A WORD OR TWO ABOUT GARDENING

Feeding your landscape plants – first understand your soil.

As we move gradually into spring, Miami-Dade gardeners need to be especially aware of the nutritional demands of the plants in their yard. This is a time when trees are setting fruit and both turf grass and ornamentals put forward major growth flushes. This and a subsequent article will discuss issues relating to understanding and meeting the nutritional needs of landscape plants in Miami-Dade. First and foremost is soil – in fact you should have been aware of local soil conditions when first landscaping your yard. Some of you might be thinking, what soil! Indeed gardeners new to Miami-Dade cannot fail to be amazed at just how well plants grow, given local soil conditions.

We can quickly summarize the seemingly not too promising properties of Miami-Dade soil. Thin, porous, and low both in organic matter and clay minerals, high in calcium and low in nitrogen potash and phosphate and with a high pH (alkaline). This latter property is attributable to the pervasive presence of Miami limestone, which in many developed parts of the county, especially the south, is overlaid with at most 1 – 2" of coarse, loose native soil. In such areas the chances are you will need to use a pick axe more than a spade when planting trees and shrubs. Workable loose and gravelly topsoil to a depth of 8" can be found on old agricultural land that was rock ploughed. Somewhat deeper but rocky soil is in evidence in housing developments where fill was used. In the north east corner of Miami-Dade are areas of fast draining sandy soil, while in some parts of south Miami-Dade, well to the east of US 1 are found poorly draining clay-like marl soils.

Let us return to the all important subject of Miami limestone and pH. Limestone (calcium carbonate, $CaCO_3$) is the reason Miami-Dade soils are so alkaline (pH of 7.4 – 8.5). Soil acidity is expressed in pH units using a scale from 1 (very acid) to 14 (very alkaline) with 7 being neutral. The scale measures the concentration of hydrogen ions (H^+ - acid forming). Since the range is so large, the actual values are transformed using simple math into a more convenient logarithmic scale. This is not a linear scale meaning that soils measuring pH 5.5 for instance are 10x more acid than those at pH 6.5 and 100x more acid than at pH 7.5. An acceptable range for growing most plants is between pH 5.5 – 7.0, from which it is apparent that Miami-Dade soils are well outside this optimum range.

Soil pH has little direct effect on the majority of plants, but it can have an indirect effect on plant nutrition. At the high pH values found in Miami-Dade soils, trace elements such as iron, manganese and zinc become increasingly insoluble, and therefore unavailable to the plant. The roots of some plants secrete organic acids which effects a localized lowering of pH, increasing the concentration of soluble trace elements available for uptake. Above pH 7.8 these plants too will suffer nutritional deficiencies.

Some local gardeners attempt to lower soil pH by incorporating material such as sulfur, which is metabolized to sulfuric acid by soil bacteria. This can easily cause plant damage, and at best exerts a transitory effect. The effect is transitory because the acid formed is leached by rainfall. This is replaced by further dissolved calcium carbonate, either washed in from surrounding soil or present in irrigation water. To date there is no research to support any beneficial effects from applying acidifying agents to Miami Dade's calcareous soils.

There are more practical ways to overcome the nutritional problems created by high pH soils. Trace elements can be supplied to the plant through foliar feeding – as a spray solution applied to the leaves. A foliar application is only temporary and must be repeated every 2 months. Some elements, especially iron are applied as a soil drench in a chelated form that remains available for plant uptake. Symptoms of iron deficiency (interveinal yellowing) are commonly seen in various fruit trees (mango, litchi and jaboticaba) and ornamental shrubs (ixora, gardenia and hibiscus). When applying iron as a soil drench the only effective products for high pH soils are those containing iron chelated as Fe-EDDHA. You will find this information on the product label. There are acid forming fertilizers available, but at most these have only a slight effect in lowering soil pH. They would be most likely to exert an effect if used on an organically enriched soil specially prepared for a planting bed for 'acid-loving' plants such as gardenias or ixoras.

Most Miami-Dade soils (marl is an exception) are extremely porous, permitting the rapid leaching of many plant nutrients out of the root zone. This situation is exacerbated by the heavy rainfall we experience, the lack of clay minerals and to a certain extent the low organic content of local soils. Clay minerals and some types of organic soil matter carry a net negative charge and can weakly bind positively charged plant nutrients (this is termed the soil's cation exchange capacity, CEC). Improving the organic content of soil, both through the use of compost or breakdown of organic mulch, can increase soil CEC. Another positive effect is a gradual improvement in soil nitrogen content as the added organic matter decomposes. This leads on to another very important topic we need to consider: the factors that determine soil nitrogen fertility.

Carbon, hydrogen, oxygen and nitrogen are the important building blocks used to synthesize plant tissue and food reserves. The first three elements are readily available from carbon dioxide and water. For nitrogen however the plant has to rely on that made available to the soil either through fertilizer application, microbial (bacteria and fungi) decomposition of soil organic matter, or through the action of nitrogen fixing bacteria. Such bacteria are found in the root nodules of legumes and are the reason leguminous crops require low nitrogen fertilizers. There are free-living soil bacteria that can also fix gaseous nitrogen into a form that can be readily taken up by plants. While nitrogen fixation can be important in some natural ecosystems, it accounts for little of the available nitrogen needed by cultivated plants.

Both microbial decomposition of organic matter and nitrogen fixation result in the formation of ammonia (NH_3), which is present in soil solution as the ammonium ion (NH_4^+). This is one of only two forms in which nitrogen can be taken up by plant roots. Depending on the cation exchange capacity of the soil, a portion of these positively charged ammonium ions are weakly bound to soil particles and remains available for plant uptake. On Miami-Dade's high pH soil some of this nitrogen is lost to the atmosphere as gaseous ammonia. Further microbial action can convert NH_4^+ to negatively charged NO_3^- (nitrate ion). This is the only other form in which nitrogen is available for plant uptake. Since nitrate is negatively charged and therefore does not bind to soil particles, it is much more readily leached out of the plant's root zone. This is especially so for high rainfall areas such as Miami-Dade. Apart from losses through leaching, additional microbial action can convert nitrate to gaseous nitrogen which is then lost to the atmosphere. This process, known as denitrification, is most in evidence on highly organic, inundated soils.

