e-GRO Alert

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Producing Robust Plugs - Part II

When producing annual bedding-plant plugs, water quality and mineral nutrient management have a major impact on seedling quality. Monitor irrigation water quality, substrate pH, and EC, and take corrective action when needed in order to produce excellent plugs.

With Mother's Day just around the corner, retail outfits across the northern US are filling up with bedding-plant material. As I look around at tightly packed racks and benches, it is clear to see which plants were grown from robust plugs and which ones were not. Many of the more troubled-looking bedding plants that I see appear to be suffering from nutrient-related disorders and/or water-quality issues. Nutrient disorders can certainly occur during finished production, but the symptoms displayed by many of these plants are far too advanced to have only begun during finished production – these issues started in the plug phase! Though plug production is mostly done for the 2019 spring season, it is important to know how and why these disorders are occurring. As such, this Alert will cover water quality, fertilizer, and pH/EC management considerations for growing plugs.

Water Quality. High-quality water is essential for plug production, and managing water quality starts with regular testing. Most greenhouse growers irrigate with municipal, ground, or surface water. Municipal water tends to be high-purity, is typically very stable over time, and requires infrequent testing; annual or semi-annual testing is often sufficient. When growing plugs with well water, tests should be conducted quarterly or semi-annually at a minimum, depending on local soil parent-materials and hydrology. If surface water is being used, monthly or bi-weekly testing is strongly encouraged, as water quality can change very quickly

Water Quality cont. after heavy rainfalls, drought periods, or during/after land disturbances (construction, agricultural activity, etc.). For the greatest level of accuracy, water tests should be performed by a laboratory. Most state land-grant universities have labs that can perform this service for a nominal fee (or for free) and commercial labs in your locale will be able to offer similar testing packages at competitive pricing. Lab results will provide a detailed report of alkalinity (total carbonates and bicarbonates; often presented as ppm or mg/L of $CaCO_3$ [calcium carbonate]), pH, electrical conductivity (EC; total measure of soluble salts in solution), and macro- and micronutrients present in your incoming water. **These lab results provide you with valuable information and will help to guide your water quality and mineral nutrient management decisions.**

Alkalinity, or the measure of water's ability to neutralize acid, is one of the most important parameters to monitor and manage when growing plugs. If alkalinity is too high, substrate pH will rise over time as carbonates and bicarbonates react with acidic fertilizer components, the substrate, root exudates, etc. The resulting high pH prevents plants from taking up micronutrients such as iron (Fe), which causes nutrient deficiency symptoms and compromises plant quality (Fig. 1). Due to the small volume of most plug cells and relative infrequency that plugs are leached (compared to pots in finished-plant production), this mode of pH increase can occur relatively quickly in plugs if the alkalinity of incoming water is not managed. **Targeting an alkalinity level of ~40-50 mg/L $CaCO_3$ in irrigation water is a good baseline for producing most taxa as plugs.**

Figure 1. When low-pH-favoring bedding plants such as petunias (*Petunia X hybrida*) are grown using irrigation water with high alkalinity, the characteristic iron (Fe) deficiency symptoms pictured above appear without fail. Correct this disorder by lowering the substrate pH or by applying iron chelate as a substrate drench.

High alkalinity levels may necessitate the use of acidic fertilizer formulations, acid injection prior to adding fertilizer, or reverse osmosis treatment of incoming water in order to prevent high-pH issues and maximize plug quality. Electronic tools like AlkCalc can be used to help identify acidification solutions or fertilizer formulations to suitably reduce alkalinity levels based on water test results. See some of our past e-Gro Alerts for more information on managing alkalinity and selecting fertilizer formulations based on your water's alkalinity:

- Vol 4.33 - Is your greenhouse irrigation water alkalinity ailing your crop?
- Vol 6.10 - Manage pH with water soluble fertilizers

*****WARNING*****

Some water treatment companies may suggest using a water softener system to reduce alkalinity in your irrigation water. These systems use sodium chloride (NaCl) or potassium chloride (KCl) as substrates to remove calcium and other carbonates/bicarbonates from water. The ion exchange that removes alkalinity from water leaves Na (or K) and Cl ions behind. Na and Cl ions will accumulate in plug media, be taken up in excess by rapidly growing plugs, and toxicity will likely occur. Using a softener system is NOT advised, *especially* when growing plugs.

