Soil: It's what goes in the pot

"The best soil for your bonsai is that soil which works best for you"
Adam's Art and Bonsai Blog

- Why bonsai soil?
- Desired bonsai soil qualities
- Bonsai soil components
- Particle size and related issues
- Bonsai soil ideas
- Soil bulk density and water filled pore space
- To akadama, or not to akadama

Why Bonsai Soil?

- It is often said that a bonsai specimen is no different from “regular” plantings grown in the wild
- If trees have grown in the soil for a long time, why do bonsai artists need to consider use of a special, unique type of soil mix?
- That is, if bonsai are simply trees from nature in a pot, why won’t they live well in common garden soil?
- The truth is they just might!

But …

- Much time and effort are expended in culturing most bonsai specimens
- Do we feel comfortable that they might live, or would we rather endeavor to help them thrive under our care and training?

Why Bonsai Soil?

- The quality of the soil directly affects the health and vigor of the bonsai specimen
- Experience has shown that a tree's poor health can often be traced to being planted in a poor (often largely organic) bonsai soil
  or worse, being planted in conventional garden soil
- Such "normal" soil readily hardens as it dries
  - Can be seen to pull away from the sides of pot walls
  - Sometimes the dried ball of soil is difficult to rewet
- This condition gives no advantage to the growth of the specimen; in fact, it is often very harmful to the tree

Desired Bonsai Soil Qualities

Good Water Retention	The soil needs to be able to hold and retain sufficient quantities of water to supply a needed amount of moisture to the bonsai between each watering.
Good Drainage	Excess water must be able to drain immediately from the bonsai pot. Soils lacking in good drainage are too water-intensive, lack aeration, and promote a buildup of salts. Excessive water in the soil may also cause the plant's roots to rot, leading to a weakening and the possible death of the specimen.
Good Aeration	The particles used in the bonsai soil mix should be of sufficient size to allow tiny gaps or air pockets between each particle. As water drains through the soil it pulls oxygen down to the roots (not commonly known is the fact that plants absorb a great deal of oxygen through their roots). Aside from the roots' need to "breathe", oxygen in the soil promotes the development of "good" bacteria and mycorrhizae (symbiotic associations that forms between plant roots and fungi in a bi-directional movement of nutrients, where carbon flows to the fungi and inorganic nutrients move to the plant) so the processing of nutrients can start even before they are absorbed by the plant's roots.

Desired Bonsai Soil Qualities

Nutrients Control	The soil must itself contribute only limited nutrients to the plant, to allow the bonsai artist to control the application (when, quantity, and type) of nutrients that the tree will receive

Summary of Bonsai Soil Component Qualities

Material	Description	Water Retention (grams in 300 ml)	C.E.C. (meq/100g)	Durability	Aesthetics	Availability	Cost
Akadama	Clay like material found only in Japan	54	21	Breaks down overtime	Good	Limited	High
Turface	Turface is calcined montmorillonite clay. Calcining is the process of heating a substance to a temperature high enough to bring about a 'phase transition'	74	25	Lasts longer than Akadama	Ok	Readily available	Low
Scoria	Lava rock: solidified molten igneous rock that has flowed from volcanic eruptions	60	nil	Indefinitely	Good	Readily available	Low
Perlite	Perlite is essentially a form of natural gl	60	nil	Does not degrade	Bad	Readily available	Low
Pine/Fir Bark	Organic material	40	150	Decomposes over time	Good	Readily available	Medium
Pumice	Non-crystalline solid form of molten rock that is blasted out of a volcano	43	nil	Does not degrade	Bad	Readily available	Low

C.E.C. (Cation Exchange Capacity) A "cation" is a term that describes a molecule (an ion) that has a positive charge. Most nutrients (nitrogen, etc.) are cations. The soils we use have a negative charge and attracts the nutrients and hold them, making the available for plants to use. A meq is the number of ions which total a specific quantity of electrical charges.

Bonsai Soil Organic Components

Colin Lewis Bonsai Art:

- As far as I'm aware there is no physical advantage in using any organic matter in your bonsai soil, but there are some disadvantages
  - After a time organic matter will break down into fine particles and, if mixed with other more stable ingredients, it will wash down to the base of the pot to form a pan that inhibits drainage
  - Once bone dry, most organic matter actually repels water and is difficult to re-wet
- Plants of all sorts can be grown in a totally inorganic medium
  - But require major and minor nutrient supplements as well as the introduction of all manner of microbes to compensate for the unnatural habitat the roots have to deal with
- Plants will thrive better and be stronger and more independent if it is growing in a soil that provides a natural environment for roots as well as all the micro-organisms that make a soil "alive"
  - To achieve this a certain amount of organic matter is necessary but too much organic matter is unnecessary and often counter productive

Bonsai Soil Organic Components

Bark

Bark has a fairly high cationic exchange capacity (the ability to adsorb nutrients for future release) but it is generally very acid and it retains much of the nitrogen to fuel its decomposition, so it's usefulness as a soil component is dubious to begin with. Be honest, if you use bark have you ever, even on one occasion, found roots actually growing into the particles when you come to repot? And if you think your trees are doing well in a mix of bark and whatever, what are you comparing them with - your past experiences or other peoples' trees that also grow in bark? There's bark and there's bark, and most of it is not very good at all!

Bonsai Soil Organic Components

Bark

Orchid bark: The small, seedling grade (usually fir bark) looks at first sight to be ideal. But since it's intended for orchid growers, it is sterile - lifeless. The sterile particles of orchid bark don't even begin to decompose for many years. When they do, they will leach nitrogen from the soil and impair the trees vigor. This is irrelevant, of course, because you will have repotted way before that happens and realized that perhaps you should rethink.

Bonsai Soil Organic Components

Peat

Sphagnum moss peat - or peat moss as it's curiously called here, is the best organic growing medium for containerized plants known to mankind. Unfortunately it is non-renewable resource (once used up it can never be replaced) and these days it's hard to find a product that is coarse enough for our use. Some years ago you could sift out around sixty to seventy percent fines and leave thirty or so percent coarse particles, but not so now. All I have managed to find is very fine and perfect for clogging the drainage in your soil. If you can find coarser peat in your area, it's worth a try, but sift it well first, and never let it become dry or it will repel water and become difficult to wet. Although peat doesn't contain a whole lot of microbial life, but it is hospitable to it, and it does have the capacity to adsorb nutrients for future release.

Bonsai Soil Organic Components

Chopped Sphagnum

Sphagnum moss is the best rooting medium on the planet - if it is fresh. Unfortunately, it seems that although much of the northern USA is knee deep in sphagnum bogs, the only products available commercially are kiln dried and virtually lifeless bags imported from Canada, Chile and even New Zealand. It's mind-boggling that nobody has grasped the opportunity to capitalize on this easily harvested, highly renewable natural resource. Dried sphagnum crumbles to dust in next to no time, whereas fresh moss retains its structural integrity for the duration of its use in a pot. If you can get hold of fresh sphagnum, all you need to do is run it through an old meat grinder or chop it into quarter-inch particles and add it to your mix.

