Contrasting Soil Management in High Tunnels Versus Field Production

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High tunnel crops and soils are often more intensively managed than field crops. Intensified production may increase soil nutrient removal, tillage and traffic. The effect that this may have on soil quality is uncertain. However, a decline of soil quality has not been confirmed by research. University research and extension studies have mainly focused on crop production methods. Also, most research in high tunnels in the US is still fairly recent. This question of soil quality sustainability becomes more important as existing tunnels age and growers ponder whether to maintain structures in their current location or construct new high tunnels at different locations, and as growers plan to use high tunnels on a larger scale where frequent structure shifting is less feasible.

It is the objective of this research study to determine if the presence of a high tunnel affects soil quality in a silt loam soil after eight years. Because of the design and management of the experiment plots, we were also able to investigate the influence of soil management (i.e. conventional vs. organic management) on soil quality.

High tunnels were established at the Kansas State University Horticulture Research and Extension Center at Olathe, Kansas, in 2002, on a Kennebec silt loam soil that was formerly pasture. Six high tunnels and six field plots have largely been managed with matching crops. Three of the high tunnels and field plots have been managed with organic amendments and three with conventional amendments.

To determine if high tunnels alter soil quality, a comparison was made of soil from high tunnels and adjacent fields. Soil samples representing a high tunnel or field were a combination of five random soil probe collections to the 15-cm depth within crop rows. Chemical indicators of soil quality include pH and salinization. Exclusion of leaching rainfall makes high tunnels susceptible to salinization, so it is advisable to monitor high tunnel salinity.

Because organic matter influences soil structure, nutrient storage, water holding capacity, biological activity, tilth, water and air infiltration, erosion, and even efficacy of chemical amendments made to soil it is commonly used as a biological indicator of soil quality. Soil organic carbon is used to estimate organic matter and in non-calcareous soils organic carbon is equivalent to total carbon

Particulate organic matter (POM) as an indicator of soil quality has the advantage of a faster response to environmental change than soil organic matter as a whole. Particulate organic matter is the labile organic matter of size fraction 53 microm – 2 mm. Particulate organic matter in other research has been correlated to microbial biomass, C and N mineralization, and soil aggregate formation and stability.

Results from our study show that soil salinity was not affected by management (organic vs. conventional) but was higher in the high tunnel plots in 2005. These levels went down between 2005 and 2010 due to a change in watering practices from only using drip tape to using a combination of drip tape and over-head watering. There was also one winter season where the plastic was removed and rainfall was allowed to leach the soil.

Total carbon didn't change significantly between 2005 and 2010, and there was only a slight effect of high tunnel vs. field. However, the organically managed plots in both growing systems had significantly more soil carbon than the conventional treatments. Soil fertility amendments consisted of only mineral fertilizers in the conventional (pre-plant and fertigation) while the organic treatments received annual additions of compost.

The particulate organic matter (POM) carbon levels went up between the two sampling periods in all plots, but this was only statistically significant in the organically managed plots. Like the total soil carbon, levels were significantly higher in the organically managed plots as compared to conventional, and for this fraction of the carbon pool, the high tunnel plots had higher levels than their comparison field plots within the organic system. In 2010, the ratio of the POM to total soil carbon was highest the high tunnel organic plots, second highest in the organic field plots, lower in the conventional high tunnels and lowest in the conventional field plots. The lower levels in the field as compared to the high tunnel may be due to protection from weathering and leaching, even though temperatures are often higher in high tunnels, that could lead to more rapid oxidation of organic matter.

In summary, this replicated field study shows that organic matter levels and particulate organic matter levels continue to go up in high tunnels managed for vegetable production after eight years, especially under organic management. Salinity should be monitored and managed as needed with irrigation and/or occasional exposure to rainfall.

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Table 1. Indicators of soil quality measure in 2010 and 2005 at Olathe KS under high tunnels and adjacent fields with conventional vs. organic management. Statistically significant differences within rows are noted with capital letters, using the Tukey's mean separation test. Significance of the main effects of treatment for high tunnel vs. field, organic vs. conventional, and 2005 vs. 2010 are noted in the three right-hand columns (+ sig at 0.10 level, ** at the 0.01 level and NS = not significant)

Year	2010				2005					Statistical Significant of Main Effects		
Management	Conventional		Organic		Conventional		Organic					
Location	HT	Field	HT	Field	HT	Field	HT	Field	Tukey mean separation	HT vs F	Org vs Conv	2005 vs 2010
pH	7.8	7	7.7	7.6	6.13	5.95	6.29	6.15	0.348	**	**	**
	A	B	A	A	C	C	C	C				
EC, dSm^{-1}	0.16	0.06	0.3	0.06	0.67	0.28	0.68	0.22	0.251	**	NS	**
	B	B	B	B	A	B	A	B				
Total Carbon, $g\ kg^{-1}$ soil	17.51	19.27	22.35	22.41	17.83	19.83	21.43	21.37	1.208	+	**	NS
	C	B	A	A	C	B	A	A				
POM Carbon, $g\ kg^{-1}$ soil	1.65	1.51	4.2	3.02	0.89	1.07	3.05	1.85	1.011	+	**	**
	C	C	A	B	C	C	B	C				
POM C: Total C	0.094	0.078	0.188	0.134	0.05	0.054	0.141	0.087	0.041	**	**	**
	BC	CD	A	B	D	D	BC	CD				

Figure 1. Soil carbon in high tunnels and adjacent fields under conventional and organic management at Olathe, KS, in 2010 and 2005. Total C is indicated by total column height a particulate matter carbon by the shaded cap topping the column.