Water Quality cont. Mineral nutrients present in irrigation water and baseline water EC should also be monitored closely when growing plugs. Prior to the addition of fertilizer, water with an EC of ~0.2–0.5 mS/cm is generally regarded as within suitable range for plug production. Similarly to alkalinity, if raw irrigation water EC is naturally high, the low volume of substrate in plugs and (generally) infrequent leaching during production can cause substrate EC to rise rapidly if unchecked. High-EC symptoms in plugs often include root browning or necrosis (Fig. 2), root tip "clubbing" (root tips become bulbous or malformed), and/or overall stunting (Fig. 3). However, even if the EC of a fertilizer solution is crop-appropriate, macro- and micronutrients already present in water before addition of fertilizer can lead to specific nutrient overdosing. For example, nitrogen (N) and phosphorous (P) are often present in greater abundance in surface water, compared to well or municipal water – especially if the source is near other agricultural operations or is part of a closed-loop irrigation system. If N and P already present in the water is not factored into fertilizer calculations, overapplication can occur.

Figure 2. Excessively high substrate electrical conductivity (EC) can damage plant roots – especially those of tender young plugs. Symptoms of high-EC damage on most bedding plant plug roots are general browning and necrosis. The EC is this zonal geranium's (*Pelargonium* × *hortorum*) substrate was ~3.2 mS/cm when this picture was taken, and root "burn" sustained was substantial.

Figure 3. High substrate electrical conductivity (EC) can cause overall stunting of plugs. These two geranium (*Pelargonium* × *hortorum*) seedlings were in the same group as the plugs pictured above (Fig. 2). Stunting was likely so severe on these two and others (not shown) because of their location along the perimeter of the tray. Greater substrate dry-down occurs along edges and corners of plug trays, and it is likely that fertilizer salts concentrated even further in these cells, causing even more damage and physiological stress.

Figure 4. In an attempt to get these English daisy (*Bellis perennis*) seedlings up to size for transplant, this growers applied a complete 20-10-20 water-soluble fertilizer at 250 mg/L N final concentration. The result was not what the grower had hoped for, as they quickly became overgrown and lush – too much so to transplant and produce appropriately sized finished plants.

Too much N in plug production can lead to excessive, soft growth and high P can encourage internode stretching (Fig. 4), neither of which are desirable among plugs. Similarly, when micronutrients such as boron (B), iron (Fe), manganese (Mn), and others are already present in irrigation water, they can impact crop quality – potentially at very low concentrations. For example, if a grower using a single-bag, complete fertilizer (with macro- and micronutrients) is unaware that they already have 0.7 mg/L of B in their water and their fertilizer supplies 0.5 mg/L at the labeled rate (1.2 mg/L B total), toxicity may occur. **If macro- or micronutrient concentrations in incoming water need to be reduced, several courses of action can be taken.** Three frequently employed strategies include:

- Hook up to municipal water (if possible). Blending municipal water with surface or well water may be an alternative if quality is not adequate but restrictions on municipal water usage are an issue.
- Adjust fertilizer inputs using laboratory- or reagent-grade salts rather than pre-formulated water-soluble fertilizers. Alternatively, some fertilizer manufacturers may be able to create a custom blend upon request.
- Install a reverse osmosis (RO) system. These systems produce high-purity water, but purchasing and maintaining them is often expensive. Many growers with RO systems blend purified water with their primary water source to reduce alkalinity or excess fertilizer salts to a manageable level, and adjust their fertilizer source and formulation to make smaller corrections.

Fertilizer Frequency & Concn. Much like in finished-plant production, mineral nutrient management in plug production has two general schools of thought:

1) Periodical fertilizer application, and

2) Constant-liquid-feed.

Under a periodical fertilizer application regimen, water-soluble fertilizer (WSF) is applied every 7–10 days at a rate of 150-300 mg/L N, depending on the crop, production stage, and individual grower practices. Alternatively, under constant-liquid-feed, a dilute fertilizer solution is applied at every irrigation event with N concentrations ranging from ~50–75 mg/L.

