A WORD OR TWO ABOUT GARDENING

If You Prefer Container Gardening Consider Succulents: there's more than just Cacti.

A much earlier article in this column described how succulents could be excellent choices as attractive low maintenance plants in Miami-Dade landscapes. Succulents are also ideal subjects for container gardening and the focus of the present article is what you need to know before starting a container collection of these fascinating plants. What are succulents? The term is used to describe plants that have developed modified stems and leaves as a means of storing water. While often popularly lumped together as 'cactuses', this is a very diverse assemblage of plants, encompassing representatives from more than 40 plant families. This includes agaves, aloes, stapeliads, various caudiciforms ('fat' plants) and a range of euphorbias many of which are most commonly confused with true cacti.

What all share in common is that for the most part they are found in areas of the world with arid to semi-arid climates. In order to survive harsh conditions where water is limited for all or most of the year, they have as a group evolved a variety of morphological and biochemical modifications. The former includes leaves that are greatly reduced or absent, swollen stems/roots, waxy surfaces and spines and prickles. While having an obvious defensive purpose, spines and prickles are also important in maximizing the use of available water. They provide surfaces on which any atmospheric moisture (i.e., early morning dew) can condense and drip onto the soil around the base of the plant. Spines are derived from modified stems or stipules (small bract-like appendages at the base of a leaf stalk). They are more firmly attached than prickles which are formed from outgrowths of modified epidermal cells. Thorns are woody modified stems and are rarely found in succulents despite being incorporated in several common names (e.g., crown-of-thorns).

Incidentally the spines found on cacti grow from areoles, unique cushion-like buds that serve to distinguish cacti from other look-a-like succulents. Each areole contains two types of buds: one differentiates into spines or hairs, the other produces either flowers/fruit or a new stem/offset, but not both. Buds that produce flowers become callused once the bloom/fruit is finished. Differentiation of buds into offsets is markedly stimulated by removing the growing tip of the cactus. This can be used where production of offsets is required for purposes of propagation. Areolar spines detach far more easily than the spines found on cactus look-a-likes such as columnar euphorbs (e.g., cathedral cactus, *Euphorbia trigona*)

Many succulents have also modified part of the biochemical pathway involved in photoynthesis - the process by which plants use sunlight to synthesize carbohydrates from carbon dioxide (CO_2) and water (H_2O). Plant cells use the pigment chlorophyll to convert light energy in to an energy rich chemical form, adenosine triphosphate (ATP, a compound common to both plant and animal cells). The energy contained in each ATP molecule is available to drive the steps involved in synthesizing carbohydrates from CO_2 and H_2O, with the release of oxygen (O_2).

Plants control the exchange of CO_2, O_2 and water (vapor) by means of tiny pores (stomata) which open and close in response to external conditions. Unlike most plants, succulents close their stomata during the heat of the day in order to conserve moisture. In doing so however they are now unable to take up CO_2, one of the building blocks necessary for the photosynthesis of carbohydrates. At night, when it is cooler and comparatively more humid, potential water loss is much less and succulents open their stomata. Although sufficient CO_2 is now available, there is no longer sunlight to provide an energy source (via ATP) to power carbohydrate synthesis. Instead many succulents chemically 'trap' the gaseous CO_2 to form an organic acid (usually malate). After sunrise, when more energy rich ATP becomes available, stomata close and the CO_2 'fixed' in each molecule of malate splits off and is available for carbohydrate synthesis.

This process of fixing CO_2 into an organic acid is referred to as crassulacean acid metabolism (CAM). Named after the group of succulents in which it was first studied, the process was only fully worked out in 1980's. This explained an early 19^{th} Ct. observation that leaves from certain garden succulents regularly tasted more acid in the morning (acidity was lost through the day as malate was broken down to release CO_2). While the above modified form of photosynthesis enables succulents to conserve water during the heat of the day, it is not as efficient as 'normal' photosynthesis and is the reason succulents exhibit much slower rates of growth. In practice this means they require little fertilizer, especially nitrogen, less pruning and less frequent re-potting.