Bonsai Soil Mineral Components

Colin Lewis Bonsai Art:

- Why do we want mineral components I our bonsai soils?
    - Guarantee good drainage
    - Maintain an open, oxygen-rich structure
    - Add body and stability
    - Ability to absorb nutrients for later release (cationic exchange capability – CEC)
        - Less relevant if you are using organic matter
        - If you feed regularly enough, your soil only needs a relatively low CEC

Bonsai Soil Mineral Components

Akadama

Akadama is entirely unique and can't be fairly compared to any other mineral, so let's deal with that first. Akadama is a naturally occurring clay-like (but not clay) mineral found only in one region in Japan. It is surface mined, dried, graded and packaged. No baking or firing is involved. When wetted, it does not form a slurry like clay but forms a gritty paste. Akadama is without any doubt the absolute best growing medium for Japanese maples and many other broadleaved species, and is arguably one of the best ingredients to incorporate in smaller proportions for most other species.

Bonsai Soil Mineral Components

The big advantage of Akadama is that roots can grow through the parcels as well as between them, which vastly increases the amount of space in the pot that is available to the roots. Once roots penetrate Akadama particles they become fine and highly ramified, forming a dense pad of functioning feeding tips. When you foist use Akadama the result is really quite astonishing compared to most other media. Although Akadama has a relatively low cec (around 18-20 meq/100g) the fact that the roots are so prolifically generated means that this is not a defect.

Some growers complain that Akadama readily breaks down into much smaller particles and therefore impedes drainage, but they are not watching closely enough. Certainly it does break down, but this only means that the pore spaces become smaller, not that they disappear altogether. Since Akadama is not a clay, but a kind of cohesive sandy structure, it still drains efficiently after several years in use just as sand would.

The big draw back? Cost: at the time of writing even lower grade Akadama is priced at over $50 per bag (compared with $18-$20 a few years ago). I can understand why it has become more expensive in recent years, but I cannot comprehend why it is almost three times as expensive in the USA than in Europe. (Note House of Bonsai $25 a bag)

Bonsai Soil Mineral Components

Lava (Scoria)

The lava most common used for bonsai soils is either the red or black lava from Colorado. Lava is solidified molten igneous rock that has flowed from volcanic eruptions. It is essentially foamed glass with sharp edges and partially interconnected pores. Depending on its source, most lava contains some heavy metals and potentially some minerals useful to plants. The cec of lava is highly variable, but generally hovers between 15 and 40 meq/100g.

Bonsai Soil Mineral Components

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Roots cannot grow into or through lava particles, but they can and do penetrate the pores to a certain extent. Lava can hold a considerable amount of water (up to two and a half times its weight) but it takes several hours of soaking for the particles to become fully wetted due to the microscopic channels between pores, where channels exist.

Lava must always be sifted and washed before use. Failure to do this will result in an absorbent layer of fines and sludge at the base of the container that will prevent adequate drainage and can cause major water logging problems.

As a soil ingredient for bonsai lava performs well. I have seen very strong root regeneration on newly collected trees planted in almost pure lava. Another major advantage lava has over Akadama is that it can be salvaged: after use it can be dried, sifted and re-used time after time.

Bonsai Soil Mineral Components

Pumice

Like lava, pumice is a product of volcanic eruption, but there the similarity ends. Rather than solidified molten rock flow, pumice is the non-crystalline solid form of molten rock that is blasted out of a volcano at extremely high pressure and temperature. It is this rapid decompression that happens as it leaves the volcano that gives pumice its softer texture and more interconnected pore structure

Bonsai Soil Mineral Components

Pumice:
With a cec that hovers around 75 meq/100g (depending on source) it requires less frequent fertilizing that most other soil components when used alone. Pumice can hold large quantities of water - up to four times its own weight. This, coupled with the soft and easily powdered surface means that when used alone or with other absorbent materials, careful watering is necessary to avoid water logging.

Although soft, roots are unable to penetrate pumice - even the surface pores since they are far too small. However, since the surface of each particle is soft, roots do seem to enjoy their company very much, and ramify well. After a while, the roots seem to break down the surfaces of the particles to form a sort of micro environment of small particles and dust that keeps them snug and fine.

Pumice drains well but tends to drain less well after a couple of years in use. However, drainage is never impeded to the extent that it becomes a problem.

Bonsai Soil Mineral Components

Turface

Also marketed as Terragreen or Biosorb among others, Turface is calcined montmorillonite clay. Calcining is the process of heating a substance to a temperature high enough to bring about a 'phase transition' - a change in physical state (like baking a cake!). If clay is fired to the highest possible temperature, the result is so hard and non-absorbent that it is used for super-sharp knifes. Reduce the temperature and we have stoneware; reduce it further and we have oven-proof earthenware, then terra-cotta (as in flower pots). As the firing temperature decreases, the absorbency rate increases. Turface is heated just enough to stabilize the particles - to prevent them forming a slurry when saturated, but not high enough to reduce its absorbency rate.

Bonsai Soil Mineral Components

Turface has a moderately high cec of 33 - 35 meq/100g and can absorb vast amounts of water. Pour water onto dry surface and you can hear it soaking and see steam arise as it does so! This incredibly high absorbency can be both a blessing and a nightmare, depending on the quantity used. although when used undiluted it seems to be a good medium for newly dug trees, as soon as the inter-particle spaces are full of roots, it readily becomes waterlogged. When sold as a soil amendment (its original purpose) the manufacturers of Turface recommend a rate of no more than 15% by volume, and I would suggest that rate should also apply to use in bonsai soils.

Some suggest that after a while the moderately high cec can cause Turface to adsorb concentrations of nutrients so high that it can cause reverse osmosis resulting in "root burn". In theory this is possible, but you would have to be consistently feeding very heavily for some time for this to happen.

Turface substitutes such as oil dry and kitty litter are less stable and not really suitable as a soil ingredient.

Bonsai Soil Mineral Components

Perlite

Once very popular as a potting soil ingredient in commercial horticulture, perlite seems to have fallen out of favor and has been replaced by cheaper, nastier stuff like pine bark. Perlite is essentially a form of natural glass. When heated the raw material will expand up to 20 times its original volume. It is extremely light in weight, can hold vast quantities of water and has a cec of virtually zero. It is very soft and crumbles very easily - so easily, in fact, that roots can split away fines that can wash to the base of the pot and form a drainage impeding pan.

Bonsai Soil Mineral Components

Perlite:
Root growth in pure perlite is excellent and it is extremely hospitable to mycorrhizal fungi, but its lightness makes it unstable as a single ingredient soil. If using perlite as an ingredient, be careful to ensure that either the other ingredients are virtually non-absorbent, or perlite forms no more than 20% of the total mix.

Bonsai Soil Mineral Components

Vermiculite

Vermiculite is hydrated magnesium aluminum silicate that has been heated to extremely high temperatures which causes it to exfoliate, or expand, into elongated particles, up to 20 times its original volume. Like perlite, it is extremely absorbent and light in weight, and can absorb many times its own weight in water - and has fallen out of favor as an ingredient in commercial potting mixes. Unlike perlite, however, it has a very high cec at over 85 meq/100g. The plate-like shape of the particles, and their fragility, can cause compaction if used alone. Hard to find and not worth the effort.