Though both approaches to provisioning mineral nutrients can yield high-quality plugs, periodical fertilizer applications tend to present more challenges than constant-liquid-feed.

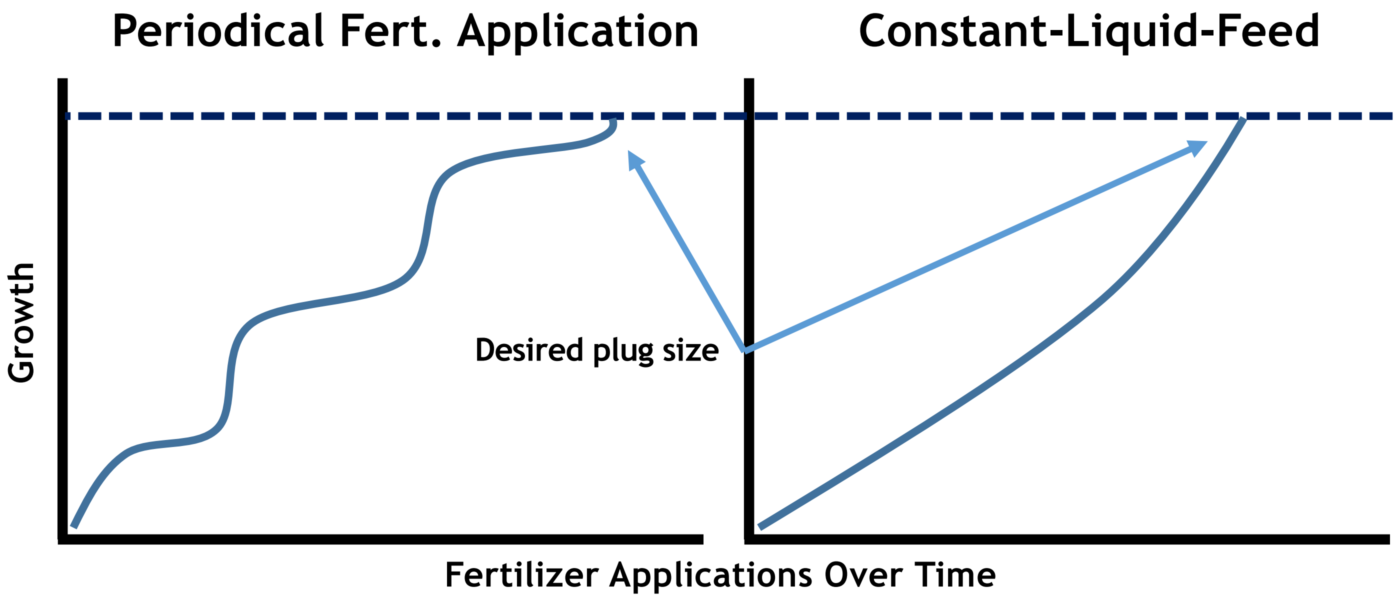

Figure 5. Different application regimens of water-soluble fertilizer to seedling plugs can result in variable growth responses. The graph above (left) depicts the type of growth pattern that one might see if fertilizer is applied to plugs at higher concentrations (150-300 mg/L of N) every 7-10 days. Alternatively, the graph to the right illustrates the more linear growth pattern that a grower would likely observe if growing plugs using a constant-liquid-feed program, where fertilizer is applied in lower concentrations (50-75 mg/L at every irrigation.

Fertilizer Frequency & Concn. One of the biggest differences between the two production methods is seedling growth pattern. Under a periodical fertilization, a burst of growth is often observable after fertilizer applications (Fig 5). This burst can be less predictable and more difficult to track and control. Also, independently applying clear-water and fertilizer solution can create moisture management challenges. During cloudy spring weather, for example, a grower might be forced to choose between under-feeding or over irrigating plugs if plants begin to show symptoms of nutrient deficiency after receiving a thorough clear-water irrigation the day before. Over-watering AND feeding plugs at a relatively high concentration of N simultaneously is a recipe for soft, "leggy" seedlings. Chemical growth regulation may then be necessary in order to keep plugs appropriately sized, which adds more labor, inputs, and potential production errors into the scenario. Another challenge, more unique to periodical fertilizing, is accidental misapplication of fertilizer to adjacent plug trays (Fig. 6). **That being said, many growers have mastered periodical plug fertilization, and plugs can be effectively grown this way.**

