What Is Your Substrate Trying to Tell You

Part V

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This article is the final one in a five-part series on 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 two articles, several of the most important chemical properties (pH, electrical conductivity (EC), cation exchange capacity (CEC), and carbon to nitrogen (C:N) ratio) of soilless potting mixes were described. In the third article, three methods used to measure pH and EC were described. In the fourth article, methods used to adjust pH and EC as well as descriptions of several important physical characteristics of potting media and ways to measure them were discussed. In this last article, I will provide some examples of chemical and physical analyses of potting mixes and describe their attributes.

I will present some examples of several substrates that were amended with components such as bark, peat moss, coir (from coconut husk), or paper sludge from newsprint recycling. These data are from one of my research projects that was sponsored by the Oregon Dept. of Agriculture. The objective of the experiment was to use paper sludge as a substitute for softwood bark used in potting mixes. My purpose in showing you this information is to demonstrate how chemical and physical properties of substrates can vary depending on the components and their proportions used in potting mixes.

Chemical Properties of Components Used for Substrates

To get a handle on the chemical properties of components used in potting mixes, the amendments that make up the mix should be analyzed for pH, CEC, EC, and C:N ratio. The four important chemical properties of five components used in my potting mixes varied substantially (Table 1). In all three tables (shown below), each number is a mean (average) of three samples and different letters within columns indicate the numbers are significantly different (at the 5% level) within each column. Note the low pH of bark and peat moss, indicating these components are acidic. The peat moss being strongly acidic. We can see peat moss had the highest CEC, and sand had the lowest. The high CEC of peat moss is one of the reasons this component is excellent for use in potting mixes. Note too that the CEC of bark was over double that of paper sludge. The EC of these components indicates that all of them contained few salts, yet the bark and coir had the highest EC. Notice the C:N ratio was highest for bark and paper sludge since these material were composed mostly of lignin and contained very little nitrogen. Peat moss had the lowest C:N ratio, but even at this level, some nitrogen fertilization would be needed if the plants were grown solely in peat moss.

Table 1. Chemical characteristics of media components.

Component	pH	CEC cmol(+)•kg^{-1}	EC dS•m^{-1}	C:N Ratio
Bark	4.9 c	30.5 c	0.8 a	105.9 b
Paper sludge	7.3 a	12.9 d	0.4 b	120.8 a
Peat moss	3.9 d	106.4 a	0.6 ab	48.2 d
Coir	5.3 c	65.6 b	0.8 a	84.7 c
Sand	6.2 b	2.5 e	0.5 ab	0.9 e

Chemical Properties of the Experimental Potting Mixes

Different proportions of the various components listed in Table 1 were mixed, and the resulting media were tested for their suitability to support the growth of tree whips. The samples used to generate this data were taken from freshly mixed substrates before adding a preplant fertilizer charge. Since the goal of this study was to replace bark in a mix with paper sludge, the media contained 0, 20, 40, 60, or 80% paper sludge which corresponded with 80, 60, 40, 20, or 0% bark and 10% peat moss (by volume). Ten percent sand was used in every mix. Three media were, however, different. The 90% sludge medium contained 90% paper sludge and 10% sand. The 80% sludge/bark medium contained 80% paper sludge, 10% bark, and 10% sand. Finally, the 20% coir medium contained 20% coir, 70% bark, and 10% sand. This last medium was included in the study to determine if coir was a suitable replacement for peat moss.

The four important chemical properties of the experimental potting mixes varied depending on the proportions of the specific component used (Table 2). For soilless media (which all of these substrates were), the pH of each mix was within a reasonable range. The 90% sludge mix had a pH slightly above neutral. Keep in mind that as long as micronutrients were available, plants potted in soilless media near or above pH 7.0 should have grown well. The CECs of the media without peat moss or coir were low. Based on these data, at least 10% peat moss was necessary in potting media containing paper sludge so that the mixes had a reasonable CEC. The salt content of all media was low, as indicated by the low EC values. Electrical conductivity of all media was acceptable since they were below 2.5 dS·m^{-1}. Note that the EC of the coir-amended medium was two to four times higher than the EC of any other mix, indicating that coir can contain salts and affect the EC of the potting mix. Notice the variation in C:N ratios of all the mixes. All these ratios were statistically similar. Note all of them were above 30:1, so a N source of fertilizer should be added to each mix. Nitrogen can be added as a preplant charge or during supplemental fertilization.

Table 2. Chemical characteristics of experimental potting media.

