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Abstract: In this article Dr. Celeste develops five principles that set the baseline of his discussion. He starts with a discussion of photosynthesis, moves on to the role of water, discusses the need for and use of nitrogen, then phosphates, then the role of potassium and magnesium and then talks about the need for micronutrients which need to be applied on a balanced basis.

The conclusion is: "Rose growers need to supply roses with a consistent supply of water, and complete fertilizer, making sure not to overdo it, and your roses will supply YOU with blooms."

What Do Roses Do With Fertilizer ?

By Vincent Celeste, Bradenton-Sarasota Rose Society

Every rose grower knows that roses need sunlight, and hopefully all of them also understand that the sunlight is used for photosynthesis. If roses make their own food through photosynthesis what do they need fertilizer for? The answer has more to do with what rose growers want than what plants need.

About photosynthesis

Unlike current plants which depend on chlorophyll, the first plants to develop photosynthesis depended only on green light, which makes up the majority of sunlight. These early "plants" covered the ocean tops so no green light got below the surface. Chlorophyll developed in the ocean depths, without green light, but in an environment rich in dissolved carbon dioxide and minerals. The photosynthesis involving chlorophyll produces oxygen (plants do not "breathe" so they do not use oxygen) and the oxygen that chlorophyll produced destroyed the earlier non-chlorophyll anaerobic plants. Today chlorophyll based plants make up virtually all plants. In the over 2 ½ *billion* years since its development, chlorophyll has not changed, it still does not use green light (that's why the only light it reflects is green, and why plants look green today) and still requires an ocean-like environment which contains dissolved minerals. Since chlorophyll has not changed for billions of years we can safely assume it will not change in the foreseeable future. In order for roses to flourish they need to provide their chlorophyll with an "ocean-like" environment, and for this purpose they are among the plants that have developed leaves.

Some scientists describe leaves as organic solar collectors, but they do much more than collect sunlight, they also provide an aquarium-like environment with minimal thickness and maximum surface area. The tops of the leaves are exposed to sunlight and the bottoms are shaded by the leaf itself. If we examine leaves we should note that the tops are thicker than the bottoms, the tops allow very little air to pass through while air can pass through the bottoms. The bottoms of the leaves not only allow more air to pass through them but they are *designed to permit air,* particularly carbon dioxide, to be absorbed, and "excess oxygen" (the waste product of chlorophyll-based photosynthesis) to be released. One problem that occurs from the release of excess oxygen is that it also allows the release of water vapor. In short, in order to get carbon dioxide *into* the leaves there is a water loss. For plants such as roses, which depend upon *leaves* to create an environment for photosynthesis, there is a real danger of losing too much moisture to the air. As long as there is an adequate supply of moisture from the roots there is no problem, however, if the supply of water is reduced the plants will stop allowing carbon dioxide into the leaves in order to prevent the loss of water. Roses use special cells called "stomata" (from the Greek word for "mouth") which open to allow the passage of air in, or close to halt the passage of air and water out. In fact, if the leaves merely sense a shortage of water the stomata are all closed, stopping the absorption of carbon dioxide and the creation of food until "better times". The dilemma for plants is that the same water that is needed to provide the necessary environment to make food is also used up in the process, and even more lost when attempting to get carbon dioxide. When plants have a limited water supply they need to choose between giving up the environment needed for chlorophyll or giving up food, in other words, destroying their future ability to create food or to stop creating food. Starving animals metabolize their own muscles and organs to survive, but land based plants *always respond to a shortage of water by stopping photosynthesis rather than losing the ability to survive*. The browning of leaves during a drought is always a result of starvation, not dehydration. This process has worked effectively for billions of years but it is not acceptable to rosarians who want blooms and will only get them if the plants have a food surplus.

First principle: **All plants, and particularly roses, require a dependable, regular supply of water to their roots.** While roses do not like 'wet feet' they should never be allowed to have dry roots, or in simpler terms: **providing a consistent supply of water to the roots of roses is the *only way to provide food* essential to their growth and health.**

Primary Requirements

All plants, not just roses, need more than glucose (sugar!) for growth, they also need a compound of nitrogen called *nitrates* which are the building blocks of protein.

if there is an adequate supply of nitrogen. ...

