eggshells ⏩ in the early versions of the Hexalogue, we have not discussed about the use of this ingredient, being against it. However, I came to the conclusion that my approach was superficial and was lacking experience. Today I can say that I totally agree with the use of eggshells, washed and very well minced (not powdered) in both mineral soils without limestone, and in compost, taking constantly into account the fact that their composition, however, consists of up to 95% calcium carbonate.

Compost (see Eduart Zimer's article) ⏩ is an artisanal product, made by amateurs wishing to produce by themselves the organic component, designed to match their horticultural needs. Beyond the development of the subject in the dedicated article, I just want to make a statement: from all the serious work on this subject it becomes apparent, that the main purpose of compost in soil mixtures is to recreate a micro flora and a micro fauna which are essential for a healthy soil.

Bone meal ⏩ is a product obtained by calcining bones and is an ingredient very rich in one of the essential macro elements: phosphorus (P), which favours flowering. It can be bought from garden centres, horticulture shops or supply stores for professionals.

I do NOT recommend for beginners to use bone meal in mineral potting mixtures, because of its influence on the pH is difficult to control. Bone meal induces an alkaline pH - especially if watering is done with water from any source, rather than with rain water or de-mineralized water. On the other hand, for the more experienced collector, in small doses, bone meal can give great satisfaction, taking into account, however, its fertilizing effect. The best way of adding bone meal to the mixture is through the amount of compost that already contains bone meal as ingredient. In this way the nutritional effect is already taken into account, without worrying about the influence on the pH. Fig. 89 photo E. Zimer.

Brown coir (or **coir**) ⏩ is a component that is used in horticultural mass-production, usually soaked with nutrients. It is an inert support and behaves better than peat (see peat), but still it remains an inert support, without object in collection or cultivation of specimen plants, which may, however, be used in large-scale horticultural operations. However, for those who have nowhere to purchase leaf mould, coir can serve in some cases, to the supplementary aeration of compost (see E. Zimer's article), increasing to a maximum the quality of its drainage. It can be found in the specialized trade but – caution! – the product is always saturated with fertilizers. Fig. 90 photo V. Posea. Attention! Brown coir is (especially when grinded) an allergenic product!

Manure (manure from sheep/stock/etc., matured for many years) ⏩ is an organic compound widely used with much success in growing vegetables, floriculture or field crops. For cactus cultivation it is totally contraindicated – also including in this statement poultry manure macerated in water or not. Fig.91 photo D. Panco.

I do NOT recommend the use of fertilizers – in general – and those of animal origin, even less. They generally have three major disadvantages when growing succulent plants:

⏩ they are always vectors of infection ⏩ bacteria, fungi, and protozoa, a wide range of **microbiota** **(12)**, with a totally different structure from the microbiota of xerophytes, not to mention the trouble with insects, centipedes, nematodes... especially with nematodes;

⏩ they always have too much nitrogen (N), affecting the natural appearance of plants and leading to their hypertrophy, which threatens their resistance to pests and diseases;

⏩ even in moderate amounts they already provide for a basic soil reaction. Whoever wants however, to feed the plants with supplements, will always find professional mixtures of nitrogen (N), phosphorus (P) and potassium (K) ⏩ NPK ⏩ and micronutrients, which are more acceptable. Do NOT forget that we work with potted plants, not in outdoor gardens! We work with cacti and not vegetables!!

Dried minced fern ⏩ is an organic auxiliary product, which is used in soils in the form of pieces of up to 5 mm, of chopped fern leaves, sticks or roots, in order to stimulate root development. I have never used this technique, but it cannot cause problems, if the sticks are well drained and if spread a few pieces in each pot. I do not know the impact of such plant debris as supplement for soils that should be exclusively mineral, but I think they cannot be perilous. It is to be experienced. Fig. 92 photo E. Zimer.

Peat (blonde, black, red) ⏩ is a mixing element resulting from the incomplete carbonization process of forest moss or of other plant parts. It is an inert ingredient, without nutritional qualities. Fig. 93, 94 blonde peat and mixed peat photo D. Rubbo.

I am firmly against the use of peat, for two reasons:

⏩ the elements of the mixture must take an active part in the life of the plant, the presence of a component that does not have a nutritional value discards any reason to use it;

⏩ once dehydrated, peat can be completely rehydrated only by boiling or by prolonged immersion, which is impossible in pots... especially after it dries off over a period of three months, such as the hibernal rest.

Molehill earth ⏩ is the earth brought to the surface by moles, mole rats or other insectivorous mammals or rodents with underground living, depending on the area, country, continent – has the properties of garden earth/furrow earth/etc. (see below) and is a very fertile soil. The molehill earth contains the excretions of ground worms operating into that soil layer, and that represents one of the most potent natural fertilizers. It uncovers the disadvantage that once exhausted its texture falls apart, and then slowly turns on the clogging of the mixture. Notable, molehill earth is free of seed and possibly of any pests, unlike most natural earth types. At the same time as it is fertile, it endangers normal development of the cacti because it is inducing aberrant growth rates. Even in places where the soils collected from the wild are prohibited, one should be able to collect molehill earth from his own lawn. Fig. 95 photo D. Panco.

Leaf mould ⏩ is the unstructured or semi-structured organic soil, resulting from the breakdown of leaf fallen on the forest ground. It cannot be found in shops or warehouses. For a solution, see further E. Zimer's article, to see to what extent the compost can replace this indispensable ingredient in cactus cultivation.

Beech leaf mould ⏩ or the mixed-leaf mould - beech/spruce - well decomposed, is what I consider to be the best quality addition of humus. It can be added in proportions of up to 35% to the mixture, for plants that need humus; for epiphytes and some columnar cacti the leaf ground may even exceed 50%, up to 80%. It is a natural organic soil with a good drainage and which will not clog the mixture. From the experience of others, I perceived good things about linden leaf mould. At first glance, the information should be considered accurate. Fig. 96 photo D. Panco.

Pine leaf mould (fir, spruce, pine, pond fir - *Taxodium* and *Thuia*) ⏩ is also very good, being an acid earth ⏩ it is harder to collect and purchase, it must be thoroughly sieved and its acidity must be "temperate" by mixing it with another type of leaf mould; Fig. 97 photo D. Panco.

Oak leaves mould ⏩ contains too much tannin and is contraindicated if used otherwise than in a small percentage in organic soil mixtures, when tannins have positive effects.

Poplar, willow and acacia leaf mould ⏩ NOT to be used, having a basic pH.

Note ⏩ natural leaf mould collected from nature has the enormous handicap of being highly infested with several pets and various unwanted seeds. That is why, after collecting leaf mould – as part of its preparation - a prevention phase is required, without which we can get to incalculable plant losses (see further in the article).

Garden earth/furrows earth/fallow earth ⏩ are popular or familiar names encountered in texts and cultivation advices for succulent plants. These names describe the structured soil which can be found in cultivated areas or between the roots of the plants in fallow areas (see Molehill earth/Anthill earth). Fig. 98-100 fallow earth, photo D. Panco.

I do NOT recommend the use of garden soil ⏩ its dosage (similar to clay), is difficult to estimate correctly and wrecks the draining quality of the mixture. Meadow earth is usually extremely "heavy" (high clay content). Garden soil is much harder to sanitize from animal and vegetal pests and its use in mixtures can produce unpleasant surprises at any time.

Organic soil disinfection **←Back to summary**

Simplicity is the ultimate sophistication
(Leonardo Da Vinci)

This section of the article is addressed only to those who will collect or use organic soils, either from the public domain, or from their land and/or who will to make such soils by their own means, such as compost.

To convert a natural soil in an approximate aseptic environment, the enthusiast has four methods, each with advantages and disadvantages: the chemical method, the microwaving method, the thermal method, and the natural drying method.

All four of the above methods have the advantage of eliminating completely or nearly completely from the soil, pests and weed seeds brought with it.

The first three methods (chemical, microwave, and thermal) have the general disadvantage of killing along with pests all the soil ***microbiota***, implying a variable but generally long time before the soil to be repopulated and the microbiota to do resume its work, i.e. to resume natural processes in the soil, fertilizing it, making it adequate for cacti, in our case. This destruction of the microbiota is far from being a negligible side-effect, to the extent that, if we destroy it, our action involves a nonsense, namely: we add organic soil, either in order to force the plant, or in order to provide it with a necessary element, but at the same time, we seize from that soil the capacity to correspond to our intentions, turning it into a nearly inert component. Of course people will argue that, pretty quickly through the air and water, lots of bacteria, fungi, protozoa, etc., will return to the ground. It is true... just that we – enthusiasts – do not know either what we have killed, or what will come back and, especially, we forget that the soil's microbiota is a set of complex and interrelated mechanisms whose knowledge is the subject of today's highly advanced studies **(13)** exceeding a lot our empirical assessment.

Chemical method

It is the way of solving that the amateur can choose to allege potential pests present in a soil, using disinfectant chemicals or pesticides/fungicides. If we choose this solution, there are two methods available:

1. Disinfection ⏩ involves the use of a strong disinfectant, such as formaldehyde and then leaving the soil to the air, until the chemical agent disappears from the mixture. It is a radical approach in terms of results. Personally I have not tried it. I know, however, from some of those who have used it, that this method can result in a great olfactory discomfort, both personal and to others, resulting in possible complaints from neighbors. This disadvantage can be however surpassed. We remain, however, with the obvious major disadvantage of destruction of the microbiota, which is why I ended up not using it, refusing it from the very start.

2. Pesticides ⏩ involve the use of a cocktail of insecticides, miticides, nematocides, and fungicides, in plastic bags closed tightly at ambient temperature. After the mixture is left so for a few days, we open the bags and air the content. In regards to this method we must mention four inconveniences:

⏩ it does not solve the problem of weeds that may sprout from seeds, which implies accepting the work of weeding, or we water of the whole picking up the seedlings once they appear, or we use of a strong herbicide;

⏩ if exposing the bags to the sun, which would destroy weeds, cancels the effects generated by pesticides, losing their efficiency at temperatures too high or too low;

⏩ there are huge risks, relating to the handling of such quantities of toxic substances close to home, family, pets, etc., even if we use commercially accepted substance classes.

⏩ in the end, the biggest inconvenient of all, is in this case too, the destruction of the microbiota.

Microwaving method

The microwave oven seemed at first to be a revolutionary and apparently elegant solution, especially for the soil necessary for sowing, used in small amounts - and for this purpose it remains very valuable equipment. The underlying principle warrants killing everything that is alive or might be alive in the soil to be sterilized, by stirring the water molecules that make up any living tissue. The method has two great advantages:

⏩ has a radical effect;

⏩ it is the fastest and convenient solution for a small amount of soil.

Fig. 101 "But how could I have passed 10 tons of leaves mould through the micowave oven, in order to prepare the mixtures for Basarab Popa's greenhouse...? " Photo V. Posea

However, taking into account the energy consumption relative to the small batches that may be sterilized in the microwaves in our kitchens, it is economical to us only for the sterilization of soils for sowing. Some talk about the 5-liter batches. It is not a small amount, however... But how could I pass 10 tons of leaves mould through the microwave oven, to prepare the mixture needed for Basarab Popa's greenhouse...?

And again I recall, with an obsessive insistence, the total destruction of the microbiota!

Thermal method

This is probably the oldest of the methods that enthusiasts have tried. To a certain extent it works, especially when using solar energy. Three artisanal methods are used to heat up soils at high temperatures.

1. Boiling – involves the preparation of batches of soil immersed in water, depending on the size of the covered boiler we have at hand and the very boiling of this mixture on a source of heat. From my point of view, this method does not pose any kind of advantages. The disadvantages are easily to anticipate:

⏩ this extremely uncomfortable process involves various odours, from interesting to unbearable.

⏩ the total disintegration of the soil, which actually we want to benefit from, precisely because it is structured or partially structured, which shapes also its degree of fertility.

2. Baking the soil in the oven – is done by wetting soil batches which are let two hours in the oven at 250°C, knowing that the temperature of the soil thus treated, will reach the temperature required for its sterilization. In terms of advantages and disadvantages, this method does not differ substantially from the previous one, these two being not only archaic, but even destructive from the physical point of view, for the soil subsequently used.

3. Heating to the Sun – this solution is also a thermal one, but more friendly as the previous ones. The well moistened soil is placed in black plastic bags. These will be placed in full sunlight, lied down and rolled to become less thick if possible, and therefore a high exposure surface. In cycles, for a few days, the temperature rises up to above 70°C, and then returns to the ambient temperature overnight, thus creating a "Bain-Marie". The results are good and very good, no odours are eliminated, and it does not take up too much space. If the bags are small and the balcony/terrace is facing south, the method can be applied in such spaces too.

Again, the only major disadvantage is and remains the same destruction of the microbiota – about which we will speak again, after presenting the next method.

Fig. 102 *Mammillaria erythrosperma* - Puerto la Huerta Villa de Zaragoza Photo P. Nájera Quezada

Natural drying method

The last and fourth solution is natural drying. This method is ecological and cheap to run at the same time. The soil collected is layered on a polyethylene foil; the whole being arranged slightly sloping, out in the open, in full sunlight. The idea is based on specific soil organic pest ecology: these creatures, most of them arthropods or worms, live in humid and shadowy environments, as the soil beneath the leaves of the forest or in the space reserved for compost. When exposed to the sun's rays and dryness, they will migrate down to the foil, then on its slope, until out of the soil and from there, elsewhere, trying to seek shelter ⏩ however, most of them losing their life in this attempt; fact is they will not stay in our soil mixture. Seeds will germinate, at least most of them, only for the seedling to die immediately in the coming days. After a week, the soil will be acceptably clean. It is the best method of all those

presented above, except that a cleaning cycle takes about two weeks. It is the method to which I stick, for years, taking into account the following considerations: we can use it almost anywhere, even in the balcony, the amount of soil required being directly proportional to the surface and number of plants ⏩ for cacti grown on a balcony you will need less soil. We shall not introduce suddenly, in a new soil that, even thought, will have to undergo all prophylactic treatments over the years, all sorts of poisons and chemicals in large quantities. It does not cause discomfort to the people around you. It costs no money, as the use of chemicals and electricity do, and the necessary foil is reusable, several years in a row.

How do we destroy the fungi and bacteria in the soil, using this last approach? On the contrary, we do NOT destroy them, we keep them! If we destroy fungi and bacteria, we also destroy the microbiota and what may become the rhizosphere of the plant which needs to adapt to its new substrate. As we keep our plants in pots, we are forced to remove all the beings from the soil that can mechanically harm the plant, but not these essential biotic elements. Exceptions are sowing mixtures, which are recommended to be sterilized in order to maximize the surviving chances of plantlets in the first phase of their growth (see below the topic of "better"). Otherwise, we need to understand that plants will grow in our soil mixture and that their life depends on the time and manner in which they will be associated with the microbiota. A soil should not be deprived of microbiota! And, as our flower pots are in contact with the ambient, our substrate will not remain too long in a sterile environment anyway. Therefore, the destruction of the existing micro-flora and fungi, the microbiota of the soil, is pointless, even more so, as results from the research already referred to, a part of the microbiota and especially the **rhizosphere** (14) contributes in a very effective way to the protection of the plant with which it is associated.

Conclusions about organic soil disinfection

As I was saying, just in case, it is sensible to sterilize the sowing soil mixtures or at least to have them well disinfected, although there are many professionals who will smile as they do not do it... So you have in Fig. 103, plantlets of *Astrophytum myriostigma* 'Kiko', which were sown on a non-sterile soil. The soil, a tiny sized natural crack from rocks of the Catalan coast, is entirely mineral, it was just washed with tap water, and these young plants, at their first pricking out, had not received any extra nutrition. Look at the roots they have and the way they form a common ensemble with grains that the have been attached to, starting to form their rhizosphere!

Fig. 103 *Astrophytum myriostigma* 'Kiko' the first subculturing procedure, one year after planting. Photo V. Posea

And who would like to learn the history of the term "mycorrhiza", coined by German forest pathologist A. B. Frank, after his experience with pine sowing, more than a century ago, will understand why plants raised with their microbiota are always the strongest. Of course, when we want, we whether have a high productivity or succeed in growing as many plants from the very expensive seeds we have bought, what I say here does not seem encouraging. It is equally true, however, that there are cases and cases, and that in general, the quality is just as important in our collection, as the amount is... for the professional grower.

Diseases originating from the soil occur only on poorly maintained plants, which are in a state of stress, which have genetic defects or on plants that we have purchased having various inadequacies regarding essential elements. So, diseases are always the fault of the grower and not because of the environment in pots... which react, sanctioning only negligence and the lack of experience. We can notice that any being resulting from the dozens and dozens of controlled hybridizations, while trying to isolate a particular trait, is not merely a being, a deception, whose genetic baggage has been stretched to the limit of viability ⏩ that is why this kind of plants are extremely sensitive, especially if it is cultivated on their own roots. From the point of view of the growers, it is a marvel - and that is even what it could be – but in terms of the laws of nature, it is a sub-product. So – caution! - cultigens can reach very quickly an open conflict with their microbiota and with these adverse reactions, compared to them, artificial beings, the grower sometimes needs to take special measures relating to the micro-organisms in the soil, which can go up to the total and permanent loss of the plant-soil relationship, by grafting.

A vigorous plant, cultivated properly based on its specific needs, will never be a victim of the microbiota in its soil. It can be the victim of nematodes, insects, molluscs, mice... or other creatures that attack it mechanically, causing injuries. As man lives only thanks to its biome, consisting of tens of millions of micro-organisms, so a plant lives thanks to the rhizosphere and the microbiota in its soil.
Therefore, it is of note that in the case of 'natural' plants, the disadvantages of protecting the microbiota are incomparably smaller than those generated by its destruction. Destruction of the microbiota, is a grower's attack to his own plants. Moreover, **the destruction of the microbiota is an act of ignorance**.

Mixing proportions – general ←Back to summary

In the exposition below, the percentages of the mixture are considered volumetric (litres, gallons), not in weight (kilograms/pounds). Therefore we discuss about percentages of mineral /organic elements to 100 volumetric units of mixture!

In nature the soil mixtures are more specific as the distribution area of the taxon is smaller or its specialization is narrower.

However, in cultivation, in the spirit of the idea that simplicity is the ultimate sophistication, the proportions of a mineral soil mixture should be simple, containing as few ingredients, on the condition that they correspond both physically and chemically to our plant's needs. Initially I experienced – as I pointed out in the introduction – on plant lots. Then I applied the laws of soil to the plants in my collection, but the real large-scale demonstration, I did it when I revamped the collection of over six thousand plants, belonging to Basarab Popa from Constanța, Romania. I had available over 50 tons of material.

Fig. 104, 105 All these plants from Basarab Popa's collection grow in the soil mixture described below. Photo B. Popa

Thus, in this enormous collection, cacti from nearly all genera, with the exception of the biggest columnar cacti and epiphytes, have received the exact same ingredients in the mixture, prepared according to the laws stated above. For the mineral base soil, I used three basic ingredients: dacite, tuff and mine scoria. It is true that I added also 4% porphyry and 2% green Dobrogea schist, but the last two ingredients were used just because I have had them at my disposal and they could give a beneficial diversity. However, the truth is that I could have prepared the mixture without any of them, without noticeable differences in the plant's development.

Out of simplicity and efficiency, for the vast majority of the plants, the soil was composed of two volumetric parts of mineral soil – the starting base – and one part organic soil. Plants needing mineral soil were planted just in it, as it was. Reputed calcicoles received an addition some dolomite. It is true that I could have planted most of the collection exclusively in strictly mineral soil, but the plants were tired of the exhausted soil having the obvious limestone deposits, after being watered with tap water with increased hardiness. As such, plants needed to be a bit forced, many of them already stagnating for two or three seasons.

The reason for the addition of organic soil – in this case – is as follows: with time, the organic part of the pots will be used up, but the remaining 2/3 of the soil – the basic mineral composition – from which they feed, will be sufficient for the plants and will feed them in abundance yet for many, many years. On the other hand, without the contribution of forest leaf mould, I would have increased by 30% the cost of raw materials. I have been looking, thus, to the volume of such works, to create a balance between the necessity and the possibility. Three seasons have passed since then, in spring we have entered the fourth and plants not only look great, but the losses have got to be sporadic and insignificant, dropping from 2-3% in 2010, to 0.2% in 2012.

Fig. 106 Plants in the ground, Basarab Popa's collection. Photo V. Posea

To get back to the mixing proportions, it can be said that, except for special cases – crushed rock should have a weight of 60-70% of the total mineral component. A mix of other ingredients, can occupy the remaining 30-40%, the tuff/zeolite and scoria, being sufficient – keeping also in mind as a possibility that limestone can be sometimes necessary. Starting from this mineral base mixture, the weight of organic material will be about 20%, i.e. about 1/3 volume, unsettled.

The introduction of pieces of larger stone chips in the mixture – some centimetres long– arranged carefully not to injure the underground parts of the plant – can only help in the formation and development of large and strong roots. However, the mixture – regardless of its structure – must be very well homogenized, so that all ingredients to be spread evenly in its mass.

Mixing is done very well – for small quantities – by swirling the plastic bags. In cases of mixing large amounts, it is preferable the process to be mechanized. Personally I used a cement mixer, measuring the liters of the ingredients with a 10-litre graded bucket. If the mechanized mixing is not possible, shovelling them, repeated several times (at least 5-6 times), is imperative.

It should be noted that this whole section is intended to especially illustrate an idea. As I have repeated, as in everything else we do, in the preparation of the soil mixture for cacti, too, we must emphasize on the quest for simplicity, especially if we want to do something sophisticated.

Therefore, if we have the three mineral components – rock, tuff/zeolite, mine scoria/crushed brick – we can form a base for a proper soil mixture, without having to look for other inaccessible, expensive or hard to obtain materials. Of course, their presence could be beneficial, but it is not absolutely necessary. Once the mineral mixture base prepared, all we need to add is leaf mould or compost, and, just in case, a handful of limestone chips.

