Greenhouse Substrate pH Management in High Alkalinity Water using Acidifying Fertilizers

MSU Plant Science Research Greenhouse Facility
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The domestic water supply on MSU's main campus comes from more than a dozen wells located in the south campus agricultural district. As is common for wells in the Midwest, the water is hard and has high alkalinity; the MSU 2021 Water Quality Annual Report indicates an average of nearly 450 ppm calcium carbonate. The water treatment plant that was brought online in 2020 removes iron and other minerals from the water but does not reduce the alkalinity.

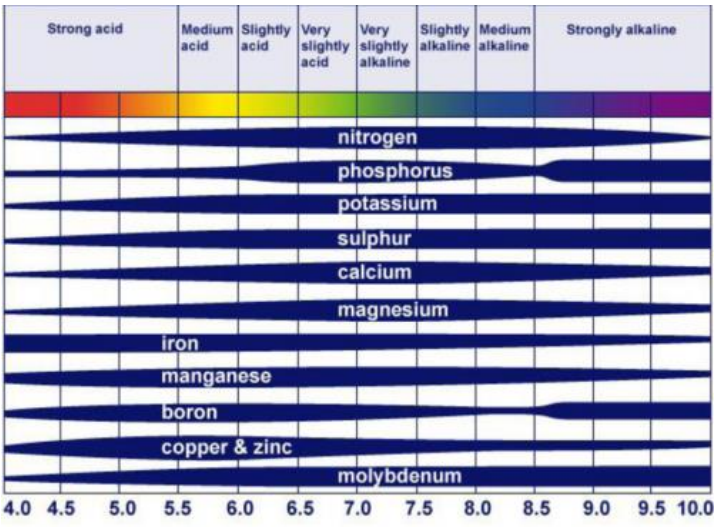

Figure 1. Availability of plant macro- and micronutrients at a range of soil pH levels.

Highly alkaline irrigation water is problematic in greenhouses because it increases the pH of the potting media over time, which limits the availability of some plant micronutrients (Fig. 1). Plant Science Research Greenhouse (PSRG) staff frequently see visual symptoms of micronutrient deficiency due to high substrate pH (Fig. 2). A common recommendation for greenhouse crops is to maintain a substrate pH between 5.4 and 6.4, and preferably between 5.8 and 6.2, but some of the crops grown in the PSRG grow better at a higher or lower pH, so it is important that users know the pH needs of their particular crops.

Figure 2. A strawberry plant from PSRG showing signs that are consistent with severe iron deficiency. Substrate pH was 8.0, as measured using the pour through method.

ICL Specialty Fertilizers produces a wide variety of water-soluble fertilizers. The PSRG currently supplies Peters Excel pHLow 15-7-25, ("pHLow") which is marketed as having an acidic reaction that can help mitigrate a rise in substrate pH over time. We recently learned of a product called Peters Excel pHLow Acid Hammer 21-7-7, ("Acid Hammer") that is advertised as being highly effective for acid loving plants grown using irrigation water with high alkalinity. We decided to test these products, along with a more standard fertilizer, Peters Professional 20-10-20,

("Professional") to determine if the specialty fertilizers could keep substrate pH at acceptable levels.

The study was initiated on April 27, 2022 using switchgrass (*Panicum virgatum*) and 'White' E3 East Wave petunia (*Petunia* x *hybrida*). Mature plants of both species were potted in Nursery Supplies C1000 8.5L pots using Michigan Grower Products SureMix, which is a peat-based soilless substrate. Plants were arranged in a completely randomized design, with five plants per replicate. After planting, all plants were watered with well water and initial pH measurements were collected.

