Cornell Cooperative Extension
Eastern NY Commercial Horticulture Program

HUDSON VALLEY FARM HUB

High Tunnel Tomato Potassium Fertility Study

2024 Annual Report

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April 30, 2025

Summary

Because of the high potassium demand of tomatoes, the concept of 'banking' potassium by applying extra potash (K_2O) upfront has gained widespread adoption, particularly in organic production. Cornell Cooperative Extension vegetable specialists Teresa Rusinek and Ethan Grundberg conducted a trial at the Hudson Valley Farm Hub (HVFH) evaluating the impact of three pre-plant K_2O application rates: 0 lbs/acre, 300 lbs/acre, and 600 lbs/acre, in reducing the occurrence of the yellow shoulder and white core in tomato fruit, both of which are linked to potassium (K) deficiencies in tomato plants.

Key Research Findings from the 2024 Trial

- There was no significant effect of potash applications on the foliar concentration of potassium (K).
- Plant tissue K levels remained below the threshold of 4.5% for the entirety of the growing season for all treatments.
- There was a significantly lower incidence of white core in tomatoes harvested from plots with the highest pre-plant K_2O applications of 600 lbs/acre.
- Numerically, the 600 lbs/acre potash treatment had the lowest percentage of tomatoes showing any amount of yellow shoulders.
- Applying no pre-plant potash resulted in the highest average percent of yellow shoulders observed on fruit and the highest percentage of tomatoes with more than 25% of the surface area with visible yellow shoulder symptoms.



Figure 1. Tomato with Yellow Shoulder Disorder

I. Background

New York State ranks #2 in the US for number of farms growing produce under protected environment agriculture with a total of 489 farms and a value of sales at $28,590,555. In the Hudson Valley, tomato crops are commonly grown in high tunnels (HT), one form of protected environment agriculture, and can provide high economic returns if growers are able to maintain high yields of quality fruit. Tomato yellow shoulder is a common disorder known to be triggered by stress factors exacerbated by the high tunnel growing environment. Tissue in the affected area, typically at the top or "shoulders" of the fruit, fails to develop red pigment due to a K deficiency. The flesh beneath the yellow shoulders and along the walls of the fruit is a lighter color, firm, and poor tasting. Symptoms range in intensity and presentation resulting in a variety of names given to this disorder including green shoulder, gray wall, white core, and delayed ripening.

The cause of yellow shoulder and white core disorder is complex and not fully understood. Studies have demonstrated that the principal cause of the disorder is a K deficiency during early fruit set. This deficiency can occur despite ample pre-plant and in-season soil potassium fertilizer applications. It has been hypothesized that as soil temperatures rise above 85 °F, tomato plant root function is impaired making it difficult for plants to access the soil exchangeable K. This theory has been supported by studies where an increase in yellow shoulders incidence is observed when plants are grown in black plastic mulch with coinciding elevated soil temperatures. High soil temperature is one of multiple factors that can trigger yellow shoulders; nutrient interactions, varietal susceptibility, high canopy temperatures, exposure of fruit to direct sun, and soil moisture extremes have also been identified as causal factors.

Regular foliar nutrient testing combined with targeted potassium fertigations and/or foliar applications is a common strategy used to help prevent yellow shoulders. In the 2023 trial Rusinek and Grundberg conducted at HVFH, it was found that foliar K applications in conjunction with pre-plant K_2O application and K_2O fertigation did not significantly raise tomato plant tissue K concentrations and only marginally decreased unmarketable yield due to yellow shoulders. This result highlighted the questionable cost-effectiveness of numerous (14 total in the 2023 trial) weekly foliar K applications. Growers are unlikely to invest the time to make multiple foliar K applications with limited benefit in return. In the same trial, it was found that the black landscape fabric was more effective in cooling soil compared to reflective plastic mulch due to the woven structure of the black fabric allowing soil heat to dissipate through the permeable material, whereas the reflective plastic mulch is an impermeable film trapping heat. Plants grown on black landscape fabric had statistically significantly lower percent tomato fruit with white core, higher tissue % K concentrations and numerically lower incidence and severity of yellow shoulders compared to those grown on reflective mulch.