Details on some plants and their relationship with soil **←Back to summary**

As a rough guide, and not an absolute one:

⏩ clay should NOT exceed, depending on species and circumstances, proportions varying between 5% and 10% ⏩ 10% to the mixtures containing organic ingredients, for some species of the Genus *Astrophytum* (*A. ornatum*, *A. myriostigma*, *A. capricorne*). The species of this genus grow on soils containing fair amounts of mine scoria, and develop perfectly without clays, for the species of the genus *Astrophytum* are stone eaters.

Fig. 107 - 110 *Astrophytum coahuilense* - Sierra Mayrán, Coahuila, limestone-gypsum and *Astrophytum asterias* - Villagran, Tamaulipas, in a colluvium (15), at the base. Photos M.A. Gonzalez Botello;
***Astrophytum myriostigma* and *Astrophytum myriostigma* v. *strongylogonum* – Guadalcazar. Photos P. Nájera Quezada**
I think the pictures speak for themselves.

⏩ Limestone, in calcicoles, shall NOT exceed, in terms of specificity, percentages between 15% and a maximum of 20%.However, in the case of *Mammillaria plumosa* this percentage may be exceeded. I repeat that the limestone game is a dangerous one, for all those who have no experience.

Fig. 111, 112 *Mammillaria plumosa*, from B. Popa collection, planted on limestone rubble, on a block of limestone (calcareous tuff), watered with rainwater and cultivated without fertilizers in a mineral soil just with organic traces from I. Floca collection. Photos V. Posea and I. Floca

A few clarifications relating to gypsum

This article is not a cultivation guide and does not wish to be an exhaustive description of some very special blends, such as the soil mixtures for certain *Discocactus* or *Uebelmannia*, *Geohintonia* or *Aztekium* etc. For such very demanding plants, sometimes even very difficult, always expensive and rare, each is liable to thoroughly research from various reliable sources and only then, to apply the principles set out above by me.

Fig. 113 *Aztekium hintonii* on 100% pure gypsum, as you can see from the photo, the plants have thrived and flowered and set fruit. Photo D. Panco

As an addition to what was said so far, I will make, though, a few clarifications:

⏩ to some *Rapicactus*, to *Geohintonia*, to *Aztekium* and to some *Turbinicarpus*, gypsum can be interesting. The more experienced will use for these plants, additions of 15-30% of the mixture. I have – experimentally – cultivated *Aztekium hintonii* exclusively on gypsum.

Fig. 114, 115 *Aztekium hintonii* and *Geohintonia mexicana* in habitat, on gypsum walls. Photos C. Perez Badillo

Throughout this article, by gypsum, I refer, generically, to the homonymous rocks – quite heterogeneous formations in terms of the chemical composition and of the physical structure especially ⏩ so not a single moment, should you consider the term "gypsum" as referring to the chemical compound itself and/or to the parts in which this substance is found in pure and crystalline form in deposits. We refer to the rock thus called, containing crystalline gypsum, debris thereof, clay and other minerals. The generic expression "gypsum" which we use, is due to the heterogeneity of gypsum formations which are not compact crystalline rocks in all their mass, but they are – most often – rugged and grooved masses of rock, porous to the surface due to the erosion or with inclusions of other minerals. Such formations, in the more eroded crumbling zones, from where you can take easier chips resulted by weathering, do not usually give clean gypsum crystals, a material that does not hold water, but something else: you will often collect pieces that are softened over time and can retain a lot of water in their porosities. The phenomenon was found by me during the experiments made with components of the mixtures prepared, when in some pots, formed a sort of paste which no longer wanted to dry. After several days I had to remove the plants, wash them and ventilate them strongly, in order not to lose them.

In nature, the gypsum rocks retain plenty of water in cavities, fissures and in various hollows where they were, either washed away, or dissolved, or eroded mechanically by winds and frosts. The phenomenon can be easily found on sites, in quarries, being noted and documented by D. Donati and C. Zanovello, during their researches in the habitat of the genus *Rapicactus* and *Turbinicarpus* **(16)**.

Fig. 116 *Aztekium ritteri* growing on a vertical wall of gypsum. Photo M.A. Gonzalez Botello

Furthermore, gypsum does not reveal – by colour or appearance —to an inexperienced eye which are the quantities of water that it has retained and, therefore, its use is recommended – as the shell /reef sand – only to perfectionists who have a longer experience in recognizing the 'states' of such an ingredient and the reactions of a plant.

So – my advice – if you are using gypsum, wash the granulation well, until only crystalline pieces remain, which will not absorb anything. If you do not want to lose the associated minerals, then be cautious when watering!

In particular, for beginners or for people who do not have enough plants to afford experimenting, it is preferable not to use gypsum at all in the mixture! ⏩ it is not absolutely necessary! The presence or absence thereof in the mixture cannot be compared with the presence or absence of limestone ⏩ the presence of gypsum can sometimes be dangerous, its absence being always benign.

As I was saying, gypsum (I still refer to the rock) is part of the "menu" for some very rare and very difficult plants. Of the gypsum loving plants, there is a certain range of representatives of the genus *Rapicactus*, *Turbinicarpus*, *Aztekium* and *Geohintonia*. As I said above, in cultivation, for these plants, gypsum can reach proportions ranging between 15% and 30% of the soil mixture, also keeping in mind that there are documented cases in which plants grow directly into the cracks of crystalline gypsum blocks.

Personally I have grown on gypsum – from 15% to 100%, depending on the species – any of the species mentioned above, with the exception of *Aztekium ritteri*, and I had results that I enjoyed a lot. However, I consider it a difficult practice, advisable to only those who have experience with these species and the frequent use of this ingredient. I consider this cultivation mode as a challenge to which the grower who went through all the satisfactions is subject to demonstrate the mastery of methods and skills. From my point of view, to cultivate in gypsum is an act of vanity.
I wish to emphasize once again: gypsum is not to be confused with limestone, even if both rocks are based on calcium compounds. *Geohintonia mexicana* loves calcium: in captivity, if placed on a limestone soil than it might wither and have much more sensitive roots, which, at the first mistake of the grower, will result in the plant's death. *Geohintonia mexicana* seems not to allow too alkaline pH, living on gypsum rocks, which generates a pH close to neutral or, depending on the impurities in the heterogeneous structure of the rocks, it might even have a weakly acid pH.

Fig. 117 *Aztekium ritteri* - Rayones, Nuevo León. Photo M.A. Gonzalez Botello
After you have seen *Aztekium ritteri* growing on gypsum, here it is, growing in a fissure of the limestone cliffs.

The second rule

NEVER use industrial and/or medical gypsum, these two materials often contain additives which are toxic for plants!!

Limestone and gypsum being so different, there are Mexican species which do not like limestone, but feel better with gypsum.

If we have the limestone chips (calcium compound) – the plant is inhibited in its growth, and even killed, if it lacks the necessary adaptations. If we have gypsum chips (also calcium compound) – the plant will not be influenced too much – to the extent that it is neutral and it will even be stimulated if the substrate is weakly acid as a whole.

A few other gypsophile species

This section is aimed at those who still want to try growing gypsophile plants with gypsum, belonging to a usually calcicole group, namely the genus *Turbinicarpus*.

⏩ *Turbinicarpus lophophoroides* (Werderm.) F. Buxb. & Backeberg 1937, grows also on soils with gypsum dominance and on soils with lime dominance – in all, but the presence of gypsum being recorded. This species is reported to be the most difficult plant of the genus, relating to the cultivation conditions – especially since some features of the habitat are not available in cultivation (soil conditions and watering system – long dry periods alternating with major flooding and submersions in the water). As such, the soil mixture characteristics recommended by me are: mineral soil (see above) with the addition of 10% to 30% natural gypsum, taken from the percentage of the basic granulation. Following the book of Davide Donati and Carlo Zanovello already mentioned – my Bible in *Rapicactus* and *Turbinicarpus* matters – it is said that the soil mixture must have a substantial presence of about 10% humus. Personally, I have grown these plants long before reading the book, and I have never used the humus for their cultivation. I have always had great results, but I do not contradict their statement, not having any argument against.

Fig. 118, 119 *Turbinicarpus lophophoroides* L723, Las Tablas on mineral soil with gypsum – left. Photo V. Posea
***Turbinicarpus lophophoroides* on mineral soil with humus traces – right. Photo I. Floca**

Here is an example below with two plants grown in different ways.

The two plants in the pictures below are of similar ages – over 20 years – and have similar diameters, being exceptional specimens. However, their shapes are totally different. The plant to the left had no limestone in the soil, but had 30% humus and was given fertilizer and plenty of water and, often, being grown in a glass greenhouse. The plant on the left has over 15% limestone in the mineral mixture, was watered profusely, but only three or four times a summer, being exposed to the full sunlight in an un-shaded solar, made of polyethylene foil.

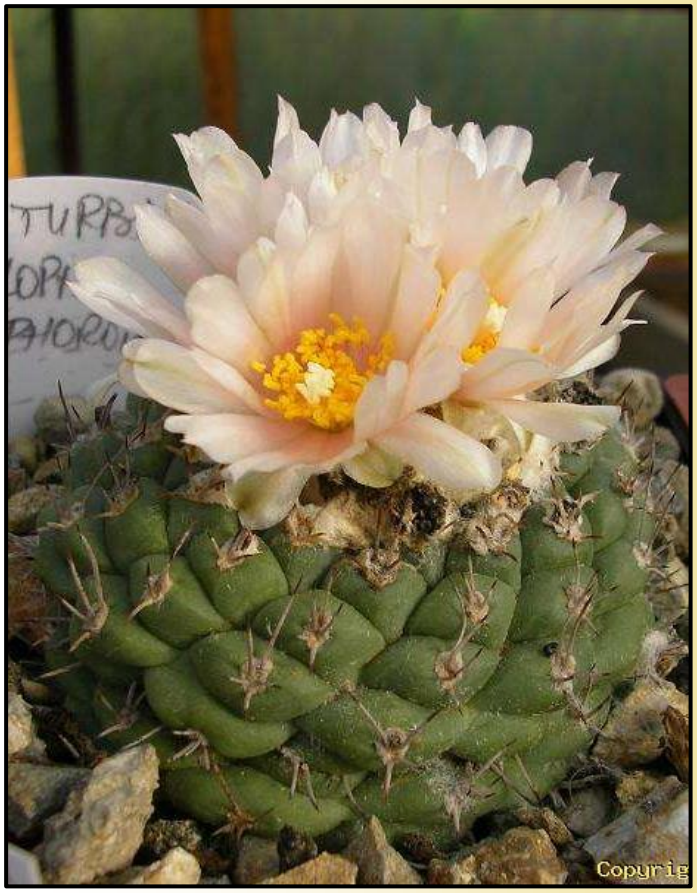


Fig. 120, 121 *Turbinicarpus lophophoroides*. The appearance reflects how plants are cultivated. Photos D. Panco

⏩ *Turbinicarpus hoferi* Luthy & Lau 1991 is a true gypsophile, with special adaptations to such soil. The gypsum on which the plant grows in nature, is, however, enriched with a number of other substances such as iron oxide. It is not easy plant in cultivation – since it grows pretty slow. The recommended soil mixture is composed of 30% gypsum, 70% mineral chips, without humus. Some growers, to obtain a faster growth rate add more humus (but obtaining also a deformation of the plant, proportional to the rush). I do NOT recommend this system, not only for the safety of the cultivation, but also for the natural appearance of the plant.

Fig. 122, 123 *Turbinicarpus hoferi* in cultivation, on mineral soil mixture, photo D. Panco and in habitat on a gypsum cliff face, in the eroded area of the layer, without a trace of humus, photo C. Perez Badillo.

Some other plants

From my obsessive support of mineral soil, I left the completely wrong idea – it has been induced in our virtual community – that I claim that in their habitat, plants have no humus in their soil, this idea being put emphasis on especially for species reputed as difficult and especially for the representatives of the genus *Ariocarpus*.

Well, it is not always like this! Although many live just with rocks, in other locations, the same species often have humus in their soil... but that happens where they are from!

Paradoxically, although in the Fourth Law, I invite you to study the habitat from photos, the situation in the habitat is not an element, that needs to be replicated in greenhouse cultivation. There are, in any moment, differences to be made between life in habitat and in captivity, between seasonal rain and controlled watering, between the movement of water in the soil and the movement of water in pot and between the microbiota in the soil of the habitat of origin and the microbiota in the native soil, the microbiota that turns soil into biotope, almost into a being, a captive being, like is the plant it feeds. I must point out that in the latter case, it is of particular importance the composition of the microbiota of the soils in our pots, incomplete and sometimes incompatible with that of the pots in which the plant has grown up before coming to us. A good portion of the losses comes from this incompatibility. It was found that throughout the living world, as specialization increases, also the adaptation to other conditions, even some more clement, decreases. Thus, the differences between the conditions in the habitat to those in captivity are becoming more and more pronounced, as we are dealing with more specialized specimens. This phenomenon increases in magnitude in older plants, in case of changing conditions and especially if moved in a different collection.

Cacti are plants with a high degree of specialization, and cacti in the areas with very dry soils, and of specific soil types (limestone, clay, gypsum, salt, etc.) - as I said above – have led this specialization towards hard to appreciate levels. That is why these plants will adapt much harder to the new conditions, as these conditions become vectors forcing their ability to interact with the environment, precisely in regards to their maximum specialization parameters.

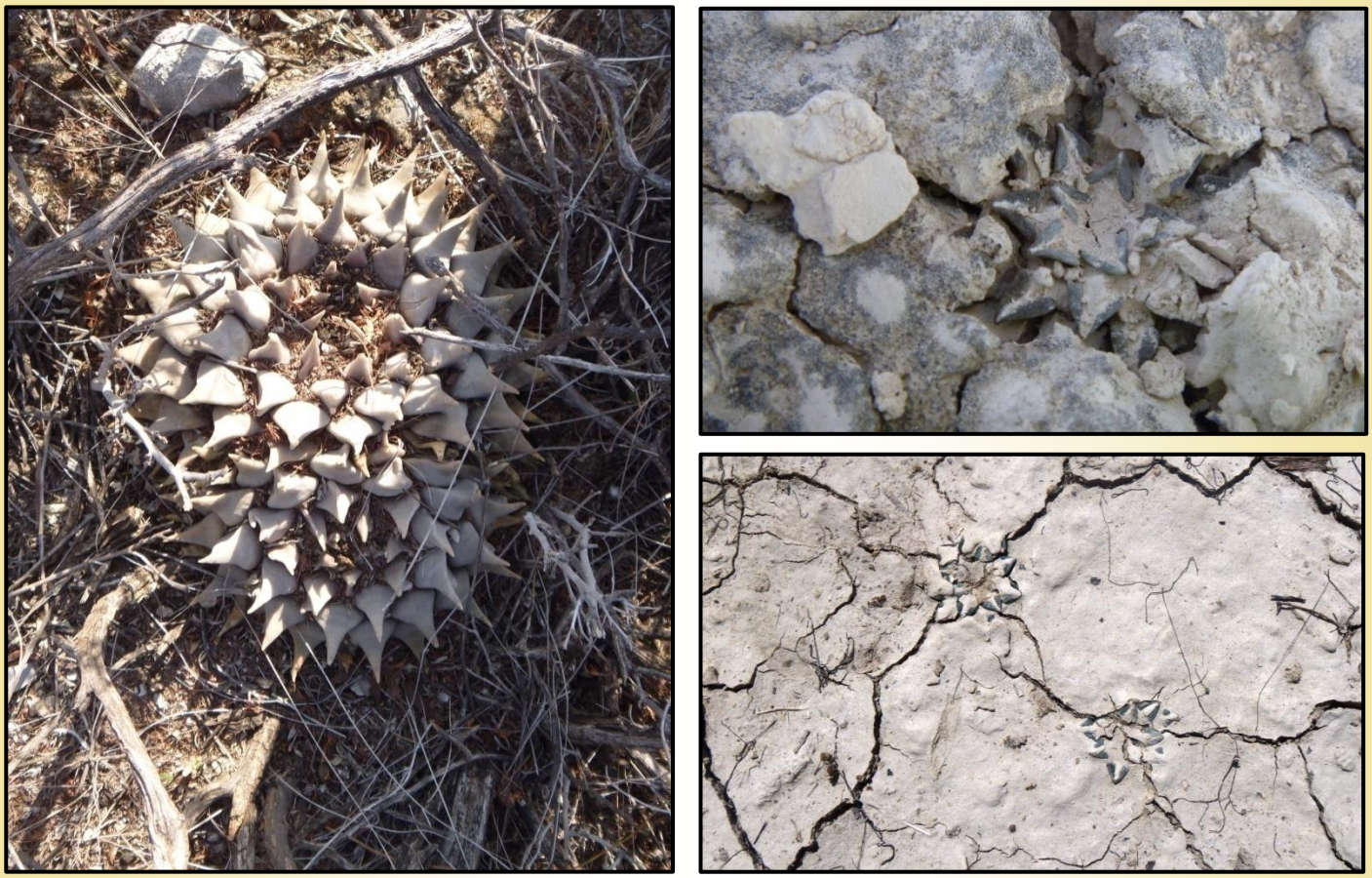


Fig. 124 – 126 *Ariocarpus retusus* - General Cepeda, Coahuila, *Ariocarpus kotshobeyanus* - Viesca, Coahuila and *Ariocarpus kotshobeyanus* - Doc Arroyo, N.L. Photos C. Perez Badillo. As you can see in the image on the left the soil contains certainly some humus, while in the two pictures from the right the soil is made up solely of clay.

Thus, an *Ariocarpus*, which grows in nature on a soil with humus (*Ariocarpus retusus* ssp. *retusus*) or buried in clay (*Ariocarpus kotschoubeyanus* ssp. *kotschoubeyanus*) has very high chances not to withstand in captivity in similar conditions, even more since other abiotic and especially biotic factors have been changed.

In nature there is a rhythmic movement of water in the soil that meets the night/day cycle. At night the water climbs through the capillaries, and through draining, during day, it evaporates from top to bottom. It is a movement that allows the plant to have the necessary moisture, a few hours each day, staying the rest of the day almost completely dry. The pot does not have a sufficient volume to react in such a way. On the soil of a too small pot, dew can be deadly, while the rock cracks in the habitat, in Atacama, where it "never" rains, it is welcomed. Therefore, although *Neolloydia conoidea*, *Mammillaria candida*, *Thelocactus hexaedrophorus* etc., grow b next to species like *Ariocarpus retusus* ssp. *retusus*. or *Ariocarpus retusus* ssp. *trigonus*, the fact that the first cited bear – in captivity – soils with mixture of humus, does not mean that all 'stone eater' species are as tolerant just because – in nature – they live in the same places and in the right conditions, as can be seen below.

Fig. 127 - 130 *Ariocarpus retusus* - Huizache, SLP, *Ariocarpus kotshobeyanus* - Doc Arroyo, NL, *Ariocarpus retusus* - Las Tablas, SLP, *Ariocarpus agavoides*. Photos C. Perez Badillo. Different *Ariocarpus* specimens and more common companion plants.

The main tuber of the pivot of the species *Ariocarpus* and the watering storage mechanism in it are an absolutely breath-taking adaptation and of a great complexity. This specialization will make them sensitive, however, to variations which – at first glance – might actually sound beneficial.

Equally, if the microbiota of the native soils is a precious ally for the natives of those soils, the microbiota of our soils, especially the one in captive pots, can become a danger for these immigrants. If the adaptation of plants to the microbiota they encounter is not complete and if the symbiosis resulting from this adaptation has not been established, or the microbiota does not help enough, or can kill the plant, since it is so weakened by stress or by various excesses caused by the grower.

Therefore, for the person who creates a soil mixture for these plants it involves, firstly, the concern to keep them out of what may be harmful, leaving – paradoxically – the care for their feeding on a secondary plan... And at a certain age, transplanting causes stress and difficulty to adjust. That is why, with the years, you will notice increased losses, proportional to age, resulting from transplantations, in the same season in which they were made or in the following spring. As much as you reduce the number of transplants of adult and old plants, preserving the value of their soil, the more you guarantee for them a longer life. If the soil does not compels them to confront with natural elements, forcing their adaptability and self defence in relation to the new environmental conditions offered, how nutritional this soil mixture is, becomes much less interesting!

Of course that a nutritional aspect is important, but there is always a time for supplements and adjustments... for deaths, however, no. Therefore, what we need to do is to provide them with the conditions with the least adaptive requirements, even if they will not take in as much as at home... where it, however, happens sometimes that during drought years they may not feed on anything at all. Being slow plants, they will grow harmoniously further... but only slower. So, if you are not satisfied with the nutritional quality of the mixture (which – in the case of mineral soil – needs to be changed only depending on the relationship 'pot size/plant size'), then you can, in the spring, after the second watering, to add a dose of macro and micro-nutrients, to half of the usual recommended concentration. Such a dose – administered only once and at half-concentration – is more than sufficient for the whole season. With such a system, you have, however, the certitude of sustainability for decades, for these plants in your collections.

Fig. 131 *Lophophora williamsii* - North Saltillo, Coahuila, on limestone.
Photo M.A. Gonzalez Botello

Let us not forget that, in terms of nutrients, **the mineral soil in pots will never become exhausted**! It will have to be changed, only if the water used for is inadequate or if the development of the root ball requires it!

Explanations for the readers of the Soil Hexalogue **←Back to summary**

An expert is a person
who has made all the mistakes
who can be made in a very narrow field
(Niels Bohr)

NOTE ⏩ This section is a necessary addition due to the reaction of the readers and all those who put into practice or have contested the six aforementioned laws.
As I said at the start of this article, we published for the first time the Soil Hexalogue on the Romanian website for cactus enthusiasts – www.cactusi.com. Over time, in the discussions on the forum several questions were outlined, relating to the new way in which we treated the preparation of soil mixtures for cacti. Taking advantage of the opportunity represented by this special issue, we isolated a few of them to give them the answer here.