It should be clear from the above description that it is of little consequence to the plant how nitrogen is supplied. Be it blood meal, cotton seed meal or urea, it requires soil microbes to transform these materials into ammonia (as NH_4^+) and nitrate (NO_3^-). Compounds such as ammonium sulfate and potassium nitrate are used in inorganic granular and soluble fertilizers. These readily dissolve in water and are immediately available to the plant. They can also be rapidly lost both to the atmosphere and through leaching as described above. For the gardener this means paying for fertilizer nitrogen that can rapidly disappear from the landscape. Of more concern is the potential contamination of groundwater supplies with leached nitrate. This can have serious adverse effects on human health, particularly for infants.

To help reduce soil nitrogen losses, inorganic fertilizers such as potassium nitrate and ammonium sulfate can be used in lesser amounts but at more frequent intervals. A better approach is to use materials that make nitrogen available over a longer period of time - slow release or controlled release fertilizers. Organic fertilizers, apart from urea, are regarded as slow release fertilizers. Examples include materials such as bone and blood meal, cottonseed meal and fish meal. These contain complex nitrogen containing compounds that are slowly broken down in the soil to NO_3^- and NH_4^+, the rate of release is dependent on the nitrogen source and the level of soil microbial activity. Blood or fish meal will breakdown more rapidly than cotton seed meal. The former would be useful for an annual flower garden or vegetable garden, the latter for ornamental shrubs. If you rely on slow release organic sources of nitrogen for a vegetable garden allow 4-6 weeks before planting to permit fertilizer breakdown to commence. Composts contain very little nitrogen (commonly $>2\%$) but are extremely important in improving the physical properties of the soil.

Synthetic organic fertilizer may seem like an oxymoron, but it describes a type of slow release nitrogen fertilizer formed when urea (a soluble organic fertilizer) is combined with formaldehyde to form methylene urea polymers (larger size polymers referred to as urea formaldehyde, UF). Gardeners are most likely to encounter these materials in turf grass fertilizers. Breakdown of methylene ureas into usable nitrogen is dependent on polymer size and soil microbial activity – soil temperature and moisture have little effect. Breakdown can vary from weeks to more than a year for UF. A variable but small portion of each of these products is soluble and becomes available first. Isobutylidene diurea (IBDU) although similar to methylene ureas differs in not forming polymers. It slowly reacts with water (hydrolyzes) to release soluble nitrogen, independent of soil microbial activity. Particle size and soil moisture levels are the determining factors affecting release. Again this material is most likely to be encountered by gardeners in turf fertilizers. On the fertilizer label both IBDU and methylene ureas are listed as water insoluble nitrogen (WIN). In the case of lawn fertilizers WIN should be at least 50% of the total nitrogen.

Another widely used approach to reducing loss of soil nitrogen is by chemically coating the individual fertilizer granules. The earliest method involved coating with molten sulfur, and using wax as a sealant. Release is dependent on microbial activity breaking down the wax to allow water to penetrate pores and cracks in the sulfur coating. In order to obtain better control over release the sulfur coated urea was further coated with plastic. Apart from urea many inorganic granular fertilizer components are also plastic coated. Fertilizer release is independent of microbial activity, depending only on soil temperature and coating thickness. Release occurs as water diffuses through the thin thermoplastic coating which swells. The newer Polyon plastic coated fertilizer granules do not swell as much and therefore claimed to be less affected by heavy rainfall. Coating thickness is not a factor in products using polyolefin resins, temperature alone determines the rate of release. For all these plastic coated fertilizer products expense is the major drawback. Cost becomes far less of a negative, when you realize that coated fertilizers need not be applied as often, and more of the nitrogen applied remains available for plant uptake. When using this type of fertilizer avoid damage to the plastic coating through rough handling. This can cause a sudden initial release of soluble fertilizer.

Potassium like nitrogen is readily leached from Miami-Dade soils. Plants require large amounts of potassium – apart from nitrogen more is required than any other soil derived nutrient. Potassium is most often applied as potassium chloride (KCl). On a weight basis it contains more K^+ than potassium sulfate (K_2SO_4) or potassium nitrate (KNO_3). However excess use of KCl is more likely to cause leaf/root burn, especially on saline soils, e.g. as a result of salt water intrusion. There are ‘organic’ forms of slow release potassium such as greensand but these are expensive. Wood ash is a good source, but it will raise soil pH, not a beneficial feature for Miami-Dade soils. A better choice is to use urea or plastic coated forms of granular potassium.

Unlike nitrogen and potassium, phosphorous is not leached from Miami-Dade soils, but because of the high pH becomes bound to calcium and is mostly unavailable for plant uptake. Since plants require much less phosphorus compared to nitrogen or potassium, sufficient is available dissolved in local soils. Deficiency symptoms are rarely seen, and this is reflected in the low percentage of phosphorus (supplied as various phosphates) in balanced fertilizers. Nitrogen, phosphorus and potassium (N/P/K) are the three macro-nutrients that make up the bulk of a balanced fertilizer. Yet to be considered are two other macro- nutrients, magnesium and calcium, as well as the various trace elements, all required to ensure a yard of vigorous and healthy plants.

Finally I cannot close this article without thanking Dr. Yuncong Li, soil scientist at UF-TREC (Homestead), for the benefit of his expertise.

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