Cornell Cooperative Extension

URBAN FARM SOIL HEALTH

Management Practices for Urban Soil Health: pH Adjustment in NYC

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 New York City looking at the effect of pH adjustment 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 farm in this case study is in Queens, NY. The 0.5 acre site has been in operation since 2013, and the current farmers have managed it as a business since 2020. Their previous farming experience was limited to 2 years of volunteer work on this same farm site, with the previous farmer; after that farmer left, he handed off the business to them. About half of the cultivated area is dedicated to perennial crops such as figs, gooseberries, and asparagus; the other half is annual vegetables, which account for most of the farm income, including farm stand and restaurant sales.

The farm is in the Rockaways, a sandy peninsula that was devastated by Hurricane Sandy in 2012; this farm site itself was underwater after the storm, and much of the surrounding area is still rebuilding. The parcel is owned by the NYC Parks Department, which brought in the original underlying soil for this farm and for the neighboring urban farm, a nonprofit that also grows vegetables. The farmers aren't sure where the underlying soil came from. Over the years they and the previous farmer have added a large amount of compost.

After soil test results consistently showed a high pH at this site, the farmers were interested in lowering the pH with elemental sulfur in order to improve yields. We also discussed a more specific potential benefit from lowering the pH: In early spring, radishes are an important crop for the farm. They often found that their early radish harvests showed substantial exterior root feeding damage (Figure 1), which we determined to be caused by a proliferation of pillbugs (aka roly-polys, *Armadillidium vulgare*). Some research suggested that pillbugs favor a higher pH soil, so we posited that lowering the soil pH would reduce pillbug damage to radishes.

Figure 1. Radish harvest from 2021, showing significant pillbug feeding damage.

Methods

Two rows were selected for the study area, each divided into a treatment and control section, for a total of two control and two treatment plots (Figure 2). Treated plots received two applications of 90% elemental sulfur, each at 1.5 lb per 100 square feet, in May 2022 and December 2023; pelleted sulfur was surface-applied and lightly raked in. The farm applied additional nutrients in the spring of each year, primarily nitrogen and potassium, and top-dressed with compost. Irrigation supplied by drip in 2022 and overhead in 2023. Soil samples were collected and submitted Dairy One Agronomic Services to assess pH, organic matter, and nutrients five times (May 2022, October 2022, December 2022, June 2023, September 2023).

Figure 2. Trial plots in December 2022, before adding sulfur. Treatment plots are A1 and B2; control are A2 and B1.

Preliminary Results

Between the first sulfur application in May 2022 and the next measurement in October 2022, soil pH reduced significantly in both the treatment plots (from 7.6 to 6.8) and the control plots (from 7.8 to 7.2), with treatment plots showing a more pronounced effect (Figure 3). Farmers were unable to report yield data, and crops were harvested ahead of schedule, preventing foliar data collection; however, the farmer reported a boost in their fall crop (lettuce) in the treated area.

After another sulfur application in December 2022, soil pH rose at the next measurement, in June 2023. This was expected, as a large amount of compost and some additional fertilizer had been recently added to all rows, and newly applied compost (on NYC farms, at least) commonly raises the soil pH considerably. However, the treatment plots' pH did not rise as much (0.36 increase in pH) as the control plots (0.54 increase), remaining at 7.29, compared to 7.55 for the control plots.

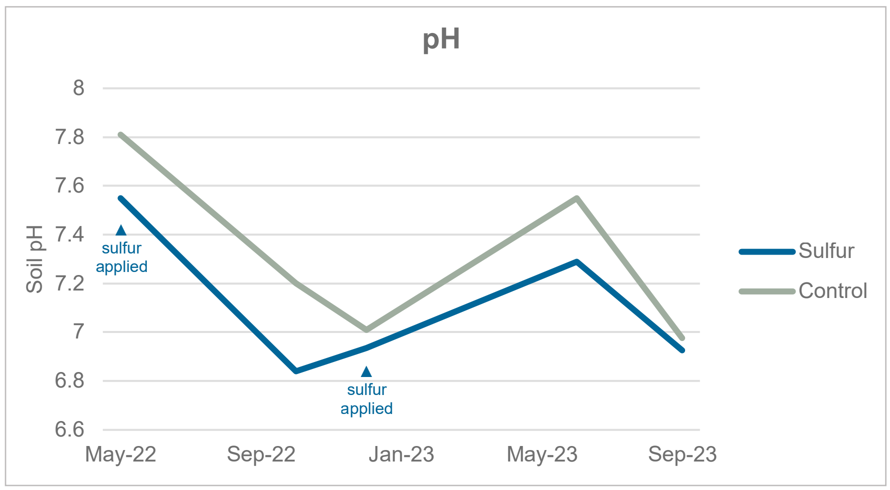

Figure 3. Average soil pH in sulfur treated and control plots. Sulfur application dates: May 2022, December 2022.