The first confusion – on the meaning of "better"

"I found in many posts here the expression of 'cultivating cacti and not cucumbers', meaning that they have to look like in their natural environment. I would like to know why. If for the vast majority of the species I also use organic ingredients in the soil mixture, which leads to a more rapid development and the plants look a bit more swollen, what is wrong with that? I read that in their habitat, 'cacti are stone eaters'. But if at my home it is obvious that they eat earth, they grow at an accelerated rate; wouldn't be a stress for them, as soon as they no longer receive organic matter?

Explanation
I think I am the first who used here in Romania (and perhaps elsewhere) the term 'Stone Eater' and I believe that the perplexity expressed above needs to be clarified, not being unique. For the same reasons – in this special issue – I added to the original article, another new section entitled "The Aesthetic Option – key element in the culture of cacti" which, beyond the below explanations, can answer also to those who nevertheless prefer to grow cacti inducing an accelerated growth rate.

The needs of living beings
Cacti, no matter how special they may be, are nevertheless plants. Plants are living beings. Living beings are systems of complex, interconnected and integrated devices designed to cope with environmental pressures. Each and every one of these devices – taken separately – has its own operating parameters, each different but harmonized with the parameters of all other devices within a living being. For a living being to exist, it is absolutely necessary that all parameters of these devices to operate at a convenient and common average value range – which allows their interconnection and thus the viability of the living being. In other words, all devices must operate simultaneously, with each element of the system in agreement with all other.

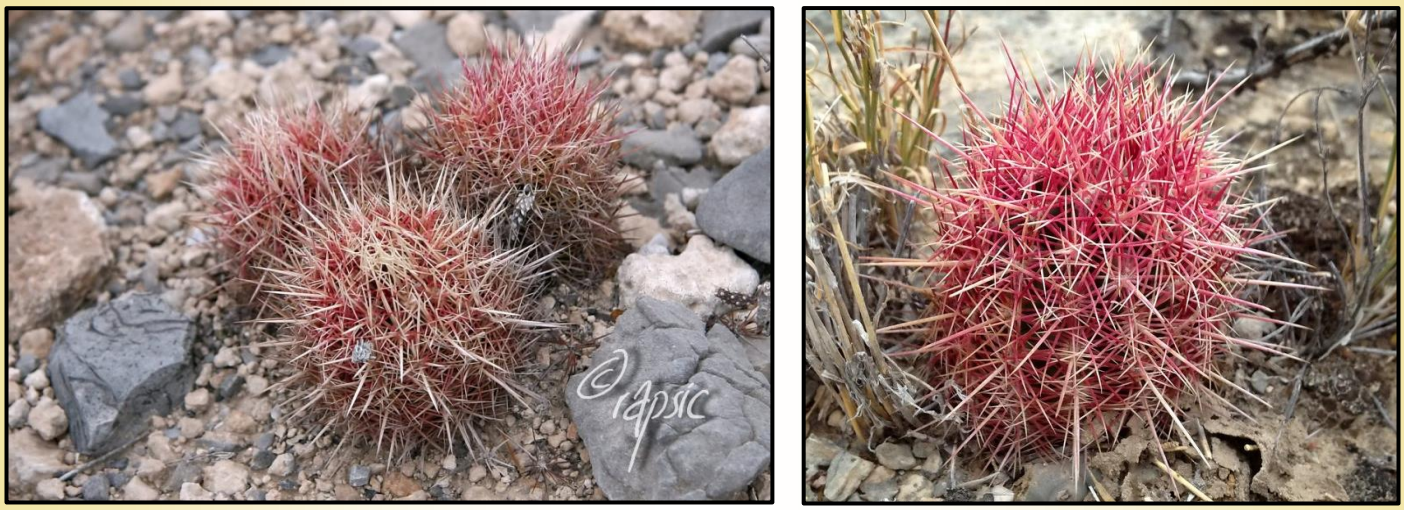


Fig. 132, 133 *Thelocactus bicolor* ssp. *bolaensis* 'wagnerianus' growing among rocks, lacking organic soil, and in areas where vegetation debris bring organic elements into the soil. Photos L. Barta

As a result, for a proper function of the system – in order to have a viable being – the general parameters must adhere to an ideal average, ranging between a minimum and a maximum. However – especially at highly specialized beings – some devices require smaller divergences from the ideal average, at least for certain parameters to which other beings might have much more permissive divergences. Thus the value range of the parameters of all the devices – which, together, form a living being – will be reduced to the most restrictive minimum and maximum values, these limits becoming universal to all other parameters within the system. In other words: a living being thrives only between the average value limits given by the most restrictive devices.

As a result there is a surprising fact: the more you try to stretch the boundaries outside the operating limits of a device, with the genuine intention to obtain a "better" result, the more parameters you remove and more devices for which your action is no longer beneficial you ruin, to the point that they stop working.

⏩ You give them water, as much as they need, it is good ⏩ you give them too much, it is bad ⏩ you give too little, it is bad;
⏩ You give them heat, as much as they need, it is good ⏩ you give them too much, it is bad ⏩ you give too little, it is bad;
⏩ You give them winter/summer rest, as much as they need, it is good ⏩ you give them too much, it is bad ⏩ you give too little, it is bad.

Fig. 134 *Notocactus roseiflorus* KCS-0278, a plants growing among rocks in a poor soil with traces of organic components but revealing, if judging by shape and appearance, a maximum health. Photo C. Kádár

When you combine two of the three examples, observing the limits imposed, but omitting the third one, we can generate a catastrophe: we give the plant as much water as it needs, to the optimum minimum temperature required... but during a period of rest ⏩ we will obtain – in the best case – the loss of the root system or, in the worst case, the entire plant is rotting.

The examples – taking into account the complexity of living beings – are tens of thousands and certainly much less schematic and less crudely presented than I did it myself – illustrative and as a sample – in the preceding lines.

This presence of the boundaries is all the more obvious and more restrictive, if the adjustment to the environment narrowed the operating parameters of these living beings. Cacti are such beings, which in the millions of years of adaptation to adverse or hostile environments have come to live from very austere resources.

Although they seem – and actually are – very defiant beings, cacti are in fact extremely sensitive if removed outside the operating limits that they have been adapted to. The greater the adaptive pressure, the higher the price they have to pay: by gaining special characters, the being loses or reduces its current options. An extreme equivalent example would be as follows: imagine a man who as a child was skilled to walk only in his hands and who never walked otherwise. What would happen if, after twenty years of work, he is required to walk on his feet to take the shopping bags to the car from the parking lot...?

Among cacti – but not only – are plants that reach a high degree of specialization. For such plants, the slightest deviation from the norms generates an imbalance between its devices, which ultimately prevents the entire system to function, i.e. the plant dies.

Fig. 135, 136 *Ariocarpus kotschoubeyanus* ssp. *kotschoubeyanus* 'macdowellii' SB100. The photo on the left was taken on the 26th of September 2005, after nine days of almost continuous rain. The plant, an *Ariocarpus kotschoubeyanus* ssp. *kotschoubeyanus* 'macdowellii' SB100, was subject of an experiment on mineral soils. As you can see, due to continuous moisture apex of tubers wool plant was infested with green algae. The second photo, dated 4th of October the same year, shows how only after eight days of sun the green algae dried out and how the plant survived, preparing for flowering. The experiment was made only to test the limits and not to accredit a cultivation method and I do not advise anyone to leave such plants in the rain, for days and, even less, when the rains are interrupted by sunny days. Photos D. Panco

Another analogy inspired by a true story ⏭ a popular TV news presenter adopted a drastic weight loss diet, pushing her body to boundaries hard to endure. It was enough to make a sudden return to the normal diet (situation of normality), for her pancreas to go into collapse... and she wasn't even short of champagne for 10,000 years!

So ⏭ NOT everything is about well thought recipes managing light, water, temperature and nutrients! The answer is much more subtle. Not the compliance to the environmental factors, factors that cover the major parameters relating to the operation of a device system called a cactus, can cause the plant to thrive, but a proper management of all these factors within the plant's potential limits.

If we do not manage the "better" issue correctly, if we push the plant steadily, instead of favouring the plant, we first manage to unbalance it and then we kill it!

An interesting example is the experience that many amateurs of "hardy" plants make on their own plants, arguing that "they resist to -23°C!". It is well said they resists! This temperature is a limit and, as such, the question arises: how long will they last? One winter, two, three? And we have no right to wonder if in the fourth, it dies at -12°C, because its body was forced too much in the preceding three winters.

Nature vs. captivity

Any living being, once removed from its natural environment, to be held in artificial conditions is a captive being, either animal or plant.

Our plants, regardless generation count in captivity, are plants that cannot be regarded neither like the plants from the nature or otherwise, such as gardening plants, created specifically for the purpose of cultivation. We must learn to accept that the plants originating in the wild are captive plants, as is the Siberian tiger at the Zoo, even if it was born there.

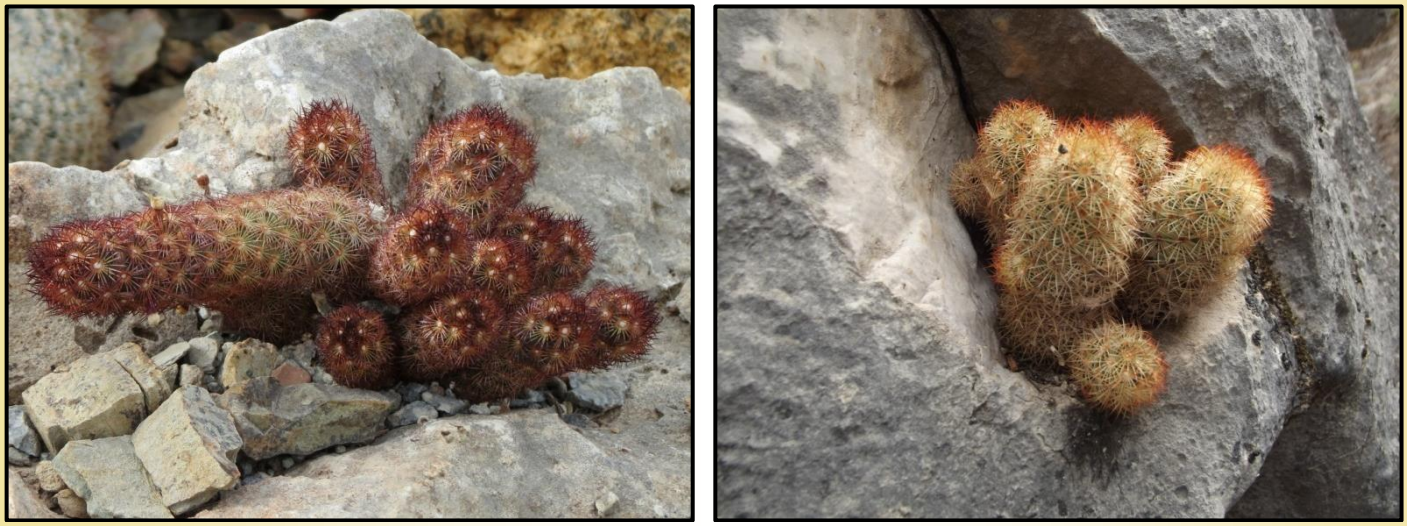


Fig. 137, 138 *Mammillaria elongata*, from B. Popa collection, planted in the hollow of a rock, in a purely mineral soil mixture in 2010, as photographed in February 2013; and in habitat, in Queretaro, growing in the crevice formed between two rocks. Photos V. Posea and R.D. Raya Sanchez

Furthermore, we have to accept a completely new concept: soils, in which our plants' roots stand, are themselves biotopes and – hence – should be understood very clearly that soil in a pot, in small amounts and without its natural interactions is a captive soil as well! It is not comparable, nor from the point of view of the physical and chemical reactions, nor from the point of view of the biotic relationships, even if we reconstruct exactly the same composition of the soil as in the natural habitat. If I take the soil from my backyard or my front lawn and put it in a pot, it is no longer a 'free' soil, but it becomes the captive soil in my pot.

From here starts a new way to putting it: we cannot substitute for nature and we do not need to copy it ⏩ we must induce – in our artificial environments – the effects the environment has on plants.

The soil – we go return again to this issue.

As I said above, soil is a combination of biotic and abiotic parameters (physical and chemical). We must add that – for cacti – soil represents more than 90% of their universe. We should not forget even for one moment that it is enough to exceed by 1% one of the admitted limits in the case of the most sensitive devices – minimum or maximum – for the entire system to go south ⏩ it is the only glass of champagne the TV producer drank.

I never said, anywhere, about cacti, that they must be grown on rocks or in a 100% mineral soil! I said just that – in practice – when we do not know the cactus' needs, we should start from a mineral soil mixture and that, depending on his reaction, either we leave it in that soil mixture, or we add organic soil or limestone, according to the needs – the Third Law Rephrased of the Soil Hexalogue.

Here we come to two issues ⏩ there is a practical aspect and an aesthetic aspect.

The practical aspect

In nature, from thousands of seeds only one, two or maybe three plants reach maturity. Instead, in nurseries, after germination, with well over 80% of the plants, survive and become products for sale. Quite easy: let us say that in nature 2 plants reach adult stage of one thousand seeds ⏩ if in nurseries the percentage is 80% - then it means that 800 plants from one thousand seeds survive and reach adult stage ⏩ thus, in nursery, 789 plants that were

supposed to die will be propagated, but which, although weaker, will transmit their genes to their descendants.... and I did not take into account cases where only certain dominant characters of the plant were selected, leading to further misery of the genetic legacy. A classic example is *Ariocarpus kotschoubeyanus 'albiflorus'* ⏩ in the populations of Tula, Tamaulipas, flowers range from magenta to white, while in nurseries the sold plants have nearly all flowers white. Do you think there is anything more to say?

Fig. 139 - 142 *Notocactus scopa* KCS-0043, *Notocactus ottonis* KCS-0054, *Notocactus glomeratus* KCS-0197 *Notocactus arechavaletae* KCS-0253. Cacti searching for traces of organic matter accumulated between rocks and stones, if they find any; if not the plants have to cope as they can... *Notocactus scopa* has found a bit of moss between the rocks. *Notocactus ottonis* was less lucky, which does not spoil the look of it. *Notocactus glomeratus* took refuge in the shade, where rock rubble accumulated. *Notocactus arechavaletae* is being forced into a Spartanic survival, on a rock surface, but still it seems to be thriving. Photos C. Kádár

Plants that do not grow out of a too easily won abundance, whose cell mass does not grow out of too much, but from what is strictly necessary – necessary but not sufficient – even if they do not grow up quickly, even if they do not reach the dimensions of others, grafted or forced, will be very strong plants and especially very resistant to the attacks of the micro fauna, and with association with micro flora and fungi of the soils in which they are brought. It should be taken into consideration that – here in Europe – they did not have the time (less than few centuries), to be able to harmonize with the foreign microbiota, such as they did for ages in the soils of the American continent. This adaptation deficiency is aggravated even more with how we have constantly defended them artificially, with various chemicals, generation after generation, even against an association entirely beneficial for them. We, as growers, fought persistently, almost desperately, against their natural selection, disabling them, knowingly, favouring large numbers over quality.

Wherefore, the more mineralized a soil is and fewer organic components has, the less complex is the biotic activity in it and the more the chances of survival and adaptation for our plants. As I noted above, the more specialized a

plant is, the less it resistant becomes to changes, the range in which its existence parameters operate being narrower, due to the state of exception that it adapted to. Starting from an almost non-existent or different microbiota, inherited from a certain grower or from another collection we purchased our plant from, the plant will be faced with the need to "get acquainted" and to adapt to the microbiota established our soil mixtures. It is a difficult step. It is the time when diseases or affections of plants, which do not generate problems in one's collection, are virulently triggered when his plants end up in another one's collection. Buying a plant or two we often overlook this, however, we do not realize that this phenomenon becomes evident and difficult to manage unless we acquire a few hundred plants from the same source.

The third rule

The odds for some plants to resist their cultivation conditions are directly proportional to their native capabilities and inversely proportional to their specialization.

The older a plant gets, the better it adapts to the condition of the environment in which it grew. That is why it can be stated that an old plant is more sensitive than a young plant – it became specialized and its possibilities of adaptive variation have been lessened. We can reformulate the Third rule as follows:

The third rule reformulated

The odds of plants to withstand their living conditions are directly proportional to their native capacities and inversely proportional to their age or specialization.

The analogy with the farm poultry (for the second time): if we grow chicken, in intensive farming, with supplements and food additives, and then we move them into the courtyard, in nature, switching for a normal biological growth, they will die. Yard birds resist however year after year, even against pests, even if they are grown "hard". They do not reach 2 kg in 42 days, but they need 6 months for the same result... however, they do not die at 6 months or 1 year if not slaughtered, but they live for many years – over 10 or even 15 years.

The aesthetic aspect

This topic is addressed in more extensive manner, further to the next section.

Here we will limit at pointing the two extreme opposing options, generally encountered ⏩ a) we want plants looking as weird and wonderful as possible, but similar to those in nature; ⏩ we want plants looking as weird and wonderful as possible, but only to match the image that we have made for ourselves about how they should look.

Fig. 143, 144 *Notocactus uebelmannianus* KCS-0165 in habitat and *Notocactus uebelmannianus* in cultivation, on mineral soil with 20% organic matter added. Photos C. Kádár and I. Floca


Fig. 145, 146 *Turbinicarpus pseudopectinatus* - Aramberri, NL in habitat on a limestone soil which evidently is not entirely mineral, photo M.A. Gonzalez Botello, and in cultivation, photo M. Crisbășanu. In order to obtain the nature-like appearance, the pictured plant cultivated in the same mineral soil since 2005, without being repotted and without being fertilized. The picture is dated December 2012

a) If we want cultivated plants to resemble plants from nature, the laws set out by me in the Soil Hexalogue, are the easiest and safest way to obtain such specimens.

b) If we want to have plants that look great and impressive, although they are miniatures in nature, then surely we can use rich organic soils and with as many fertilizers. However, note the fact that such plants are best obtained by grafting. Grafting cancels almost all causes of death due to cultivation failures. Of course there are cases where the rootstock wears and it is difficult or impossible to replace – but these are less common cases if grafting was done correctly, relative to both purpose and the type of plant used (scion and rootstock). To want to get plants similar looking to grafted specimens, but on their own roots, means to take unnecessary risks on the road. On the other hand, if we don't try to obtain plants resembling specimens seen in habitat, we do not have any reason to want plants on their own roots... even more so, since with the exception of the case of plants with a total deficit of chlorophyll, the short and buried grafting can hide very well this often unsightly survival support.

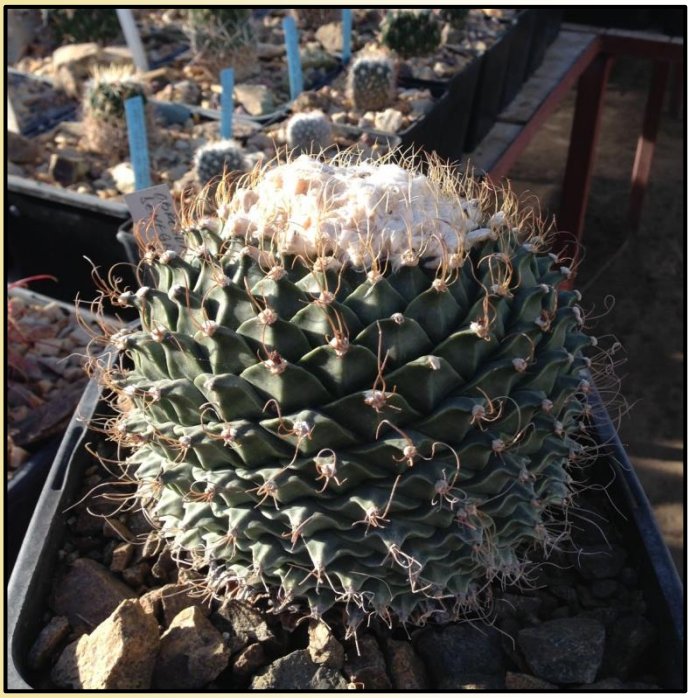



Fig.147, 148 *Obregonia denegrii* and *Blossfeldia liliputana* – grafted plants having the grafting stock burried. Photos B. Popa

Of illustrative reasons, of course, I have pushed my exposure toward exaggeration. In fact, plants can be held correctly, non-grafted, on their own roots, on a substrate with a lot of organic ingredients and/or fertilizers in different doses, but in these cases we are talking only about quantitative and qualitative approaches – the effects over time, varying according to our excesses, but leading to the same result: always an untimely death.

In the end, what should be noted is that the plant raised like this remains a sensitive plant. As long as it does NOT look like that in nature, i.e. as the species was "designed" and validated through natural selection, it still is a plant abnormally grown, which does not manage well the risks, and **risks increase with age** (see The third law reformulated)! The adaptability of any living being is reduced to a minimum by this factor, whether we are talking about a wolf, a man or a plant... because **Nature does not offer gifts**, and growers cannot give Emergency Ordinances!

It is the moment to clarify an aspect that is closely related to the topic. Sometimes it is mentioned that there are plants which – in nature – may have different appearances, looking 'like this' or 'not quite like this', depending on the characteristics of the place where the seed germinated and where they grow. It is true. Virtually, however, this is just a random happening. Statistically, those plants are exceptions, which grow in the virtue of an ancestral potential, and not an adaptation to the environment. At first, the limits for which they are prepared will be turned upside down, and they shall die first, both when grown by us and in nature, because they are no longer suitable for those conditions. Nature, as well as our own mistakes, never forgives!

However, in culture we must take into account the general conditions to which a species is adapted and not the exceptions it can cope with... unless we are prepared to losses that do not matter to us, either financial or emotional, or for both reasons.

Finally: we must recognize that it is the right of anyone to grow his/her plants as by the own taste and to reconstruct the experience gained by others. It can be a good way of learning, even if sometimes it seems counterproductive.

This development towards enlightenment is not intended to be a pro-case argument, but merely an explanation of the way growers can choose, to take up the learning of the Soil Hexalogue. In fact, for a beginner, the path opened by the Soil Hexaloge is much easier, than any other chosen path, although it may seem complicated because of the theorization.

If you ask "Why?", you should know that the answer is childishly simple: because it eliminates most of the risks!

