Cornell Cooperative Extension

URBAN FARM SOIL HEALTH

Management Practices for Urban Soil Health: pH Adjustment

We are looking at the effect of pH adjustment on urban soils and crop health. A critical component of the chemical dimension of soil, pH indicates how acidic or alkaline the soil is and affects what nutrients are available for crop uptake. The majority of urban agricultural soils in New York State exhibit a pH between 7.1 and 8.1, well above recommended ranges for most vegetable crops. Excessive soil pH may impact plant health and reduce yields. This is a research update on an urban farm in Erie County looking at the effect of pH adjustment in high tunnels using elemental sulfur applications.

Amending soil with elemental sulfur works by soil microbes oxidizing the sulfur which produces sulfuric acid that can lower soil pH. In addition, elemental sulfur can interact with free lime in the soil to create gypsum which can free up sodium to be leached out by watering. Our hypothesis is that pH adjustment of urban soils will lead to increased plant nutrient availability and overall crop health.

Farm Background

Our cooperating urban farm in Erie County is a 2-acre USDA Certified Organic farm that has been in operation since 2015, and is managed by two farmers with over 18 years of farming experience between them. Prior to becoming a farm, the space was a vacant lot for many years and a lumber mill in the mid-1900s. Crops are grown in the ground in compost-based soil on top of unidentifiable fill. These constructed soils are highly variable and characteristic of urban farms. The farm grows produce year-round and has three high tunnels.

Over a three-year period, this farm hosted a high tunnel demonstration trial tracking soil pH and crop response to elemental sulfur applications. The farmers have been practicing pH adjustment using elemental sulfur across the farm prior to our trial. They practice pH adjustment to help maintain soil and crop health. Prior to our trial, the farmers observed positive outcomes after adding elemental sulfur such as lower soil pH and improved crop yield for broccoli and cabbage that they had previously not been able to grow successfully.

Figure 1. The high tunnel trial is located next to a brick building with a south facing wall which radiates heat onto the tunnel.

Two points of interest:

- The demonstration takes place in a high tunnel located next to a brick building with a south facing wall (Figure 1).
- The farmers installed a well in 2017 to be used for irrigation. Prior to the well installation, municipal water was used but the water pressure was quite low. The higher pressure well water has allowed the farm to efficiently irrigate multiple planting beds at once. After installation, the farmers learned the well water is alkaline and high in salts.

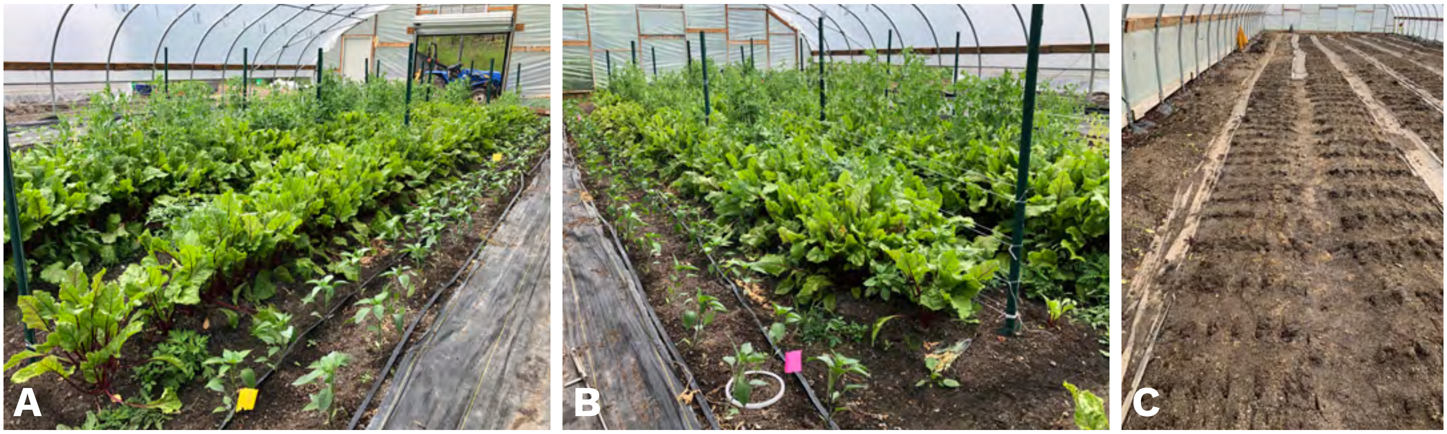

Figure 2. Images from the demonstration. A) Control plot planted with peppers in May 2021; B) Sulfur plot planted with peppers in May 2021; C) Plots during bed prep after broadforking in May 2023.

