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High pH caused by excessive leaching

Nutrient deficiencies and high pH often go hand in hand when rooting cuttings under mist.

Figure 1 shows petunia cuttings that are nutrient deficient after 10 days under mist. The peat/perlite substrate had an initial (and normal) pH of 5.8 at sticking (lime was incorporated before planting). The substrate also included a pre-plant nutrient charge, which raised the electrical conductivity (EC) of the growing medium at sticking to 1.2 mS/cm (also normal) using the plug squeeze method. However, when the cuttings started to root, leaves turned yellow and growth became stunted. Another plug squeeze test after 10 days showed that pH had risen to a high 7.2 while EC had dropped to a low 0.3 mS/cm. What had caused this to happen?

This article explains how EC and pH of the growing medium interact. In general, a high substrate-EC (for example, from excess fertilizer) will decrease substrate-pH, and a low substrate-EC (for example, from leaching of nutrients with excess water) will increase substrate-pH. By understanding these relationships, growers and substrate companies can take action to prevent and correct nutritional problems.

Figure 1. Heavy mist in propagation can leach pre-plant nutrients, resulting in high substrate-pH and low substrate-EC. Photo courtesy of P. Fisher.

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Substrate-pH and EC

Substrate-pH refers to the acidity or basicity of the growing medium, with a target pH between 5.6 and 6.4 for most crops. You can measure substrate-pH with a simple soil testing method such as the plug squeeze, 1 substrate:2 water, pour-through, or saturated paste extract method.

A low substrate-pH (4.5 to 5.5) increases iron/manganese solubility and uptake by plant roots, and can result in toxicity problems for iron-efficient crops such as marigold, seed and zonal geranium, and New Guinea Impatiens. A high substrate-pH (above 6.4), such as in our mist propagation scenario, decreases uptake of these micronutrients and tends to result in deficiency, for example iron deficiency in iron-inefficient crops such as petunia and pansy.

Electrical conductivity (EC) is a measure of the concentration of total ions. You can measure the EC of growing medium (substrate-EC) using one of the soil testing methods mentioned above. You can also measure EC of the irrigation water (water-EC, a measure of chemical purity) or fertilizer nutrient solution (solution-EC, resulting from the combined water-EC and dissolved fertilizer nutrients).

A high EC indicates a high level of dissolved ions, whereas a low EC indicates a low level of dissolved ions. These ions can include both essential plant nutrients such as nitrogen and calcium, as well as ions less useful to the plant such as sodium and chloride.

Pre-plant nutrients such as calcium drop pH

Substrate-pH tends to drop and substrate-EC increases when nutrients are incorporated into the substrate before planting (called "pre-plant nutrients"). The research substrate in Table 1 had an initial substrate-pH increased to 5.8 using hydrated dolomitic lime with no pre-plant nutrients. Several water-soluble pre-plant nutrients (all nitrate salts) were added to the substrate and tested a week later. All the pre-plant nutrients increased substrate-EC and dropped substrate-pH (Table 1). Calcium caused the greatest drop in substrate-pH overall, followed by magnesium, potassium, and ammonium.

Table 1. Pre-plant nutrient effects on substrate-pH and substrate-EC. Values in a column with different letters are statistically different.

Pre-Plant Nutrient Effects		
Cation	Substrate-pH	Substrate-EC
Control (clear water)	5.8a	0.6c
Ammonium	5.5b	2.0a
Potassium	5.5b	1.9b
Magnesium	5.5b	1.9b
Calcium	5.2c	1.9b

Leaching washes out nutrients and raises pH

Figure 2 shows research from the University of Florida where increasing volumes of pure water were added to a peat/perlite growing medium. The medium had an initial nutrient pre-plant charge that raised EC to 2.1 mS/cm using the saturated paste extract method. After about one container volume of clear water was washed through the substrate, the nutrients were almost completely leached out and the EC was down to 0.4 mS/cm. As the substrate-EC declined, the substrate-pH increased. This effect also happens under mist propagation when excess water washes through the plug tray and pre-plant nutrients are leached out.

Cation Exchange Capacity

Because peat is naturally acidic, lime is added to the substrate to bring pH to around 5.6 to 6.4. Lime is typically calcium and magnesium carbonate. The lime reaction adds base (carbonate) that neutralizes acid from the peat, and also supplies calcium and magnesium.

Calcium (Ca^{2+}) and magnesium (Mg^{2+}) are examples of nutrients that have a positive charge and are called "cations". Acid (which is a proton, also written as H^{+}) is also a cation.

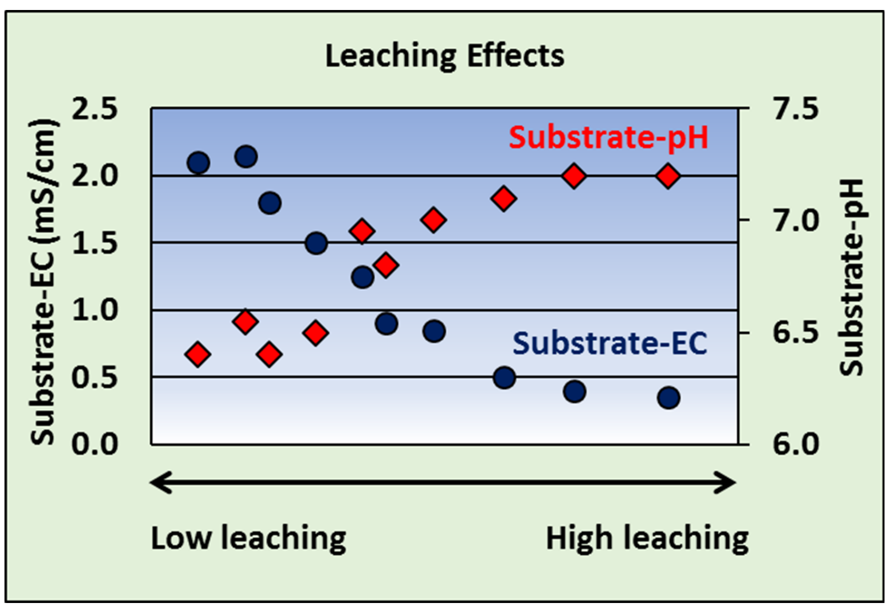

Figure 2. Effects of leaching with clear water on substrate-pH and substrate-EC. Photo courtesy of P. Fisher and A. Cretu.