Bonsai Soil Mineral Components

Grit

Grit, gravel, sand

Although this should be the most straight forward to discuss ingredient, there is considerable confusion. What I call grit some call sand and others call gravel. I imagine somewhere there is an official, USDA, Supreme Court approved definition of grit, for this discussion we will use mine!

For this purpose, grit comprises grains of stone between 1.5mm and 3mm. Anything smaller is sand, anything larger is gravel. Grit is used primarily to reduce water retention in the soil in general, to aid rapid drainage after watering, and to maintain an open soil structure. It also adds weight to the soil making it a more stable anchorage for roots.

Bonsai Soil Mineral Components

Material

It really doesn't matter from what material your grit is derived - crushed granite (ie: chicken grit) sifted paving sand, pool filter sand, aquarium gravel - they are all inert. The one major type of grit to avoid is anything that has been gathered or mined from or near the shoreline. Although non-porous, sand and grit can become covered in salt which bonds to the surface and can take a long time to re-dissolve. If using chicken grit, make sure it doesn't contain crushed oyster shell, which is also high in salt content and very alkaline.

Shape

Here many myths abound…. Some would have you believe that sharp-edged grit is best because when a root hits the sharp edge it it forced to split in two. Preposterous! For one thing that is not what causes root division, for another, the chance of a root tip colliding precisely head-on with the edge of a grain of grit are millions to one. Others suggest that round grit is best because of the "ball-bearing" effect: the particles cannot nestle in against each other and reduce oxygen space. While this may be true, in practice there are so many other ingredients in the mix, and so many roots weaving between particles, that the ball-bearing effect is not an issue.

Bonsai Soil Mineral Components

Size

Having defined the size range of grit above, that is the size range I recommend. Anything smaller than 1.5mm (1/16 inch) can either fill valuable pore space in the mix, or wash to the bottom of the pot creating a drainage impeding pan. Particles larger than 3mm (1/8 inch) add no additional drainage properties and create pore spaces large enough to be occupied by other ingredients. Large particles of grit are nothing more than chunks of rock that serve no purpose other than to take up valuable space that could otherwise be occupied by roots.

Particle Size & Related Issues

Retention of Moisture and Nutrients

Nutrients are absorbed while in solution in water, so these two functions are closely linked. They are both influenced far more by the nature of each ingredient than by the size of the particles, with one obvious exception: The smaller the particles, the more water will be held in the inter-particulate spaces by surface tension (sand holds more water than gravel, silt even more). A soil comprising very small particles will inevitable be wetter and thus hold more nutrients than a soil comprising larger particles of the same ingredients.

But retention of moisture and nutrients is only half the story, both also have to be made available to the roots. Roots absorb by direct contact with water or water-bearing solids. Larger particles have larger spaces between them so the roots cling to the surfaces of the particles and are therefore only in contact with a source of moisture along one side - the other side being exposed to the empty inter-particulate space.

This causes the roots to become flattened in order to maximize contact, and to increase in length and girth rather than to ramify. They grow rapidly between the particles until they reach the side of the container, whereupon they begin to spiral around or extend directly downward.

Particle Size & Related Issues

Retention of Moisture and Nutrients (continued)
The exception to this is Akadama: Roots are able to grow into and through the grains of Akadama so they can ignore the vacant spaces and ramify freely within the grains, breaking them down into smaller particles as they do so.

In general, the coarseness of the vegetative growth is directly proportional to the coarseness of root growth and thus, in turn, the coarseness of the soil.

Rapidly growing roots produce large amounts of the hormone cytokinin, which stimulates shoot growth. Heavy extending roots produce heavy extending shoots; finer ramified roots produce finer ramified shoots. If you don't believe me, try tipping a bag of builder's sand on the ground and letting the weeds grow in it for a season. Check out the roots, and you'll wish you could get roots like that on your bonsai - fine, vigorous, white feeders. Then try the same with a bag of gravel….

Particle Size & Related Issues

Drainage and Oxygen
For the purposes of this discussion, we'll define sand, grit and gravel thus: Grit comprises grains of mineral between 1.5mm and 3mm. Anything smaller is sand, anything larger is gravel.

The main reason we are so emphatic about good drainage is to ensure there is oxygen in the soil, which is why these two functions are treated together. The bacteria that cause root death and decay are anaerobic, which means they thrive in soil where there is little or no oxygen. Furthermore, the roots and valuable microorganisms in the soil need a certain amount of oxygen to function.

Clearly, very fine particles drain more slowly than very large particles, but they do still drain efficiently enough for our purposes (sand drains rapidly, certainly more rapidly than we need a bonsai soil to drain, yet gravel drains even faster). On the other hand, builder's sand would hold more water by surface tension than would gravel. In theory, sand would make a wonderful bonsai soil if you could irrigate it several times a day!

Particle Size & Related Issues

Drainage and Oxygen (continued)
Optimum drainage is achieved through pure non-absorbent mineral with particles of around 4mm (1/4 inch). Smaller particles drain just as well, but more slowly. Larger particles add little or nothing to drainage efficiency and become mere obstructions to root growth. One simply has to find a balance between the need for rapid drainage and the need to fulfill all the other functions of a soil.

There is another factor that is a significant influence on the rate and efficiency of drainage: the shape of the pot. A shallow container, no matter how well endowed with drainage holes, will drain less water than a deep container of similar volume, and is far more likely to become and remain waterlogged. The old "bath sponge experiment" illustrates this perfectly (see below). However, a shallow container will dry through evaporation far quicker than a deep container, particularly when the surface is not dressed with moss.

Particle Size & Related Issues

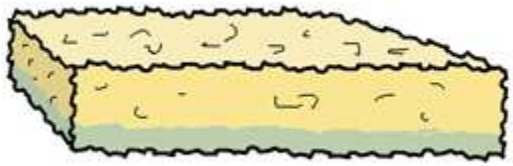
Drainage and Oxygen (continued)

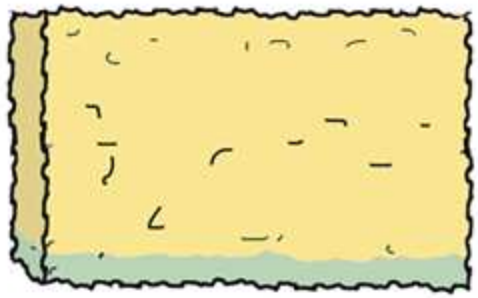
"THE BATH SPONGE EXPERIMENT"

You must have noticed this when you were a kid.... Take a bath sponge and saturate it with water, then lay it flat. The water will drain down but leave a saturated layer about a quarter inch deep. A sponge 5"x4"x1" would drain to five cubic inches of water.

Now stand the sponge on edge and it will drain more, leaving a similar quarter inch saturated layer, but only one and a quarter cubic inches of water.

