Organic research projects at PARC

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We have recently begun two research projects on organic horticulture, specifically looking at organic fertilization in greenhouse peppers and field peppers in plasticulture.

1. Greenhouse peppers

Generally speaking, organic and non-organic greenhouse production methods for vegetables are quite similar. Both may use materials such as plastic ground sheets and bags, and twine. Climate control systems (eg. heating pipes, vents, computerized control) are similar and CO_2 enrichment is permissible in both cases. Pest control is surprisingly alike in that both use biocontrol. The main difference is in the root environment. Soil is often the medium of choice for organic growers but substrates are the norm for conventional hydroponic growers. Having said that, according to COABC standards, a number of substrates are allowed in organic growing in BC. One criterion for use is that a biologically-active medium must be established by the end of each growing cycle. In other words, significant microbial activity must be present. Three possible media options for greenhouse growing are soil, liquid and substrates.

<u>Soil</u>
More popular than soilless, because its simpler and the concept is familiar.
Soil has a higher CEC and is more forgiving in terms of nutrient imbalance.
Can use soil in raised beds or plant on level ground.
Soils in organic greenhouses range from 10 to 30% organic matter.
Weed control – hoeing, steam pasteurization, mulching (fabric, plastic, organic), solarization, poultry grazing.
Soil disinfection – solarization, steam, biological control

<u>Liquid systems</u>
Examples: floating rafts, nutrient film technique (NFT)
Usually recirculating or closed systems - good from an environmental point of view but could lead to spread of root diseases.

<u>Substrate systems</u>
Examples: sawdust, perlite, rockwool, coir, peat
Substrates are the most popular medium in greenhouses today.
Depending on the substrate, irrigation can be very different than in soil - rather than several times per week, 20 to 30 times per day is the norm because of a reduced water-holding capacity and reduced volumes of substrate used per plant compared to soil.

In light of the prevalent use of substrates for greenhouse vegetable growing in BC, we decided to examine the possibility of applying organic fertilizers to two conventional hydroponic substrates, sawdust and coir.

There are two ways to apply organic fertilizers to a crop: either as a liquid feed or as a solid amendment to the substrate or soil. Examples of liquid fertilizers are liquid fish products, compost teas, blended liquid products (eg. Earth Juice) and seaweed extracts. Examples of solid fertilizers are guano, seaweed, bonemeal, composts and naturally-mined salts. There can be problems with both methods. If a solid fertilizer is top-dressed, the release of nutrients may be too slow or too fast, leading to uneven growth and flushes of production in indeterminant plants such as tomato, pepper and cucumber. Also, the fertilizers may not be completely balanced leading to mineral deficiencies. Presumably, liquid fertilizers overcome the first problem, that of availability, since the minerals should be completely soluble in the liquid feed. However, liquid feeds may still be subject to the problem of correct mineral balance for optimum growth. We decided to conduct one trial with liquid and another with solid organic fertilizers.

Liquid feed trial

We compared a conventional hydroponic feed with two liquid organic feeds. All three treatments were applied to pepper plants (Zamboni) growing in 5 L pots (one per pot) of sawdust or coir. The trial was conducted in the fall and was only 96 days long, so production data was not collected through a typical production cycle. The conventional feed consisted of $Ca(NO_3)_2$, KNO_3, $MgSO_4$, and KH_2PO_4 with a minor element mix to give final concentrations, in ppm, of 190 N, 289 K, 144 Ca, 25 Mg, 64 S, and 64 P. One organic feed, termed AOO, consisted of citric acid (for pH control), CalPril, K_2SO_4, Age Old Organics-Grow and Age Old Organics-Bloom. The other, termed MN, substituted two Meta Naturals solutions, Meta Naturals-Grow and Meta Naturals-Nitrogen, for the two Age Old Organics formulations. The K_2SO_4 was the only non-organic mineral used because we had difficulty in dissolving K-Mag Natural, an organic source for K and SO_4. The two liquid organic feeds were chemically analyzed and matched as closely as possible to the nutrient composition and concentration of the conventional feed.

Overall, plants in coir did better than those in sawdust. This was not as apparent in the production data (which was quite limited), but more evident in measurements of plant biomass. Plants in both organic feeds did poorly compared to those in the conventional feed. In virtually all measurements (total fruit, total fruit fresh weight, and plant biomass), the organic treatments produced about half as much as the conventional treatment. Fruit size was reduced by about 30%. Both organic fertilizer treatments were prone to mineral deficiencies, one of which was probably Fe. The results were unexpected since mineral status in the organic treatments was designed to be the same as the conventional treatment. Differences could have been due to the sedimentation, presumably of minerals, which occurred in the tanks and drip lines of both organic treatments. Or perhaps optimal microbial populations had not yet built up in the substrates.