Media	pH	CEC cmol(+)•kg^{-1}	EC dS•m^{-1}	C:N Ratio
0% Sludge	5.0 e	12.6 a	0.3 c	70.2
20% Sludge	5.9 d	12.9 a	0.5 b	64.9
40% Sludge	6.0 d	14.1 a	0.6 b	82.0
60% Sludge	6.1 cd	13.2 a	0.6 b	71.7
80% Sludge/Bark	6.4 bc	4.2 c	0.5 b	88.3
80% Sludge/Peat	6.7 b	10.4 b	0.6 b	65.2
90% Sludge	7.2 a	3.4 c	0.5 b	76.8
20% Coir	5.2 e	12.7 a	1.2 a	92.0

Physical characteristics of the eight substrates varied somewhat but were generally at acceptable levels (Table 3). Even though plants used in the study were potted in 5-gallon pots, the measurements in Table 3 were made using 1-gallon pots, except for bulk density. All media were well aerated. Air capacities of all substrates were high, and although some were statistically different, they were all close to each other. All substrates appeared to have a satisfactory water-holding capacities. Water-holding capacity of the media varied by as much as 10%. These data indicate that plants grown in media made with 60% or more paper sludge would need to be watered less frequently than those grown in the control (0% sludge) or coir-amended mixes. Total porosity of all substrates was pretty good, being above 70% for each mix. Bulk densities of the media varied, but they appeared to be in a reasonable range.

Table 3. Physical characteristics of experimental potting media.

Media	Aeration (%)	Water-holding Capacity (%)	Total Porosity (%)	Bulk Density (g·cm^{-3})
0% Sludge	32.3 a	41.5 e	73.8 d	0.35 a
20% Sludge	29.9 cd	45.1 cd	75.0 d	0.29 c
40% Sludge	31.3 abc	47.2 c	78.5 c	0.28 c
60% Sludge	30.3 bcd	49.6 b	79.9 bc	0.27 d

80% Sludge/Bark	30.8 abc	51.0 b	81.8 ab	0.31 b
80% Sludge/Peat	28.5 d	53.5 a	82.0 ab	0.28 cd
90% Sludge	32.0 ab	51.4 ab	83.4 a	0.30 b
20% Coir	31.8 ab	43.8 d	75.6 d	0.34 a

Plant Growth in the Substrates

In an earlier article (see the Jan./Feb. 1998 issue), I mentioned that the best test for judging the suitability of a substrate for crop production was seeing how plants grow in the medium. I will briefly describe how 'October Glory' red maple, 'Royalty' crabapple, and European birch whips grew in the different media (shown in Tables 2 and 3) over one growing season. The red maple and crabapple whips grew at similar rates in all potting mixes, regardless of the amount of paper sludge present in the mix. In other words, these two species grew well whether the potting media contained mostly bark or mostly paper sludge. In contrast, European birch whips grown in a substrate that contained 80% or more paper sludge were shorter and produced less leaves that those grown in the 80% bark (Figure 1). Birch grown in potting mixes containing 60% or less paper sludge grew as well as those grown in 80% bark (data not shown). In another study with zinnias and geraniums grown in paper sludge-amended media, plants grown in a substrate containing more than 20% paper sludge did poorly compared to those grown in 70% peat moss without paper sludge (the control) or a commercial mix (data not shown).

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Figure 1. Shoot growth of European birch whips grown in a potting mix containing 0% or 80% paper sludge. The tree on the left was grown in 0% paper sludge (80% bark), but the tree on the right was grown in 80% paper sludge.

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The important point to be made is that different plant species may respond differently to potting mixes. Even though the chemical and physical properties of the substrates that contained 80% or more paper sludge were fine, European birch whips grew poorly in these media, but 'October Glory' maple and 'Royalty' crabapples grew well in them. For this reason, if you are making your own potting mix or changing ingredients or proportions of ingredients, grow some of your plants in the new mix first before potting up a large number of plants in the substrate. I want to emphasize that plant growth in a potting mix is the best indicator of its suitability as a growth substrate, so be sure to examine your plants' growth in a new or modified medium BEFORE an entire crop is committed!

Summary

Substrates can tell us many things, if we know what properties to examine. We should determine several chemical and physical properties BEFORE planting the crop in the substrate. Among the most important chemical properties to examine are pH, CEC, EC, and C:N. pH and EC of the substrate should be determined before planting and as the crop continues to grow, since pH controls nutrient availability and EC indicates salinity of the medium. pH can be controlled by fertilizers or water used as well as the preplant ingredients. Several extraction methods can be used on substrates to enable you to determine the pH and EC of mixes. Air capacity, water-holding capacity, and total porosity of a substrate are the physical properties to measure to help you determine if the crop may grow well. Even if chemical and physical properties of a substrate appear to be satisfactory, growing plants in a mix is the ultimate indicator of medium suitability for crop production.

I hope you have found this series of articles to be useful If you have questions about information contained in these articles, contact your local county extension educator or contact me (by phone: 208.885.6635 or by e-mail: btripepi@uidaho.edu).