This layer of water is called the "perched water table" and is a major consideration in the efficiency of bonsai pot drainage.





Particle Size & Related Issues

Drainage and Oxygen (continued)
Moisture is also lost by evaporation, especially when the soil is fresh and the roots have not colonized the pot. When the soil is warm larger particles will dry quicker than smaller particles because water vapor can travel to the surface more freely. When the soil is too cool to cause evaporation small particles can dry faster than large particles as the capillary action draws moisture to the surface to replace that lost to the wind.

But what about oxygen? Now, let's be rational here: we're not talking about vast empty caverns between chunks of rock. Look at all those healthy trees around you, in the parks, in the street, even. Their roots have access to oxygen because the soil in which they grow is alive and drains reasonably well. The oxygen is held in countless gazillions of microscopic pores. Granted, they have massive root systems that operate at different levels in the ground whereas, by comparison, our poor trees have very restricted roots and no opportunity to migrate to different soil conditions. But enough oxygen is enough, and over-size air pockets are just as much a waste of space as oversize particles of gravel. **If your soil drains reasonably well, it will contain more than enough oxygen for your tree's requirements.**

Particle Size & Related Issues

Stability

Okay, I know, you wire the tree in the pot. But then, when the roots have filled the pot you're supposed to cut the wire off, right? If you don't, you're risking damaging the nebari, and you're preventing the tree from rising in the pot as the roots increase in volume - result: compacted and inefficient roots.

So, assuming you're a conscientious, responsible bonsai grower and you cut the wire from the nebari, the soil has to be such that the roots can bind the particles together to form a cohesive, stable root 'pad'. This should happen with an established healthy tree in one season at the most. If it doesn't, something is wrong with your soil: either it is inhospitable to roots for some reason or the particles are so large that the roots cannot bind them together.

Particle Size & Related Issues

Space for Root Growth

There is so much discussion about ingredients, sizes, drainage and so on, that there's a danger of ignoring the prime purpose of having soil in the first place, ie: to provide a healthy environment for roots to grow in. And based on the premise that healthy roots mean a healthy tree, this is the most important function of all.

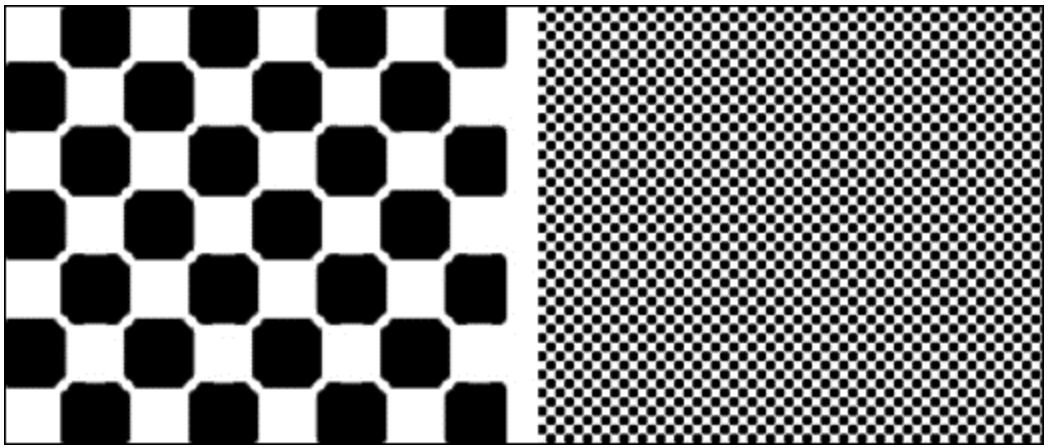
Akadama, the best medium on the planet for maples, at least, is often criticized for breaking down after a year. So what? It still drains well enough - just a little slower maybe; there are still oxygen pores; and the growth of fine feeder roots is phenomenal. Why is this? Because, unlike other mineral ingredients, roots can grow into and through the particles which means that they have virtually 100% of the pot volume in which to grow unimpeded. It also means that the roots are in contact with moisture-bearing matter over their entire surface, so they are finer. Plus, the ease with which they can grow means they ramify prolifically.

Particle Size & Related Issues

Space for Root Growth (continued)

With solid mineral ingredients, of course, we want as much inter-particulate space as possible for roots to occupy. However, the size and number of the individual spaces is at least as relevant as the total volume. Smaller particles do not mean less space, they mean smaller spaces - the volume of space remains the same.

Both illustrations are 50% screen: there are equal areas of black and white. Imagine the black as mineral and the white as space and you will see that the proportion of space remains constant regardless of particle size



Since we have learned that smaller particles encourage finer, more ramified feeder roots, and larger particles encourage heavier, more structural roots, we can adjust the particle size according to the stage of the tree's development without affecting the amount of space available.

Particle Size & Related Issues

Space for Root Growth (continued)

Note: To compensate for the effect of surface tension, the smaller the particle size of your soil, the greater the proportion of drainage mineral you should add to the mix.

Particle Size & Related Issues

The Happy Medium

Our task is to arrive at a mixture that offers close to 100 percent of the pot volume for root growth, drains well yet holds water at 'field capacity', retains oxygen and provides stability for the tree. How you achieve all this and what ingredients you use is up to you, but here are a few general tips....

In many cases the particle size available to you will depend on the products you acquire. Lava, Akadama, pumice, Turface, etc., all have a specific size range, and grading it for the perfect mix can take some time. Standard Turface is a good size for general purposes, but lava tends to be larger. I sift out the dust and the larger particles of lava and try to match the Turface. Similarly, Haydite has a larger aggregate, so that should also be sifted to size. Both lava and Haydite can be crushed and re-sifted with care, but it's hardly worth the effort.

If you choose a large particle soil (4mm or larger – between 1/8 and 3/16) *please don't use gravel for drainage*. The inter-particulate spaces between lava, Haydite, pumice or whatever will provide enough drainage (provided they are not clogged with nasty bark) and the gravel will merely use up room and will contribute nothing. I have little experience with pumice, but from what I have observed, its soft surface tends to induce finer root growth, which may excuse the use of slightly larger particles.

Particle Size & Related Issues

The Happy Medium (continued)
If you use organic matter, *please don't use commercial bark*, and please, please sift out all the fines. Organic particles can be a little larger than other ingredients, but anything less than 3mm - or soft unstable particles - should be discarded.

Important note: Add organic matter to your mix immediately before use, not in advance. Ingredients such as Turface, Akadama, Haydite, pumice and even sand, will suck all the moisture out of the organic matter, making it easy to crumble to dust and difficult to re-wet.

My preferred particle size for drainage material is 1.5 - 3mm (#1 filter sand or starter grade chicken grit), no larger. In theory 3mm (#3 filter sand) particles would be ideal, but when you consider that smaller spaces induce finer roots and reduce evaporation, the inclusion of smaller grains of grit to increase the number of smaller spaces can be a benefit. I commonly use a mix containing at least 65% grit (as defined above) for pines and some junipers.