Fig. 149, 150 *Obregonia denegrii* and *Astrophytum myriostigma*, in habitat, with the colled deeply burried into the ground. Photos P. Klaasen and C. Perez Badillo

The second confusion – about the plants' collet

"What must be done to protect the plant's collet, in the spirit of the Hexalogue?"

Explanation

The question above compels to a quite important explanatory addition to the corollary of the Soil Hexalogue.
The corollary that I will present you now refers not only to the soil. It concerns the relationship between the way of potting cacti and using the soil mixtures in a proper way. The reference is general and does not strictly relate to the use of mineral soil, although in most cases, the mineral soil is the solution.

Starting point ⏩ in nature, during the dry season, most of the globular cacti species from arid and semi-arid areas, avoid dehydration, by withdrawing in the soil various percentages of the over ground part of the body, depending on the species, age, size of the plant, and also on the soil texture.

Fig. 151 – *153 Turbinicarpus pseudopectinatus*, in cultivation, with the colled burried into the substrate, *Turbinicarpus jauernigii*, during the resting period, a plant with the collet deeply burried into the mineral mixture it grows in since 2005. Photos M. Crisbășanu
***Mammillaria herrerae* plant with the collet deeply burried into the mineral mixture. Photo L. Szanto**

Starting points ⏩ 1. Becoming visually aware of the phenomenon – in species throughout America, Canada and Argentina; ⏩ 2. linking the habitat information with the aspects relating to own experience; ⏩ 3. Linking the precedence to a series of information resulted from direct experience of other collectors.

Once again I repeat the previously said: we need to forget what we know and start from the scratch! This is what I said in the introduction of the Soil Hexalogue, and I repeat it every time. And in this case – that of protecting the collet – we need to do the same: EVERYTHING I learned about planting a cactus, including the protection of its collet, should be reconsidered, based on a different approach.

The way of putting the problem was somewhat expected, because of the fact that the elements discussed in the Soil Hexalogue cannot be observed independently from the rest of the pursuits relating to the cultivation of cacti. And if the six laws changed the approach to prepare soil mixtures, what could be more normal than – by their virtue – to also change the approach of the relationship between soils and plants for which these are intended.

As always in cacti cultivation everything revolves around natural and simplicity – just as it was and with Columbus's egg: in nature, nobody protects the cactus collet and no one casts spells for cacti buried by bad weather not to rot! What may follow?

A rhetorical question ⏩ *Why should we seek, to do what the adaptive potential of the plant is not asking us to do?*

The answer is not rhetorical. It is of common sense: because we are set up to proceed incorrectly!

And if the meaning of the answer fell under the senses, the approach too will have to be at least as simple. However, to some, at first glance, it may seem more complicated and more savant than it actually is.

It all comes down to giving the plant the soil it needs, not from the point of view of the composition – mineral or not – but regarding the drainage. Cacti – when it comes to soils – first of all, they need a well-drained soil. Of course that, alternatively, the water regime needs to be in harmony with the soil mixture we have prepared for our plants.

Fig. 154 – 157 *Turbinicarpus pseudopectinatus* and *Obregonia denegrii*. Cultivated plants with exposed collet, photos B. Popa and cultivated plants with a well burried collet. Photos D. Panco and B. Popa

Grown on unsuitable soil mixtures – as the proportional recipe 3/3/3 and its variations is – plants are forced to make efforts. Of course, experience shows undeniably that plants rot sometimes (too often) on such soils as above and even more obvious is that rotting often attacks the collet (or starts from the collet).

This sparked the idea (otherwise correct in such situations) to protect the collet. However, this way out is only a palliative one, because it does not fight the fundamental problems. The real solution to this problem is to prepare a proper soil mixture in which the plant does not have to strive for survival. And this because in the 3/3/3 type mixtures, cacti are – even if you might think it is exaggerated - often pushed to the limits of survival, even if they go on for decades and even if they grow as big and "beautiful", as pumpkins do! (In incarceration too, there were people who lived for decades, and obesity is not a sign of health anyway!).

Instead, if the soil has been prepared properly, especially in terms of the drainage, at potting/repotting, plant can be partially buried ⏩ **or, for better rooting, do we not burry the cutting/offset for least a third? Keep in mind that the cut not more sensitive than the plant's natural collet... Why in this procedure, it becomes possible, and during normal cultivation, not?** In case of a good soil mixture, with good drainage, we are no longer concerned about the depth at which the plant's collet is located, nor do we have reason to be worried and try by any mean to protect it... and how to identify what soil mixture does a plant need, is set out in the Soil Hexalogue - the Third Law Reformulated.

You might ask me another rhetorical question: *"How do we find out of which group of species a plant is and how much can it be buried...?"*. Again, the answer is surprisingly simple: we study and gather information. We find everything we need, at the visual level, in the internet or in specialized websites, or in certain groups of social networks, such as the profile groups on Facebook, where many photos from the habitat are posted.

The third confusion – about heterogeneous and heteroclite soils

"Which is the optimal granulation for mineral soils?"

Explanation

Maybe I should have asserted this claim as one of the Soil Laws. However, I did not do it, because there are things that, if we look around us, with attention an interested person is capable of, we can deduce this by ourselves. However, given the number of similar questions raised, I consider it useful to respond.

A soil mixture – mineral or not – must be heterogeneous. **The less pivoting the roots are, the more heterogeneous shall be the soil mixture we use.**

And once again, the answer is related to the practical simplicity and efficiency: the more heterogeneous the soil is, the easier it will be for the roots to spread in it, moving through the finer grains, from one bigger chips of rock to another. Have you not seen that always plants tend to cover the pot walls with roots, even more so, if they are made of amore porous material? Larger chips of rock from the soil – possibly even smaller boulders in extra-large planters – attract the roots to them. Using a soil in which there are larger chips of rock, you give the plant the possibility to dwell in everywhere in the available soil ball... and it will! It does, even though the plant is small and the pot disproportionately big, because in nature the "pot" has an unlimited size... only it is filled with boulders and rocks.

Fig. 158, 159 *Mammillaria luethyi* with sizeable rocks in the soil mixture; the same plant two years later. Photos D. Panco

It is even recommended that a plant with slender roots or barely rooted, to be planted between two porous stone slabs, of sandstone preferably. Roots will run towards them, will stick to them and then, gaining power, will begin the conquest of the entire soil ball. Below I shall exemplify with a few examples of *Blossfeldia liliputana*, planted with rooting supports.

First I shall present the plant:

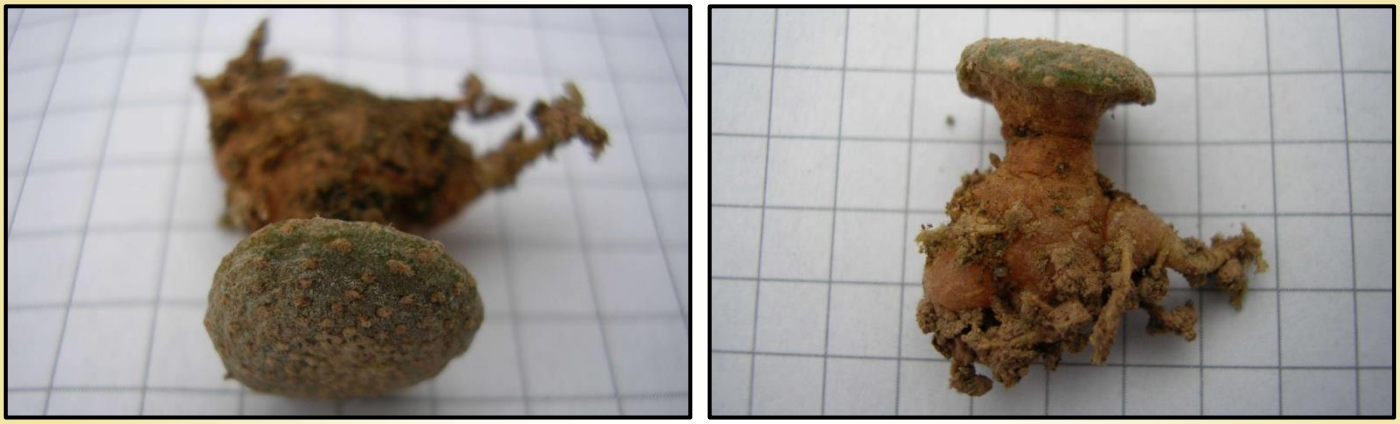


Fig. 160, 161 *Blossfeldia liliputana.* It can be seen that although the root is massive plant looks dehydrated. Photos D. Panco

The planting procedure starts with the selection of the soil, the rock slabs and the pot:

Fig. 162 – 164 Substrate, stone slabs and pot. Photos D. Panco

Then the arrangement:

Fig. 165, 166 Setting the pot. Photos D. Panco

The potting procedure ends with the plant being placed, fixed it into the soil and the setting completed:

Fig. 167 – 169 Setting the plant, fixing it into the mix and finishing the look. Photos D. Panco

Below you can watch a few of the specimens I have potted this way. You will notice at one of them that they were not under watered, on one of the supports moss was even appearing... and you know how sensitive *Blossfeldia* plants are!

Fig. 170 - 173 *Blossfeldia liliputana*. Several plants pricked out after the same system, years later. Photos D. Panco and B. Popa

In any case, be sure that the rock slabs walls come close – as Walter Haage says in his book more than 40 years old – because it encourages rooting. Therefore, if you have weak plants, pot them – for the first time – closer to the edges of the pot, preferably in the corners, and after two years, come the next repotting, you will witness a momentous surprise. A lovely one.

Fig. 174, 175 *Sclerocactus* (*Toumeya*) *papyracanthus* on its own root, planted close to the pot edge. Photos D. Panco

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The fourth confusion – a surrogate for the natural rooting supports

"What can be done if you cannot find mineral rooting supports?"

Explanation

Plastic plates can replace rock slabs and still serve the purpose. By extension, very small pots, buried in larger pots, can serve the purpose. And because the photos sometimes say much more than words, I will leave them to explain everything:

Fig. 176 – 179 After four years you can clearly see the roots occupying all the available space in the soil, and even ascending to the surface. The plant roots after a superficial cleaning. The roots now freed form the soil, coming out of the rooting support. The rooting support (now cut on the side to release the plant's roots). Photos D. Panco

A few years ago I wanted to save an *Astrophytum* hybrid, a spontaneous occurrence in my greenhouse, which had about 3 cm in diameter and a very frail root system – almost non-existent. Not having sandstone slabs at hand, I used a 4 x 4 x 4 cm square pot, which I cut off the bottom to allow the roots to get out more easily once formed.

I 'planted' the ensemble – plant and pot – in a 9 x 9 x 10 cm planter, in which there was a mix of forest soil with a few granulations of volcanic tuff ⏩ in this phase I was interested more in the acidic and nutritional qualities of the soil mixture and I have given priority to the rooting and volume growth of the plant I wanted to save, rather than its later appearance.

The fifth confusion – pot size

"What kind of pots should I use for my plants? Should they preferably be big or it is better for them to be small?"

Explanation

We are actually talking about the ratio of the volume to be dried out of a geometrical body and the surface that allows drying of one of its sides – in this case, the ratio between the volume of the soil mixture in the pot and the surface. By pot, I understand roughly rectangular plastic pots – the so-called "square pots" **(17)**.

In cactus cultivation, as long as the soil mixture is well-drained and sufficiently heterogeneous, if the roots find intermediate spaces to extend into, the distance up the side edges of the pot, do not matter anymore! Also, the volume of a well-drained soil mixture becomes irrelevant if – besides the drain holes – there is a well proportionate surface that allows drying. Hence the size of the cactus must not be proportional to that of the pot, from the standpoint of its cultivation, but only in terms of the available space and – why not – of the aesthetics.

Fig. 180 The planter is 2.75 m wide, 40 cm deep and contains 3 m^3 of soil mixture. Photo D. Panco 2010

In the case of "deep" pots ⏩ if the depth of a pot is significantly larger than its side, the evaporation of the water in the substrate will be slow and uneven in depth – the time the soil mixture dries out being sometimes too long, no matter how well-drained the soil is. Caution! In this case, the effects of watering are all the more difficult to control, as the depth increases disproportionately in relation to the width of the pot. Thus there is a danger of excessive watering that we cannot predict from the aspect the upper layers of the soil.

In the case of the well "proportionate" pot ⏩ if the depth of a pot is significantly lower than its width, the evaporation of the water from the substrate will be accelerated basis and more uniform, and thus the effects of watering become much easier to control. Caution! Watering, however, becomes uncontrollable, if the depth decreases very disproportionate in relation to the pot's width, the porous parts of the soil not having enough time to hydrate, while water passes through it. This time, there is a risk of insufficiently hydrating the plants.

The evaporation of water from a well-drained substrate – in order to assure enough moisture the substrate, but also to dry out quickly – is obtained much well if the pot's depth and width are proportional, this means 20%-30% less deep than wide. It is worth noting that for pots less than 10 cm wide, these proportions are no longer relevant, their volume being anyway too small.

I emphasize once again that for cacti, their underground development is essential! It is preferable to have a cactus that – after transplanting – develops two years only the root system in the underground, than to have a cactus potted in an insufficient soil volume, which vegetates above the ground immediately, but with a poor or overcrowded root system. I assure you that the first will show its potential in its third year, through an over ground vegetative explosion, and in years to come it will vastly exceed the one that at first seemed to look better.

Therefore, as far as your available space allows, give your plants plenty of soil at their disposal!

To support this statement – linking it to the previous question about granulation and heterogeneous soil – you have here a set of photos, depicting a disproportionately large planter, how its filling was designed and what the results are. The "planter" has 2.75 meters on each side and a depth of 40 cm ⏩ i.e. accommodates a volume of more than 3 m^3 of soil mixture. On the bottom there is a 5-7 cm layer of coarse minerals. Then the boulders from the ground were placed in it (Fig. 181).

I filled with a soil mixture between the stones and I planted. The result can be appreciated from two photos. The first was shown above (Fig. 180), the picture was taken in the summer of 2010, after planting the entire arrangement (unfortunately the quality of the photo is poor), and the second and third pictures were taken in February 2013 (Fig. 182). For scale I give you two benchmarks ⏩ an *Echinocereus* in the left front corner and *Carnegiea gigantea* in the rear middle:

Fig. 181 – 183 By zooming the last photo you will note in the center of the planter some plants reputed as difficult: *Obregonia denegrii*, *Ariocarpus retusus*, *Ariocarpus agavoides*, *Strombocactus disciformis* and *Digitostigma caput-medusae*. As it can be seen, they grow very well after three years while their roots could not reach any of the edges or the bottom of the planter ... They're like planted in the ground. The higher soil volume is, the more completely the abiotic-biotic relationship from his mass recovers, physical and biological processes and circuits returning to the normality cycles of nature. Photos D. Panco and V. Posea



Fig. 184 – 186 And here the very same procedure, in the very same greenhouse >> a total depth of 50 cm, with a 10 cm layer of mineral soil mixture on the base, then setting the boulders and arrangenment items up to 40 cm above. Photos D. Panco

The sixth confusion – plants grown on peat

"What to do with my plants bought from the flower shop and which have been grown only on peat? How do I adjust them to the recommendations of the Hexalogue?"

Explanation

This time we are dealing with a practical method. Plants that have been grown on peat or its substitutes, such as minced brown coir, have become dependent on fertilization. They need to be adapted to a primary environment where we can keep them and, later on, where they can re-learn to feed themselves in a natural manner. The biggest losses with this type of plants – beyond their great sensitivity – are due to the fact that we do not properly readjust them to normal conditions..

The procedure to be followed is straightforward: at the first repotting, it is recommended to prepare for them a soil mixture of 80% mineral and 20% humus and fertilize two or three times at half strength for the first season. In the second season simply discard the extra fertilizer. If the plants yearn, during the next season we give them, after the

first watering, a half-strength dose of fertilizer. In the third season – or if appropriate in the fourth – we no longer administrate fertilizers or – if we know that the plant requires it, we discard humus, by allowing it to exhaust, without conditioning or replenishing the organic compounds.

The seventh confusion – the time for repotting

"I would like to know which the best time of the year for repotting is."

This time too, the answer is simple and somehow... natural.

Any repotting generates stress for the plant; the more stress if the plant needs to make a greater adaptive effort and – like every time – this stress is bigger as plants get older.

In case of seedlings, and after successive pricking, several times during the allowed growing season, we may detect unexpected growths and developments; however, for mature plants, things are exactly opposite. Cacti do not like to be removed from their spot. They enjoy even less to be removed from the ground and repotted.

That is why – when we do routine work and when we are not faced with extreme cases or emergencies – it is preferable to repot them during the period of maximum rest for such plants: winter break. They will not be aware of what is happening to them very clearly. On the other hand stress caused by being forced to cease growth will be amplified by a spring repotting.

In short, for the northern hemisphere, repot in January! For the southern hemisphere... I do not know, but a priori, repot in July.

I repeat, it is to be noted that the only repotting reasons when using mineral soil mixtures, are those dictated by plants becoming under potted, by overcrowding of the roots or by the consequences of an improper watering..

Different approaches of cactus cultivation ←Back to summary

NOTE ⏩ this approach is a completion, which I felt it was needed as a result of the numerous opinions that were pushing the Soil Hexalogue into a partisan and discriminatory position towards other cultivation options, or so it seemed. It is a false line of attack for the problem. Still, I hope the lines below to distinguish between a practical approach in cactus cultivation and its aesthetic approach.

Fig. 187, 188 *Ariocarpus fissuratus* var. *Fissuratus.* Two specimens of the same species, more or less of the same age, but grown in different manners: the first one was heavily fertilized, while the second one was grown hard. Collection B. Popa, photos V. Posea

The aesthetic option - key element in cactus culture

Realize that everything
connects to everything else!
(Leonardo da Vinci)

Apparently, the claim may seem – especially for a newcomer – paradoxical. However, this is not about a paradox, but about the natural relationship between cause and effect. So, in what follows, we will not be able to discuss on a philosophical note and – as such – these lines are not intended to be the starting point for a future essay, but a section explaining the purpose for practical reasons. The explanations which will be highlighted further are addressed to all those collectors who do not want to grow cacti at random, but aim to obtain plants with a predictable appearance.

The phenomenon ⏩ caught by the avalanche of heteroclite cultivation advices, received from various sources - books, websites and forums or from other collectors - a beginner cannot understand the relationship between the gathered information and the result of its implementation.

The plan is that – depending on his own aesthetic option – after reading this section, the collector should be able to identify in the future, the advices to follow in order to accomplish his purpose.

Clarifications ⏩ throughout the text "aesthetic option" is referred only to what the collector likes to see/have, when looking at his cacti. Therefore, further, either the overall appearance of the collection, or the particular aspect of the pots, or the decorative grits/pebbles or the tags will not be taken into consideration. Finally, some practical considerations will be compared, between the foremost cultivation methods encountered today, as an expression of the two main existing aesthetic trends.

What is the connection between aesthetics and cultivation?
As I said, this relationship is one of cause and effect: in order to obtain plants with a certain appearance, the one that you like, you will need to cultivate them in a certain manner corresponding to the goal. So it all comes down to the practical use of some parameters when cultivating plants. It seems simple and, at first glance, such an article on this topic does not make sense. That would be if the information and advice that can be found published in different media would be unitary or would take into account the collector's desires.


Fig. 189, 190 *Rebutia cintia*. What kind of look you want to reach with a cultivated plant that? One way or the other? This is the question we have to know the answer when you grasp the cultivation of this species or you choose the look of the specimen you purchase. Photos B. Popa and D. Panco

The collector goes – for example – on a forum asking for cultivation advice for *Epithelantha*, which he finds more difficult and which he is afraid to lose. He will be given recipes of soils, info on lighting, watering and overwintering. Some will tell him to provide plenty of fertilizers, while other will say that these are not required. Even in a high end specialized book , a collector cannot find what to expect if he chooses a cultivation manner over another, without saying that most of the times he does not know what to choose or not, as he combines various more or less incompatible advice, taken from all over the place.

If the person in our example would know what he wants – from the esthetical point of view – he simply could ask the question correctly: "What to do so my plant would look *like* that?"- the "like" being his aesthetic expression of his goal. To a large extent, in such situations, on forums or by emailing to an experienced grower, the one who asks will get the answer sought for, or at least the trend to follow.

So, when someone starts growing cacti, it is good to be fixated on his aesthetic option, because otherwise he will not be able to cultivate his plants in unitary parameters and will have all chances to accumulate failures of various kinds, covering everything from losses to obtaining plants that would not satisfy his aesthetic sense...

The two main options

Of course we have more than two aesthetic options to choose from, our options are not limited to two, but representing a wide range of approaches, ranging from one extreme to the other. However, generally, we can reduce them to two dominant styles ⏩ 1. plants with similar appearance to those from mass-production greenhouses and florists ⏩ 2. plants with similar appearance to those in the habitat.

And because any term must be clearly defined, an explanation of the terms used above is required. So, when speaking of "plants with similar appearance to those from mass-production greenhouses and florists", we mean plants similar to those that can be bought from most specialized commercial growers. Likewise, when speaking of "plants with similar appearance to those in the habitat", we refer to plants looking alike to habitat specimens, preserving in captivity those characteristics which may be recognized in the original description, or, especially, can be visually observed in habitat pictures.

Fig.191 *Sulcorebuitia rauschii*. Colony formed by the offsetting of a single plant, very spectacular because of the number of heads and age, but still retaining a compact aspect and close to the natural one. That's what you want? Collection and photo B. Popa

Plants form the first category are, and I am referring in particular to the globular ones (the columnar plants not being the subject of this discussion for practical reasons **(18)**), plants that are large, highly developed, with visible epidermis, and weaker spination. Those are plants that, for many, became a standard regarding health, successful growing and beauty.

The second category, our target and reference, are exactly for the same species as the above, but have the required compact appearance, glaucous, with large, dense spines, and are partly withdrawn into the substrate. Their aspect is the ultimate goal for those who chose to grow cacti for their strange and wild appearance.

