



Figure 5: Here Derek pulls a transplant of a week old kale to examine the roots. A lack of water or certain nutrient deficiencies (ex: phosphorus) will inhibit strong root growth.

aware that Cu kills microbes and can be a shock to the system when added. Liquid copper (biomin copper) can be added to irrigation (follow recommended amounts on product label) with a carbon source like humates as a buffer to minimize negative impacts.

**Nitrogen (N)** – If adding unfinished compost with carbon sources that have not broken down (ex: wood shavings in bedding from animal manure), you will need to be mindful of a potential nitrogen tie up to future crops. A fall addition of unfinished compost, for example, may severely affect growth of greens in late winter or early spring. This is another reason to choose your compost carefully. If not possible, add a nitrogen source with compost during bed preparation such as alfalfa meal or blood meal to maintain harvest potential.

**Phosphorus (P)** – Poor or slow root growth could be a P deficiency, common in New England soils, and especially common in

high tunnels where the soil biology that unlocks P from soils suffers as soils dry out. Add phosphorous sources such as bone meal or rock phosphates with compost applications for maximum impact. Note that gardeners or small-scale growers using large amounts of compost or manures may have problems with too much phosphorus.

**Silica (Si)** –Silica or silicon is an important micronutrient for building strong plant cells and for resisting insect and fungal damage. Adding Si can be a good preventative investment for ensuring healthy, good quality produce. Calcium Silicate (Wollastonite) is a good source of silica as are blends containing sea products.

The high tunnel environment has particular challenges when it comes to growing high quality nutrient-dense food, and has specific needs that are different from growing in the field. In addition to being aware of your soil's high tunnel nutrient needs, choose plant varieties carefully for this environment such as slow-bolting greens and crack resistant, even-branching tomatoes. Have extra transplants available, particularly in winter, to put in the ground quickly should anything unexpected disrupt the high tunnel environment. And remember soil biology is an ally and a buffer in these challenging growing conditions, helping both to store water and unlock nutrients. Maintain adequate soil moisture and cover the soil where possible to maximize these benefits.



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## Nutrient Dense High Tunnel Growing Derek Christianson, Brix Bounty Farm

Maintaining good soil fertility in order to grow nutrient-dense produce can be quite a challenge in the high tunnel environment: the lack of rain, high air humidity, soil prone to drying out, and high nutrient needs of summer crops compared with the relatively low fertility needs of winter crops. Derek Christianson of **Brix Bounty Farm** in Dartmouth, MA shares some of his insights on ensuring high soil fertility and high yields to grow nutrient dense food in his two 30' by 96', unheated high tunnels. He uses the tunnels to add summer crops to his markets early in the season, maintain year-round work for farm employees, and provide a high quality winter greens CSA.



Figure 1: Red Russian kale a week after being transplanted in the fall.

For any farmer, gardener, or land manager considering these practices, realize that any time you plan to add mineral amendments to your soil, particularly trace elements in pure powdered form, use extreme caution and consider what alternatives may be available to get you the same results. **Many trace elements can be dangerous to human health or to your soil if applied incorrectly.** Derek recommends the practice of trialing soil amendments, especially when trying new products, to gain confidence and build observational awareness of improved crop quality. Go slow. Avoid excesses (especially of micronutrients!) in high tunnels as the lack of rain and potentially mineral-rich irrigation water can cause them to accumulate in the soil causing problems that are hard to correct. Adding micronutrients should always be combined with a carbon such as compost or humates, to help nutrients stick in the soil and be

more accessible to plants. **Choose safer micronutrient products whenever possible** such as pelleted versions (instead of powders), rock dust blends that contain the trace elements you want, sea products, or specific trace element product blends such as from Peaceful Valley (ex: liquid blends for Copper, for instance, that can be applied through irrigation lines) or Advancing Eco Agriculture liquid micronutrients blends.

Although there are many nutrient needs to be aware of in soils, the following are those to pay particular attention to in a high tunnel environment. The recommended nutrient amounts below are based on a Mehlich 3 or strong



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Figure 2: To maximize transplant success, it is important to rehydrate the soil in the fall, particularly if your compost application is dry. Here driplines are laid in between the rows of new transplants.



Figure 3: Hardier greens are grown in the beds adjacent to the wall of the tunnels. More sensitive crops like lettuce are grown in the central beds.