Bonsai Soil Ideas

‘lyn Stevenson favorite mix:

- 50% scoria
- 20% pumice
- 5% sand (sometimes)
- 10% tiny orchid bark
- 15-20% Miracle-Gro potting soil (contains Canadian sphagnum peat moss, forest products, compost, perlite, and slow release additives)
- Might use decomposed granite for larger trees
- Usually add some cottonseed meal and gypsum to the mix just before potting
- Remember ingredients should be sifted (wear a mask) and washed. Ingredients should be about the same size.

Bonsai Soil Ideas

Bonsai Boon soil recipe contains:

1 part lava rock
1 part pumice
1 part Akadama
a cup of horticultural charcoal (per 5 gallon mix)
a cup of decomposed granite (per 5 gallon mix)

For deciduous, use small size mix (1/16"-1/4") and add 1 extra part of Akadama.
All ingredients must be bone dry, screened and sized. The dust is discarded.
The use of pumice for bottom layer drainage (5/16") is recommended.
For conifers from the desert and high mountains use medium size mix (3/8" - 5/16").
For lower elevation conifers and water loving conifers, use small size mix (1/16" - 1 / 4")

Note:

Proper repotting technique needs to be applied; otherwise this mix is not recommended. For best results, organic fertilizer is recommended at the correct times and season. A thin layer of coarsely screened New Zealand sphagnum moss should be placed on top of the new soil. The moss will keep the soil in place during watering. The thickness of the moss layer should vary according to climate and watering habits.

Bonsai Soil Ideas

Pine:
1 part scoria
2 part perlite
7 part akadama

Juniper:
1 part scoria
2 part perlite
8 part akadama

Deciduous:
1 part scoria
2 part perlite
9 part akadama

Safari Park Mix:
4 Dry Stall (pumice)
4 part scoria
2 part orchid bark

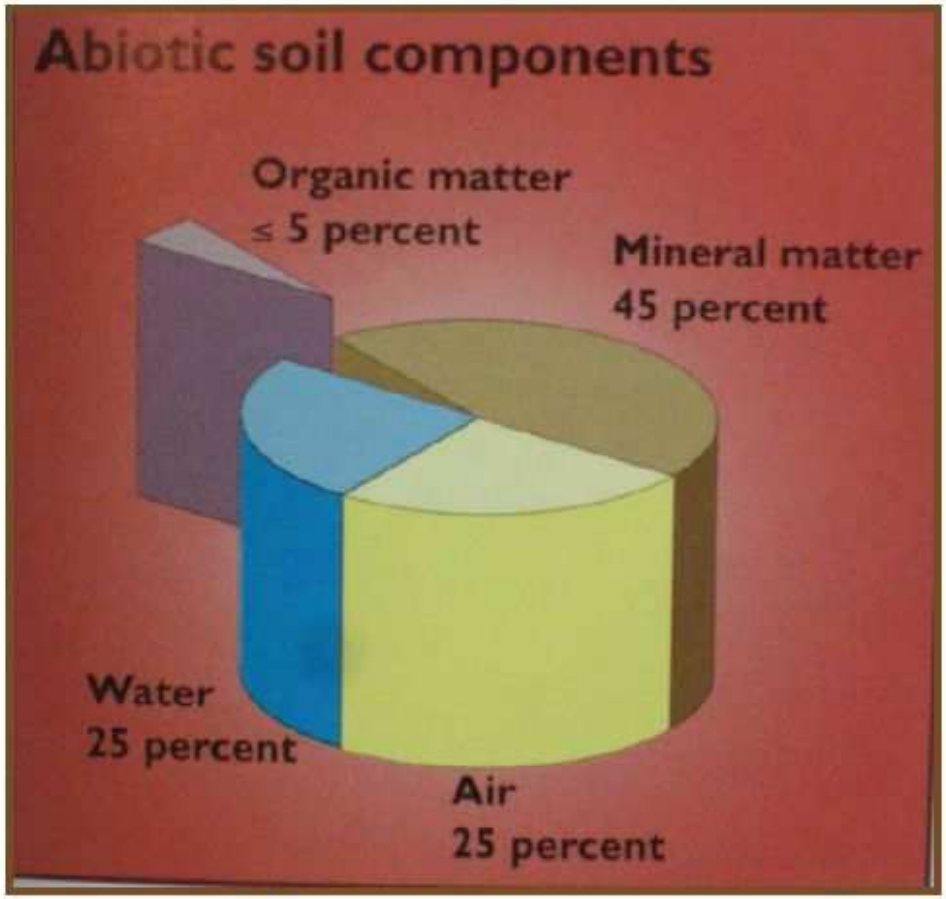
SDBC Club Mix:
1 part scoria
1 part pumice
1 part fur bark

Other Mix Idea:
6 akadama
3 part pumice
1 part scoria

(Note: A small quantity of charcoal, less than 5%, can be added to any of these mixes.)

