ORGANIC MANAGEMENT IMPROVES SOIL HEALTH AND STRAWBERRY NUTRITIVE VALUE

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ABSTRACT

Soils and strawberries from 13 matched pairs of organically and conventionally managed fields were assessed over two years. Available plant nutrients were generally similar under organic and conventional management except that organically managed soils contained more available Zn and B. Soil C, N, and biological parameters were much greater under organic management. Organically produced strawberries matched by variety were smaller and had greater dry matter content than conventionally produced strawberries. Organic strawberries provided 9% more vitamin C, 8% more total antioxidant activity, and 10% more total phenolics by fresh weight than the conventional berries.

OBJECTIVES

This study was conducted to:

1. Determine soil fertility and biological effects of organic management;
2. Determine strawberry quality effects of organic management.

METHODS

The study was conducted using matched organically and conventionally managed fields on commercial strawberry farms in the Watsonville area, California. Detailed methods can be found in Reganold et al. (2010). Certified organically and conventionally managed fields were paired by proximity, similarity of soil profile, and strawberry variety. All fields had been established in organic or conventional management at least 5 years prior to the study. Organically and conventionally managed fields were managed similarly regarding tillage, bed building, planting, and harvest. Organic fields received fertility inputs primarily through 20.2 – 24.6 Mg ha^{-1} composted green waste. Conventional fields also received 11.2 – 13.4 Mg ha^{-1} compost annually, a common practice in the area. Both types of management also received other fertilizers: nearly all organic fields received a liquid organic fertilizer derived from bloodmeal and feathermeal; nearly all conventional fields received inputs of inorganic N, P, and K mineral fertilizers.

RESULTS AND DISCUSSION

Organically and conventionally managed surface soils (0-10 cm depth) were similar in extractable mineral nutrients (Table 1). Extractable boron and zinc were significantly greater ($P < 0.05$) in organically managed fields, and iron and electrical conductivity were both notably greater ($P < 0.10$, Table 1). None of the soil chemical differences were dramatic until we consider organic C and N, and the biologically labile components. All measures of active C and microbial biomass and activity were significantly and dramatically greater in the organically managed soils. No significant differences were seen in mineral nutrients in the subsurface (20-30 cm depth), although biological differences were generally maintained (Reganold et al. 2010).

Table 1. Selected qualities of surface soils (0-10 cm) in organically and conventionally managed strawberry production fields.

	Organic	Conventional	
Olsen P (mg kg^{-1})	60.9†	64.5	
K (mg kg^{-1})	248	200	
S (mg kg^{-1})	134	119	
Fe (mg kg^{-1})	28.6	26.8	*
Zn (mg kg^{-1})	2.88	1.97	**
B (mg kg^{-1})	0.88	0.74	**
EC mmhos cm^{-1}	2.72	2.18	*
pH	7.05	7.09	
Total bases (cmol (+) kg^{-1})	15.8	14.7	
Total C (g kg^{-1})	10.0	8.3	**
Total N (g kg^{-1})	0.87	0.67	***
Dehydrogenase (µg TPF g^{-1})	1.38	0.65	***
Acid Phosphatase (µg p-nitrophenol g^{-1})	121.5	58.2	***
Mineralizable C (µg g^{-1})	17.7	14.1	***
Microbial C (µg g^{-1})	249	96	***
Cmic / Cmin	16.0	8.6	***

† Treatment averages from Reganold et al. 2010.
* Notably different at P < 0.10.
** Significantly different at P < 0.05.
*** Significantly different at P < 0.01.

Table 2. Selected qualities of strawberry fruits grown in organically and conventionally managed fields, reported by dry weight (DW) and fresh weight (FW).

	Organic	Conventional	
% DM	10.03†	9.26	***
N (%DW)	1.02	1.08	*
N (%FW)	0.105	0.103	
P (%DW)	0.247	0.286	***
P (%FW)	0.026	0.027	
K (%DW)	1.5	1.65	***
K (%FW)	0.154	0.157	
Ascorbic Acid (mg g-1 FW)	0.62	0.57	***
Antioxidant Activity (mmol g-1 FW)	11.9	11	**
Total Phenolics (mg g-1 FW)	1.37	1.24	***

† Treatment averages from Reganold et al. 2010.
* Notably different at P < 0.10.
** Significantly different at P < 0.05.
*** Significantly different at P < 0.01.

The strawberry fruits from organically managed fields had higher percent dry matter (Table 2) and were smaller and slower to rot (Reganold et al. 2010). On a fresh weight basis (for human consumption), there were no significant differences in strawberry mineral contents but ascorbic acid, antioxidant activity, and total phenolic content were greater in organic strawberries. On a dry weight basis (for plant nutrition), the conventional strawberries had significantly more P and K, and notably more N and B.

Consumer and producer reasons for choosing organic range from environmental services to health, profit, and support of local food security. In multiple studies, organic farming practices consistently improved measures of soil quality and often other measures of environmental services. The belief in nutritional benefits is one of the most debated reasons for choosing organically produced foods. Dozens of studies have now compared the nutritional qualities of organically and conventionally raised foods (see reviews Benbrook et al. 2008 and Dangour et al. 2009). Many studies used foods from stores, which fairly represent the consumers' choice but often confound production effects with crop varietal effects. Even among studies using farms or fields in close proximity or matched by soil type, few have considered the effect of crop variety. Varieties within a crop differ in the myriad factors of flavor and other food quality parameters, and react differently to environmental conditions. Therefore, studies must control for crop variety to be considered in the food quality debate. When varieties and soils are well paired, most studies that measure antioxidants and polyphenolics find greater concentrations in organic foods (Benbrook et al. 2008). Approximately one-fourth of such studies find greater N, P, and/or K in conventional fruits and vegetables.

It is often stated colloquially that conventionally raised foods are "pumped up" with salts and water due to greater availability of soluble nutrients in inorganically fertilized soils. Although food quality and soil quality in organic and conventional agriculture have been compared in many studies, few studies combine both types of measures for the same set of well-paired fields. In this study conventionally produced strawberries had a lower dry matter content, across 2 years, 13 field pairs, and 3 varieties of berries (Table 2). Individual extractable nutrients in soils were similar and electrical conductivity, an indication of total ions in solution, was notably greater in organically managed soils. In this study, the common assertion that conventionally grown foods are more watery is supported while the commonly hypothesized cause (more available nutrients and salts) is not clearly supported.

Nutrient density in fruits and vegetables is often lamented to be on the decline in the U.S. (Davis et al., 2004), and this decline tied to the loss of soil organic matter and biological activity. Organic production usually adds large doses of organic material to soil to provide both short- and long-term fertility. Such methods can thereby start to mitigate the gross effects of decades of topsoil organic matter loss within a few years. In this study, although soil organic C and N were 24% and 32% greater, respectively, in organic fields, and most biological activity measures were approximately doubled, differences in food quality were significant but not as dramatic.

This study, like many others, found organic produce to be similar or lower in N, P, and K, and higher in antioxidant content. Considering the wide variety of crops and situations that have been studied, these trends are remarkably consistent if not remarkably large. Also like many others, this study found that organic fertility sources provided similar levels of plant available nutrients and dramatically greater organic matter and biological activities. Organic agriculture has been shown to provide environmental services and protection while producing abundant high-quality foods. While organic methods can substantially improve the quality and functioning of soils, improving the quality of foods and diet will require additional directed efforts. The mechanism(s) whereby antioxidant content of organic foods is increased should be further studied and optimized to support human health as organic agriculture supports soil health.

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Volume 9

MARCH 3-4, 2011
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