Methods

There are two plots at the demonstration site. The treated plot received two treatments of 90% elemental sulfur, one treatment at 2 lb/1,000 square feet of sulfur in Spring 2021 and another treatment at 5 lb/1,000 square feet of sulfur in Spring 2023. The other plot served as a control and did not receive any treatments of elemental sulfur. The farm's typical bed prep process in the spring is to remove any tarps, broadfork, apply soil amendments including sulfur by hand, and then use a tilther to incorporate amendments and create a uniform planting bed (Figure 2). Drip irrigation by well water was used for crops grown in the trial (Table 1, Figure 2).

Thus far, soil samples were collected at least once a year and submitted to Dairy One Agronomic Services to assess pH, nutrients, soluble salts, soil microbe active respiration, amino nitrogen and quality of soil structure. Soluble salts, amino nitrogen, and soil structure were assessed five times (May 2022, September 2022, April 2023, June 2023, September 2023). Basic fertility testing (pH, nutrients, organic matter) was assessed six times (same as above in addition to May 2021).

Table 1. Crop history in high tunnel trial location

Treatment	Summer 2021	Winter 2022	Summer 2022	Fall 2022	Winter 2023	Summer 2023
control	pepper	spinach	eggplant	eggplant	spinach	tomato
sulfur	pepper	spinach	cucumber	radicchio	endive	tomato

Preliminary Results

After the initial sulfur application in Spring 2021, we did not see a pH decrease in the treatment plot one year later in Spring 2022. In Spring 2023, we did see a 0.3 pH decrease seven weeks after sulfur application. There was a 0.1 increase in pH seen 21 weeks after sulfur application (Figure 3). Our control plot consistently shows the same or lower pH than the treatment plot which we speculate may be due to other factors.

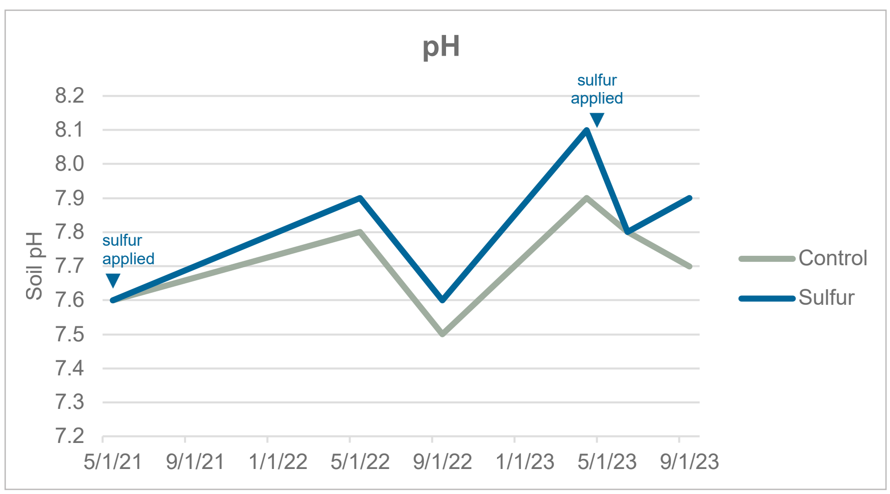

Figure 3. Tracking soil pH in each plot from May 2021 to Sept 2023. Sulfur was applied in early May 2021 and then again in early May 2023 to the treated plot.

Throughout the trial, the treatment plot has consistently had lower organic matter than the control plot. We did not detect an increase in organic matter in the treatment plot one year after sulfur application. In spring 2023, we saw a 0.5% increase in organic matter seven weeks after sulfur application in the treatment plot. There was a 1.0% decrease in organic matter in the treatment plot 21 weeks after sulfur application (Figure 4).

Soluble salts levels were high in both plots at various times. We speculate the high tunnel being located next to a brick building with a south facing wall adds additional heat to the high tunnel which could contribute to the high soluble salt levels. The treatment plot has consistently had lower soluble salts than the control plot throughout the trial (Figure 5). This might be due to occasional flooding of the back half of the high tunnel when the farmers have left the irrigation system on for too long. We began tracking soluble salts in May 2022 when levels were quite low; we speculate this was due to plastic being taken off the tunnel early in the Spring 2022. This leaching period allowed for snow and rain to lower salt concentrations.

Summer 2021 foliar testing on peppers showed higher nutrients (N, K, Mg, Ca, S, Mn) in the treatment plot compared to the control plot. Summer 2023 foliar testing on tomatoes showed higher nutrients (Fe, Mn) in the treatment plot compared to the control plot.