**Potassium (K)** – Summer fruiting crops like cucumbers and tomatoes have incredible needs for potassium especially in a high tunnel where lack of soil moisture dramatically limits potassium's ability to move in the soil. However, care must be taken because adding too much K at the expense of other nutrients (especially Ca) can increase production at the expense of quality and flavor. Adding Potassium Sulfate during the season can be a powerful way to increase production. A K deficiency will show up as yellowing shoulders

acid soil test, however weak acid tests (such as the UMass Amherst Soil Testing Lab's Modified Morgan soil test) can also be useful in a high tunnel because they reveal what is more immediately available to the plants. Know what soil test you have and get the advice of a soil consultant if needed!

**Compost:** Adding good quality, finished compost to tunnels before planting in the fall can be an excellent way to jumpstart soil biology, increase organic matter content, and add needed nutrients, particularly for soils with low organic matter content (all too common in tunnels!). Choose a high quality, finished compost. An excellent compost will be more expensive, but the investment is worth it, says Derek as a poor quality, unfinished compost with wood chips or other carbon-rich materials like animal bedding can tie up nitrogen and cause a lot of problems, maybe even cost you a growing season. Look for compost with a good nutrient profile, especially calcium and trace elements. Derek adds up to 2 inches of compost to pre-prepared beds in the fall once every few years or as needed.

**Calcium (Ca)** – Having adequate calcium levels in high tunnel soils can help mitigate major problems like soil compaction, correct other nutrient imbalances in the soil, and can enhance nutrient content and flavor of the crops. Ensuring adequate calcium levels (68% base saturation on a soil test) is probably one of the most important things you can do to ensure healthy growth and good harvests. Adding lime (avoid dolomitic lime unless you need magnesium), a high calcium compost, gypsum (also helpful for dealing with sodium excesses) or crab and oyster shells are all good options for adding this essential nutrient. Follow soil test recommendations to get the ideal 68% base saturation of Ca.



Figure 4: Preparing for winter growing. Notice the beds have had a recent compost application

levels in the field can be as high as 75 ppm, however, with regular applications of sulfates in other fertilizers (ex: potassium sulfate) in a high tunnel and no rainfall, your levels will accumulate. Add sulfur sparingly if you are very low when first starting out and be on alert for signs of excesses if you apply it regularly.

**Boron (B)**–High humidity and high heat in high tunnels equal less respiration in the plant leaves, which in turn means less movement of nutrients through the plant and less flavor development, especially if calcium and boron are both deficient. Boron can be added as Solubor or even Borax, a common household cleaner. Boron like many trace elements is needed in *tiny* amounts in the soil (too much can be toxic and inhibit seed germination). Ensure a deficiency first and be *very careful* not to add too much in your high tunnel, especially if Calcium is low. Ideal amount is up 1-3 ppm (target 3ppm only if Calcium levels are sufficient).

**Molybdenum (Mo)**–Ensuring adequate levels of molybdenum in the soil can be a useful strategy to help manage nitrates in high tunnel greens in winter. Molybdenum is key to the nitrate reductase enzyme which will help reduce nitrates that can build up to very high levels in winter growing conditions in greens. Aphids outbreaks in February or March are often a signal that nitrates levels may be high. A good source of Mo is Sodium Molybdenate (39% Mo), although Molybdenum, like Boron, is a trace element needed in *VERY* tiny amounts in New England soils. Ideal amount: 0.5 to 1ppm. Often you must specially request to have Molybdenum measured on a soil test.

**Copper (Cu)** – Cu is another micronutrient important for fruit formation that can get tied up with higher organic matter levels, a possibility when adding a lot of compost to your high tunnel. A deficiency may look like too much splitting in tomatoes (barring uneven watering and drying cycles which also cause tomatoes to split). Add Cu early in the season to help with fruit set. Be

on tomatoes, in the yellowing of older leaves of tomatoes or misshapen, stunted cucumbers. Fertigation or fertilizing through the irrigation system is a good method for supplying adequate potassium during the high demands of summer. Derek follows recommendations from University of Minnesota that range from 1-2 pounds of potassium sulfate per 30' x 96' tunnel per week.

**Sulfur (S)**– Sulfur is often deficient early on when starting a high tunnel because it is often deficient in New England soils, but with the lack of natural rainfall, S can accumulate over the seasons. Overly soft fruits can be an indicator of too much sulfur. Deep, prolonged irrigation can flush out sulfates or you might also consider removing the plastic cover of your tunnel to expose it to rain for part of the season. Ideal sulfur