What Is Your Substrate Trying to Tell You

Part II

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This article is the second in 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 mix, container growth medium, and substrate are used interchangeably throughout these articles.

In the first article, we reviewed properties of soilless potting mixes and covered two chemical properties of potting mixes, those being pH and electrical conductivity (EC). In this article, we will cover cation exchange capacity and carbon:nitrogen ratio. Both of these characteristics can have major impacts on plants grown in potting mixes.

Cation Exchange Capacity (CEC) of Potting Mixes

Cation Exchange Capacity is a measure of a medium's or soil's ability to regulate the supply of cations to the plant. Cations are positively charged ions of minerals. Examples of cations include potassium (K^+), calcium (Ca^{2+}), iron (Fe^{2+}), and others. The higher the CEC, the better the medium's ability to hold added cations, which ultimately improves the potential for plant growth. To measure CEC, cations must be chemically extracted from the substrate. One of several solutions can be used to extract cations.

The unit of measure for CEC is defined as the sum of exchangeable cations (also called bases) per weight of soil. Cation exchange capacity is usually expressed as milligram equivalents per 100 g. The abbreviated units were expressed as meq•100 g^{-1}. The abbreviation now used in the scientific community is cmol(+)•kg^{-1}., which is essentially equivalent to meq•100 g^{-1}. A substrate's CEC will depend on several factors, particularly the individual components in the potting mix. Composted or decayed organic components usually have higher CECs than fresh organic materials. Some examples of CECs for soil or potting mixes or their components include (in meq•100 g^{-1}):

humus	200	vermiculite	150	sphagnum peat moss	100 - 200
fine clay soils	55-65	(2:1 v/v) bark:perlite	24	(1:1 v/v) peat:vermiculite	141

Notice how these CEC values vary, in part because of the chemical nature of the component or soil and because of the weight or bulk density of the component or soil. For instance, clay soil is heavy compared to peat moss. Therefore, 100 grams of peat moss will occupy more volume and contain more surface area than 100 grams of clay soil. Since more surface area is available for the peat moss compared to the soil, the CEC of the peat moss is generally higher than that of the clay soil.

Some people question the relevance of measuring CEC of potting mixes for several reasons. First, colloids are responsible for CEC in soil, and very few commercially available substrates contain soil. Material present in the media could be considered boulders rather than fine particles (like those that make up clay). Second, potting media in containers are limited in volume. For this reason, growers must convert cmol(+)•kg^{-1} or meq•100 g^{-1} to meq•$liter^{-1}$ to get a number that means something. The bulk density of the medium must be known to make the conversion from weight to volume. In addition, the analytical test for CEC can be expensive. Finally, to get the most accurate CEC results for <u>soilless</u> potting mixes, the extraction procedure should be completed with <u>barium chloride</u>. Using the barium procedure prevents problems from medium pH levels and provides a more accurate (usually higher) CEC value. At least one soil scientist I know thinks that mineral levels in soil solution (soluble nutrients) correlate better with plant growth than CEC. Measuring these nutrients, however, can also be expensive, depending on the company completing the analyses. Controlled release fertilizers should be absent from the medium when the soluble nutrients in the potting mix are analyzed.

Plants can grow in potting mixes that have a wide range of CECs, but substrates having a relatively high CEC levels (50 to 100 meq•$liter^{-1}$) support a consistent cation supply. Notice that the range in the previous sentence is provided on a volume (liter) basis. The take home message for CEC is that management of plant growth is usually easier when the potting mix has a reasonable exchange capacity.

Carbon to Nitrogen (C:N) Ratio of Potting Mixes

The C:N ratio is a measure of the percentages of carbon and nitrogen in a substrate. Plants grown in substrates with high C:N ratios can have problems with N deficiencies since many microorganisms in the potting mix can out-compete roots for available N. Substrates or their components that contain higher quantities of lignin will decompose slower than those high in cellulose or hemicellulose. Materials that breakdown slowly have reduced chances of causing N deficiencies than those that break down readily (like cellulose).

The C:N ratio for a substrate will vary depending on the components in the potting mix. In general, materials high in lignin content or wood have higher C:N ratios. Different components of potting mixes will have different C:N ratios. Carbon to nitrogen ratios for several components include:

softwood bark	106:1	de-inked paper sludge	121:1
spaghnum peat moss	48:1	western red cedar sawdust	729:1
coir	85:1		

A ideal C:N ratio for a potting mix should be around 30:1. Based on the C:N ratios shown above, you can see that substrates made with large quantities of any of these materials will need to have N-containing fertilizers added to the mix either during the preplant stage when mixing the medium or by using supplemental fertilization as the crop is growing. Substrates with high C:N ratios can be improved by composting the some woody components before using them in the mix.

The cost of determining the C:N ratio of a potting mix is usually modest. Since the C:N ratio can strongly influence N use by plants and thereby affect their growth, this chemical characteristic should be known for the substrates that you use.

Complete These Tests BEFORE PLANTING your crops

Now that I've covered these chemical tests, the most important thing you can do is complete them BEFORE PLANTING your crop in the substrate. Many growers (and often us researchers) fail to check these four parameters before planting and end up having disastrous results. Unfortunately, I have to say I've failed to test my media before planting an experiment and lost one species due to high EC in the mix. Had I done what I've told my students and now you to do, I would have had more plants to use in an experiment. The problem was that the softwood bark I was using had an EC of 7.1 $dS{\bullet}m^{-1}$, causing severe damage on some royal azaleas. More recently, a Northwest grower used some sawdust that apparently had a pH between 2.0 and 3.0, causing severe damage on a number of landscape plants. In both cases - mine and the grower's - had the substrate been tested first, problems could have been avoided. In the next article, I'll discuss some simple tests that you can run to check for problems before planting or during the production cycle.

Plant Bioassays

One last factor to consider is that just because these four chemical properties and other chemical characteristics of the potting mix appear to be good, plant growth may still be poor. Physical properties must also be check. In addition, minerals in the substrate may interact in unexpected ways and could yield unanticipated results. For this reason, the real test of a good potting mix is how plants grow in it. Plant growth is the best indicator of substrate suitability. I'll cover some ideas for plant bioassays in a later article.

In the next article, I will discuss methods you can use to measure pH and EC of your own potting mixes. In addition, I will cover basic steps that can be used to control pH and EC of potting mixes. Future articles will contain information about physical properties of potting mixes and ways you can measure these properties. The final article of the series will contain 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 (by phone: 208.885.6635 or by e-mail: btripepi@uidaho.edu).