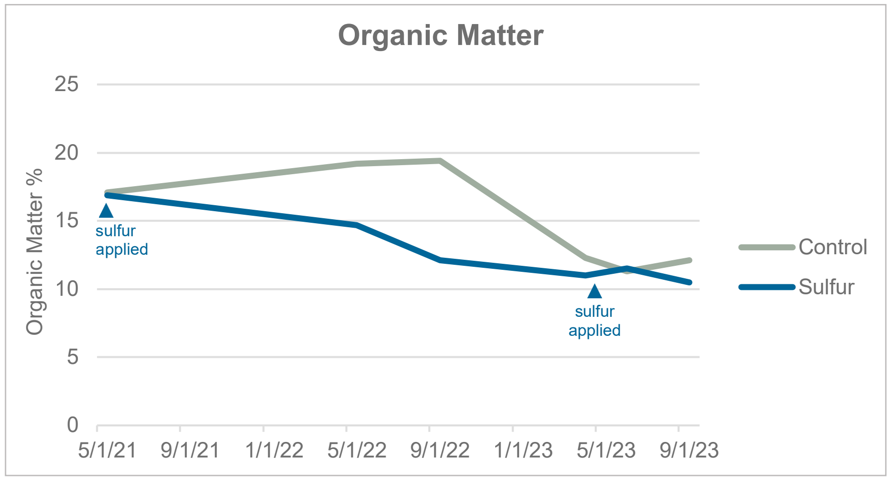

Figure 4. Tracking organic matter in each plot from May 2021 to Sept 2023.

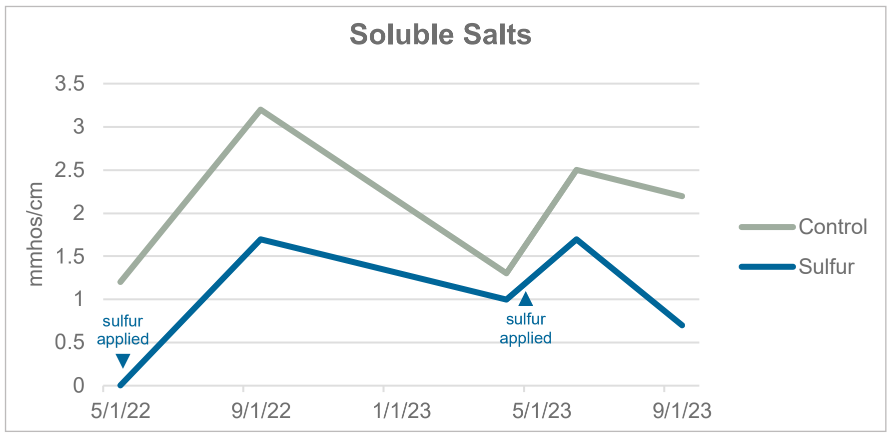

Figure 5. Tracking soluble salts in each plot from May 2022 to Sept 2023.