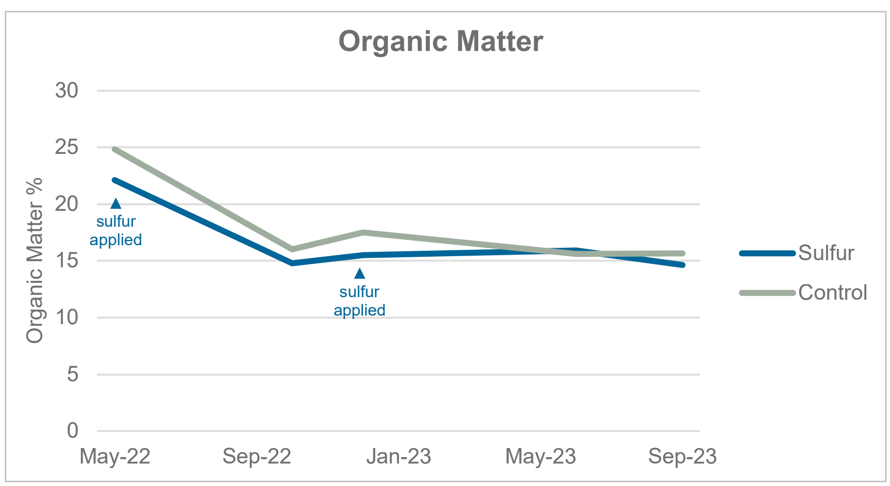

Figure 4. Average organic matter percentage in sulfur treated and control plots.

Organic matter percentage (Figure 4) and nutrient levels were remarkably similar between treatment and control plots at each point of measurement, aside from the first measurement (which may indicate sampling error for that date). See especially the similar calcium levels, where a disparity could have had implications for sulfur's effectiveness (Figure 5); the consistently slightly higher calcium in treatment plots may relate to those plots' lower baseline pH. We also looked at manganese levels, due to a consistent history of manganese deficiency in foliar samples of high pH, high organic matter soils across NYC urban farms, including this one; the Mn lbs/acre present in the soil was nearly identical between treatment and control plots (Figure 6).

As an additional evaluation, the farmers planted spring radishes in both 2022 and 2023 to determine whether a lower soil pH would reduce pillbug feeding damage. In 2021, this farm experienced substantial feeding damage from pillbugs which rendered most of their early radish harvest unmarketable. In 2022 and 2023, after adding sulfur, they found substantially less pillbug damage (Figure 7). In this trial's control plots, damage was reduced compared to 2021 but still present; in treatment plots, no damage was detected at all. The farm added sulfur to other rows in the winter of 2022, partially as a response to these results, and found again in 2023 that where sulfur had been added, pillbug feeding damage to radishes was negligible—even though pillbugs remained abundant in other areas of the farm.

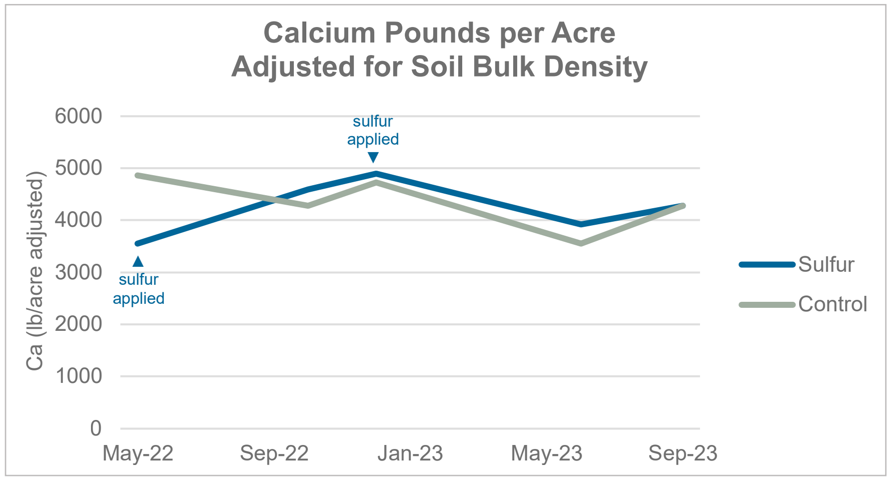

Figure 5. Calcium pounds per acre, adjusted for soil bulk density, in sulfur treated and control plots.