Those who like the plants in the first category, will find those form the second one, as being too small, “bonsai-like”, suffering, struggling, in a word, ugly.

Those who are keen on plants of the second category, will find the first, as swollen, insufficiently resembling to the species as described, overfed and with other words... hideous.

This article is not aimed at making considerations on the validity of those aesthetic guidelines – nor could it. We simply try to present the cultivation parameters needed to go one or the other way, so that, those who want one or the other formula should be able to easily identify exactly what to choose from the heteroclite advices randomly received. No matter the aesthetic preference, always, the final appearance of the plants grown should be predictable and derived from the cultivation method the grower has chosen.

Fig. 192 *Sulcorebuitia rauschii*. Colony formed by the offsetting of a single plant, very spectacular because of the size of the main head, but looking completely different than plants in nature. Maybe you want this one? You have to decide! Collection B. Popa, photo V. Posea

What are the parameters to be taken into consideration?

Four main parameters contribute in achieving a certain plant type **(19)**: the soil mixture, fertilization, frequency of watering and light conditions.

We will summarize these parameters one at a time, so they can be used as a comparative reference for both cases.

Soil

As a nutritional basis for cacti, the soil is the first element to be analysed. Soils can be classified into two categories:

⏩ active soils ⏩ are soils whose components represent not only the substrate for the fixation and development of the plant's root system, but also the main feeding source;

⏩ inert soils ⏩ are those soils whose components represent only the substrate for the fixation and development of the plant's root system, their feeding being obtained by addition of nutrients by the grower.

Active soil mixtures can be prepared, depending on the desired purpose, after several recipes, starting from various mineral mixtures **(20)** to mixtures having an organic dominant, as in the case of soil mixtures prepared for many of the epiphyte cacti. What is important to remember is that all of these soil mixtures, in order to be used in cactus cultivation, must have a common feature: they must be very well drained.

By source, active soils mixtures are of two kinds: prepared from ingredients collected by the grower (where possible and available, and only where this practice is permitted by law), or from ingredients purchased from specialized manufacturers.

The composition of soils mixtures generally contains the following active ingredients: mineral granulations ⏩ sands, gravels, crushed minerals, etc. Earth ⏩ garden earth, molehill earth, leaf mould, etc. Various granulations of artificial origin ⏩ agricultural zeolite, crushed brick, etc. The most common active soil mixtures contain a well-balanced proportion of all these ingredients.

Inert soils especially designed for cacti, can be obtained from professional producers, and have usually a very good drainage. Their composition is typically very simple, containing perlite, peat, brown coir, lava, akadamia, etc.

Flg. 193, 194 *Mammillaria theresae*, on the left, *Mammillaria theresae* fma. *albiflora*, grafted, on the right – both plants have been fertilized for years. Collection and photos B. Popa

Fertilizers

The most commonly used and available fertilizers are of two kinds: natural and artificial. Natural fertilizers of animal origin are extremely dangerous, both because of the development of an alien bacterial and fungal environment for the plant, and because of nematodes and other pests, which can be introduced into the soil together with the fertilizers. Natural fertilizers of vegetable origin are better from the phytosanitary point of view I do not know any sources to purchase from in Romania, and their artisanal preparation is an experimentation playground for everyone, to the extent that we have no means or sources of information in order to be able to determine the exact

concentrations of nutrients contained by this or the other "brew", in order to formulate a correct dosage. In this case, not excessive feeding, but deficiencies are rather expected. Artificial fertilizers, whether liquid, or with slow-release granulations, are easy to find in specialized stores, super markets and florists.

All these substances have two series of extremely important components. On one hand we have the main fertilizing compounds massively used in floriculture, referred to as macro-elements **(21)**, well known under the generic name of NPK fertilizers, based on nitrogen (N, from Nitrogen), phosphorus (P, from Phosphorus) and potassium (K, from Kalium – another term for Potassium). On the other hand are fertilizing compounds, called micro-elements **(22)**, the latter being the salts of some chemical elements vital for the well-being of our plants.

The purpose of fertilization is to compensate the lack in the soil of certain compounds or elements necessary for properly feeding the plants and allow them to reach their growth potential throughout. Therefore, in the case of inert soil mixtures not containing nutrients, fertilizing will be needed nearly all the time. In contrast, in the case of active soils, fertilization will be only partial or even not necessary at all, depending on the conditions and the aesthetic option of the grower.

Fig. 195, 196 *Mammillaria theresae* – a remarkable specimen grown on a mineral soil mixture, which is receiving the necessary and sufficient water only, which keeps it look similar to the habitat plants. Photo B. Popa
***Mammillaria theresae*, a habitat plant – Paso de Coneto, Durango. Photo L. Barta**

Water

When we talk about cacti, water is always considered in regards of its quantity or as a vector for nutrients. However, bear in mind that, even if quantity is important, water needs to have an essential qualitative characteristic: it should be soft and slightly acidic. A hard water and/or with a basic pH, regardless of the aesthetic option of the grower, must be regarded as a poison for the plants. The use of such water in pots, can lead, over time, to real mass catastrophes among the specimens of a collection. Beyond these aspects, as a cultivation parameter, water is a key factor in shaping our plants and is directly related to the soil type used. We will return with the necessary details.

Light

A source almost mandatory for photosynthesis, natural light is a very important parameter for the cacti of a collection. Moreover, they need sun... the question is how much?

We can see that this essential cultivation element which can make the difference in the appearance of our plants has a very important feature that is most often omitted: sunlight is a growth inhibitor of plant cells, which means that a plant exposed to full sun will look totally different from a plant grown in the shade. The best example of the statement is heliotropism – the orientation following the sun. It is not the entire plant that moves after the sun, but the shaded cells turn / bend it toward him, because they grow larger than those facing the daily star. In obtaining the desired appearance, this detail is of the utmost importance, we will further see.

We got now to the core of the subject ⏩ how to obtain "beautiful" plants? The answer is very simple: by dosing the four parameters mentioned above, depending on the desired goal.

Fig. 197, 198 *Mammillaria pectinifera*. Two plants grown in different manners for many years. The one on the right, planted in mineral soil, kept in full sun and watered less frequently, will keep its shape. Photos B. Popa and D. Panco

The basic principles

Soil ⏩ soil with high percentage of organic compounds in the mixture and/or highly fertilized ("rich soil") = big plant with the desired appearance by those who want "flower shop" plants; ⏩ mineral soil and/or with small percentage of organic compounds in the soil mixture without added macroelements ("poor soil") = plant of natural size and appearance.

We will detail now the stated above, discussing the mechanisms that lead to the results set out ⏩ thus, any living organism is a complex construction that takes up the nutrients, processes them through specific metabolic processes and turns them into cellular mass. The richer the feeding (quantitative and qualitative), the more will the body grow. It follows that those who want large, fat plants – like the plants at the flower shops – will have to opt for the rich soils.

Fig. 199, 200 *Yavia cryptocarpa* – the plant on the left, grafted, grows in a 18x18x12.5 cm pot, while the plant on the right grows on its own roots in a 9x9x10 cm pot , and looks almost like the plants in habitat. Photos B. Popa and D. Panco

Will those who use "poor soils", underfeed their plants? No! Cacti, as almost all xerophytes, grow almost only on such "poor" soils. This is their normal environment. Of course that in captivity, in pots, they will not have the same soils available as in the wild, but soils mixtures producing similar effects. The result will be that they will feed as much as they will need, but will grow hard, as happens in nature, because, again, Nature does not offer gifts.

The drive for adaptation to the environment is natural selection. Natural selection is done by "struggle for life" – the struggle for survival – and the xerophytes are adapted to these soils and arid conditions of life for tens of thousands of generations. That is why where other plants would not find anything, they would thrive. A poor soil mixture is regarded as such, just by comparison with the rich soil mixtures mentioned above, but our plants do not know luxury. Thus, soil mineralization is sufficient for them and sometimes it is even necessary. For xerophytes, exhausted soils are considered normal and not poor. It is noted that the lack of the fertile elements of an arid soil, does not assume that we are talking about an inert soil for cacti. It is a soil that contains resources that the plant was adapted to for millennia to be able to exploit them; generally it is all about extracting the nutrients mentioned above from stones.

It follows that collectors wanting plants with a similar aspect to those in the wild, smaller, more flattened, heavily spined, should opt for more barren soils, i.e. with a greater proportion of mineral granulations.

Note ⏩ it should be considered that the plants occupy sufficiently large pots, an undersized pot being a factor for stopping the growth of the plant, regardless of the particular cultivation style preferred.

Fertilizers ⏩ fertilization with NPK = big plant with the desired appearance for those who want "flower shop" plants; ⏩ moderate fertilization with micronutrients = plant with almost natural size and appearance.

Fig. 201, 202 *Turbinicarpus jauernigii* – the plant on the left was fertilized for over two decades; the one on the right grows on minberal soil mixture, its roots deforming a pot that apparently seemed to be large enough. Photos B. Popa and M. Crisbășanu

Certain ideas must be highlighted. So if we say that nature does not offer gifts, instead we can affirm that a grower has no choice and sometimes must do so. Therefore, the assertions above do not apply when sowing or to plants in the early juvenile stages, as the terms NPK or micro-element are not exhaustive (see notes **21** and **22**). When we say "early juvenile stage", the expression may seem vague and, therefore, thinking that a plant is mature when it reaches the flowering age of, the early juvenile stage is about half of the time span from seedling to flowering stage (= the plant reaches the sexual maturity). In cases where plants flower beyond the age of five, this early juvenile stage may even extend to two thirds of this time span. As a practical conclusion, young plants need help and fertilizer, right up to that threshold of their youth, when the grower begins to prepare the plant for its later appearance.

As I was drawing the attention, the term itself "fertilization with NPK" is an approximate expression in so far as this operation differs greatly from grower to grower, the advice that those in need will find, being multiple and seldom dealt with specifically, although the horticultural practice shows us that it should happen as such. Going further on the statement that a plant that feeds a lot will grow, and being here preoccupied only to explain the cultivation trends, we will not go into details that would make this section unnecessarily complicated. We only note that an accumulation in the soil of unabsorbed fertilizers can lead to its contamination, this being in time fatal to plants.

Plants grown in order to look nature like, after passing through the "early juvenile stage" should be "weaned"**(23)** gradually and adapted to the growing conditions they will have from now on as long as they will live. The adjustment is made by repotting into the final soil type and proceeding to a drastic reduction in the number and concentration of fertilizing actions. Considering that preparation of "ideal" soil mixtures is rather a rare case, maintaining a moderate, annual or biennial fertilization, however, using only micronutrients, remains practical. Thus, it ensures the plant the entire range of compounds that it needs for its health **(24)**.

Water ⏩ abundant and frequent watering = big plant with the desired appearance for those who want "flower shop" plants; ⏩ moderate watering (necessary and sufficient = plant with almost natural size and appearance.

Fig. 203 – 205 These *Turbinicarpus pseudopectinatus* almost 13 years old, on the left, and *Turbinicarpus valdezianus* roughly 15 years old, are cultivated hard and maintain their shape despite the years. Photos M. Crisbășanu. Below: this huge *Turbinicarpus valdezianus* specimen has received fertilizer and plenty of water on an inert substrate. Photo B. Popa

In addition to feeding (quantity and quality), there is however an element that is rarely taken into account: the period of time during which food is absorbed. It is not the same thing if one eats a loaf of bread in one week, or in a day... or during one meal! So the more and faster can the plant absorb nutrients, the more it will grow. Beyond its capacity to provide the necessary water for its tissues, the watering is designed to allow the fine roots to harvest from the substrate the dissolved salts. Therefore frequent watering leads to an increase in the volume of the plant, which in addition to an increased turgidity, is forced to produce new cells.

Fig. 206 *Mammillaria sanchez-mejoradae* – was this plant designed to grow in rich soil...? Photo M.A. Gonzalez Botello

If we speak of active mineral soil, the absorption of salts, being made mostly with the help of symbiotic bacteria, at the level of contact of the fine roots with the rock, the quantity of water should affect only the intake of salts from soluble rocks contained by the mixture. It is not so. For xerophytes water is a dream comes true: as soon as they find water, they do not stop from taking it in, unless it becomes excessive. In this case, water has mostly a role for triggering the use of resources in the support of the plant, to increase cell growth, in order to create new storage spaces, this being the purpose of the succulent tissue. In addition root system is forced to a greater intake of nutrients to support the production of new cells. Very frequent watering in active soils is most often the main factor of deformed growth of plants, rather than looking like in nature.

Water is essential to all living beings! That is why the cactus grower must never fall into the other extreme of depriving the plants of water! It is much easier to prepare a soil through which water passes easily, which retains a certain amount of moisture by its porous ingredients, and which becomes harder to be absorbed by the plants at once, and at the same time without becoming waterlogged. The plant must work hard to absorb water... but it must not be allowed to suffer from the lack thereof.

Fig. 207 *Epithelantha rufispina* - Parras, Coahuila, on sandstone. Was this plant designed for frequent waterings? Photo M.A. Gonzalez Botello

Light ⏩ Filtered light/sunlight, shaded = big plant with the desired appearance for those who want "flower shop" plants; ⏩ Un-shaded, strong sunlight **(25)** = plant with natural size and appearance.

To determine the value of this parameter, more than for any of the foregoing, each grower must make their own experiences, because situations vary greatly from one place to another, depending on the overall situation of the greenhouse, the latitude and/or the dominant climate. However, bearing in mind that direct insulation leads to a smaller size of the sun-bathed cells, depending on the aesthetic option chosen, the graduation of the sun exposure of the plant will compete with the other three parameters, in order to get its final appearance.
To note is that the plant development will be more obvious in the shade rather than in the sun.


Fig. 208, 209 *Epithelantha unguispina* ssp. *huastecana* - Hidalgo, Nuevo León, on limestone. Photo M.A. Gonzalez Botello. Does shadow ever get this *Epithelantha unguispina*...? The one on the right was cultivated with added humus in the soil mixture and is shaded during summer. Photo B. Popa

The four control buttons

Making use of the four parameters taken into consideration, the grower is in a position to have a control panel with four control buttons: soil, fertilization, water, light. Bearing in mind that the plants discussed here are perennial plants with very long lifespan, and with an exceptional apathy to visible reactions, seeing the results sometimes after a season or two, becomes essential to know and understand the effects of the four parameters detailed above. But knowing, however, what they involve, their use becomes predictable, even if their effects are not observable immediately.


Fig. 210, 211 *Sulcorebutia rauschii* and *Blossfeldia liliputana*. Grafted plants may lead to spectacular results, but also safer than plants grown on their own roots, in the style of florist plants. Collection B. Popa, photos V. Posea

It should be noted that choosing an aesthetic option implies a consistency in practice, changing the set of procedures always leading to undesirable results. It is also noted that by alleviating some methods or the other, one can always obtain intermediate results... just that the latter are not predictable, by not being generally true, but depending on the cultivated species. Of course that a person wishes to stretch his or her patience over a decade or two, even in circumstances of mixed cultivation conditions, may come to identify certain predictability, relative to the region in which they grow and the recipe applied.

Practical considerations

I will show you a few of the consequences of the chosen cultivation method in order to meet the aesthetic option. These consequences are seen – this time as well – only from a practical point of view.

1. Plants grown on rich and frequently fertilized soils have very big cells due to a too abundant feeding – that is why they require in winter higher temperatures. They have a thinner epidermis – that is why they are more susceptible to injury, parasites and burns and fungal attacks by air.
2. Plants grown on rich and frequently fertilized soils have less developed and much more sensitive roots compared to plants grown on poor soils, especially because of having a restricted rhizosphere and a less integrated soil microbiota.
3. Plants grown on rich and frequently fertilized soils, which in nature, are adapted to specific environments, such as limestone areas, rocky cliffs and extremely arid areas have a lifetime inversely proportional with the sizes attained in this cultivation system.
4. Compared with the plants grown in full sun, plants raised in the shade have a less developed and less aggressive spination, accumulating less protective coating or wax on the epidermis and they seldom look glaucous. Note that ultraviolet radiation is essential for a well-developed spination **(26)**.
5. Columnar plants – although they are not the subject to this discussion – on rich and frequently fertilized soils, grow too quickly at the expense of the internal wooden structure, needing very often of a tutor in cultivation.
6. Plants grown on poor soils have a sometimes an exasperating slow growth. They are, however, resistant to external factors, adapt easily to lower temperatures during winter, have a strong and aggressive spination, are glaucous and also accumulate protective coating on the epidermis.

Fig. 212 *Thelocactus bicolor* ssp *bolaensis* Sierra Mayrán, Coahuila, on gypsum. Here is the quintessence of the Soil Hexalogue: *Thelocactus bicolor* subsp *bolaensis* growing from bone dry stone! Photo M.A. Gonzalez Botello

Are now, finally, I return to a statement I kept repeating: **Nature does not offer gifts**! In nature everything is operating on the principle of "is necessary and sufficient" and is based on an unforgiving competition ⏩ a tough struggle for existence ⏩ truly shaping in time the life forms, as we know them today. From my experience of nearly four decades, I have come to believe that if we help plants have a good start, it is essential than then, to make them work hard in order to upkeep... themselves.

That is why, although I started out differently, in the years that followed, I have changed the way of evaluating and collecting and today I am a partisan of the aesthetic option that allows growing natural-looking plants – plants that are strong, because they are fighting to live.

Conclusion

You will NOT be able to perform in growing cacti without a continuous research on information concerning the characteristics of the habitat of the plants you grow!... Not to imitate them – that would be impossible! – but to understand which they are, and the full potential and also the limitations in adaptation of the collected plants.

Of course, sometimes there is scarce information available for this purpose, so in order to solve the lack of information, the collector has to document primarily through photographs and/or films – the Internet being a source of almost unlimited information. Films and photographs are invaluable sources of knowledge and understanding of the environment conducive to species we seek to keep alive in captivity ⏩ therefore we learn to understand these plants, as if from another world.

Last, but not least, an advice ⏩ **NEVER buy a plant until you know if you can to provide it the soil it needs!**

Notes

(**1**) pH shows the chemical activity of hydrogen ions – the measurement of the pH in a solution (in which water is always in the form of solution) determines whether the solution is acidic, neutral or basic. For amateurs, the measurement can be made with the specialized probes sold in horticultural shops; the accuracy of the measurements given is relative and approximate, but may indicate a trend of the pH of the soils in our pots. **← Back 1**

(**2**) Hardness shows the concentration of cations Ca^{2+} and Mg^{2+} dissolved in one litre of water, and is measured in dGH (Degrees of General Hardness), 1dGH = 17.848 mg $CaCO_3$ per litre of water. Even if it is expressed as mg $CaCO_3$, water hardness is determined by the totality of calcium and magnesium salts. Hardness can be temporary or permanent. Is called permanent hardness, that hardness resisting water boiling and that is due to all Ca and Mg salts except for bicarbonates – Ca $(HCO_3)_2$ and Mg $(HCO_3)_2$. The latter represents temporary hardness. Temporary, whereas through water boiling, bicarbonates come out of the system by turning in precipitating carbonates. Waters become hard if they pass through layers of limestone, or calcareous mineral dolomite. Water hardness may contribute with other metal ions (iron, aluminium, manganese, magnesium, etc.), but for practical use, we do not consider relevant to bring the, into question, this article having no claim of completeness in this area. On the other hand, water containing such chemical elements in small quantities, as long as it is not hardened by the main factors listed above, can only be beneficial to plants.**← Back 2**

(**3**) Mineral/inorganic soil ⏩ pedologic definitions of the Encyclopedia of Soil Science,Ward Chesworth –Springer 2008 are ⏩ page 482 "Mineral Soil: A soil composed primarily of mineral material, with usually no more than about 20 percent organic matter below the A horizon. This does not preclude an organic rich A, which may be up to 30 cm thick."; ⏩ page 362 " Inorganic soil: A soil composed mainly of minerals, with organic matter playing only a minor role in determining the properties of the soil. A less precise term than mineral soil."**← Back 3**

(**4**) Organic soil ⏩ the pedologic definition of the Encyclopedia of Soil Science, Ward Chesworth –Springer 2008 is ⏩ on page 501 "A soil in which the organic component is dominant with respect to the mineral component (in Histosols for example)." **← Back 4**

(**5**) The term **colluvium** (n.) defines a slope deposit due to gravity, which is at the base of a slope (formed as a result of erosion and breaking) ⏩ **colluvial soil** – can originate from colluvium ⏩ natural soil consisting of breaking granulations. **← Back 5**

(**6**) In Cactus and Succulent Journal, Vol. 77 March-April 2005, No 2, page 61, as the resumption of an article in Plant Biology 6: 643-650, was mentioned - in the article "Rock-Loving Cacti Rely on Bacteria in Roots" – research carried out at Center for Biological Research of the Northwest in Mexico over the relationship between the four species of bacteria in the roots of cacti and their ability to grow on solely mineral soils. In the same issue, Vol. 77 September-October 2005, No. 5, page 221 in "Do Fungi Live in Cacti?" summarizes the research carried out by Trichur S. Suryanarayanan et all, 2005 "Entophytic Fungi Associated with Cacti in Arizona", in Mycological Research 109. 635-639, of which were identified in 21 species of cacti, 22 species of fungi associated with them in order to protect them against insects and pathogens. Moreover, in his book "Plant Roots: Growth, Activity and Interactions with the Soil", Wiley-Blackwell 2006, Chapter 1, page 10-13, and Chapter 6, page 174-182, Peter Gregory shows how complex **rhizosphere** is, and what complex roles their micro-inhabitants take. In their book about compost, "The Complete Compost Gardening Guide", Barbara Pleasant and Deborah L. Martin, reveal the importance of microorganisms associated with the roots using a highly suggestive phrase: " ...the secret world known as the rhizosphere, which is the incredibly bioactive real estate where roots and soil come together".**← Back 6**

(**7**) Halophyte plants are those plants that have special adaptations to be able to live in salty soils – the most common example being the origins of the genus *Salicornia*, whose surprising ability is revealed even by the name of the genus coming from the Latin root *sal*, meaning salt.**← Back 7**