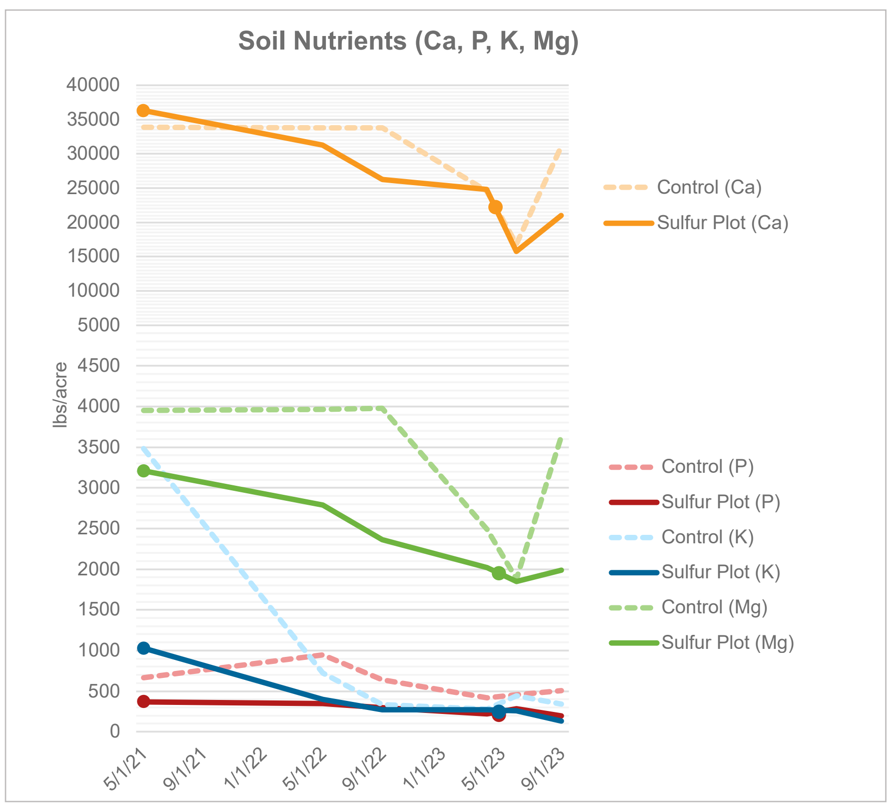

Figure 6. Tracking calcium (Ca), phosphorus (P), potassium (K) and magnesium (Mg) in the soil for each plot from May 2021 to Sept 2023. Sulfur was applied in May 2021 and May 2023 to the treated plot.

Discussion

This site experiences seasonal flooding which included our treatment plots. Soil calcium and salt levels were lower over the course of two years in the sulfur treated plot, and these levels may be associated with the leaching events, natural soil variation, or possibly sulfur application. Other soil nutrients including phosphorus, magnesium and potassium were lower (but still often excessive) in the treatment plot (Figure 6). Soil aggregate stability as measured by VAST (Volumetric Aggregate Stability Test) decreases drastically in both plots, potentially an impact of season-long irrigation with high pH, calcium and EC water (Figure 7). Higher foliar nutrients (N, K, Mg, Ca, S, Mn) were detected in the treatment plot which again may be related to leaching, sulfur applications, or both in combination.

Our demonstration at this farm did not provide clear evidence of soil acidification potential of elemental sulfur applications. There may be several factors that influenced this. Foremost, soil Ca levels range from 15,758 to 36,292 lbs/acre (Figure 6). These levels of Ca are a magnitude higher than many rural vegetable soils. This represents an enormous buffer for the sulfur to overcome to affect a pH change. We also note the very high levels of organic matter and relatively low aggregate stability. This may influence microbial populations and their potential to convert elemental sulfur to sulfuric acid.

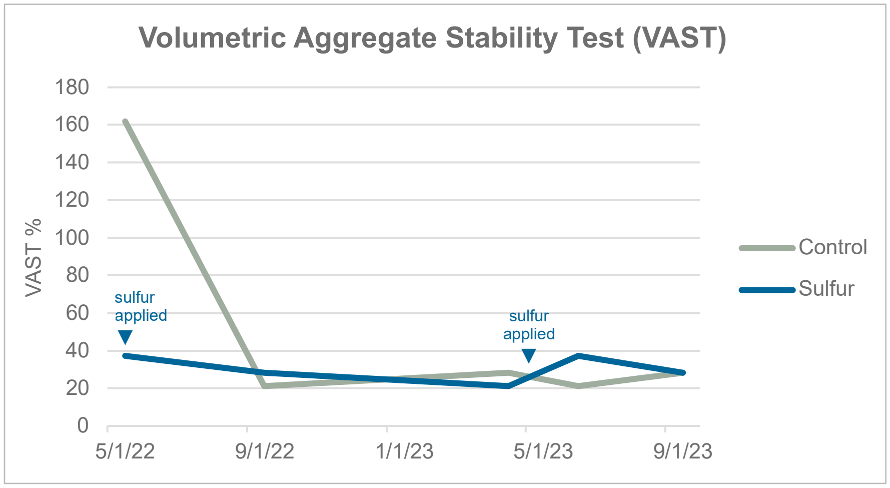

Figure 7. Tracking volumetric aggregate stability in the soil for each plot from May 2021 to Sept 2023.

At this time, we are still waiting to receive soil test results from samples taken in June 2023 that are to evaluate microbial communities and function.

Our next steps for this demonstration site are to explore ways to manage the high pH and soluble salts levels in the high tunnel. To do this, we are planning to try a multipronged approach which includes:

- Continuing yearly elemental sulfur applications and increasing the rate to 10 lbs/tunnel
- Acidifying the irrigation water with citric acid
- A single flooding event in the tunnel in early spring to leach out excess salts
- Planting a cover crop between winter production and summer production
- Switching irrigation water to one with lower salt levels, if possible
- Removing plastic off the tunnel every 3 years, if possible
- Exploring soil testing options to take a closer look at physical and biological components of soil

Interested in learning more?

Contact Lori Koenick (lbk75@cornell.edu) or Judson Reid (jer11@cornell.edu) of the CCE Cornell Vegetable Program.

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