What Is Your Substrate Trying to Tell You

Part I

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This article is the first of a five-part series of articles on potting mixes and properties of potting mixes that are important for optimum plant growth. The goal of these articles is to provide you with some guidelines for chemical and physical characteristics of potting mixes. The words potting mixes, container growth media, and substrate are use interchangeably throughout these articles.

Overview

Substrates are perhaps the most important part of the overall production process when growing landscape plants in containers at the nursery or potted crops a greenhouse. Having the proper potting mix with optimum chemical and physical characteristics will promote plant growth and should decrease the amount of time needed until the plant is salable. Reducing production time while improving plant quality should increase profit from your crops.

Many potting mixes are soilless, meaning soil is absent from the potting mix. Potting mixes or substrates without soil have inherent advantages and liabilities. Advantages include light weight substrates and lack of pests that are commonly found in soil. Perhaps the biggest disadvantage to keeping soil out of potting media is that a potting mix could lack several essential elements needed for plant growth. In fact, one or more elements could be completely absent from a soilless substrate.

In this series of five articles, I will discuss what I believe are four of the most important chemical characteristics of potting media and describe how you can do a quick measurement of two of them. Since pH is such an important characteristic of media, pH basics will be discussed. I will also discuss physical properties of media. Finally, I'll present some work I've done with paper sludge and show how its properties have affected the substrate.

Soilless Potting Mixes

When plants were shifted from field growing to container growing, the root environment changed drastically. Roots faced different situations in containers. These situation were foreign to plant since the most "fit" plants always survived in field growing situations. For this reason, container media must be carefully composed or blended and managed so that plants thrive rather than merely survive in container culture.

Functions of potting mixes include anchoring the plant and being a reservoir for nutrients and water for plants grown in them. In addition, media should allow proper root respiration, meaning potting mixes should be well aerated when adequate moisture is present.

Mineral soil drains better as the soil column increases in height. When used in a pot as the sole component, however, mineral soil will have a perched water table. In other words, most of the root zone will be too wet to provide sufficient aeration for optimum plant growth, particularly in shallow pots (those six inches or less in height). Too many small pores are present in a mineral soil and the height of the column of saturated soil is too short too allow gravity to remove excess water. For this reason, many growers exclude soil from their potting mixes and few commercially produced substrates contain soil. Growers that make their own potting mixes containing mineral soil add around 20% by volume. Other reasons to use potting mixes with little or no soil include light weight of potted plants for handling and shipping and reducing employee fatigue. In addition, some growers believe they have better control over substrate fertility when soil is absent from a potting mix.

Soilless potting mixes are composed of different organic and inorganic materials blended together to provide good aeration, mineral supply and available water. Individual components will affect chemical and physical characteristics of potting mixes. These effects will be discussed in this article and several others in the series.

Four Important Chemical Properties of Potting Mixes

Substrates or potting media have many chemical characteristics that could be examined, including macronutrients and micronutrients. In other words, fertility of potting mixes can and probably should be assessed before planting so that adjustments can be made to the media. Altering fertility of growing media before planting is best, but completing all the necessary chemical analyses can cost from $20 to $100 or more per sample. In my experience, I have found four chemical characteristics of potting mixes are vital to assess before planting. The chemical properties are pH, electrical conductivity (EC), cation exchange capacity (CEC), and carbon to nitrogen (C:N) ratio. pH and EC will discussed in this article, and CEC and C:N ratio will be covered in the next one.

pH of Potting Mixes

pH is the first and probably most important chemical property to discuss about potting mixes because pH of the substrate <u>affects nutrient availability</u> and can influence mineral deficiencies and toxicities. pH is measured as the inverse logarithm of the hydrogen ion concentration (abbreviated as $[H^+]$). The pH can range from 0 ($[H^+] = 1$ M) to 14 ($[H^+] = 1 \times 10^{-14}$ M), and pH 7 is considered neutral and has a $[H+] = 1 \times 10^{-7}$ M. Note that M is the abbreviation for moles per liter ($mol \bullet liter^{-1}$).