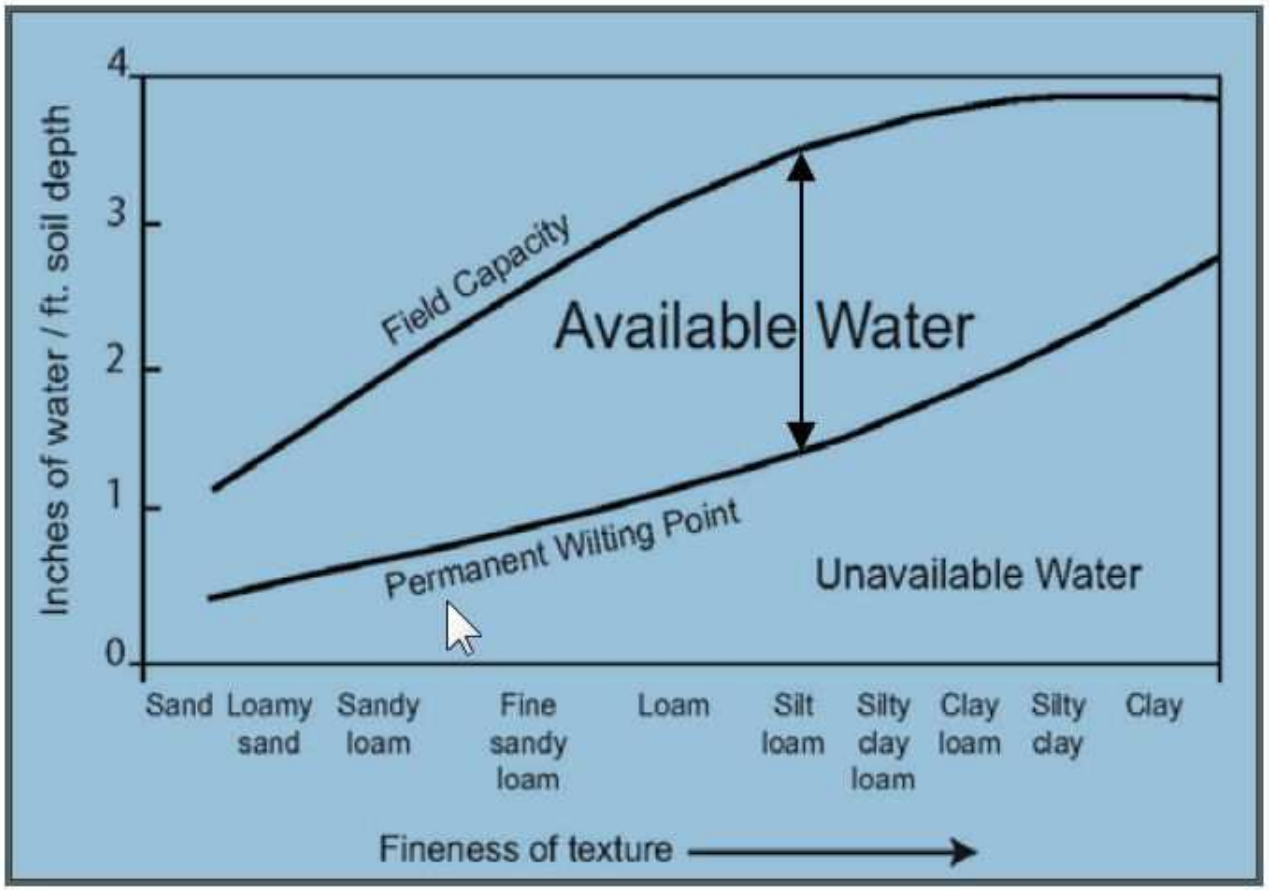
Soil Bulk Density/Moisture/Aeration

- **Bulk density is an indicator of soil compaction and soil health**
- **Affects infiltration, available water capacity, soil porosity, plant nutrient availability, and soil microorganism activity**



Four major components of soil volume (Michigan Field Crop Ecology, 1998, E-2646, p. 13).

Water and Texture



Relationship between available water and texture (Ohio Agronomy Guide, 14th Ed. Bull. 472-05).

Soil Bulk Density and H20 Retention

- **Bulk density is the weight of dry soil per unit volume**
- **Results of evaluating various bonsai mixes**
  - **No significant difference in bulk density**
  - **Idea bulk density for plant growth <1.6 grams/cubic cm**
  - **Commercial mix absorbed water well in excess of the other mixes**

Soil Bulk Density							
Sample	Volume of Soil (cubic cm)	Initial Weight of Soil Plus Container (grams)	Weight of Moist Soil Plus Container (grams)	Weight of Dry Soil Plus Container (grams)	Dry Weight of Soil (grams)	Soil H2O Content (grams / grams)	Soil Bulk Density (grams / cubic cm)
Boon Mix	300	204	255	204	190	0.27	0.63
'lyn Mix	300	164	218	164	150	0.36	0.50
Pine Mix	300	215	232	210	196	0.12	0.65
Scoria	300	247	309	247	232	0.27	0.77
Commercial Bonsai Soil	300	210	340	210	196	0.67	0.65
				Note:all organic mix acted like a sponge			

Available Soil Water Capacity

- **Affected by organic mater and compaction**
  - **Organic matter increase's soils ability to hold water**
  - **Compaction increases bulk density and reduces total pore volume, consequently reducing available water holding capacity**
- **Commercial soil mix with mostly organic material held much more water than the other mixes**

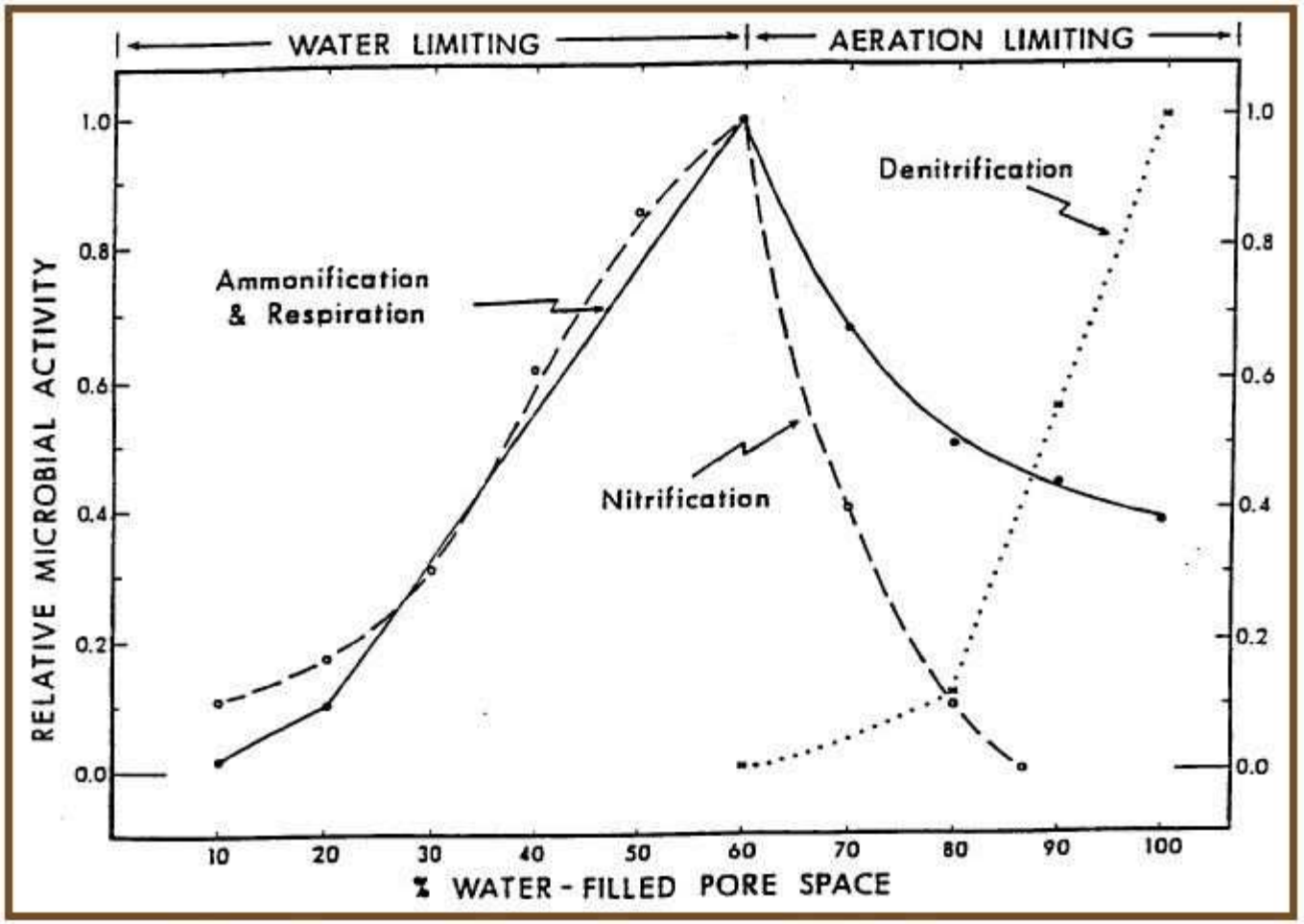
Soil Water Content				
Sample	Soil Water Content (by wt) (grams/ grams)	Soil Bulk Density (grams / cubic cm)	Volumetric Water Content (grams/ cubic cm)	Inches of water/ft.Soil Depth
Boon Mix	0.27	0.63	0.17	2.0
'lyn Mix	0.36	0.50	0.18	2.2
Pine Mix	0.12	0.65	0.08	0.9
Scoria	0.27	0.77	0.21	2.5
Commercial Bonsai Soil	0.67	0.65	0.43	5.2