Since nitrogen is eight times as plentiful in air as carbon dioxide we might think that there should always be enough nitrogen. Unfortunately, the reason nitrogen is so plentiful is that it is *chemically locked up* in what is called a "triple bond" that is extremely difficult to break. The only natural sources of nitrogen for most plants are the nitrogen made available by lightning strikes that have the power to break the triple bond, nitrogen available from other decaying plants, and nitrogen fixed by anaerobic microbes and legumes. The nitrogen fixing process can not function in the presence of oxygen, and since the photosynthesis process produces excess oxygen, photosynthesis cannot be used to produce nitrites. To make matters worse, nitrogen available for plant use becomes unavailable by rapidly re-forming triple bonds. Since rose blooms require **growth**, and since the cutting of roses also removes leaves, requiring still more growth just to replace what was cut, we need to provide a sufficient source of nitrogen. This leads us to:

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Second Principle: **Roses require a constant, consistent source of usable nitrogen for growth and bloom production, but nitrogen cannot be "stockpiled" (** or it will rapidly return to its "triple bond" un-usable form)

There are at least two common approaches to this requirement:

1. use **slow release** fertilizers provide measured doses of nitrogen
2. supply inorganic fertilizer at low rates but more frequently

.. **many small steps** ..

Nothing in nature is done directly, rather than proceeding directly up the mountain the paths involve switchbacks and a circular route. In living organisms all changes are carried out in a series of small steps, some appearing to be side or backward steps. Living organisms need to be able to make changes in a controlled manner; these changes often involve forces and energy releases which could be destructive. The use of *enzymes* allows plants and animals to make large changes in a series of small steps, each of which involve very low energy levels but cumulatively become significant. The enzymes themselves are almost always proteins that are unique to the specific plant or animal, but the source of energy for all living organisms has remained unchanged since before the existence of chlorophyll. This commonality has enabled plants and animals to evolve in an orderly manner by simply changing the enzymes and genes, but still using the same processes. There are a number of names given to portions of the process that provides energy; the name we will look at is Oxidative ***phosphory****lation* (the formal name is ATP adenosine tri**phosphate**) If we concentrate on only one syllable we should recognize the familiar name of *phosphates*, sometimes listed as phosphorus, but almost always the second listed ingredient in fertilizers, or even the **only** ingredient in the familiar names "super-phosphate", "triple-phosphate", and "bloom booster". A significant feature of the ATP cycle is that even though all the ingredients change with each step, the original ingredients are all returned to their original state except for the metabolized nutrient. However, without an adequate amount of phosphates living things are unable to metabolize anything. Supplying enough phosphates, **especially after pruning is** important to rose growth, and ultimately, blooming.

Third principle. **Roses require a consistent source of phosphates to ensure growth, and especially to ensure continued blooming.** Just in case you haven't caught onto a developing pattern, excess phosphate will rapidly combine with manganese, zinc and iron, depleting the soil and depriving the plant of essential nutrients, so we SHOULD NOT **stockpile phosphates for our roses, but must supply a consistent, steady amount.**

..what leaves need…

If a plant is going to grow leaves it needs **stems** to hold them up. In roses stems start out as the same cellulose (starch) as leaves, but cellulose lacks sufficient rigidity so the stems need to be more "woody" than the leaves. Plants use **potassium** to make their stems (or trunks) sturdy the same way animals use calcium for their bones. Potassium was originally identified in Germany and named 'Kalium' so it is often listed in fertilizers as **K,** and is usually the fourth listed ingredient. Because the primary source of potassium used to be from the ashes of wood it is also called *potash*, but today that name is only used if the source of the potassium is from burnt wood or woody plants. Potassium is also needed in the production of over 60 different enzymes that roses use for improving root growth, increasing protein development, and improving photosynthesis.

Leaves are of no use without chlorophyll, and chlorophyll is made up from water, carbon dioxide and *magnesium*, so plants need a supply of magnesium. A shortage of magnesium will result in a lack of new chlorophyll, which in turn would prevent the "greening" of new leaves. Remember, every time you cut blooms and leaves the rose bush needs to build replacement leaves with chlorophyll, and therefore additional magnesium. Magnesium occurs naturally in most soils, but for a dependable supply many rosarians have relied on products such as Epsom salts, or even banana skins.

Magnesium poses new problems. Magnesium and Potassium are ***adversarial*****,** an excess of either blocks the availability of the other. For rose growers this means there must be a *balanced application* of *both Potassium and Magnesium*. In addition, Magnesium is not available for plants in *acidic soil (low pH)*, so a **soil test** should be performed to determine the acidity (pH) of your soil. If you need to raise the pH of your soil the addition of *limestone* will increases your pH, but if *dolomitic limestone* is used then the level of magnesium will also be raised. Making magnesium available requires paying attention to the potassium levels, the pH, and how you manage each.

Fourth principle Roses require an adequate, but *balanced*, source of potassium and magnesium. If magnesium levels are low a soil test should be performed to ensure appropriate pH. Potassium and magnesium must be managed together.