Plants can be grown in a pH range between pH 4 and 8, <u>if</u> micronutrients are maintained in available form. The pH range for plants grown in organic soils or soilless mixes is around 1.0 to 1.5 pH units lower than the pH range for plants grown in mineral soils due to differences in nutrient availability. Nutrient availability is higher in soilless mixes around pH 5.0 to 5.5

compared to a mineral soil that has maximum nutrient availability around pH 6.0 to 6.8. Having the pH too low, however, can result in micronutrient toxicities. For instance, Mn, Al and sometimes Fe will become available at toxic levels if the pH of the medium drops below 4.0. Greenhouse crops such as geranium and celosia need to be grown in a medium with a pH around 6.0 to 6.8 to prevent Fe and Mn toxicity. On the other hand, azaleas need to be grown in a medium that has a pH between 4.5 and 5.8 to prevent Fe deficiency. Many ericaceous plants need the potting mix to have a pH around 5.0 to prevent minor element deficiencies, including minor metals and Boron (B).

Four factors can strongly influence pH of the substrate solution, and it is this solution that we are actually measuring for pH of the potting mix. Substrate components themselves and preplant materials such as limestone affect pH. Alkalinity of the irrigation water can affect pH over time. Acidic or basic reactions caused by the fertilizer used can affect pH of the potting mix. Fertilizers that contain high proportions of ammonia-N cause an acid reaction, whereas those products that contain mostly high amounts of nitrate-N cause a basic reaction. The plant species being grown is the fourth factor that can affect pH of the substrate. Plant preference for one form of N, meaning ammonia over nitrate or vice versa, will affect substrate pH over time as the crop is grown.

The take home message about pH of potting substrates is that it is extremely important to know this chemical characteristic of your potting mix <u>before</u> planting your crops. In a later article, I'll discuss some ways to control medium pH.

Electrical Conductivity (EC) of Potting Mixes

Electrical conductivity is the second important chemical property that you should know about your potting mix. An EC meter measures the amount of electricity that a solution will conduct. The unit of measure for EC is dS(Siemen) per meter (m^{-1}) which is equivalent to $mS{\bullet}cm^{-1}$ which is equivalent to $mmhos{\bullet}cm^{-1}$. Soil scientists use the $dS{\bullet}m^{-1}$ units for EC, but many growers are familiar with the last unit mentioned, $mmhos{\bullet}cm^{-1}$. For those of you who remember your physics, the unit of resistance is ohm. The opposite of resistance is conductance; if you spell ohm backwards, it spell mho, which was the unit for conductance.

EC is an indirect measurement of the salts in a medium. EC readings can be multiplied by 700 to determine the salt content in parts per million (ppm). This value, however, is only an approximation and be off by as much as 20% or more. Salts, mainly in the form of fertilizers or essential minerals, are needed for plant growth. High rates of fertilizers are used to achieve high rates of growth in container culture, but too many salts will damage plant roots and ultimately the plant. High salt concentrations cause problems by changing the osmotic potential of the substrate, causing water to leave plant roots and flow into the medium. Therefore, affected plants will grow poorly since they are in essence suffering from drought or water stress.

Plant sensitivity to salinity depends on age, environment, cultural practices and species. A brief list of species sensitivity includes: very sensitive: azalea, *Camellia*, and *Mahonia aquifolium* 'Compacta'; sensitive: *Erica*, *Ficus benjamina*, and many bedding plants; tolerant: carnation, chrysanthemum, and *Magnolia grandiflora*; very tolerant: *Atriplex*, *Hibiscus rosa-*

sinensis, and *Bougainvillea* 'Barbara Karst'. For most plants grown in soilless media, an EC below 3.5 dS•m^{-1} is satisfactory. See Table 1 for an interpretation of EC readings based on the saturated paste extraction method.

Table 1. Interpretation of EC Readings

Saturated Extraction Method (dS•m^{-1} or mmhos•cm^{-1})	Comments
<0.74	Very low
0.75-1.99	Suitable for seedlings and media with high organic matter
2.0-3.45	Satisfactory for most plants except sensitive ones
3.5-5.0	Slightly high for most plants
5.0-6.0	Reduced growth, stunting, wilting and marginal leaf burn

In the next article, I will discuss Cation Exchange Capacity and C:N ratios of soilless potting mixes. Future articles will contain information about methods of pH and EC analyses that growers can complete, pH basics for substrates (including controlling pH and salts), physical properties of substrates, and some examples of physical and chemical properties of potting mixes made with paper sludge. If you have questions about information contained in this article, contact your local county extension educator or contact me (phone: 208.885.6635 or by e-mail: btripepi@uidaho.edu.