PHYTONUTRIENTS AND GENOMICS OF ORGANIC TOMATOES: SOIL FERTILITY AND/OR PLANT DEFENSE

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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 content. 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 lycopersicon* 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, & $Ca(H_2PO_4)_2 \cdot H_2O$) 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.

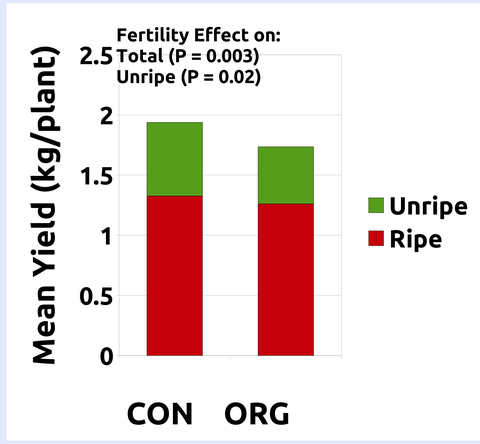
Treatment	$NO_2 + NO_3$	NH_3
Organic	< 1 %	13 %
Conventional	57 %	30 %

Measurements
Fruit were harvested as they ripened. After a minimum number of fruit were collected, the vines were harvested along with all 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-Ciocalteu (F-C) phenol reagent (2N), expressed as gallic acid (GA) equivalents, according to revised methods of Singleton *et al.* (1999).
Lycopene was measured via spectrophotometer by method of Rodriguez-Concepción & Gruissem (1999),calculated using molar extintion coefficient of $3400mM^{-1}$.
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.

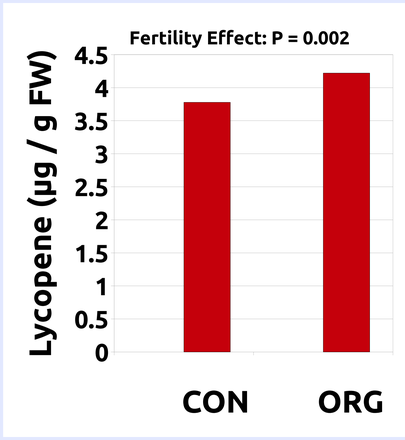
Statistics
Data were analyzed by ANOVA (mixed model and GLM) on SAS (v. 9.1). Natural log transformation was used when data did not meet normality and variance assumptions.

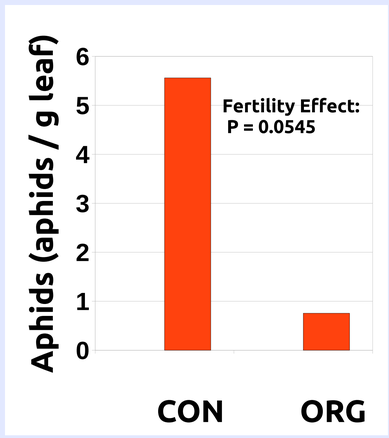
Results

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.

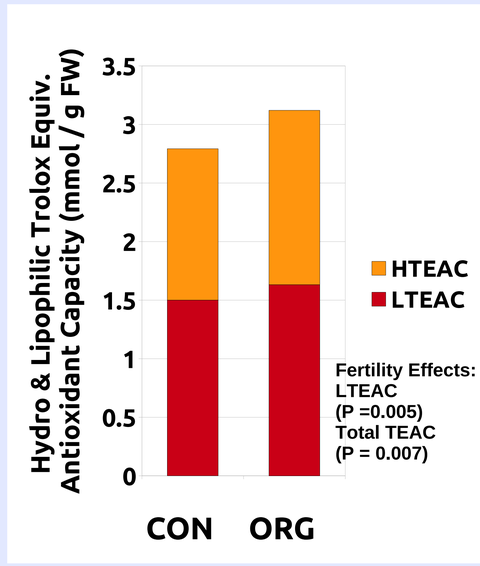


Lycopene concentration in ripe fruit was positively affected by organic fertility, with 12 % greater concentration compared to conventional.



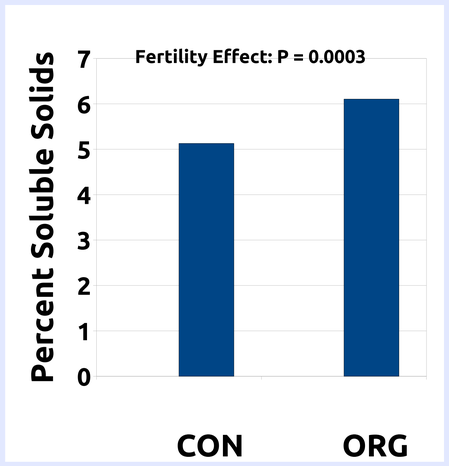


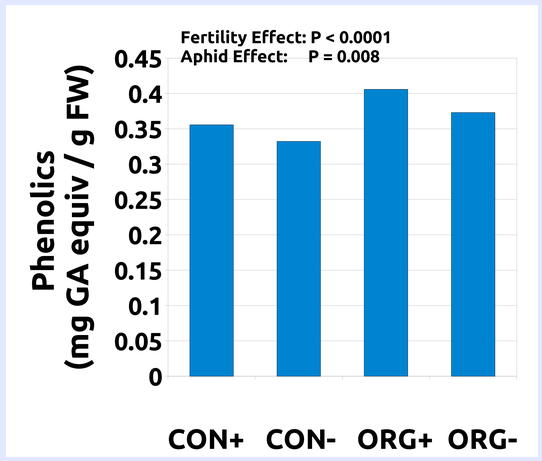
Counts from leaf subsamples revealed aphid numbers over seven times higher in plants under conventional fertility than those under organic fertility treatment.



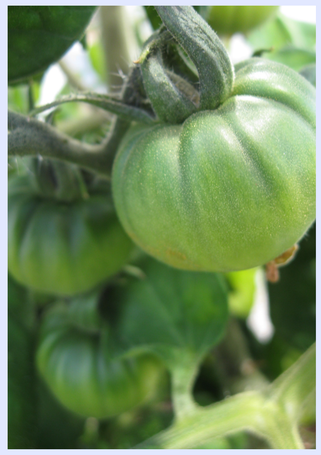
Lipophilic Trolox equivalent antioxidant capacity (LTEAC) and total TEAC in ripe fruit were 9 and 7 % higher under organic fertility, respectively.

Percent soluble solids in ripe fruit was positively affected by organic fertility treatment, with 19 % higher concentration compared to conventional fertility.





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 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) & dehydroascorbic 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

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References

Andrews PK, Fahy DA, Foyer CH, *Physiol Plantarum* **120**, 519 (2004)
Arnao MB, Cano A, Acosta M, *Food Chem* **73**, 239 (2001)
Cano A, Hernández-Ruíz J , García-Cánovas F, Acosta M, Arnao MB, *Phytochem. Anal* **9**, 196 (1998)
Rodriguez-Concepción M, Gruissem W, *Plant Physiol* **119**, 41 (1999)
Singleton VL, Orthofer R, Lameula-Raventos RM, *Method Enzymol* **299**, 152 (1999)