Plants were watered as needed, and due to the size of the plants compared to the size of pots, plants were usually not watered more than once per week. Fertilizer treatments were initiated at the first watering after planting of both crops (except as noted), and were:

1. Professional only
2. pHLow only
3. Acid Hammer only
4. Professional, switching to Acid Hammer as needed to decrease pH
5. pHLow, switching to Acid Hammer as needed to decrease pH
6. Osmocote Plus 15-9-12 5-6 month (switchgrass only)

The plan for treatments 4 and 5 was to use Professional or pHLow until the pH rose above 6, switch to Acid Hammer until the pH dropped below 6, and then switch back to the original fertilizer. Acid Hammer was first applied to plants in these treatments on July 1. However, the pH in these treatments did not decrease below 6 before the end of the study, so Acid Hammer was used until the study ended. We terminated the study on August 4 because switchgrass plants had become too pot bound to properly water.

Substrate pH was measured nine times during the study using the pour through method. At the end of the study, pH was higher overall in switchgrass than in petunia (Table 1). Switchgrass is well-known to produce root exudates, which ultimately increase substrate pH.

Table 1. pH of petunia and switchgrass plants at the end of the study on August 4.

Treatment	Endpoint pH
Petunia Professional	6.4
Switchgrass Professional	6.8
Petunia pHLow	6.6
Switchgrass pHLow	7.0
Petunia Acid Hammer	5.2
Switchgrass Acid Hammer	5.8
Petunia Professional, switch to Acid Hammer	5.9
Switchgrass Professional, switch to Acid Hammer	6.4
Petunia pHLow, switch to Acid Hammer	6.0
Switchgrass pHLow, switch to Acid Hammer	6.3
Switchgrass osmocote	6.3

The petunia and switchgrass plants receiving only Acid Hammer had the lowest substrate pH at the end of the study at 5.2 and 5.8, respectively (Fig. 3 and Fig. 4). Optimal pH for petunia is between 5.5 and 6.2, but plants still appeared healthy, with no signs of micronutrient toxicity due to low pH. Switchgrass is tolerant to a wider range of substrate pH (5.5 to 7.0).

Results showed that the plants (both switchgrass and petunia) that received pHLow alone did not have lower substrate pH than Professional. However, when looking at the product sheets, Professional has a greater percentage of ammoniacal nitrogen than pHLow; when ammoniacal nitrogen is taken up by plant roots, they release H^+ ions, which react with the substrate and reduce pH.

The switchgrass plants that received Osmocote showed an initial drop in pH, and then pH continued to rise through the rest of the study. This is not unexpected, as Osmocote releases nutrients (including ammoniacal nitrogen) rapidly when soil temperature increases, leaving little nutrients to continue to fertilize plants. While the type of Oscmocote used in this study is formulated to last five to six months, the release of nutrients over those months does not appear to happen evenly.

Substrate pH in the two "plus Acid Hammer" treatments increased while plants were fertilized with either pHLow or Professional. After applying Acid Hammer for the first time on July 1, pH continued to rise before finally decreasing. We had hoped that Acid Hammer would drop the pH in these treatments after one watering, but that was not the case.

Overall, results indicate that Acid Hammer would be a good choice in the PSRG for plants that grow best in low substrate pH, such as blueberries. We do not recommend that it be used on plants that tolerate a more neutral substrate pH. In addition, because it contains a relative high percentage of ammoniacal nitrogen, it can create ammonia toxicity when plants are grown at a low temperature (e.g., <15 C). This product is now available in PSRG, but users must consult with Chrislyn Particka prior to using it.

While we had hoped that Acid Hammer could be used to reduce substrate pH when it rises above acceptable levels, it did not decrease pH as quickly as we had hoped. Given the need to monitor pH for several weeks to determine if pH has decreased to acceptable levels, a better solution for solving high substrate pH could be to instead repot plants into fresh substrate, or perhaps to deliver an acid drench treatment.

We plan to continue testing other fertilizer options in the upcoming months, including a 50/50 mixture of Acid Hammer and Professional. Based on what we learned in this study, we think the mixture may keep substrate pH at levels that are acceptable for plants that perform best at a pH of <6.4.