Succulents have therefore responded to the challenge of surviving in their predominantly arid surroundings by modifications to both form and function. As was pointed out in a previous article on the use of succulents in Miami-Dade landscapes, the major challenge facing local gardeners is devising strategies to mitigate potential problems from a surfeit of moisture. Soil that remains excessively moist impairs root function through decreased soil aeration and increases the risk of disease. Conversely if soil is allowed to dry out too much growth suffers as more of the root system is lost. These considerations also apply when growing succulents in containers, where the choice of container is itself of great importance in controlling excess soil moisture. This is especially important if containers are placed outdoors, rather than indoors. The former is preferable to take full advantage of sunlight; in adition our locally dry, warm winters are such that unlike other parts of the mainland US, even tender succulents can remain outdoors year round.

When choosing which type of container to use the first decision is basically choosing between plastic (from basic polypropylene to simulated decorative stoneware) and unglazed terracotta (red clay) pots. The former are light weight, robust and are usually less expensive, the latter are more expensive (especially if handcrafted rather than molded), heavier and porous (unless fired at a high temperature or sealed). Plastic containers may be suitable for smaller succulents that are amenable to growing indoors but outdoors, given south Florida's heavy summer rainfall, the porous nature of unglazed terracotta is an obvious plus. It facilitates a much more rapid loss of excess soil moisture, with evaporation from not only the soil surface but through the porous sides of the container. Like plastic, glazed or sealed ceramic containers are more suited to growing succulents indoors.

The size and shape of the container are also both important; it is essential not to use too large a container as this increases the risk of soil remaining excessively wet. The shape of the container is dictated by the type of succulent. In general it is best to use containers that are wide and shallow: either bowl shaped (excellent for shallow rooting stapeliads and squat caudiciforms such as adeniums) or somewhat deeper azalea pots for deeper rooting caudiciforms such as *Adenia* and *Fockea* species. Unglazed clay pots of this type offer more surface area from which excess soil moisture can evaporate, especially important during the summer rainy season.

The other important decision that can help reduce the risk of succulents rotting is the composition of the soil mix. Basic to this question is balancing the type and amount of aggregate (to ensure a mix that is free draining and aids soil aeration) with sufficient organic matter so that some moisture is retained and excessive leaching of soil nutrients is reduced. As aggregate, products such as fine gravel (≤¼") can be used to a certain degree, but it is preferable to use a porous aggregate that promotes soil aeration and retains water (which becomes available to plant roots as the soli dries out). Vermiculite and perlite are the two most readily available materials of this type.

Perlite is a light weight heat expanded alumino-silicate based mineral of volcanic origin having surface pores, but very limited internal pore space. As a consequence it absorbs so little water that it floats to the surface of the potting mix after heavy rainfall. Where soil is frequently inundated, this can lead to a loss of aggregate from the lower half of the container rendering the soil mix less free draining and less able to anchor developing roots. For this reason if you use perlite combine it with some other aggregate and top-dress with a layer of ¼-½" gravel. The fact that it is so light weight may prove an advantage when it comes to moving large succulents. However over time its' physical structure tends to breakdown causing compaction, lessening its effectiveness in keeping the soil aerated.

Vermiculite is a heat expanded mica-like mineral that forms open sheets able to trap moisture and provide aeration. In addition it exhibits good cation exchange properties (this lessens the leaching of plant nutrients from the growing media by reversibly binding potassium, magnesium and calcium ions which on release are available for uptake by plant roots). However it exhibits very poor physical stability and for this reason needs to be handled carefully when preparing a growing mix. Loss of structure and soil compaction is more pronounced than with perlite.

Pumice is a stable, porous rock of volcanic origin, used by landscapers (more so in western states) to lighten heavy, poorly aerated soils, and widely used by growers of succulents and other container plants including bonsai and orchids. Horticultural grade material such as Hort-T-Lite is up to 70% porous but does not float and exhibits extended physical and chemical stability. This permits excellent soil aeration combined with rapid drainage of excess water, while moisture retained within internal pore spaces ensures that soil does not dry out completely. Perma-Till is a product made in North Carolina from heat expanded slate, which also combines good chemical and physical stability with a porous structure. It too has found use in both aerating heavy clay soils as well as a growth medium for a variety of container plants. Compared to perlite and vermiculite both of these latter two products are more expensive and are not available locally – you will have to order from out of state suppliers so you will need to figure in shipping charges.