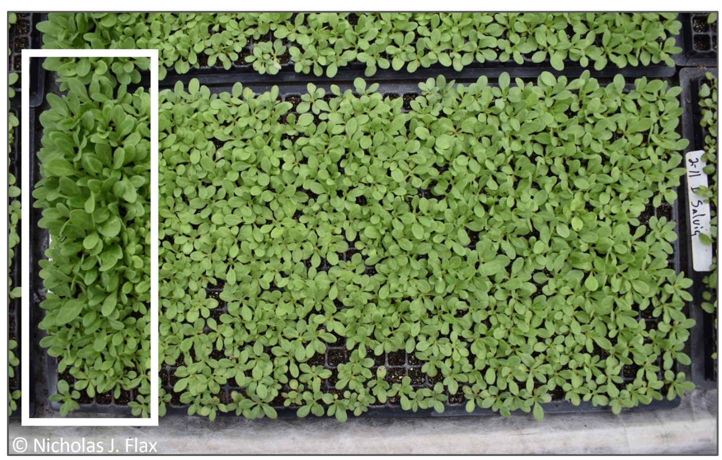

Figure 6. Provisioning fertilizer to seedling plugs at high concentrations (150-300 mg/L of N) every 7-10 days can be an effective production strategy. However, application errors can be difficult to correct once they are made. This grower, for example, was fertilizing the group of petunia (*Petunia × hydrida*) plugs adjacent to this tray, and unintentionally applied fertilizer at 250 ppm of N to a few rows of seedlings in tray of much smaller plugs.

Fertilizer Frequency & Concn. In comparison, plug growth on constant-liquid-feed can be easier to manage. Under this type of regimen, the amount of mineral nutrients applied remains constant and growth is often more linear and predictable (Fig. 5). Restricting N is primarily what achieves this more-linear growth pattern, though restricting P also plays a strong role in keeping plugs compact. However, in an attempt to manage plug growth by restricting N using constant-liquid-feed, growers occasionally under-provision micronutrients if using a single-bag fertilizer formulation. For example, let's say a single-bag 15-5-15 fertilizer provides 1.0 mg/L of Fe when applied at a final concentration of 200 mg/L of N. If a grower switches to constant-feed and targets 65 mg/L of N at final concentration, this means only 0.325 mg/L of Fe is being provided. Over the entire production cycle of a plug, insufficient Fe may be applied and nutrient deficiencies may occur (Fig. 7). **If constant-liquid-feed fertilization is being used, be sure to supply additional micronutrients at crop-appropriate concentrations.** This may require adding another fertilizer injector in-series to accompany the injector providing primary fertility from a single-bag mix, or switching to a two-bag WSF system.

Managing pH & EC. Various plant taxa impact growing media differently from one another and have a range of substrate pH and EC optima. As such, it is critical to regularly monitor these parameters and take corrective action to maintain those optima when necessary. Procedures such as the Pour-Thru method (as outlined in e-Gro Alert 6.37) can be used to test plug substrate pH and EC. Though traditionally used to monitor substrate pH and EC of plants grown in finished containers, this method can be adapted to accommodate a plug tray. However, if the same tray is tested repeatedly throughout production, plugs that received additional water via the Pour-Thru may become leggy and disproportionate compared to those that did not. The alternative is to use pH or EC pens (Fig. 8) to test the plug medium. Meters such as these require only a few drops of leachate, which can be gently squeezed through the bottom of a plug

Figure 7. This petunia (*Petunia × hybrida*) and others from the same trays began to show iron deficiency less than 5 days after transplant into 4.5-inch pots. This grower supplied a complete 15-5-15 water-soluble fertilizer at 75 mg/L of N constant-feed from sow to finish. In all likelihood, deficiency symptoms began to manifest while plugs were still in their trays, but were not visually noticeable until after transplant. All plants were treated with an iron (Fe) chelate drench to correct the deficiency, and the grower switched to a more acidic fertilizer formulation for finished production.