The surface of peat particles has many negative charged locations called "cation exchange sites". These negatively-charged sites attract positively-charged ions, because the peat and cations have opposite electrical charges. The cations adsorbed to the peat include nutrients such as calcium and magnesium, and also protons. The "cation exchange capacity" or CEC refers to the amount of cations that can be held at these exchange sites. "Base saturation" refers to the percentage of exchange sites occupied by cations such as calcium and magnesium, rather than protons.

Adding lime before planting tends to saturate most cation exchange sites with calcium and magnesium, displace the acid on the peat, and neutralizes the acid with carbonate. Nutrients are also added to the substrate from other sources, including fertilizers and irrigation water.

Adding calcium and magnesium displaces acid protons (H^+) from the unsaturated exchange sites. These displaced protons move into the soil solution and drop pH (Figure 3A). In contrast, leaching with clear water removes cations such as calcium and magnesium from the substrate exchange sites and soil solution. Protons in the soil solution then adsorb back onto the peat, which raises pH of the soil solution (Figure 3B).

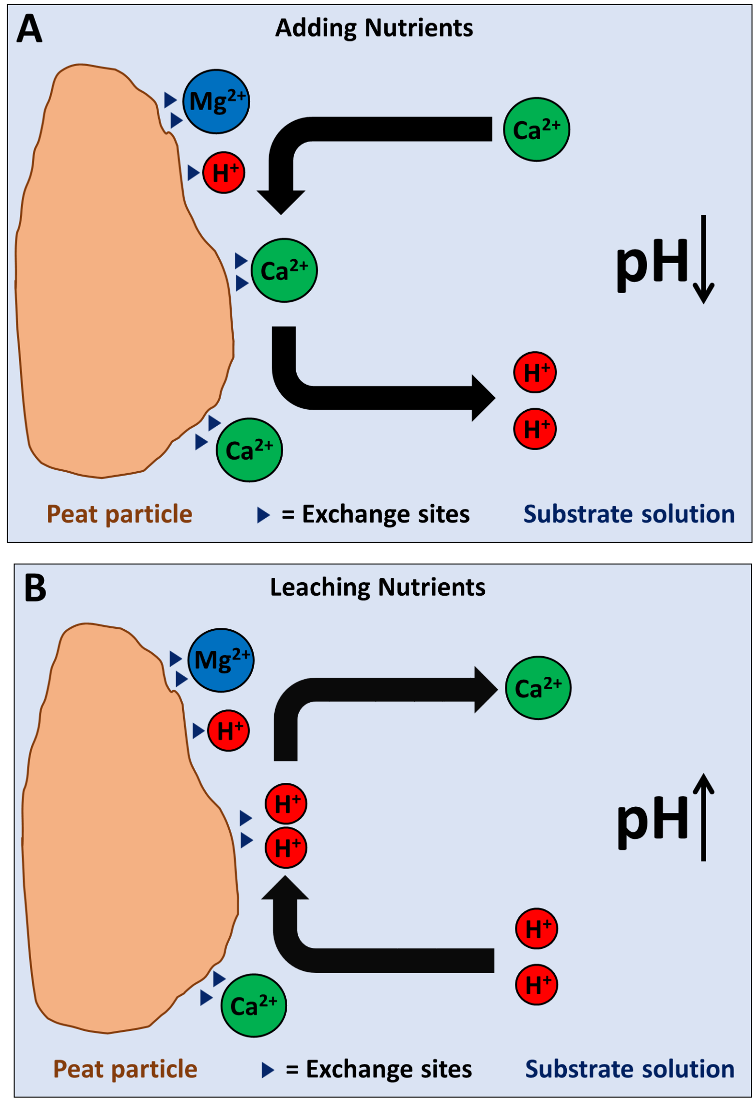

Figure 3. Nutrient interactions with the cation exchange sites on peat particles. (A) Adding fertilizer displaces protons into the soil solution and drops pH. (B) Leaching with clear water removes nutrients, and raises pH.

So what is the solution for our sick petunias?

When the substrate-pH is high and substrate-EC is low, the best corrective action is to add fertilizer! When plants are coming off mist, provide a heavy irrigation with water-soluble fertilizer at around 200 ppm N. This will provide nutrients for a hungry rooted plant that needs nutrients. The fertilizer will interact with the CEC of the substrate to drop pH. Most NPK fertilizers are effective at lowering pH in this situation. You could also consider adding 5 ppm iron from iron-EDDHA chelate to the fertilizer solution.

To prevent this issue from occurring, avoid leaching with excess irrigation. That makes it less likely that pre-plant nutrients (which you have paid for, and are a pollutant) to be washed down the drain.

Regular substrate-pH and substrate-EC testing also help you identify potential nutritional problems before they occur and make corrections to prevent crop damage. We recommend selecting a few general and sensitive crops to test every 1-2 weeks. Keep in mind that substrate-pH and substrate-EC tend to change more rapidly in small containers and seedling trays compared to large containers.