Drainage and aeration of the growing medium is improved by mixing aggregates of different size, so as well as one of the above materials incorporate some material of smaller particle size such as granite grit or coarse sand. Granite grit is sometimes available from local feed-stores as bird grit. Be careful however, you are more likely to find bird grit prepared in part at least from crushed oyster shells which can eventually contribute to soil compaction and potentially raise the pH of the mix. Supply houses that cater to bonsai growers offer various types of grit, but these are invariably expensive.

Coarse sand is also not readily available; there are however a few local sources. Choose the coarsest grain size available – ideally ≥1mm. On no account should you use regular play or foundation sand as it is too fine and will impede drainage. You should also choose a ¼-½" aggregate to top dress the container. Apart from its decorative value, a top dressing helps prevent soil from splashing onto the succulent stem, reducing the risk of disease. You can use pumice or Perma-Till or bonsai suppliers offer a variety of attractive materials – for small containers or succulents grown indoors bonsai grit is suitable.

The composition of mixes used for growing succulents will differ depending on the type of succulent and where they are being grown. In all cases the mix needs to be loose and friable even when wet, and never sticky. Use a less coarse mix (increase the proportion of coarse sand/grit) for succulents with fine root systems, such as crassulas. For succulents such as adeniums, aloes and stapeliads, use a coarser mix, containing relatively more of the larger size aggregates (Perma-Till/Hort-T-Lite) Considering Miami-Dade's wet summers, I use a mix containing less organic matter than recommended for drier climates such a southern California, restricting organic matter to 25 35% by volume. The remainder consists of equal parts coarse sand and/or grit plus Perma-Till and perlite (the latter only to help reduce the weight when dealing with large containers). Indoors, where there is more control over soil moisture, the amount of organic matter could be increased, especially if a porous a clay pot is used.

The organic components of soil mixes are most often either brown peat moss or coir. Use a long fiber peat moss which incorporates a wetting agent – peat moss is resistant to wetting. Coir (coconut fibers) absorbs water readily but it is fine enough to restrict soil aeration if too much is used – limit the amount to 10-15% by volume, with any additional organic matter Canadian peat. Other organic materials such as oak leaf mold can be used in combination with peat moss, as can sterilized well rotted home-made compost (it should be black and crumbly). Sterilize by spreading a 4" layer in a tray, cover with foil, place in a 200°F oven and once the compost reaches 180°F (use a candy thermometer to check temperature) heat for 30 minutes. For every 4 gallons of soil mix add 1½oz each of dolomitic lime and bonemeal.

Do not use the dry composted cow manure available in garden centers it is too fine and will impede drainage. Cactus and succulent soil mixes are available from garden centers but often contain ordinary sand and perlite as the only aggregate. If you decide to use one of these products, especially for outdoor containers, add some additional pumice or Perma-Till.

Some other supplies that are useful include thick gloves (rose gauntlets are ideal) to protect from spines and prickles. The glochids (small irritating hair like spines found on opuntias) are so fine they can become embedded in most gloves, in this instance handle with a sheet of folded foam which can be discarded after use. A sharp grafting knife to remove rotted tissue and cut stem sections for propagation (unless sharp, secauteurs can crush soft stems of succulents). For larger specimens specially designed cactus saws are available. A pair of fine tweezers to remove dead leaves, as well as debris that becomes trapped on spines, and a selection of hemostats for weeding. Non-medical grade hemostats are available on line, and are ideal for reaching into otherwise inaccessible areas to remove debris and pull out weeds growing around the base of spiny succulents, especially multi stemmed specimens such as *Alluaudia.* Since several groups of succulents contain poisonous or caustic sap (in particular euphorbias and monadeniums) a pair of goggles is prudent when working around such plants.

The next article will consider additional external factors, such as light and temperature, and conclude with a selection of succulents with which to start your collection.

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