(**8**) Of the volume "Knowing, understanding, growing *Turbinicarpus-Rapicactus*", Davide Donati and Carlo Zanovello, page 96 – "*T. lophophoroides* is the only taxon of the genus specialized to growing in salty plains with mostly gypsum soils, that are seasonally flooded with great concentration of salt and pH that can in some areas exceed 9...".**← Back 8**

(**9**) Valentin Posea, chemical engineer, says in the topic "Limestone, gypsum" from 04 December 2004, published on the www.cactusi.com : "... calcium salts that we talk about have all quite low solubility. **Marble** is indeed something less soluble than other minerals containing calcium. A liter of water can dissolve, at room temperature, about. 0,.01 g **marble**, or 0,3 g **dolomite**, or 2.4 g **gypsum**, or 0.01 g **calcite**. Of course it comes to neutral water. Slightly acidic conditions (acidic earth, acid rain, peat etc.) things change radically. Gypsum shall retain its solubility and all the other, depending on the acidity and type of acid, will be at least equally with soluble it." **← Back 9**

(**10**) I used the term "gypsum" and not the most commonly used "plaster" due to the phonetic similarities with some widespread languages, due to the phonetic similarities with the etymological roots and especially because I never liked the matching of the terms "gypsum" and "gypsophile". **← Back 10**

(**11**) en./fr. ⏩ Lapilli; it. ⏩ Lapillo **← Back 11**

(**12**) Grebenişan, Irina, Conf. Dr., *Microbiologie - Note de Curs* – Universitatea de Ştiinţe Agronomice şi Medicină Veterinară Bucureşti, Facultatea de Îmbunătăţiri Funciare şi Ingineria Mediului, Specializarea Protecţia Mediului – sectiunea 9, Microbiota din Sol ⏩"Soil microbiota is represented by bacteria (eubacteria, actinobacteria, cyanobacteria), microscopic fungi, algae and protozoa." Not to mention the bacteria that is the most numerous and most active in the soil," here is what I use, as evidenced by the following quote: "They are involved in geo-bio-chemical circuits (carbon, nitrogen, sulphur, phosphorus, iron); **They participate in the processes of mineralization assuring soil fertility and plant nutrition; They participate in the solubilisation of organic and inorganic compounds, insoluble and inaccessible for plants;** They are organisms fixating the atmospheric molecular nitrogen, necessary for plant nutrition; They participate in the aggregation of soil particles using extracellular polysaccharides; **They participate in the formation and degradation of humus. "** **← Back 12**

(**13**) The role of soil micro flora was and is widely studied ⏩ In 1904, Lorenz Hiltner, German bacteriologist, Professor of Agronomy at the Munich Technical College defines the term rhizosphere ⏩ a century later "…Young and Crawford (2004) have drawn attention to the important role of microbes in the dynamic generation of soil structure and stressed the interactions of microbial and physical processes in soil and the self-organization that occurs in the soil–microbe system." – in Gregory, Peter – Plant Roots: Growth, Activity and Interactions with the Soil, Wiley-Blackwell 2006, page 10-13**.** **← Back 13**

(**14**) Barbara Pleasant and Deborah L. Martin, in their book "The Complete Compost Gardening Guide", say about the importance of microbiota, as follows ".... yet the greatest gift compost brings to soil is **its huge array of beneficial life forms**, which include fungi, bacteria..."; further, they clear up: " How many types of bacteria are there in compost? Microbiologists usually manage to grow out about 300 different strains of bacteria from random samples of compost...".**← Back 14**

(**15**) The underside of a colluvium is that it gathers most of the organic part among the mineral elements of breaking.**← Back 15**

(**16**) "Knowing, understanding, growing Turbinicarpus-Rapicactus", page 56, the section about *Rapicactus booleanus*.**← Back 16**

(**17**) The volume of soil that enters a nearly parallelepiped-shaped pot will always be greater than the amount of soil covered by a nearly cylindrical pot, with a diameter equal to the side of the first one – we are interested in having as much soil. It was argued that in parallelepiped pots the roots are forced to make angles which prevent the sap to circulate correctly – we invite all those who have such views not to confuse plant vessels with blood vessels and to look through the cracks and crannies that roots drift through, making the rock to crack and concede… **← Back 17**

(**18**) The so-called columnar plants – we do not mean the plants that can become columnar plants over time – are mostly plants that grow on organic soils, or requiring, in captivity, organic soils that will look as stylish as possible. Therefore, in order to obtain the desired aesthetic appearance to columnar plants, the differences in culture between the two options are not significant. **← Back 18**

(**19**) One of the most important parameters of culture – if not the most important – is ventilation. This fact is not taken into consideration, because it does not affect the aesthetic appearance, from the points of view expressed by this article. It is an element which should be common to all methods and positively affecting the aesthetics of plants, regardless of the option chosen. Ventilation substantially diminishes the actions by fungi (sooty mould, rust, etc.), the effects of burns and pest attacks (Caution! Ventilation reduces, it does not eliminate!) **← Back 19**

(**20**) Mineral mixtures are active soils, where plants (cacti) that grow on such soils are in symbiosis with a series of bacteria in their root system. These bacteria produce enzymes needed for the dissolution of rocks, of which – later – the absorbing fine roots absorb the necessary mineral salts. Thus, the plant feeds directly from the mineral substrate, without needing a reduction of an organic substrate to provide them with the necessary mineral salts. Under this angle, in cultivation – as opposed to mineral soils – organic soils are not exhaustible. **← Back 20**

(**21**) The terms of 'macroelements' and 'microelements' are generic terms with horticultural use. In the case of macroelements (N, P, K) their symbols do NOT refer to the respective chemical elements themselves. The use of their symbols, followed by a digit, with the exception of nitrogen (N), serves only for the expression of the percentage of the substance in the fertilizing mixture composition. Macroelements bear this name because the fertilizing cocktails that compose them are formed by large percentages of such substances. In this article reference was made only to products sold as being for *Cactaceae*. **← Back 21** , **← Back v. nota. 21**

(**22**) Unlike macroelements, microelements are mixtures of substances the small percentage, sometimes seemingly insignificant. **← Back 22**, **← Back v. nota. 22**

(**23**) It is preferred that a plant that has been grown with fertilizers to be disaccustomed by them, by reducing the dose gradually, so that it has time to form non-assisted feeding mechanisms. **← Back 23**

(**24**) The deficiencies in captivity for cacti – plants with huge inertial response – are very hard to recover, without distorting the appearance of the plant, where the option is to have the natural looking plants. **← Back 24**

(**25**) The statement is valid in both hemispheres, in the temperate zone, in terms of outdoor cultivation or cultivation under an airy shelter. In greenhouse conditions, however, or in locations where you can reduce the greenhouse effect, the exposure of the plant in full sunlight, without shading and without very strong ventilation is completely contraindicated! Also in tropical or subtropical areas, where the Sun's rays have other repercussions, sun exposure should be made under specific conditions, that only local experience can recommend it.. **← Back 25**

(**26**) Greenhouse glass – shaded or not – prevent almost completely the passage of ultraviolet light. Polycarbonate and especially polyethylene foil allows its transition. **← Back 26**

Acknowledgements ←Back to summary

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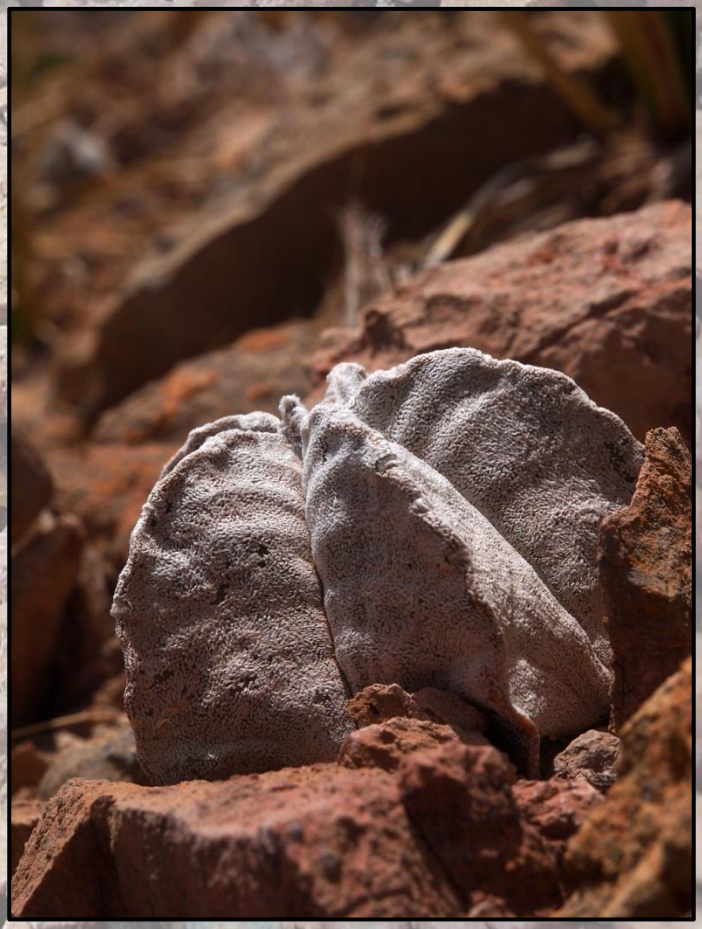
Fig. 213 *Neolloydia conoidea* v. *grandiflora* - La Trinidad Photo G. Matuszewsky

Coryphantha tripugionacantha - Tepetatita, Zacatecas and *Echinocereus dasyacanthus* – Tx Photos A. Delladdio

Aztekium hintonii and *Echinocereus reichenbachii* Photos C. Perez Badillo



Mammillaria lenta and *Astrophytum coahuilense* – Ahuihla Photos G. Matuszewsky

Rediscovering the compost (2013)

by Eduart Zimer, Auckland, New Zealand

The subject of this article - a revised, updated, illustrated, but also somewhat more focused version of my 2010 text, is intended to be a customization of some well-established techniques. Much was written and published about the technique of compost making, from articles to studies and books. In the following will review the common manufacturing processes, but I will also focus on those elements of the process through which organic soil components specially designed for cacti and other succulent plants can be obtained.

The lines below are not a counterweight to the Soil Hexalogue, moreover, they are written by a declared follower of rather poor soils / potting mixtures preparation, with a low content of organic matter. In many cases, however, in numerous species, both of cacti and other succulents, the presence of organic compounds in the potting mix is necessary. That is why, in what follows, I want to redefine the organic compost (hereinafter only referred to as "compost"), as a component that can be used also for plants growing in poor soils and not only as a "booster" for garden plants. The most important element in achieving this objective is to get hold of a compost of the best possible quality, which needs to have all those characteristics required for its use in the culture of xerophyte plants. It must be stated clearly that for some cacti and succulents, the only acceptable substrate in culture, is strictly mineral; for others, perhaps most of them, a minimal amount of organic matter is necessary. Very rarely they need rich mixtures with a high content of black compost. But whatever the amount added into the mix, never must xerophyte plants receive incompletely matured compost! This is the aspect that may cause fatal errors: we focus too much on reducing the time of compost making and on the quantity (weight) of organic matter that we have to add into our mixture, forgetting or completely ignoring the importance of its quality.

Of course, at first glance, instead of bother producing the compost ourselves and to prepare ourselves the potting mixtures, the most convenient thing would be to buy them readymade, from specialized stores or garden centres; compost from these sources is good... but only for vegetables and general gardening purposes. Using commercial potting mixtures, even if they have been prepared for our own very specific purpose (growing cacti and other succulents), we will have to face several problems:

We may be forced to improve them, in particular to improve the drainage, with various mineral components (sand, chippings, etc.), without ever saying that we start at the wrong end. To a balanced mineral mixture one can add or not organic component and not vice versa. Drainage is important, but the quality of a mixture is not summarized only to drainage.
We do not have any control over the components used and over the organic/mineral ratio.
Commercial mixtures contain, in addition to fungicides and insecticides, slow release fertilizers, which is not desirable. We fertilize only when, how and if we want. There are groups of plants which, although accepting some organic compounds into the substrate (rather traces I would say), should not be fertilized at all!
Assuming that experience said its word and a certain commercial mixture is used in acceptable conditions and in controlled risk conditions, by changing the brand one may conclude the use of an adjusted potting mix having totally different set of characteristics that may no longer meet equally well the requirements of the plants in our collection or that may no longer fold as well on the habits and behaviours formed by us when we use the same product for a long time, as a major ingredient in the preparation of potting mixtures.

Another possibility is to use in the potting mixtures prepared by us of natural earth with high content of organic matter. The Romanian cactophile tradition proposes various generic types: farrow earth, Taxodium earth, molehill earth, garden earth, clayish earth, or simply the leaf mould and many others (see above). Depending on the type of soil and the place of collection, the content of organic matter can vary in an uncontrollable way. Though usually, for commercial mixtures, recommendations also include the mention uncontained and uninfected (pest-free), the

extraction from places apparently not polluted (green is not always clean), especially by less experienced people, can lead to unpleasant surprises, to say the least. Pollution and, in particular, that due to heavy metals, from various chemicals and petroleum residues, is not always obvious. On the other hand, neither the presence of pests can be always observed. Moreover, the natural sources for earth collection are not in everyone's reach, the quality possibly varying from one place to another, and the limited quantities which can be collected and especially their transport can in time become a real chore, especially if you need large quantities on a regular basis. There is also another extremely important limiting factor: in many countries of the world, collecting earth/soil/components thereof is unlawful; if for mineral components this may become an insurmountable problem, in contrast, with regard to the organic component, there is an answer and this is we are talking about in this article. There is a way allowing us to obtain reasonable quantities of black earth (compost) of very good quality. Of course it will have to be prepared by ourselves, but we will do it without too much effort! In other words, being unable or not knowing where to take it from, being unaware or unsure of what to buy, we are forced to rediscover the wheel: the artisanal compost making. And since wheels have evolved through history, we will improve ours to be specially designed for growing cacti and other succulents.

Fig. 1 - 3 Furnace type compost bin which is operating for over 6 years. Air vent. Lower side door for compost extraction.

We begin to go through the production of quality compost, this word referring to the properties that the obtained material must have depending on the desired goal, i.e., to obtain an organic compound, which is sometimes essential in the preparation of potting mixtures for xerophytes. Compost making is even more simple than it seems at first glance, but it is essential to follow the details of a process that is not overly technical or complicated; beyond understanding the process a "good hand", as gardeners need that "green hand" will help, but, like any other thing, ultimately producing compost can be taught too, and especially, in the absence of reasonable alternatives, it deserves to be put into practice.

There is a first downside: it cannot be produced in small quantities. Compost requires a dedicated space that should be big enough, as aired as possible, which is a limitation for those who only have terraces or balconies, at the block, at their disposal. However, there are solutions too for those who benefit from such conditions: they will use the

more compact compost boxes with compartmented sorting trays (see below), which can be bought or made to order. Unfortunately they do not yield as the big ones. The only discomfort caused by the common compost bins is a shortage of space in a balcony. If the manufacturing procedures are properly followed (see below), there will be no problem as to the unpleasant odours, this being the immediate signal of the fact that we did something wrong. On the other hand, a closed or semi-closed balcony is permanently sheltered from cold air currents and wind, being always a warmer place where warmth and light are reflected from the walls, while the box can be sheltered from direct sunlight (avoiding the overheating), which is a real advantage.

In the open air too, the location of the compost bin must be sheltered from strong winds and sun, especially during the hottest time of the day – ideally placed in a corner formed by two walls or fences. Shading from direct sunlight is an aspect that should not be overlooked, even more so, as the composting process naturally releases a certain amount of heat which allows the continuation of the process in the winter too, although more slowly. Therefore, any interference leading to an artificial cooling slows down the process, but at the same time, excessive heat input, particularly through exposure to direct sunlight during the summer, is not desirable, as "overheating" of the vegetal mass in decomposition leads to the same effect of slowing down or entirely stopping the process, as well as its cooling.

Fig. 4, 5 Just added compostable materials - grass (hay) and garden waste (in this case dried Aeonium flowers) and leaves from ornamental shrubs.

There are several methods of artisanal compost making:

1. **the compost heap** – basically consists of a heap of materials to be composted, placed directly on the ground, after the removal of the existing vegetation and complete topsoil stripping, where grass lawns. Such a heap shall not be made on concrete, cement, asphalt paving, boards, etc. The heap shall be covered with a polyethylene foil, preferably black, well fixed to the ground with stones, bricks or other heavy objects to avoid being taken by the wind. The covering thus arranged, on the one hand it retains the heat generated by the breakdown processes, and on the other hand it does not allow any dryness or excessive watering of the mixture, due to heavy rains. Such a heap is a single charge – all composted material is processed at the same time, which, to the extent that we are only left with one source of compost, constitutes a disadvantage. In order to have a steady supply of compost it becomes necessary to form more compost heaps, from time to time. The ideal dimensions are 100 cm x 100 cm x 100 cm; if the volume is smaller, the compost does not heat enough and, implicitly, composting takes longer. If the heap is larger, it becomes difficult to mix.

2. **furnace type compost bins** – are containers, more high than wide, larger or smaller, from 100 liters to more than 1,000 litres, are usually made of dark plastic (in the past they were made of wood as well); they are bottomless, with non-compartmented interior, with side doors, located in the lower side; they also have narrow side air vents and – important –a lid that closes tight, in order to maintain a high temperature inside. The compostable material shall be placed on top and the fully processed compost is removed through the

lower side doors. It is perhaps the most convenient to use and it has the great advantage that once the process is started compost can be collected at any time, after the first "charge". If you wish to collect on a regular basis, you should continue to add periodically compostable materials. My experience is based on this type of composting process and, therefore, in what follows, I will focus on that method;

3. **composting bins with sorting trays** – are similar to furnace type compost boxes, with the essential difference that inside there are several subdivision drawers whose essential role is to sieve. They usually are more compact as well. They allow the passage of the composted materials from the upper tray to the lower one, only after having reached a certain stage of breakdown. It is a more elaborate system and requires more direct interventions, than the other methods and relative to the total volume of the installation, the total quantity of compost produced can be noticeably smaller. It has however the great advantage in that the aeration – very important factor – is much better, which leads to a very fine grade compost of good quality.

Of course, there are also other methods or variations of the above, the basic principles remaining the same. Thus, I can also mention an anaerobic process, in plastic bags, hermetically closed; it is a process that I do not recommend though, for various reasons exceeding the essence of this article.

Using for several years the furnace type compost bin, I will progress in even greater detail how to use it below, and how to make adequate compost for cacti and other succulents.

First, the materials to be composted have to be placed in layers of about 5 cm thick for each type of material used, alternating as much as possible the structure of the component layers. Thus, the household vegetable waste or other soft materials are alternated with semi-fibrous materials, such as the grass resulting from mowing and/or herbs/weeds from the garden; or both with very fibrous materials, from garden plants with rigid leaves, such as Agave, Yucca or Furcraea. You can even stretch out layers with half-woody vegetation fragments, out of stems up to 5-6 mm thick, still green and incompletely lignified. It is also recommended that you create a specific balance between the weights of these types of materials, this influencing – heavily – both the usefulness and the quality of the compost, as well as the speed at which it will be produced (as breakdown of fibrous materials is generally slower).

Fig. 6 Thin layer of texture material (coarse pumice sand) sprinkled between two layers of compostable materials.

At first, we will see how the compost bin will fill as if too quickly, but compostable materials lose relatively fast 70-90% of the volume, thus creating constantly a new space available for fresh material. These additions are made at regular intervals of the order of 1-2 weeks, in quantities that would be as appreciable in relation to the volume of the container remaining empty, a complete refilling being optimal. In this case, the basic rule is: add much and rarely, and not little and often!

There is no universal recipe; each may to develop a way of his own, starting from whatever the compostable materials available. However, one cannot compost any quantity of "anything". Using, for example, too many soft, green and rich in nitrogen components, will result in a very compact organic paste, hard to get it loosened and which has the main disadvantage that generally does not allow good aeration of the roots or a fair draining of the potting mix, thereby becoming a hidden infection outbreak, and in particular, especially for xerophytes, it stimulates a rapid growth of the vegetal mass, which is totally uncalled for. On the other hand, if very fibrous or woody materials are excessively being used, the overall duration of compost making will increase accordingly. On top of that the eagerly user will bear the risk of ultimately having not enough matured compost, which – if used - represents a major risk for almost all types of succulent plants **(1)**. However it is to be noted that this type of compost, if fully matured, will have a very well-draining texture and will be more likely relatively poor in nitrogen. As an example, in order to achieve such a good texture, which may not have excess nitrogen, I recommend up to 20% soft components, around 50% fibrous and semi-fibrous components, approximately 20% very fibrous components and 10% thinly chopped stems from semi-woody plants. In order to ensure a rapid and uniform breakdown, it is indicated that all components to be cut/chopped as short/this as possibly. The stronger/more fibrous they are, the smaller they will be chopped. In general, the compostable materials of medium consistency shall be chopped about 2-5 cm long, even in the case of thick stems of only 5-6 mm, although a more trivial chopping thereof would hasten the process. This will ensure a more uniform texture of the matured compost, which once relatively dried out, it should easily crumble into tiny fragments that do not contain components being still incompletely decomposed.

Fig. 7, 8 Texture materials – lime chips (white chips) and coarse pumice sand.

From the very beginning compostable materials must be watered regularly, so that they remain constantly moist. Like excess heat also excess of water can seriously slow down the breakdown a process, which makes the whole operation a waste of time. Moreover, only when the mixture is excessively wet or it becomes waterlogged, unpleasant odours start to appear. Another rule is: if composting materials have an unpleasant smell, then either they were watered in excess or inadequate components were used. This is actually the main reason why compost bins/containers have no bottom lids – to allow free flow of any excess water. The amount of water that will be added on a regular basis depends on many factors and ultimately, one has to rely on its own personal experience adapted to the specific conditions. I add 5-10 litres of water every 2-3 weeks in summer and every 5-6 weeks in winter; I also lightly squirt whenever I add significant amounts of compostable material. The information is only indicative, being not valid for people who live in other latitudes, or in different climate zones. It also depends on the bin size. Another rule that has to be remembered: the higher the weight of "soft/green" materials, at the expense of the fibrous ones, the lower the water demands is and vice versa. For every layer roughly 10-15 cm thick, add a very thin layer of auxiliary materials used to improve the texture and/or acidity of the compost (see below).