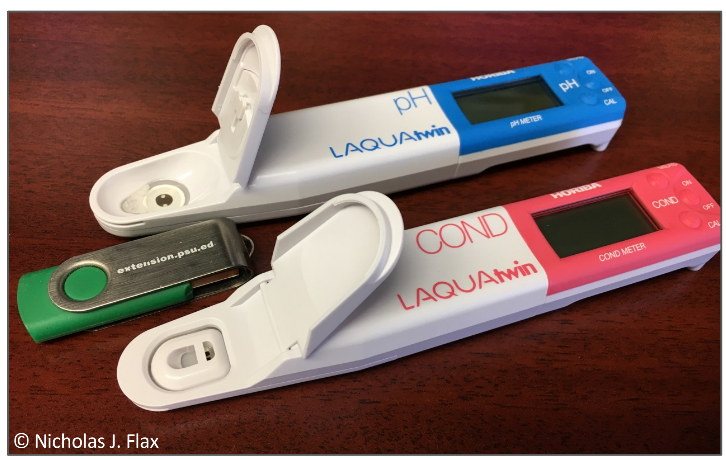

Figure 8. Small testers like these can be used to monitor substrate pH and EC of even the smallest plug cells. Only a small volume of leachate is required to get a reading (2-3 drops). So long as plug cells aren't completely compressed, meters like these are powerful tools for non-destructive plug pH and EC monitoring. USB flash drive is included in picture for scale.

cell by pushing lightly downward on the top of a recently-watered plug. If done too vigorously or too frequently in the same cell, these "push-tests" can result in destruction of the seedling. If having a completely full plug trays at the end of production is not a major concern, the loss of 3 – 5 plugs out of a 288-cell or 512-cell plug tray is a small price to pay for knowing your plants are on the right track. In general, EC values for most bedding-plant plugs should be between 1.0–2.5 mS/cm, whereas pH values will vary more depending on species. **Consult production guides or technical sheets from plant breeders to ensure that you are targeting the correct pH and EC values for your plugs.**

If pH and EC tests suggest that corrections need to be made, action should be taken quickly. Again, plug cells are much smaller than most finished containers and lack the same buffer provided by a larger substrate volume. As a result, sub- or super-optimal pH and ECs and the physiological ramifications of those conditions can negatively impact young, tender plugs quickly.

Low EC → Increase fertilizer application. To avoid over-fertilizing, only increase fertilizer concentration by 25–50% if using constant liquid feed for 1–2 irrigations and check EC again. If using periodical fertilization, apply fertilizer an additional time half-way between regular fertilizer application intervals and check EC again.

High EC → Leach. Irrigate with clear water to fully wet the plug substrate and let sit for ~15-20 minutes. Follow-up with a thorough clear water irrigation until water is visibly leaving the bottom of the plug cells and wait 1–2 days; check EC again. If EC has reduced to appropriate levels, resume fertilizer applications.

Low pH → Switch temporarily to fertilizer with a more nitrate-based N source (ex. 15-0-0 or 15-5-15), or apply flowable lime or hydrated lime at 1/2–1/3 of the recommended rate for larger container crops (see e-Gro Alert 7.02 and Alert 8.22 for some great instructions on how to apply these).

High pH → Switch temporarily to a fertilizer with a more ammonia-based N source (ex. 21-7-7 or 20-10-20), or apply an acidified water drench.

*****Note:** Avoid over-acidifying plugs if attempting to lower plug substrate pH, as this may deplete the medium's buffering capacity and cause additional issues. If using acidic fertilizer to lower pH, avoid applying high concentrations. Ammonium toxicity can occur if ammoniacal N is taken up in excess, especially during low-temperature production conditions.

Summary. Monitoring incoming water quality and taking corrective measures before water reaches your plugs is the first step to managing plug fertility, pH, and EC. If only high-quality or properly adjusted water is used to grow your plugs, the risk of encountering many pH- and EC-related disorders can be greatly reduced. Selecting the correct fertilizer for your crops and making necessary adjustments based on your application regimen provides the next layer of security for producing a high-quality plug. Finally, if pH and EC parameters begin to fall out-of-line with crop optima, taking corrective action to bring pH and EC back into suitable range will ensure that plugs stay healthy and vigorous. Ultimately, these factors all contribute to producing a robust plug and, in turn, a spectacular finished plant!

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