Solid fertilizer trial

As in the liquid feed trial, plants were grown in 5 L pots, and the trial was conducted for 96 days in the fall. Treatments were as follows: sawdust with conventional feed (control), sawdust/compost (60:40), sawdust/compost/canola meal, (40:40:20), sawdust/compost/soy meal

(40:40:20), and sawdust/compost/feather meal (40:40:20). The compost used was spent mushroom compost and all organic treatments received only water. (Note that the canola meal and soy meal may have been genetically modified. Further work will only be conducted with soy meal, where non-GMO sources are more readily available).

One problem which we discovered with solid feeds is the high initial EC. The compost/soy meal treatment had the highest EC, (about 9 mS cm^{-1}), but the EC in all treatments dropped to manageable levels (1 to 3) within a week. Harvested fruit number, total fruit weight and fruit size were similar in the conventional feed and the compost/canola and compost/soy treatments, but in terms of plant biomass, which indicates overall growth, the two organic treatments did not do as well, with reductions of up to 50%. The compost/feather meal treatment showed reductions in fruit number (25%), total fruit weight (50%) and fruit size (50%) and reductions in plant biomass of 75%. This treatment was prone to waterlogging, so the results may have been associated with reduced root aeration. Further work with feather meal will use lower concentrations. The compost treatment showed the poorest results, with extremely low fruit production and plant biomass, possibly associated with the observations of severe foliar N deficiencies. Further work will focus on more complex mixes of solid organic fertilizers, which may provide more consistent and long-term release of minerals.

A simple costing analysis over the 96 day period of the trial showed that both organic liquid feeds were over 10 times the cost of the conventional feed per plant. These are dynamic costs, which will increase with duration. All solid feeds, which are fixed costs, varied from half to twice as much as the conventional feed.

Remaining questions for organic greenhouse vegetable production
Is quality, shelf-life or flavour different?
Can yields as high as those of conventional growing be achieved? Is this even necessary?
Can full season (11 month) crops be grown in substrates?
Is organic greenhouse growing in substrates economical?
Can nutrient solution recirculation be used?
Which fertilizer option (liquid or solid) is preferable in substrates?

2. Field peppers

In this trial, sweet peppers (Bell Boy) were grown in irrigated raised beds with plastic mulch (plasticulture) with either conventional fertigation or one of three organic treatments. In all cases, plants were seeded April 7, transplanted May 27 and harvested September 7 to Oct. 4. The target N rate was 24 kg/ha (that is, the goal was to apply this rate of N in all treatments).

Treatments
1. Water
2. Fertigation with NH_4NO_3, KH_2PO_4, $MgSO_4$, micronutrients (4 applications)
3. Fish fertilizer (2-3-0) applied three times through season: once as a pre-plant soil drench, twice as a foliar feed.
4. Spent mushroom compost at 9.6 kg/m^2 (assumes 5% release rate)
5. Spent mushroom compost at 4.8 kg/m^2 (assumes 10% release rate)

Other particulars of the trial: Soil was a silt loam; compost was raked in to a depth of 10 cm (4 inches); all plots were irrigated 11 times (60 minute duration); plots were fertigated in 4 applications (also 60 minute duration); fruit were harvested at mature red stage

Fertigation and the two compost treatments produced the most fruit. The fish fertilizer treatment did not do as well, probably because of an error in our first foliar application, where the foliar solution was much too concentrated and burned the leaves. There were no differences in total fruit weight per plant among any of the treatments. The fish fertilizer produced the largest fruit, but this was probably compensating for a reduced total fruit number. All fertilizer treatments produced fruit with more lobes than did water. There where no differences among treatments in marketable fruit, except for fruit size, where fish fertilizer and the highest rate of compost application produced the largest fruit.

The soil was sampled in June and September. N and K were the only minerals to change (decease) over time in all treatments. The biggest differences among treatments were also in N and K, with the highest rate of compost having the highest N and K, and water and fish fertilizer having the lowest. The results with the fish fertilizer may be due to the fact that the soil only got one application early in the season with subsequent applications being applied to the foliage. We also measured populations of nematodes which are indicative of the rates of N mineralization in the soil. The fish fertilizer treatment had the lowest populations of these nematodes indicating reduced rates of N mineralization.

Overall, we were able to produce a pepper crop with compost organic fertilizers which was as productive and as high a quality as that obtained from conventional fertigation. The fish fertilizer may have performed better had there not been a mistake in the first foliar feed.