Basically at first we put all the components in the compost bin/container and add water. The breakdown process starts by itself. However, this process can be accelerated. In many countries where recycling and caring for the environment are taken seriously into account, in specialized trade there are compost accelerators, usually in the form of a powder, which is added according to the product specifications. This powder is loosely sprinkled and the thickness of the compostable layers they are applied on varies depending on the product, from 5 to 15 cm. Compost accelerators contain both texture materials, and components for the control of acidity and enzymes, fungi, and bacteria required for the breakdown. Alternatively, you can add small amounts of fresh compost or semi-composted material from other sources or a little of well matured cow or horse manure, but not from other animals, especially not from sheep! Earthworms from the garden are also very useful; once added, they will breed to thousands becoming, after bacterial decomposition, the second engine of the "furnace".

Notably is that all we want is an aerobic breakdown! Therefore, because the composting operation to be carried out in the correct conditions, it is particularly important that – occasionally – the mixture to be well ventilated! Compost heaps must be well shovelled to bring some fresh air to all layers, after which, if necessary, add water again. In the case of furnace type composting bins/containers, although there all have the lateral air vents, in my experience they are insufficient, especially in the case of larger bins. Periodically, at 1-2 months, depending on the volume, mix well about 60% of the compost, starting from the surface, trying to be loosened as best as possible, especially the very compact clumps or if too waterlogged. The remaining 40% located at the base of the compost bin is in the more advanced stage of decomposition, and should not be mixed or stirred in order not to mix it with the upper layers, containing less matured compost. The earthworm population thriving here contributes – if everything done by the book, and especially not too wet - to an adequate aeration.

Fig. 9 Texture materials – natural sandy clay (needs to be crushed

If we use compost accelerators, we can reasonably expect to get "black earth" after 6 months or 1 year. Without accelerators, I had the first quality "charges" only after 2 or 3 years, acceptable for cacti and other more demanding succulent plants. My grandfather – who used to be an old fashioned gardener with a real culture of gardening – did not use of course any accelerators; he used to tell me that good compost is produced in 5 years. Back then, it seemed to me a huge amount of time!... Today it seems natural to me.

In the case compost making for cacti and other succulent plants, the composting process does not end however with the removal of the compost, through the lower doors of the furnace bin. Thus, even if for adding to/ameliorating raised beds for vegetables or flowers, the compost can be considered fully processed at this stage, for xerophytes, the compost is still "raw". Therefore, it is crucial that after extracting it from the compost bin to be left to "rest". This is another subsequent process, the last stage of decomposition which continues (at a slower pace) for at least 3 months. In fact, the longer this period, the better, especially if the compost was collected at the beginning of winter; it is important not to hurry during this period, and try shortening the process: even though for ordinary plants it simply wouldn't matter, for xerophytes, the repercussions could be disastrous.

As a first step, during this post-maturation process, the fresh compost should be well loosened, mellowed, crumbled, in order to avoid leaving larger compact lumps. All earthworms, slugs or centipedes encountered will also be removed – in fact anything that moves! – as well as incompletely decomposed fragments; even after 3 years you will find some subsisting in the mix, most often being fragments of the lignified woody tissues. Both the beings and the non-composted debris shall be reintroduced in the compost box, topping the last introduced materials, because they make an excellent natural accelerator. Do not ever throw them! It is a very careful and time-consuming work, but is absolutely necessary if we want to use this black earth for cacti and other succulents.

Fig. 10, 11 The opened lower side door for compost extraction. Fresh compost (not matured yet) immediately after being extracted from the compost bin (unfortunately a bit too dry in this case).

The process followed by me is as follows: after I loosened, controlled and cleaned the compost from any inappropriate objects or beings, once I have mixed it well, I prefer keeping the compost in lots of about 6-8 kg in plastic bags. I do not close the bags completely airtight, not to stop the aeration, but I neither leave them fully open, to avoid too rapid drying out of the compost. A certain humidity set is required for the maturation process to continue. Periodically, a week later, I mix the content of these bags. All this winnowing dries out the compost and therefore I must from time to time, even every two weeks, to slightly wet the "charge". At this stage the compost will literally cool down, finally ceasing all self-sustained exothermic processes. This is one of the essential conditions that must be satisfied by the compost in order to be used in the preparation of the substrate for cacti and succulents. After complete maturation, the final stage is a final inspection. Becoming relatively dry meanwhile, the compost is sifted with a rare sieve having – depending on the desired goal – meshes from 5 to 10 mm. From this moment on the organic compost obtained can be used immediately. Remember: always, all the "leftovers" from the sieving process are reintroduced into the compost container! Unless you find garbage, that shouldn't be there anyway.

Another advantage of this method of final maturing of the compost, after extracting it from the container, is that many of the still viable seeds will germinate now, the seedlings being easily to remove whenever you mix and aerate the compost. Good compost should have a fine texture and as uniform as possible, should not contain very dense lumps of organic paste or incompletely composted components; it must have a colour ranging from dark brown to black, should not smell bad, it actually should smell of plain earth. If the smell is sour, it means that maturing has not finished yet! If the smell is too sweet – attention to the pH! – it probably is slightly alkaline! The smell is extremely important when distinguishing a good compost charge; if the charge is not good enough, you simply have to put it back in the compost bin.

Fig. 12 After the extraction, the less decomposed compost clumps can be immediately added back into the compost bin.

After we have reviewed the overall process, let us see which are the suitable materials and respectively the prohibited materials when compost making. It is necessary to keep in mind that a good compost must contain both carbon and nitrogen, the optimal proportion for general gardening purposes, being largely considered to be around 20-30 nitrogen /1 carbon. For compost to be used in potting mixtures for succulents and cacti, the proportion rises to 30-50 carbon/1 nitrogen (shouldn't be that rich). Find below a brief summary of the materials which may or may not be used in the manufacture of compost.

1) Compostable materials that can be used:

a) nitrogen-rich materials (carbon/nitrogen ratio of 10-25/1)

- fresh vegetable household waste (virtually anything!);
- alfalfa;
- clover (its vegetal mass is very good for composting, but has the disadvantage of persistent seeds);
- coffee grounds;
- generally, any food leftovers containing no animal products (except for cooked food, primarily for the smell that it produces when it decomposes, but also because it attracts flies);
- hay and grass fragments resulting from lawn mowing;
- cow or horse manure (in very small quantities, well minced, helps to start the process after which there are NO longer needed);
- seaweeds and marine vegetation (they will be kept for a while in fresh water to reduce the amount of salt);
- aquatic vegetation in general (but no freshwater algae!).

b) Materials with moderate content of nitrogen (carbon/nitrogen ratio of 25-50/1)

- the vast majority of horticultural waste (non-woody);
- the vast majority of weeds (caution! without seeds or wilted flowers, without roots or tubers, only vegetable mass);
- juicy fruits of any kind;
- tea (including the paper bag);
- shells from walnuts, peanuts, etc. – well minced;
- small fragments of semi-woody materials;
- wood ash (not coal ash, because it may contain various harmful sulphides).

c) Materials with high carbon content (carbon/nitrogen ratio 50-100/1)

- pine bark, well minced (very useful in reasonable quantities, stimulates the development of roots);
- fragments of roots or stems of ferns of any kind (very helpful in reasonable quantities, stimulating the development of roots);
- pine needles (in reasonable amounts as the acidity of the compost increases);
- corn cobs (well minced);
- leaves (caution! preferably avoid the leaves containing tannins – oak, for example, to increase the acidity of the compost use maple or oak);
- straws.

d) Materials with high content of carbon (carbon/nitrogen greater ratio of 100/1)

- recyclable unprinted cardboard (well minced);
- recyclable paper well minced, uncoloured and unprinted (caution! typographic inks may contain heavy metals or other toxic substances);
- sawdust (only in small quantities, well mixed in the mass of the compostable materials; take care not to come from the chemically treated wood);

Fig. 13 Fresh compost, two weeks into the maturing process.

2) Compostable or non-compostable materials that cannot be used:

a) Materials which are not bio-degradable. You cannot compost any rubbish, moreover you can introduce by mistake unwanted additions of toxic substances in your compost. Even for many plastics considered bio-degradable the decomposition duration is measured in years and cannot be used for such purposes. So excluded any metals, aluminum foil, ceramics, plastics, glass, non-recyclable cardboard, etc.

b) Coal ash, due to the very high content of sulfides and iron. In high concentrations it can negatively affect most plants.

c) **Dead or diseased plants.** There is always the risk of introducing some diseases and pests even if we use compostable material of the highest quality, therefore the plant material must be thoroughly inspected, and the plants that appear to be diseased or infested, parasitized or simply have a dubious appearance will be disposed to trash. Dead plants, even if not apparent, have surely been victims of diseases and pests that – even if they have not directly caused the death of the plant – they took advantage of its weakness. For increased safety, simply do not use dead plants, or that have an atypical appearance, or that are affected by rust, or that have mouldy parts.

d) **Tomato or potato plants** (however, tomatoes or potatoes can be composted). There are dissenting opinions in this regard. Many argue that these plants are as safe as any others, others argue on the contrary that they transmit "diseases"; personally I would not use these plants out of caution. If I am looking for a strain of truth in this theory and provided that both species have powerful defensive mechanisms against aggressor insects and especially against some competing plants, I would rather say that secondary metabolites contained in these plants might adversely affect the well-being of the plants grown in the compost resulting from them.

e) **Roots or tubers of plants that can regenerate even in composting conditions.** Dandelion roots are a perfect example – they can regenerate under extremely harsh conditions and sometimes out of partially composted fragments. Again, for safety, better dispose of the roots or tubers of unknown plants, generally large roots, roots of dandelion (Taraxacum officinale aggr.), elderberry (Sambucus nigra), field horsetail (Equisetum arvense), couch grass (Agropyron repens), bindweed, morning glory or Rutland beauty (Calystegia/Convolvulus), whereas they will regenerate.

f) **Tree bark** - It is best to avoid it, except for well minced pine bark, in small quantities.

g) **Weed flowers and seeds** – the invasive potential of most weeds is based on the fact that their seeds can survive for many years in extreme conditions, including in the compost. Furthermore, there are numerous ornamental plants having virtually indestructible seeds are – the best example is Agapanthus praecox ssp. orientalis; its seed continues to develop even after the flower head was cut off and basically it cannot be destroyed but by incineration. Therefore, for safety, do not compost flowers or seeds of very persistent plants and particularly of weeds.

h) **Toxic materials, poisons or materials containing heavy metals.** You cannot compost petroleum products, paints, toxic substances of any kind, pesticides, fungicides and herbicides, medicines; you shall not use newspapers and other printed materials made of components which are sometimes recommended, because of the typographic ink; do not put in the compost bin materials containing heavy metals, etc. Most of the substances set forth in the listed categories, will not break down during the composting process and if so they can be harmful to plants and perilous for the gardener! The list can be long, so it is best to be guided by a rule as straightforward as possible – what is not expressly indicated, may not be used!

i) **Fish, meat, bones, milk and dairy products, horn-like material**. They will completely derail the process by over-heating the compost, they will alter the texture, producing an excess of nitrogen, they will generate a terrible odour and will promote the development of populations of undesirable worms and other creatures in the compost, becoming a potential outbreak of infection. In all these cases, their use is contraindicated for composting, completely, even in the smallest quantities.

j) **Domestic animal or human excrements.** There are multiple grounds for being unwanted, starting with excess nitrogen and following with the potential introduction of pathogenic organisms in the compost; they alter the texture and the pH, generate a very unpleasant odour, attract flies; the only exceptions are the small amounts of cow or horse manure in the early phase of starting of the composting process, whereas they are an excellent accelerator;

k) **Any other organic materials that have been chemically treated**, in particular, wood and wool or fabrics of vegetable fibre.

3) Auxiliary materials that improve the texture and/or the pH of the mature compost intended for cacti and other succulents:

a) **Sandy clay and/or coarse sand/very fine chippings.** These materials - used separately or together – help to definitely obtain a very good compost texture provided they are not made up of excessive fine particles. After the rehydration and mixing of the compost with these granulations, fine particles of organic matter will stick around them, forming aggregates, which, on the one hand, absorbing moisture very well and, and on the other hand, maintain certain gaps between them that can allow the air to permeate. Such organic aggregates may take up to 10 times more water than their dry weight, without becoming waterlogged. The first effect of these properties is that they provide at the same time and in a very simple way, all the necessary moisture, nutrients, and oxygen the roots need. It may be paradoxical, but even using a high content of these aggregates in the potting mix, it helps improving drainage, which becomes better than what could be achieved in an excessively sandy or excessively loamy substrate. It helps keeping an open, light substrate. It is an important aspect to keep in mind when trying to obtain very rich substrates, but which also need to have a good drainage, such as substrate for grafting rootstocks of the genera Pereskia and Pereskiopsis, but also for... tulips.

b) **Bone meal.** Besides the intake of minerals, especially calcium and phosphorus, it can ensure a pH balancing of the compost, where it becomes excessively acid.

c) **Egg shells, preferably washed and minced.** They also help for the texture and pH of the compost and are also a welcomed calcium intake. I will return to this component, disputed by many, but very important in my opinion in compost making.

d) **Horticultural limestone** (or fine limestone rubble, white chips, etc.) – mainly improves the pH of the compost, pushing it to less acidic levels, and also improving the compost texture.

e) The so-called "*cat litter*" – ideally the sort produced from 100% natural clay granules (sometimes known as the moler clay). **Zeolite** products are also acceptable. Read carefully the components listed on the packaging! Do not use **Sepiolite** or any other artificial products or those containing chemicals or deodorizers.

Fig. 14 Compost kept in a plastic bag during the maturing process. Note the seedling.

As I was saying, compost for xerophytes can only be used after completing the compulsory stage of maturing. I use it as such in the garden for soil conditioning, particularly for daffodils and freesias, or whenever I do planting or replanting in the rock-garden and I believe a certain organic input becomes necessary.

For most succulent plants grown in pots, the quantities of compost used are relatively small, typically up to 10% (volumetric) of the potting mixture; maybe less for cacti (there are exceptions, of course) and not at all for plants like extremely succulent Lithops, Conophytum and other Aizoaceae. Remember, compost (black earth) is an extremely fertile, nitrogen-rich component and therefore its weight added into the potting mixture has to be lower than that of any other organic natural soils!

Concerning to compost, I must mention a certain risk: it may contain organisms that are beneficial in the garden, but surely not in pots, such as centipedes, which under certain conditions can attack and destroy quickly the roots of young or very sensitive plants. Therefore, compost may be used in seed raising mixtures, however, it is required to apply prophylactic methods first (sterilization).


Fig. 15, 16 Compost that has undergone the maturing process. After chopping and spreading and removing of all unwanted items, it is time for the final sifting.

It is not my intention, however, to introduce methods of sterilization of the substrate – I am convinced that most of the readers practice them currently with a great deal of success – I just want to say that:

- for seed raising, primarily, the sterilization of the organic compost, and respectively of the substrate is absolutely necessary;
- as for the rest of the plants – it is preferable not to do it! Plants cannot directly assimilate minerals, but need certain microorganisms in the substrate. Sterilization of the substrate destroys all this range of micro-organisms and their natural recovery may take a long time.

Finally, I would like to come back on the utility of egg shells in compost making. It is a controversial issue, with many considering that – although used in the traditional preparation of mixtures for cacti – it is only the reminiscence of various household recipes and, as such, egg shells are useless. In my opinion, the egg shells are not required for mineral substrates; instead they are desirable in the organic ones, and even more specifically in compost making. Many artisanal compost recipes (if not most of them) mentions egg shells. There are several good reasons:

- egg shells contribute towards a much better texture of the compost;
- help a lot in the formation of those “aggregates” mentioned above, and which provide an excellent drainage!
- in addition to calcium, egg shells have an incredible contribution of minerals like phosphorus, magnesium, sodium, zinc, manganese, iron, aluminium, sulphur and copper! In this way, the compost is “ennobled” with various elements, all necessary for healthy plants;
- egg shells provide some protection of plants against snails – if sprinkled on the surface the better!;
- composting does not happen out of the blue – it is the result of the action of micro-organisms (fungi, bacteria andviruses), centipedes and various worms living in earth (particularly the trivial earthworm) – and egg shells are an excellent food for the last two mentioned organisms.

In my opinion, egg shells are essential for compost making! However, their use on an industrial scale is absurd, through the complications and probably the costs associated with. Which is why neither are they included in the "recipe" of mass products, and from here the impression left: it is nothing but an old fashioned trifle. We propose, however, an artisanal method of compost making, so that there is no cost for us to add egg shells in the compost, instead of throwing them in the trash.

Without a doubt that you can say or write a lot about compost, there is, as I said at the beginning, an extensive bibliography on the subject. I just wanted to put it up to the ropes addressing primarily to those who are making first steps in growing plants in general and xerophytes, in particular, based on the idea that very often the role of this ingredient is wrongly understood and incompletely exploited. For most plants, compost is like sugar in food for humans: a great energizer, but used in excess can cause many inconveniences or can be the origin of diseases. At the same time, it should not be forgotten that a balanced intake of nutrients and beneficial microorganisms populating the compost contributes to the harmonious development of our plant.

There is a danger of excess compost in our potting mix for cacti, or other succulents and xerophytes, but its absence may harm where it is really needed! Moreover, its quality is the determining factor for the processes taking place in the substrate and, not to forget this at any moment: compost is not an inert, mineral ingredient, but a live ingredient!

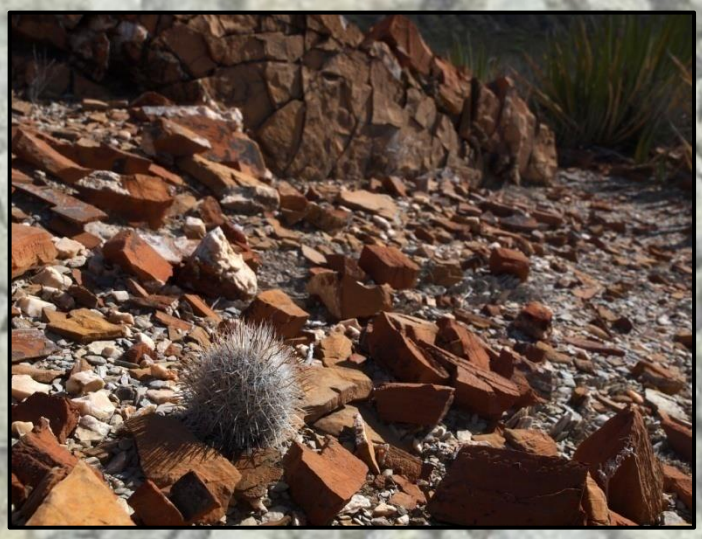
Fig. 17, 18 Fine compost, ready to be used. One of the "beneficiaries" - *Ornithogalum caudatum* – with 35-40% compost in its substrate.

Warning: in recent years medical studies have pointed to a somewhat higher incidence of Legionnaires Disease (Legionellosis) – infectious disease caused by a bacteria called Legionella – among people who produce compost or who work regularly with it (particularly in plant nurseries). Although I have not personally had any kind of problems, although I do not know anyone who might have contracted the infection, I feel obliged to make this statement/warning, for the people to assume this risk, be it hypothetically, only after being informed of the situation, and as a personal choice. The immense majority of the people do not show any symptoms upon the contact with Legionella –common bacteria otherwise; however, the disease – which can sometimes have very severe forms – can be triggered, especially in case of elderly people and/or persons having immunity problems. I recommend you first get informed on this issue. For protection I also recommend to wash your hands and disinfect as soon as you complete your work. Also compost must be slightly moist when handled it because the risk lies mainly in the inhaled fine particles (you can also use a respiratory gauze mask).

Note

(1) The less decomposed components will remain large enough to soak up water and become an accumulation of microorganisms of anaerobic decomposition. For garden it will work, but not in pots, even for tough plants. That is why I leave the compost to post-mature another three months, during which time I stir it up and airing it as much as possible.

Turbinicarpus flaviflorus **- La Polvora and** ***Mammillaria albicoma*** **- San Francisco Photos G. Matuszewsky**



Rapicactus mandragora **- Tanque Menchaca,**
Astrophytum myriostigma **and** ***Thelocactus panarottoanus*** **- La Polvora Photos G. Matuszewsky**

Epithelantha greggii **- Las Flores and** ***Mammillaria candida*** **– Sandia. Photos G. Matuszewsky**

A potting mix story

by Zsolt Mihail Demeter, Turda, România

I received my first cactus from a neighbour, an Echinopsis hybrid, about 33 years old. That's how all started. I liked the "little spiky guy"!

From here on, wherever I saw a cactus which I did not have, in the yard of any neighbour or wherever I went, in a shop window or in flower shops, I went in and bought or I called the bells at the gate and I asked for cuttings. So over time, my collection has increased from 3 to about 15 to 20 plants. As time passed by I started noticing that my plants are not doing so well. They grew, but as regards flowering, they did not flower at all or they rarely did. Then was raised the first question, "what soil would these plants need?" I must say that, back then, I did not have someone to ask, except those to whom I asked for cuttings. The answers were not good enough: "sandy soil". I have searched documentations about cacti and I have not missed browsing in any library or bookstore. To my happiness, in 1988 I was able to buy the book "Little Gardeners" by S. Copăcescu, B. Bobârnac, V. Grigoraș, where I got my first reference for soil preparation.

Fig. 1-6 "That is how I came to the current composition of my potting mix..."- crushed brick, dacite, marl and calcined clay, mica schist, rocks from the Olt Valley, volcanic tuff.

All the necessary components have been collected by me and they were in total four: leaf mould, molehill earth, sand, and crushed brick – all of them in equal parts, i.e. a very rich organic soil.