Minor requirements

Plants have no muscles, so they cannot chew, swallow, or pump nutrients and water out of the soil and *up* to leaves. The roots of a plant will absorb water and anything *dissolved* in it. Things that merely mix with the water – such as mud – will not be absorbed. Recall from the start of this article, that chlorophyll developed (and still depends upon) a soupy mix of water soluble minerals. Water is made up of balanced and equal parts of Hydronium, a positively charged *acidic* radical often referred to as a *proton*), and Hydroxyl, a negatively charged *caustic* radical. Minerals which dissolve in water

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can alter the balance between the two water parts resulting in either an acidic or caustic solution. When an acid producing mineral combines with a caustic producing mineral the combination is called a *salt* (common salts are Epsom salts, aspirin, bromides or stomach antacids, and of course table salt) so the only minerals that plants can use are those in salts. Many salts involve strong acids or caustics so they are too dangerous for plants to use. Plants can safely use *chelated* minerals which are salts formed from a metal and an organic product ("ligand"), so our focus has to be on ***chelated nutrients***. When different metals dissolve in water they create a small electrical current termed "*proton exchange*", this

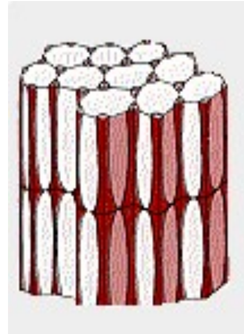
Soil scientists have identified sixteen essential elements for plant growth; four of these have been described above: Nitrogen, Phosphorus, and Potassium are sometimes called ***primary or macro*** nutrients because they are used up in the greatest quantities. Magnesium, Sulphur and Calcium make up the ***secondary*** nutrients: magnesium was noted as an essential part of chlorophyll and Sulphur is needed in the process of building the chlorophyll as well as being an essential ingredient of proteins. Calcium is needed in the formation and growth of plant cells. A consistent supply of the secondary nutrients is needed for the replacement of leaves and stems removed by deadheading, cutting of blooms, and pruning.

The remaining 10 ingredients are called ***micronutrients*** because they are needed in very small quantities compared to the primary or secondary nutrients, but they are still essential for plant survival. Most of the remaining 10 nutrients are building blocks of essential enzymes or cell wall contents, but two of the ten, and one other nutrient, have special value.

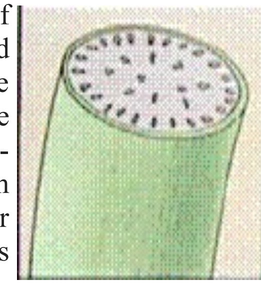
Iron is not an ingredient of chlorophyll but is essential to the process that *creates* chlorophyll, as well as to the photosynthesis process itself. Iron is also critical to enzymes which control water loss (transpiration). Unfortunately Iron has an adversarial relationship that requires balancing applications with each of Nitrogen, Phosphorus, Potassium, Zinc, Manganese, and Molybdenum. Further, Iron cannot be used by plants if the pH of the soil is too low.

Fifth Principle: Micronutrients need to be applied according to a balanced ratio

There is one final observation involving two key roles played by the essential nutrient Chloride and the element Silicon which is not one of the 16 essential nutrients. Anyone who has cut a rose stem knows that a healthy stem is not hollow. The stems of plants and trees are filled with special cells called ***xylem***. These cells are extremely narrow and very long, (see right) with hollow centers. The stems are filled with thousands of xylem which touch each other on all sides, tops and bottoms (left). In trees the xylem, viewed on end form the annual rings, in plants (or monocots) the xylem are scattered in multiple bundles.

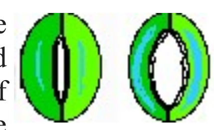


When water is measured in a glass measuring cup you can see (right) that the water 'climbs up' the side of the glass, this effect is called meniscus. The xylems use chloride and silicon in their side walls to magnify the height of the meniscus so that the combination of "proton drift" and water pressure difference between one Xylem and the one immediately above it pushes water, with its dissolved minerals, from one xylem up to the next one. In other words, xylems act as bucket brigades even though they do not move or push. each xylem can only function if every xylem cell below it maintains its constant pressure or supply of water, that's why rose cuttings need to be put in water as soon as possible to prevent wilting or loss of fluids at the top.



Xylem scattered in roses (monocots)

In the second key role played by chloride and silicon they are used to create the stomata which control air flow into and out of the leaves. The stomata consist of pairs of sausage shaped cells that are side by side and joined at the top and bottom. The concentration of chloride and silicon are used to make the common sides less "stretchy" than the outer sides. When the cells fill with water they bow apart or "open", and when they cells dry they collapse together or "close", (see right) all without muscles.



CONCLUSION

Rose *growers* need to supply roses with a consistent supply of **water**, and complete fertilizer, making sure not to overdo it, and your roses will supply YOU with blooms.