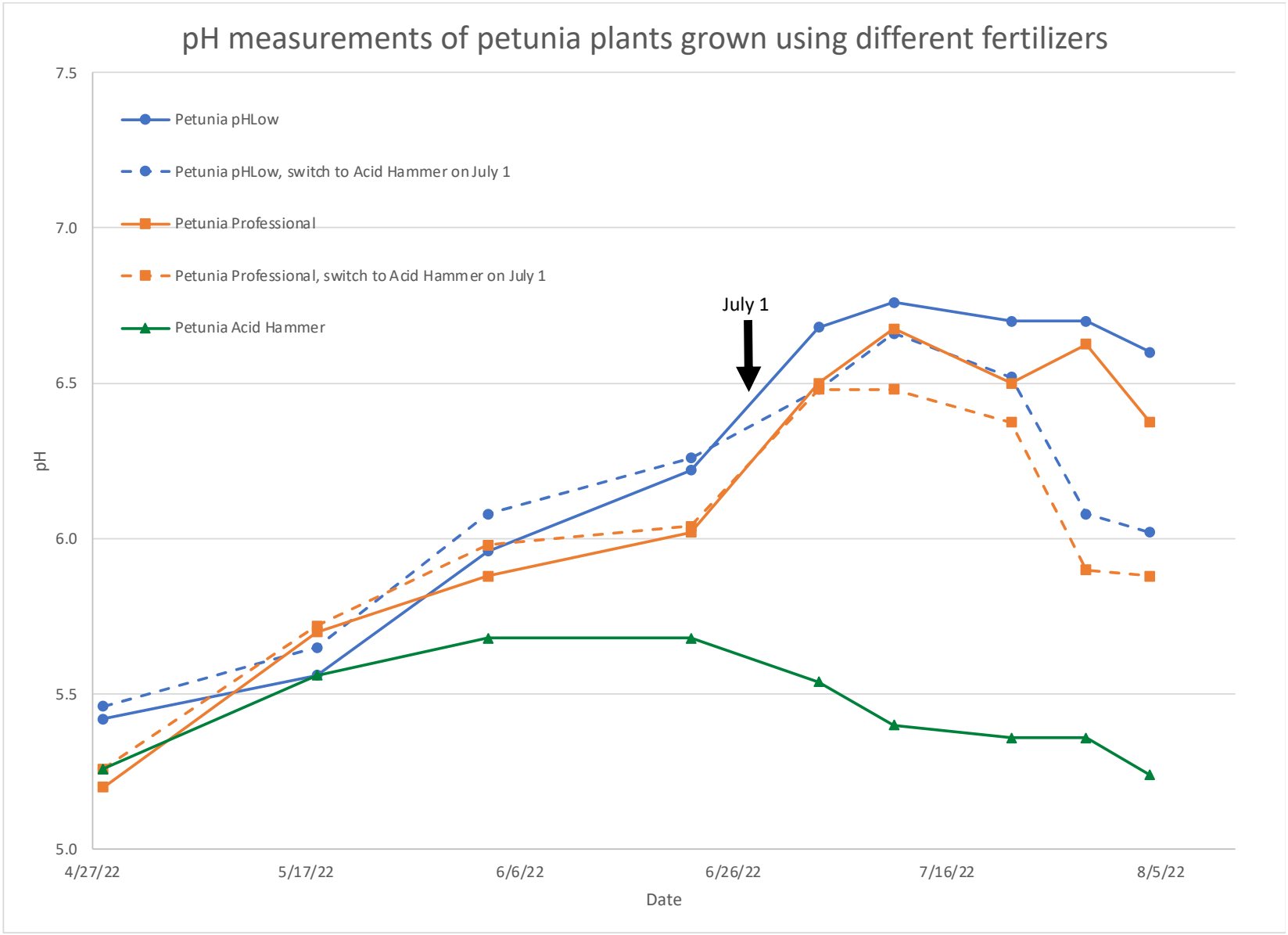

Figure 3. Substrate pH of petunia plants fertilized with different products.