Organic growers typically front load potassium because it is less challenging than spoon-feeding the plants through multiple fertigations and foliar feedings. Because of the high potassium demand of tomatoes, the concept of 'banking' potassium or applying extra upfront has been gaining adoption among organic high tunnel tomato growers. Based on data collected from the 2018 New England High Tunnel Survey, guidelines have been developed for optimizing tomato production in high tunnels. Based on soil tests, K_2O applications up to 750 lbs/acre are recommended for high yields. In 2024, Grundberg

and Rusinek evaluated the effect of three K_2O rates on the foliar concentration of K as well as the incidence and severity of yellow shoulders and white core disorder on tomato fruit.

II. Materials and Methods

The trial was hosted by the Hudson Valley Farm Hub (HVFH) in Hurley, NY (41.918901, -74.082975) in a 216' X 42' Harnois OvalTech HT with ridge ventilation and roll-up sidewalls. The researchers used a small plot randomized complete block design with three replicates and three treatments. Each plot was 7' long by 5' wide. The tomato variety 'Rebelski' was selected as it was observed to be significantly impacted by yellow shoulder disorder when previously grown at the HVFH. Treatments and rates are listed in Table 1. Allganic 0-0-52 sulfate of potash was used to supply K at the treatment rates. A pre-plant application of 100 lbs/acre of nitrogen was applied to all plots using Nature's Safe 13-0-0. Plants were seeded on 13-Feb. into 72 cell trays and transplanted on 2-April in a double staggered row with 24" between rows and 24" in-row spacing. All tomatoes were planted into black landscape fabric. Subsequent K applications were made via fertigation through drip lines under the landscape fabric (3 drip lines/bed).

Table 1. Experimental Potash Application Rates

Treatment	Potash (K2O) Application
A	0 lbs./acre
B	300 lbs./acre
C	600 lbs./acre

Leaf tissue samples were collected for nutrient analysis from each plot on April 24, May 22, July 14, and August 28 and shipped to Waters Ag Lab in Warsaw, NC. All treatments received supplemental K fertigation eight times over the course of the production cycle at a rate of 30 lbs/acre of Allganic 0-0-52 through drip irrigation lines.

Harvest Evaluations- Fully ripened tomatoes were harvested by plot and evaluated nine times on -June 14, 26, July 6, 16, 24, 31, and August 6, 15. At each harvest, fruit was removed from the same four tomato plants (two center plants from each row in the plot). Harvested tomatoes were sorted as marketable or unmarketable if yellow shoulder was observed to be over 25% or more of the fruit shoulders. Yields were measured using an Ohaus Catapult 1000 compact bench scale with 0.02 lb. resolution. At each harvest, all harvested tomatoes were individually evaluated for yellow shoulders.