Water Filled Pore Space

- **When water filled pore space exceed 60% important soil process are impacted**
  - **Commercial bonsai mix at 58% is very closed to 60%**
  - **If a perched water table exists then water filled pore space could exceed 60%**

Soil Water Filled Pore Space (%)				
Sample	Volumetric Water Content (grams/ cubic cm)	Soil Porosity (%)	Volumetric Water Content / Soil Porosity x 100	Soil Water - Filled Pore Space
Boon Mix	0.17	0.76	22.35	22%
'lyn Mix	0.18	0.81	22.14	22%
Pine Mix	0.08	0.75	10.03	10%
Scoria	0.21	0.71	29.38	29%
Commercial Bonsai Soil	0.43	0.75	57.65	58%

Water Filled Pore Space



Relationship of water-filled pore space to soil microbial activity (Linn and Doran, 1984).

To Akadama, or Not to Akadama

Expert opinions on Akadama for Bonsai Soil

- Boonyaraqt Manakitivipart (Bonsai Boon) (US)
- Colin Lewis (US)
- Harry Harrington (UK)
- Morton Albek (Denmark)
- Robert Steven (Indonesia)

(1) Do you use akadama? If so, for all your trees? And for trees in all stages of development?

- Yes, I use akadama for all my trees. I use less akadama for the tree in training (25% of less) - **Boonyaraqt Manakitivipart**
- I haven't used akadama on my own trees for over 10 years now. Pines and Junipers cannot have a complete soil-change to remove akadama and repotting is infrequent; it stand to reason that any akadama introduced into the soil of a Pine or Juniper will become very compacted before there is an opportunity to remove it – **Harry Harrington**
- Do not use akadama. Doesn't fit the growing conditions here (Denmark) – **Morton Albek**
- No, in Indonesia, we only use volcanic lava soil for all bonsai, for all stages. Excellent and cheap! - **Robert Steven**

To Akadama, or Not to Akadama

(2) If you use akadama in soil mixtures, would you share what mixtures you personally use?

- 1 part lava rock, 1 part pumice, 1 part akadama, ½ cup of horticultural charcoal (per 5 gallon mix), ½ cup of decompose granite (per 5 gallon mix). For deciduous, use small size mix (1/16”-1/4”) and add 1 extra akadama. Use of pumice for bottom layer drainage (5/16) is recommended. For conifer from the desert and high mountains use medium size mix (3/8”-5/16”). For lower elevation conifer and water loving conifer, use small size mix (1/16”-1/4”). Note: Proper repotting technique needs to be applied, otherwise this mix is not recommended. A thin layer of coarsely screened New Zealand sphagnum moss should be placed on top of the new soil. The thickness of the moss layer should vary according to climate and watering habits. - **Boonyaraqt Manakitivipart**

- This depends on what is currently available. Some turface, lava and/or pumice, plus some organic and plenty of coarse sand. – **Colin Lewis**

- The soil mix I use for all of my trees contains cat-litter (Diatomaceous Earth available in UK) and various amounts of chopped-bark, depending on the water retention required. – **Harry Harrington**

To Akadama, or Not to Akadama

(2) If you use akadama in soil mixtures, would you share what mixtures you personally use? (continued)

- I use sphagnum peat for trees loving an acid soil and alkaline basic nursery soils for other trees. This I mix with pebbles of Leca (fired clay pebbles) or lava e.g. to adjust transpiration and drainage. Shohin bonsai gets a mixture with up to 80 percent soil, and 20 percent drainage pebbles or small stones like lava pebbles. For large trees that doesn't want a free draining soil, a 50/50 mixture is used as basic soil mixture. Pines and other trees who need a very free draining soil are planted in 70 – 90 percent Leca pebbles and 10 – 30 percent sphagnum peat mixed with normal garden soil. – **Morten Albek**

- We use 100% volcanic soil without any mixture except adding the slow release fertilizer. – **Robert Steven**

To Akadama, or Not to Akadama

(3) When using akadama, how often do you repot your trees? What is your experience with akadama breaking down, as in, after how many years?

- Depends on the size, age, container shape and size and type of tree. Shohin are repotted once a year. Medium sized conifers are repotted once a year or every other year. Old and larger conifers, once every 2–5 years. - **Boonyaraqt Manakitivipart**
- I think many people repot their trees too often – three years should be the minimum period between each repotting. Akadama does break down. The cheaper grades break down more quickly than the better grades, and the surface breaks down quicker than lower in the pot, but it still drains well and performs as it should. It's not clay, so particles do not adhere to each other. Trees grown in pure akadama seem to require repotting less often than those grown in other purely mineral soils (see 4, below). – **Colin Lewis**
- Akadama breaks down over 1 to 2 years, depending on the quality of the akadama freeze/thaw cycle in your climate and frequency of watering. A bonsai growing in broken-down akadama won't automatically die; it is wrong of me to state this. But as with all broken-down, airless clay-soils in bonsai pots, drainage is poor, absorbance of water into dry akadama is poor, and the overall health of the tree as well as its vigor is greatly reduced.

To Akadama, or Not to Akadama

(3) When using akadama, how often do you repot your trees? What is your experience with akadama breaking down, as in, after how many years? (continued)

- Unless the akadama can be completely removed (the tree bare-rooted) every two year, it should quite simply not be used. One misunderstanding that many enthusiasts seem to have is that although akadama has been used for many years in Japan; this is not because it is the "best" soil for bonsai. It is simply because in Japan it is, or at least it was, a relatively cheap and freely available to enthusiasts. – **Harry Harrington**
- Not using akadama because it easily breaks down in freezing periods. Akadama is a clay sol, and will be very compact and poor of oxygen, harming roots when broken down. After only one or two seasons the akadama will break down and begin decreasing in value. The Japanese climate and their lack of availability of other soil types makes akadama their choice. The humid Japanese climate during summer and frequent repotting of trees, practically makes akadama a favorite choice of bonsai soil there. - **Morten Albek**
- I tried akadama many years ago for a few of my bonsai, it broke down after 2 years and I didn't find any better than our volcanic soil. – **Robert Steven**

To Akadama, or Not to Akadama

(4) Do you have experience with possible alternatives to akadama, like cat litter, turface, Primera one, permatil, mule mix, Calidama, Mocha lava, etc?