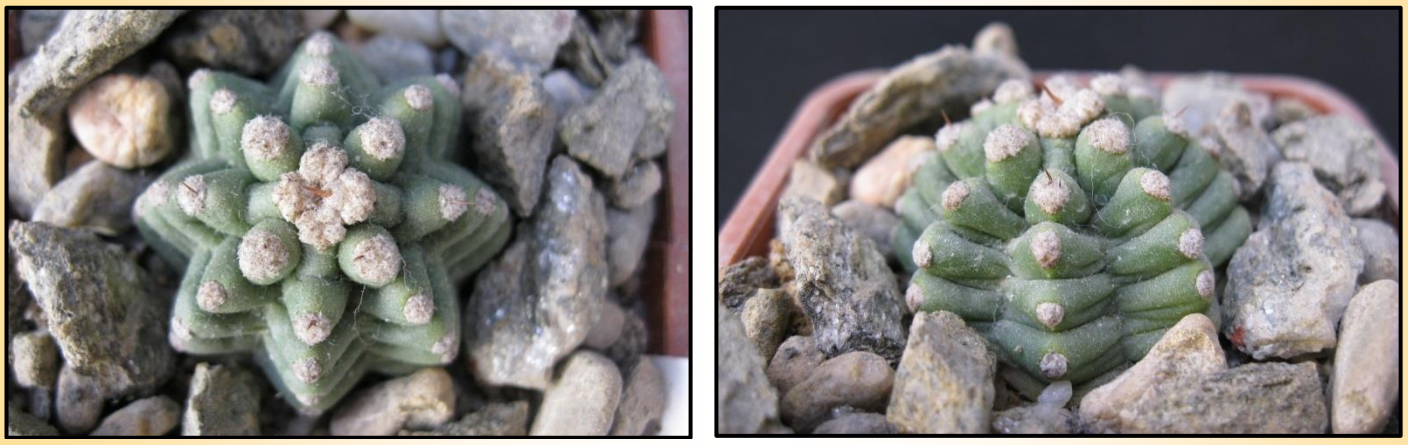


Fig. 7, 8 *Echinocereus triglochidiatus* v. *inermis*

In the beginning I was satisfying but, again, over time I noticed that it was not the potting mix that I wanted. How did I come to this conclusion? Very simply: not being an advocate of fertilizing, I changed the soil every 2-3 years. Thus I found that after two years, the soil was so compacted that it was almost impossible to come off the roots. The other problem was occurring when I had to water the plants. The root ball was taking up some at the surface, maybe to 2-3 cm, but downward, the water could not get to the roots or hardly moistened the compact mass. I tried to water by immersion, but the results were not great either.


Fig. 9, 10 *Gymnocalycium cardenasianum* and *Gymnocalycium monvillei*

I started experimenting by reducing one of the ingredients and adding more of the others. I also met other collectors from which, buying plants, I asked for advice for potting mix preparation and so I came to a better mixture, that no longer compacted and left water pass through.

The new composition was, one part of leaf mould, 2 parts of sand and a half part each of molehill earth and crushed brick. It was a much better substrate, permeable, but nevertheless with a serious shortfall: it maintained moisture for a long time. For this reason some plants have lost their roots, while others have died.


Fig. 11, 12 *Mammillaria haudeana* and *Epithelantha micromeris*

The great revolution in my soil preparation techniques came after I became a member of the website www.cactusi.com. There I asked questions and I read discussions on topics related to the soil, until I read "The Hexalogue". I confess that at first I was puzzled and incredulous about the properties of mineral soil. But being curious, I did a few attempts, however, on a smaller batch of plants. To my astonishment, the mineral potting mix seemed really beneficial. So I continued.

Based on this I made up a potting mix recipe collection and started my "mining" period, i.e. of browsing wherever I was going after all kinds of rock rubble.

I found places to obtain minerals, I can say everlasting sources, but in vain I knew all these places from where to gather plenty of rocks if I did not know what kind of rocks they are, what minerals they contain. Through a friend, Vasile

Plăcintar, a cactus enthusiast and co-author of the photos of this article, I met with a geologist. He explained to us where to look, and what kind of rocks we will find. To ease our work he gave us the geological map of the Aries Valley.
That is how I came to the current composition of my potting mix: mica schist, sandstones from the Olt Valley, dacite, crushed brick, volcanic tuff, calcined clay, marl, gypsum (where necessary), and leaf mould.
After 3 years of experiments with mineral mixtures I have come to the conclusion that:

- it supports a lot the development of the roots, which are much more massive, thicker, longer, stronger, with far greater volume than it would have had in the predominantly organic soil, previously used by me. Plants grown in such a soil are healthier and more resistant to pests;
- I got more compact plants with denser and stronger spination;
- the plants are much easier to maintain;
- watering can now be made most frequent and more abundant, thus the good drainage prevents stagnating water at the bottom of the pot;
- it is a well aerated soil that helps the roots to breathe;
- being a loose soil, it allows the plants to withdraw into the soil, during the summer or winter dormancy, especially those plants I was overwintering outside, for example *Pediocactus knowltonii* in fig. 16;
- personally, I think mineral soil is a more hygienic soil.

Now, a very important thing has to be mentioned: when transferring the plants from organic soil to a mineral one, do not expect immediate miracles. Everything I mentioned above shall be carried out in time, in two or three seasons of vegetation.

Fig. 13 - 15 *Thelocactus lophothele, Echinocereus knippelianus* and *Echinocereus pulchellus*

For the first nearly two years, a plant transferred to mineral mixture shows no visible development. In the first phase the plant seems to be stagnating, but, in fact, it develops its root system. Instead of growing in size as most would expect, the plant becomes rather flattened but it increases in diameter; it has a general slower growth rate.
Unfortunately I do not have photos of my plants while I used the "classical" mixtures, so I cannot show you a comparison. Who would have thought a few years ago that I will get to write this article? I think though that the photos of my actual plants will tell you more than I did it myself in a few words.

Fig. 16 *Pediocactus knowltonii*

Stenocactus ochotherenanus **- El Potosino, San Luis Potosí and** ***Thelocactus tulensis*** **Photos P. Nájera Quezada**

Stenocactus ochotherenanus **fma.** ***brunneispinus*** **– San Luis Potosi Photo P. Nájera Quezada**

Stenocactus lloydii **BKM 864** ***and Gymnocalycium spegazinii*** **ssp.** ***sarkae*** **(major) n.n. KFF 1303 Photos P. Kupčák**

I started with the Hexalogue and... I continue with it!

by Laszlo Ambrus, Târgu Mureș, Romania

I started collecting cacti in 2008, when I received, as a gift from a friend, a Mammillaria polythele. I wanted to offer it the best conditions, so I began searching on the internet information about the necessary soil and about cacti culture in general. Thus I discovered the forum www.cactusi.com, stepping in a virtual space where I discovered an absolutely fascinating new world, a world of cacti, collectors of cactus and other succulents.

I started to get familiar with the different types of cacti and, from the very beginning I was passionate especially about the genera Thelocactus, Rapicactus, Turbinicarpus and Epithelantha. Seeking information about their cultivation, I came across The Soil Hexalogue written by Dag Panco. The first time I was shocked, but after reading and re-reading the article, I realized how logic the idea of mineral soil in cactus cultivation is.

Fig. 1, 2 *Turbinicarpus krainzianus* ssp. *krainzianus* and *Turbinicarpus pseudomacrochele*

So I had a chance to plant, from the beginning, my cacti (which soon reached a total of over 100 plants) into a mineral soil.

Today I have a number of over 300 plants (except the many plantlets resulting from my own sowing), most of them belonging to the genera *Thelocactus, Rapicactus, Turbinicarpus, Epithelantha, Mammillaria, Ariocarpus, Aztekium, Echinocactus, Lophophora, Echinofossulocactus, Coryphantha, Pelecyphora, Strombocactus, Astrophytum, Ancistrocactus* and *Glandulicactus.*

Fig. 3-5 The roots of plants grown in mineral soil. *Aztekium hintonii*, *Lophophora jourdaniana* and *Gymnocactus gielsdorfianus*

Fig. 6 – 9 *Turbinicarpus hoferi*, *Thelocactus conothelos* ssp. *garciae*, *Echinocactus parryi* L 1372, *Rapicactus beguinii* ssp. *beguinii*

Their soil I am using now is made exclusively of mineral ingredients; basically I used a mixture of rock chips in the following proportions: 35% andesite (rocks of different colours and grades), 35% granite schist, 15% zeolite, and 15% crushed brick.

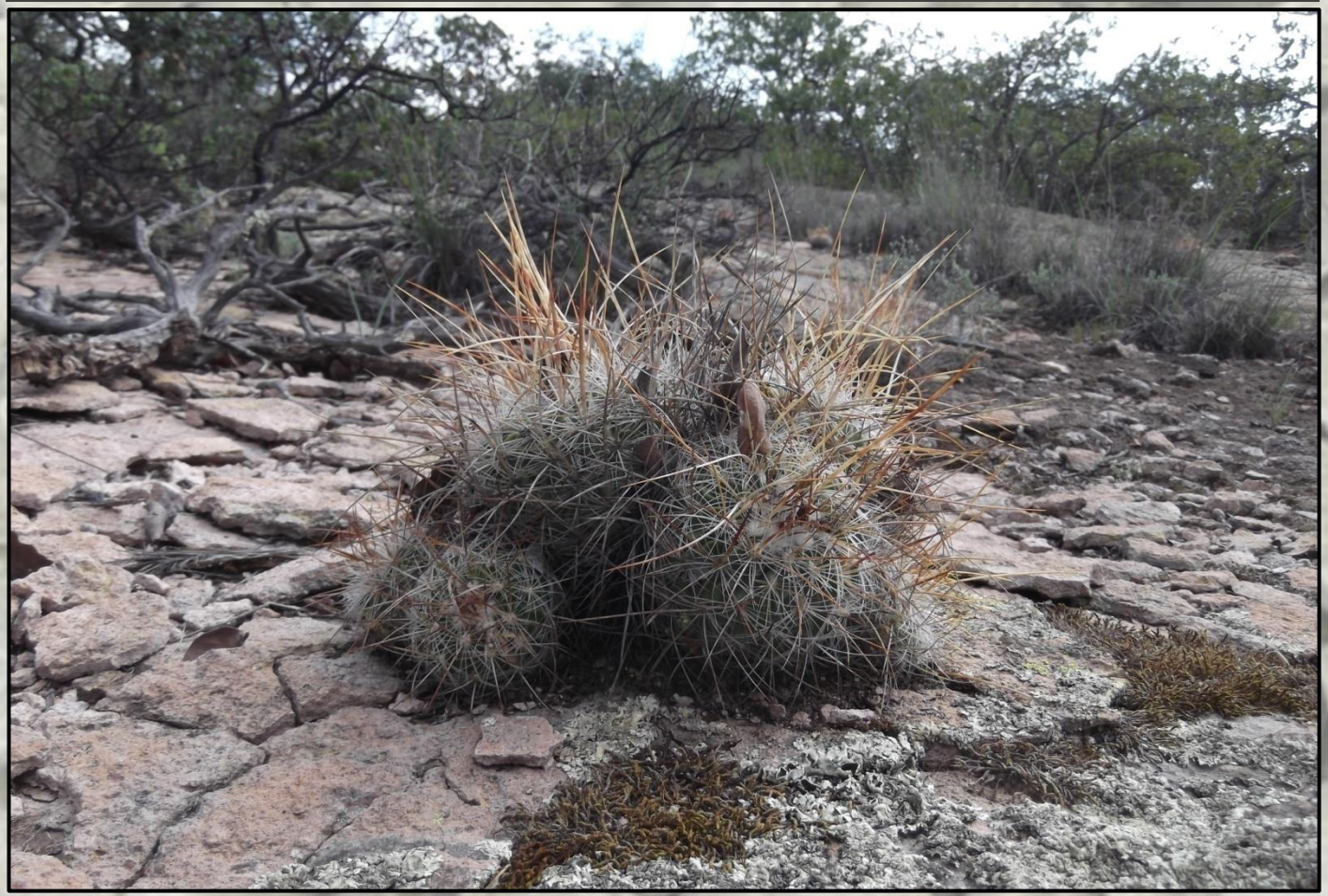
To these rocks I add, where appropriate, clay (*Lophophora, Ariocarpus, Thelocactus, Rapicactus, Mammillaria, Astrophytum, Coryphantha, Echinofossulocactus, Pelecyphora*), limestone (*Thelocactus, Epithelantha*), natural gypsum (*Rapicactus*, several species of *Turbinicarpus, Aztekium*) and in some cases different types of sandstone (*Thelocactus bicolor* ssp. *bolaensis* "wagnerianus").

From spring (March-April) until late autumn I keep the plants on two of the balconies of the house (being oriented to the South and respectively the South-west), being exposed to the direct sun and also protected against adverse weather conditions by the roof of the house. I water my plants with rain water about once every two weeks (sometimes at bigger intervals). I do not use fertilizers of any kind.

During winter I move the cacti in the stairwell, where the temperature in winter varies between 5^0C and 8^0C.

Fig. 10, 11 *Turbinicarpus laui* Buenavista and *Turbinicarpus knuthianus*

Echinocereus ferreirianus **- Volcan de las Tres Virgenes, Baja California. In the foreground volcanic scoria. Photo L. Barta**



Stenocactus ochotherenanus **- San Luis Potosí Photo P. Nájera Quezada**

The Laws of the Soil Hexalogue – endorsement from a Friend and... Customer

by Basarab Popa, Constanța, Romania

I had several attempts to write this article... but my friends know how little I like to write. However, yesterday and the day before yesterday, on Saturday and Sunday, I was here, at the greenhouse. I plunged into my world of cacti... What I live here is virtually an extravaganza. And at one point, no matter how much I dislike writing, I can no longer stay indifferent, when I see what is happening around! That is why I have to tell you how it all began...

A few years ago, more precisely in 2000, I met Dag. I just returned from Ukraine, and I brought a few cacti with me, which I was keeping outdoors... exposed to the Dobrogean sun and rains... One day Dag came, looked around and we discussed a bit; I gave him a Geohintonia as a gift (a new plant back then... wooow! You really have grown old over the years, dude.....!) ... and in the end he left.

Fig. 1 Arrangement in the ground - in the center, Dag placed two *Turbinicarpus lophphoroides* and one *Thelocactus macdowellii* on a rock. Photo B. Popa.

A few years later, after establishing my company and building my greenhouse, I began to increase the number of specimens of the collection. And the collection got larger... and larger... and larger... Of course, I grew my plants in all sorts of pots that I could find, into the soil that I had, prepared by myself, after the recipes I knew, learned from friends, from books, from the internet... The plants were developing well, but they were not quite what I wanted them to be. I had beautiful specimens, I had already bought left right and centre and created a large collection, and eBay had become an on-going source for new plants.... and what's more, for fun...!

Fig. 2, 3 To build these 18 x 18 x 12.5 cm pots, Dag blocked my mechanical workshop! Photo B. Popa.

However, whenever Dag came over, I had the feeling that there was something that didn't suit him. At the same time, whenever I was visiting him and saw his collection I was left thoughtful... The plants looked different... and it was something I did not understand.

A few years later, during one of his lengthy visits, I saw that glimmer of madness in his eyes which, worn by words, gave birth to more than a touch of insanity in my mind. So without too much thought, both looking at the greenhouse and the collection, tea pot fashion, we said YES. No, we did not propose ourselves to marriage...We were already married on our own... In fact we had decided on the spot to revamp completely, but absolutely COMPLETELY, the entire collection.... over 6000 plants in 250 m2of greenhouses. As my company had a contract with Poarta Alba penitentiary, I had the work force available... I had already imported from Italy a few tens of thousands of pots, mainly of larger size.... So, I had "where" to plant them into... I had "who" to do the work.... But, I did not have "what" to prepare the potting mixtures from.

Fig. 4, 5 In addition to a neat and orderly arranging, these almost 4 liter pots allowed root development. Photo B. Popa.

The solution... came also from the Old Man. He simply walked "step by step" the entire Dobrogea region, and with his car we began to collect bags with soil samples and mineral ingredients. Following his prospecting, I was sending the pickup truck to load them up. At one point, when we found nothing else interesting to mine from nearby, we began seeking in the country. And so started coming pickup trucks with varieties of mineral granulations from all over the country...

However, he did not want to start work at anything, because he had not found his boulder, a certain boulder that he kept persistently saying that he needed it (even to this day I can't understand why).

I became already exasperated... He needed money for this, and money for that, and money for the other one... Time was passing... and I was getting angry, but there was nothing I could do: as I had said YES... (even though I did not sign anything off).

Fig. 6 A planter of nearly 3 m^3 of soil. In the center-back *Notocactus schlosseri*. Photo B. Popa.

Finally he cheerfully delivered the good news: he had found the boulder in question, I gave him six workers (six! ... although three were enough...) and a truck and only then the madness really started!
Everything that was transported in my yard, over 50 tons of raw materials, was sieved and sorted by hand. Do not imagine that it was easy work! The tens of tons were sifted four times, sorted by size, on varieties and types. At some point I have lost their count. I only know that at the end of each day Dag looked like miners do... you could only see his sparkly eyes that said: it won't be long, we'll do it...!

Fig. 7 *Discocactus*... *Melocactus*... You deal with those – told me Dag – I don't like them! Photo B. Popa.

One day, when I had no more hope for anything, it was finished! And I thought then things would calm down! Only now the really beautiful part began...I had somewhere in the greenhouse, planted directly in the soil, a few mimosas I brought from Brazil and some other plants. Plants for my soul! My plants! Planted by me! Grown in the soil... by me!... Have you by any chance noticed how I wrote "had"...? Taking advantage of my absence, Dag took pulled them all out and wrecked everything, to the very last plant... Fronted by my anger next to explosion, he explained to me that in the area of the cactus plantings he was taking care of, no… weeds were allowed! And that was that.

Fig. 8, 9 A *Turbinicarpus*... super*valdezianus* and Lady *Pelecyphora aselliformis*. Photo B. Popa.

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The topsoil was excavated about 50 cm deep from that location, and all the dirt was moved outside. Inside the big sinkhole, deep pockets were made from boulders transported specifically from 200 km; the only reason supplied was: “I need those!”. Over those pockets he spread the mixture put in which the plants were to be planted, in the ground. Large, old plants were requiring this. I want you to imagine an area of approximately 3 m wide and 10 m long where before there used to be a veritable jungle of plants, how it looked now, drilled, ploughed, from place to place with pockets in which mineral mixture was poured in... a depressing desert.


Fig.10, 11 *Parodia* ... *Mammillaria* ... The tables were arranged by genera and species ... Photo B. Popa

The mixture was prepared under the strict supervision of Dag. I mean, he was sending out orders and people were working. Great mourning... I was just coming in and watching absent minded, it seemed to me that it is just destruction and that nothing good will come out of it; I laid my hands over my head and I would leave... while my only rumbling thoughts were beep Dag... beeeep greenhouse... beeeeeep cacti... beeeeeeeep and generally beep-beep-beep!

And since it was not enough how much he exasperated me with all he was doing, while these seemingly destructive operations were carried out, Dag began preparing planters for the plants, simply blocking my mechanical workshop! He said he wants big pots, 18x18 cm. I gave him what he wanted. He ruled then they were too high!... so they had all to be cut to 12.5 cm, while the cut part was encased inside, thus resulting in additional thermal protection in the summer months. I admit today that these pots have solved many of the problems encountered by me in the past.

With the very large plants being planted into the soil, with the mid-sized and smaller plants being potted in very large and large pots, the only unsolved problem was d was the problem of the large colonies, because Dag did not want at all to keep them in pots.... and there were quite a few. Solving? Simple!


Fig. 12, 13 Dag threw away the old tags, telling me that he will replace them... I’m waiting for three years now! Photo B.

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I mean, today I see it simple, because back then I really caught fire. I found out that I had to give up a few square meters of presentation tables and that my locksmith and my welder started to craft two big trellises... almost 8 m2 each; inside several other boulders were placed, from the ones brought from other 200 km distance...! Pockets were formed and then 3 m3 fillers... mineral soil with 20% organic additions and in some pockets only mineral mixture and nothing else. Pure madness!

... There, in the two trellises, he grouped the specimens and colonies characteristic to North America and South America, respectively. I thought it was merely a fantasy of the "artist", but in the meantime, plant development was spectacular. I no longer have photos of how they looked at first, but trust me on my word that plants have doubled and, in some cases, even tripled their size...

The most painstaking job was potting the rest of the plants. Including writing the tags (what have you done with the ones from the Astro section, you Old Man...?). Anyway, the area originally occupied by the collection is now twice as large... about 500 m2.

The work lasted for almost 5 months. It was an inferno, literally and figuratively speaking... We were working even at 50^{o}C swelter. But.... the results are absolutely FANTASTIC!

Plants are now in the fourth growing season. I already watered for the fourth time this spring, carefree... and this for 4-litre pots for every plant!! The result is a symphony of colours and floral explosions. Species that bloom now earlier than they used to do before: Strombocactus is at the second series of flowers already; Uebelmannia I don't even remember how many flowers they had and on how many plants...; Lophophora, Astrophytum too started their performances...

What fascinates me the most is the way in which the plants are beginning to return to a nature-like appearance, i.e.: flattened and battered. During the rest period they withdraw in the ground up to downthrown...

My conclusion is simple: the Hexalogue is everything! No one and nothing will be able to convince me to apply other techniques of mixture preparation. Nobody and nothing will be able to convince me that Dag wasn't right. Even though sometimes I was sceptical in what concerned the entire setting and planting mode, the means to create the micro-climate which he said it is necessary, now after I saw with my own eyes, on my plants, now I understand what means to RESPECT a cactus, giving it what it needs, because you know its biology, morphology and soil requirements, I can simply say: You Old Man, you've done it again!

To the less experienced growers – please grab The Hexalogue, and don't settle only with reading it: apply the lessons and don't forget..!

Fig. 14, 15 My Mesembs – my work Dag didn't interfere with and a flower that I dedicate to him! Photo B. Popa.

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