Abstract

There is growing evidence that organically grown crops contain higher levels of phytonutrients (phenolics, ascorbic acid, carotenoids) relative to their conventional counterparts. This study investigates the relative effects of organic and inorganic nutrient treatments and herbivory on tomato phytonutrient concentrations. Organically managed soils generally have higher organic N to inorganic N ratios, and research indicates that organically grown apples, strawberries and tomatoes have higher antioxidant activity than those grown conventionally. Because organic producers have fewer available insect management tools, organic crops often tolerate more insect pests. Herbivory induces production of plant defense compounds, many of which act as antioxidants.

In this study, tomato plants (Solanum lycopersicum L. var. Oregon Spring) were grown in a RCB experimental design in a greenhouse under either organic or inorganic nutrient management. To determine the effect of herbivory on fruit quality, green peach aphids (Myzus persicae) were introduced to half of the plants within each nutrient treatment. To contain the aphids, all plants were grown in mesh exclusion cages. Fruit was harvested at varying stages of ripeness and measurements were taken of percent soluble solids (Brix; ripe fruit only), mass and diameter. Frozen ripe fruit samples were analyzed for total phenolics, lycopene and Trolox equivalent antioxidant capacity (TEAC). Organically fertilized tomatoes had statistically higher concentrations of soluble solids, total phenolics, lycopene and lipophilic and total TEAC. Organic tomatoes supported lower aphid densities. Mineral analysis of leaf tissue revealed differences in contents. Portions of the frozen samples are being used for genomic analyses. Results of these analyses will be compared to those of phytonutrient analyses to establish correlations between gene activity and the physiological effects of nutrient management and herbivory.

Materials & Methods

Crop

Oregon Spring tomato (Solanum lycopersicum L). Compact, determinate, early season, bearing small to medium-sized fruit.

Experiment

Grown in #7 pots with either organic (75% Sunshine LC1 peat-based, 20% Whitney Farms Compost, 5% organic soil) or conventional (Sunshine LC1 peat-based) growing media. Fertilized with either a complete organic (BioLink 5-5-5, & BioLink Micro) or conventional (Peters 20-20-20, & Ca(H2PO4)2; H2O) solution at equal rates of total N (260 ppm initially; 360 ppm when fruiting). Nitrogen composition was as shown below. Grown fall 2010 – winter 2011 in a 6-block randomized complete block design in a glasshouse (14 hrs at 21.1°C / 10 hrs at 18.3°C) with supplemental light via 1000W metal-halide lamps. All were grown in insect cages. Green peach aphids (Myzus persicae) were introduced to +aphid treatment at flowering stage (300/plant). Plants in the -aphid treatment received no aphids and remained aphid-free throughout the study.

Measurements

Fruit were harvested as they ripened. After a minimum number of fruit were collected, the vines were harvested along with the remaining fruit of varying ripeness. Aphids from leaf subsamples were counted and vegetative measurements were taken. Also, the following analyses were conducted.

Phenolic compounds were measured with the Folin-Ciocalteau (F-C) phenol reagent (ZN), expressed as gallic acid (GA) equivalents, according to revised methods of Singleton et al. (1999).

Lycopene was measured via spectrophotometry by method of Rodriguez-Concepcion & Grussem (1999), calculated using molar extinction coefficient of 34000M⁻¹cm⁻¹.

Antioxidant activity of hydrophilic and lipophilic fractions (Arnao et al. 2001) were measured by the end point 2, 2'-azino-bis-(3-ethylbenzthiazoline-6-sulfonic acid) (ABTS)/hydrogen peroxide/peroxidase (Horseradish peroxidase, Type VI-A) method of Cano et al. (1998). Expressed in Trolox equivalents.

Statistics

Data were analyzed by ANOVA (mixed model and GLM) on SAS (v. 9.1). Natural log transformation was used when data did not meet normality and variance assumptions.

Results

Ripe fruit yields were not different between fertility or aphid treatments. Yield of unripe fruit, however, was 29% higher under conventional fertility. As a result, the total yield was greater in conventional fertility.

Counts from leaf subsamples revealed aphid numbers over seven times higher in plants under conventional fertility than those under organic fertility treatment.

Concentration of phenolic compounds in ripe fruit was 13% higher under organic fertility and 8% higher under aphid (+) treatment. There were no treatment differences on leaf phenolics (data not shown).

Conclusions

Treatment had no effect on ripe fruit yield, but conventional fertility had a positive effect on unripe yield.

Aphid subsamples counts were seven times lower under organic fertility management, indicating a higher plant resistance.

Percent soluble solids were highest under organic fertility. For all phytonutrients measured, organic fertility had positive effects. Aphids also positively affected phenolics.

Research in Progress

Ascorbic acid (vitamin C) & dehydroascoratic acid (oxidized AsA) will be measured using the method described by Andrews et al. (2004).

Genomic analysis including de novo sequencing will be completed to determine differentially expressed genes. These results will be compared to and correlated with physiological data.

Acknowledgements

We gratefully acknowledge funding from the BI0A program through the CAHNRs Center for Sustaining Agriculture and Natural Resources. We appreciate the input, advise and work of many, particularly of Dr. Bill Snyder, Dr. Gretchen Snyder and Dr. Rich Aldridge.

References