Figure 1. Tomato Fruit with 25% Yellow Shoulder

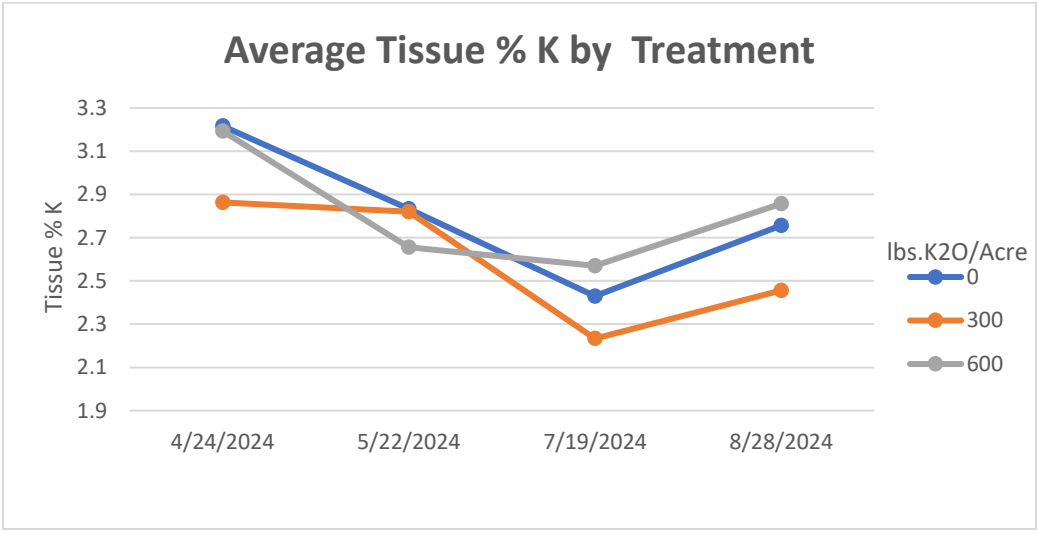


Figure 2. Tomato with 80% Yellow Shoulder

Percent yellow shoulder was determined visually by estimating the area of the fruit shoulders showing yellow or green discoloration. Presence or absence of white core was evaluated by slicing the tomato fruit in half on the last four harvest evaluation dates of the season.

III. Statistical Analysis and Results

Pre-plant soil K Application Effect on Plant Tissue K Concentrations



Treatment	Mean Foliar K Concentration Over Season
0 lbs K_2O/acre	2.81
300 lbs K_2O /acre	2.59
600 lbs K_2O /acre	2.82
P-Value	0.3911

There was no statistically significant effect of treatment on plant tissue K concentration in 2024. For all treatments, tissue % K levels were below the threshold of 4.5%, beginning with the first tissue sampling on April 24 and remained below the threshold through the season.

Pre-plant Soil K Treatment Effect on Quality: Season Averages

Potassium Rate (Lbs/Acre)	% Tomatoes with White Core	% Yellow Shoulder Observed	% Tomatoes with Yellow Shoulder > 0%	% Tomatoes with Yellow Shoulder ≥ 25%
0	27.47 a	15.48	75.29	24.63
300	24.16 ab	11.38	66.57	15.55
600	18.26 b	12.85	64.76	16.22
P-Value	0.0317	0.2486	0.3761	0.169

The average percent white core observed in fruit was statistically significantly lower in the plots receiving 600 lbs K_2O/acre pre-plant compared to the 0 lbs K_2O/acre treatment.

Numerically, the 600 lbs K_2O/acre treatment had the lowest percentage of tomatoes showing any symptoms of yellow shoulders. The 0 lbs K_2O/acre treatment had the highest average percent of yellow shoulders observed on fruit and the highest percentage of tomatoes with yellow shoulder ≥ 25%, though these differences were not statistically significant.

IV. Discussion and Future Investigations

In this trial tomato tissue sampling results did not indicate a significant effect of pre-plant K_2O application rates on tissue K concentration, nor was there a numerical trend that correlated to application rates. Fruit quality metrics reveal a significant reduction in white core incidence in tomato fruit grown in plots receiving the highest K_2O pre-plant applications of 600 lbs/acre. Yellow shoulder incidence and severity was numerically highest in the plots receiving 0 lbs pre-plant K_2O. The fruit quality data collected and analyzed in this trial support the concept of 'banking' or 'front- loading' potash to optimize tomato production in high tunnels.

Optimizing tomato plant K uptake by cooling soils, applying additional K through foliar applications and/or frontloading potash can help minimize yellow shoulders and white core. In open field trials, it has been demonstrated that tomato varieties differ in susceptibility to these disorders (see 2019, Johnson & Ernest, University of Delaware). The 2025 yellow shoulders and white core trial will examine a selection of commercial and pre-commercial Hyloom varieties for their susceptibility for these disorders as well as overall fruit qualities under high tunnel production.

V. Acknowledgments

This work would not be possible without the support of Jeff Arnold, Rosa Villegas, and the vegetable production team at the Hudson Valley Farm Hub. A special thanks to Sarah Tobin with the Eastern NY Commercial Horticulture Program for her work compiling this report.