- No there is no possible alternative to akadama. If not available I would use lava, pumice, and small amount of charcoal and crushed granite. – **Boonyaraqt Manakitivipart**
- No other mineral component is a substitute for akadama because the roots can penetrate each grain of akadama but cannot penetrate other minerals. This means that in 100 percent akadama roots have 100 percent of the pot volume available for growth. In a mix of other mineral ingredients, the roots only have the space between the grains, which may be as low as 30 percent of the pot volume.
- Products like turface are soil amendments that the manufacturer recommend using at no more than 10-15 percent of the total volume. I follow that recommendation. I have noticed that turface gives good results for a year, possibly two years when used for newly collected plants, but in year three there is a deterioration in vigor at the time when one would normally expect an improvement. Cat litter is a similar product to turface, but may contain contaminates, so I avoid it.

To Akadama, or Not to Akadama

(4) Do you have experience with possible alternatives to akadama, like cat litter, turface, Primera one, permatil, mule mix, Calidama, Mocha lava, etc? (continued

- I have used lava a lot, and I am impressed by the results I have seen with newly collected plants. Lava appears to contain available beneficial minerals, although I have no scientific evidence of this. But I find that at lower levels in the pot the rough texture of the grains holds too much water by surface tension which, ironically considering the large particles, impedes drainage. An additional problem with lava is that the surface has sharp edges that can easily damage tender roots during repotting. This means that extra care must be taken when working a lava-rich soil between the roots.
  Pumice is an improvement on both turface and lava. Surface texture, water retention and drainage are all near optimum, although roots still can't penetrate the grains. - ***Colin Lewis***
- I have experience of using turface, seramis, cat litter on my own trees and experience of a wide range of alternatives used by clients on their bonsai. I have been using Diatomaceous Earth or 'Diatomite' (Catlitter) on my trees for around a decade now. - ***Harry Harrington***

To Akadama, or Not to Akadama

(4) Do you have experience with possible alternatives to akadama, like cat litter, turface, Primera one, permatil, mule mix, Calidama, Mocha lava, etc? (continued

- I mostly use sphagnum peat (not to be confused with the fresh mosses used for air layering i.e.) for trees loving an acid soil (like Azalea, which loves this soil), and alkaline basic soils for other trees, generally all based on a good soil structure that is water holding and at the same time have a high level of oxygen. All available at good garden centers. This I mix with pebbles of Leca or lava e.g. to adjust transpiration and drainage. Have worked very well for my bonsai growing during 20 years now, and therefore I have had no reason to experiment with soils not having the quality I want. - ***Morten Albek***
- No experience other than volcanic material. - ***Robert Steven***

To Akadama, or Not to Akadama

(5.) Any general comments you like to share when discussing the topic "to akadama, or not to akadama"?

- I use Akadama because it is one of the best ingredient to use. But you need to know how to use use it. You need to learn how to repot and remove and add soil properly. And then learn how to water and fertilize properly. I used to suggest and argue on the soil subject. Now I do not do that. If you decide to use organic and potting soil, you are not with me. And you will never know what the good healthy roots look like. - ***Boonyarat Manakitivipart (Bonsai Boon)***
- Back in the dark ages before Akadama was available in Europe I used a combination of coarse organic matter (sifted peat, pine or oak leaf mould, genuinely decomposed bark) mixed with coarse sand and a handful of turface. I can honestly say that the results were as good as they are with Akadama. The big difference being that with Akadama the repotting process is easier since the roots are not entangled with fibrous organic matter. Frankly, in the USA Akadama is becoming so expensive that a cheaper, viable alternative must be found. For many species native to my area (picea, larix, abies, native acer) I am resorting to organic and sand, with about 25 percent recycled akadama/lava/whatever. For native pines I use one part of the above recipe with two parts sand. - ***Colin Lewis***

To Akadama, or Not to Akadama

(5.) Any general comments you like to share when discussing the topic "to akadama, or not to akadama"? (continued)

- In brief; there are still a number of enthusiasts that have used Akadama exclusively or as part of a soil-mix for many years, and their bonsai will not have exhibited /obvious /signs of ill-health as a direct result of using Akadama. And understandably, they will not have reason to question its use.
  But I firmly believe, as do an increasing number of people over the past decade, that Akadama does not realize the true potential, health and vigor of a bonsai or in many cases, is the underlying cause of weakness, susceptibility to fungal or insect attack or even death (in irregularly repotted trees). - ***Harry Harrington***
- Akadama is a Japanese soil, located in Japan, and useful in Japan. It is not a perfect or mysterious receipt solving any problems or making any bonsai look better. It is a soil, and not made for bonsai only. Several other types of soils will do exactly the same job, with differences in handling its job, primarily depending on climate conditions and the growing demands of the tree it serves. Twenty-five (or more) soil combinations may fore-fill the exact same purpose. So no exact formula is the one and only.

To Akadama, or Not to Akadama

(5.) Any general comments you like to share when discussing the topic "to akadama, or not to akadama"? (continued)

- We all have different experiences based on climate, local conditions (as down to how the bonsai are placed in the garden like in semi-shade, a hot place with stones on the ground warmed by the sun, a humid area with a moist ground i.e., or how we water and feed, how well we transplant our trees, how much knowledge we gain, and so on. Bottom line, make your own experiences and do not use money at a advertised "quality" akadama because it is Japanese, or because your bonsai dealer tells you to use a Japanese soil, because bonsai is Japanese. Your trees are growing at your destination, and must be treated that way. Depending on where you live, find a soil that fits your needs, and be happy with what works for you. But akadama is not doing it´s job for me. Whatever soil type you may prefer, make sure it is heat treated to solve any issues with diseases or pests, and therefore it is advisable newer to use any soils from the garden. Buy a good soil in a garden centre, and not the cheapest one, because they break down too fast. - ***Morten Albek***

To Akadama, or Not to Akadama

(5.) Any general comments you like to share when discussing the topic "to akadama, or not to akadama"? (continued)

- I believe Akadama is good, but just not better than our volcanic soil. The most important thing for bonsai soil is all the characteristic features, and we found them all better in Volcanic soil. I used to export a lots to many countries, especially Thailand, Malaysia, Taiwan and China, but we are no more allowed to export. - ***Robert Steven***

Conclusion, to Akadama or not to Akadama?

- As you have noted by now, there is no unchallenged or straightforward answer to this question. Some experts endorse the use of Akadama, while others (the majority of experts we interviewed) prefer different types of Bonsai soil.

- The discussion above does reveal the importance of one matter; the question whether or not Akadama is a good soil for Bonsai depends very much on your climate, your budget, availability of alternatives and how you use soil in the first place. Thus, while the main question is left unanswered, the experts did help us understand much more about the use of Akadama. Hopefully enough information for you to decide for yourself what's best for your trees!

Acknowledgements

Living Art Bonsai Society
http://www.livingartbonsaisociety.org/how_to.html

Bonsai Empire
http://www.bonsaiempire.com

Colin Lewis Bonsai Art
http://www.coliniewisbonsai.com

Soil Bulk Density/Moisture/Aeration
http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_053260.pdf

Adam's Art and Bonsai Blog
http://adamaskwhy.com/