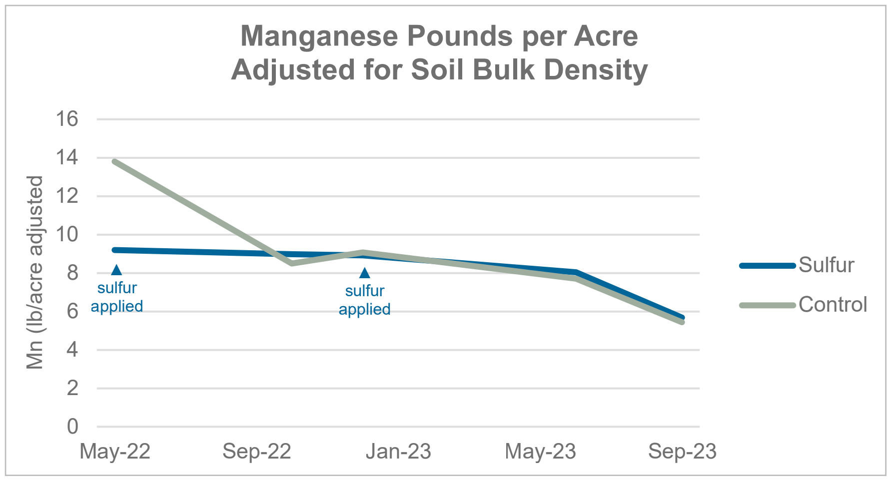

Figure 6. Manganese pounds per acre, adjusted for soil bulk density, in sulfur treated and control plots.

Figure 7. Radish harvest from 2021, showing significant pillbug feeding damage (left); from control plots in 2022, showing modest feeding damage (middle); and from treatment plots in 2022, showing no feeding damage.

Discussion

The consistently lower pH of the sulfur treatment plots compared to the control plots suggests that sulfur applications were successful in lowering soil pH. Although the treatment plots began with a lower pH, the notable difference in the June 2023 measurements suggests a buffering effect of the previous fall's sulfur application. At the next measurement, in September 2023, the treatment and control plots showed less difference in pH, perhaps raising a question about the longevity of sulfur applications' pH effect in these soils.

We might have seen stronger effects if not for the high Ca levels in these soils, which create a buffer for sulfur to overcome in order to change pH. High levels of organic matter and low aggregation may also influence microbial populations' ability to convert elemental sulfur to sulfuric acid (the mechanism by which sulfur applications reduce soil pH).

We anticipate obtaining foliar samples from these plots in 2024, allowing a comparison of plant health in treatment and control plots; this is the most important missing piece of data. We will be watching for differences in manganese levels in the foliar samples; across NYC urban ag soils, the great majority of foliar samples have indicated manganese deficiency over the past several years. This may be due to a combination of high organic matter and high pH, causing much of the manganese in the soil to become bound to organic particles and inaccessible to plants; however, it is still possible that these soils are simply low in manganese. The nearly identical manganese levels in this farm's treatment and control plots across the past two years will make this an excellent case study for the effect of soil pH on manganese uptake (once we have foliar samples).

The initial success of reducing pillbug damage by lowering soil pH (Figure 7) warrants further research, and shows promise for a niche pest issue that is rarely discussed. An informal survey of NYC urban farmers suggested that early spring pillbug damage is very common on radishes, particularly in urban ag soils with high levels of organic matter and high pH (which is to say, most urban ag soils). We will plan to help other urban farmers trial the same approach and gather their input on its effectiveness.

Interested in learning more?

Contact Sam Anderson (swa39@cornell.edu) of CCE Harvest NY, or Judson Reid (jer11@cornell.edu) of the CCE Cornell Vegetable Program.

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