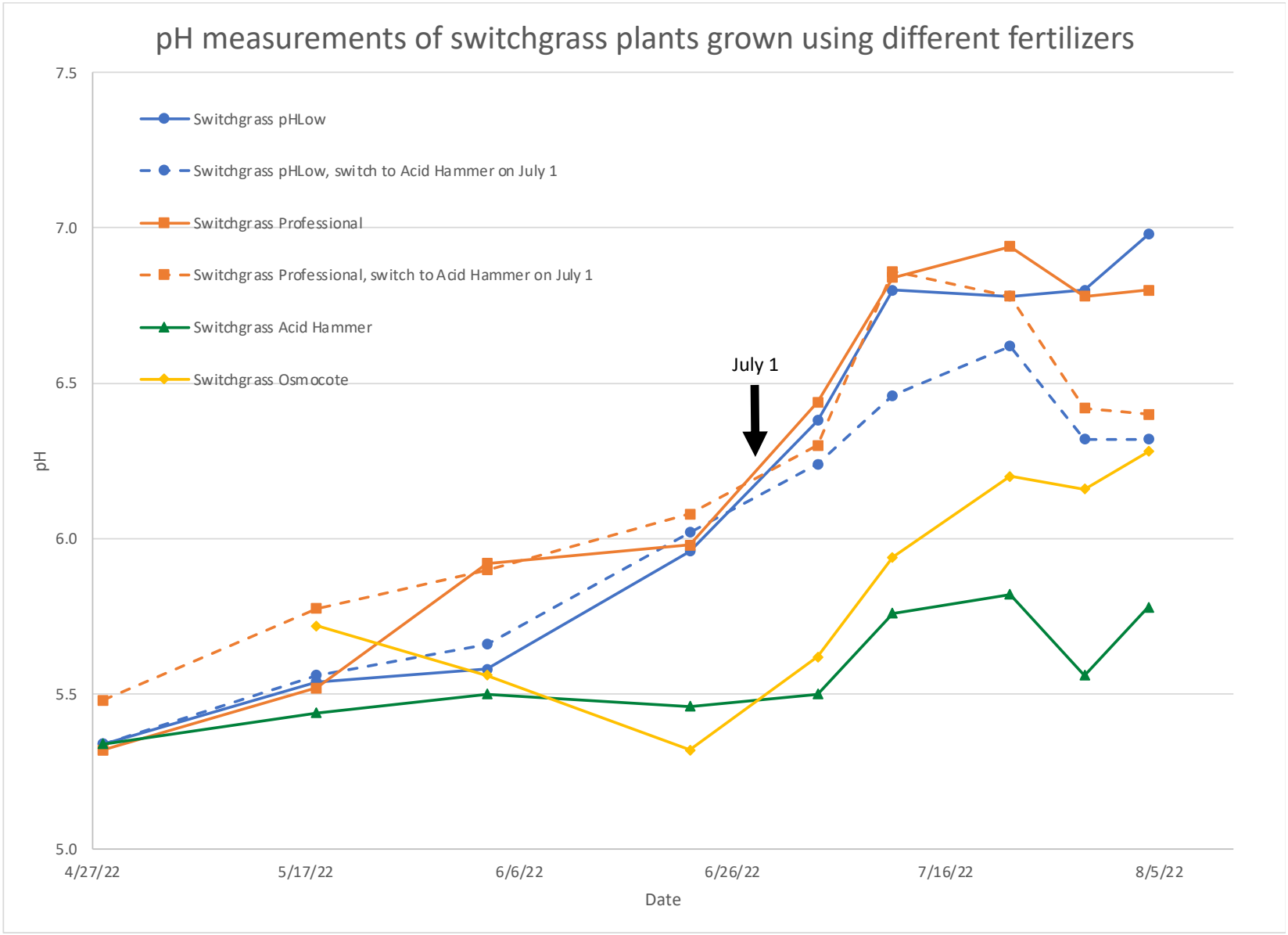

Figure 4. Substrate pH of switchgrass plants fertilized with different products.