



# Soil Health Response to Thermal Weed Management in an Organic System



Jill E. Souliere Staples <sup>a</sup>, Kerry Clark <sup>a</sup>, Robert J. Kremer <sup>a</sup>, Kimberly Griffin <sup>a</sup>, and Kristen S. Veum <sup>b</sup>

<sup>a</sup> University of Missouri School of Natural Resources, Columbia, MO; <sup>b</sup> U.S. Department of Agriculture – Agricultural Research Service, Columbia, MO

## Abstract

Tillage is the dominant practice for weed control in organic agriculture; however, tillage reduces soil organic carbon and can alter soil properties which lead to soil degradation and erosion. This study evaluated soil health indicators for two alternative thermal weed control practices in row-crop grain production: propane flame and hot water spray. The study also included between-row mowing and a conventional tillage practice of between-row cultivation for comparison. All four weed treatments were integrated into an organic system that included grain crops consisting of corn (*Zea mays* L.), soybean (*Glycine max* L.), and winter wheat (*Triticum aestivum* L.) in a two year rotation. Other organic practices were utilized for a systematic approach, such as compost application, crimped winter cover crops, and tillage after harvest. The study site was located in central Missouri in Mexico silt loam soil, and indicators analyzed were aggregate stability (AgStab), bulk density (BD),  $\beta$ -glucosidase activity (BG), acid phosphatase activity (AP), phospholipid fatty acid (PLFA) biomass indicators, permanganate oxidizable carbon (POXC), and soil organic matter (SOM). Hot water spray in conjunction with a crimped cover crop had the highest overall soil health indicator values, and with a 15% increase of total PLFA biomass compared to cultivation. Between-row mowing was significant with 70% stable aggregates, and POXC (0.80 g kg soil<sup>-1</sup>). Propane flame had decreased soil quality indicator values and was similar to the cultivation treatment values, exceptions are: although not significant, AgStab, AP, fungi community, total PLFA, and SOM. Hot water spray had significant yield results in soybeans (2,098 kg ha<sup>-1</sup>) a 22% increase from cultivation, but was not as effective in corn. Propane flame has potential in corn (6,643 kg ha<sup>-1</sup>), a 10% decrease compared to conventional cultivation.

## Introduction

- Restriction of herbicide in organic farming leads tillage/cultivation as the dominant practice for reducing weeds, however mechanical disturbance alters many soil properties and decreases overall soil quality.
- Organic producers use multiple practices to obtain goals of soil sustainability, conservation, and productivity. A systematic approach is used as crop rotation, winter cover crops, crimped cover crops, and compost can increase soil microbes, moisture, structure, and nutrients.
- An alternative weed control treatment along with existing sustainable practices can theoretically optimize soil health. The thermal weed management of propane flame and hot water spray has been used effectively to terminate weeds on small scale operations, and in areas sensitive to herbicides. However, it is unclear how differences in these organic weed treatments impact soil health in a cropping system.

Figure 1. Thermal weed control: hot water spray, custom made (top) and propane flamer, Red Dragon KS (bottom)



Figure 2. Effects of thermal weed control treatments on row crop soybeans and corn. Left to right: Hot water, tillage, propane flame



## Objectives

- To evaluate the seasonal (i.e., pre-harvest) effects of alternative weed management practices on soil properties using soil health analysis.
- Organic weed management practices included:
  - 1) Propane flame & hot water spray (Figure 1)
  - 2) Between row mowing & cultivation
  - 3) Crimped cover crops

## Materials and Methods

- The study is located in Boone County, Missouri, USA (N 38.8929, W 92.2010). The predominant soil series is Mexico silt loam. The site consists of 2.89 acres that has been organically certified for the past 6 years.
- The site was divided into 3 plots (0.96 acre) accounting for each crop type, corn, soybean, and wheat. These sections were further subdivided into 4 blocks which had each weed treatment replicated twice.
- A winter cover crop mix and compost was utilized in the fall across the entire study. Depending on the weed treatment the cover crop was terminated by mowing or crimping in the spring.
- After seedling emergence weed treatments were conducted when necessary, on average every 12 days.
- Soil samples were collected pre-harvest from each treatment plot. Sample depth depended on soil analysis; 0-15 cm (AgStab. & fertility), while all the other soil health measurements were 0-5 cm.
- Soil enzymes were conducted following Tabatabai and Bremner (1977) & Eivazi and Tabatabai (1988). PLFA was done following Buyer and Sasser (2012). POXC conducted according to Weil et al. (2003), and AgStab. as reported by USDA Soil Survey Kellogg lab manual (2014).

Figure 3. Effect of weed treatment on PLFA markers (nmol g<sup>-1</sup> soil) across microbial groups. Bars with different letters within a microbial group were significantly different ( $\alpha=0.05$ )

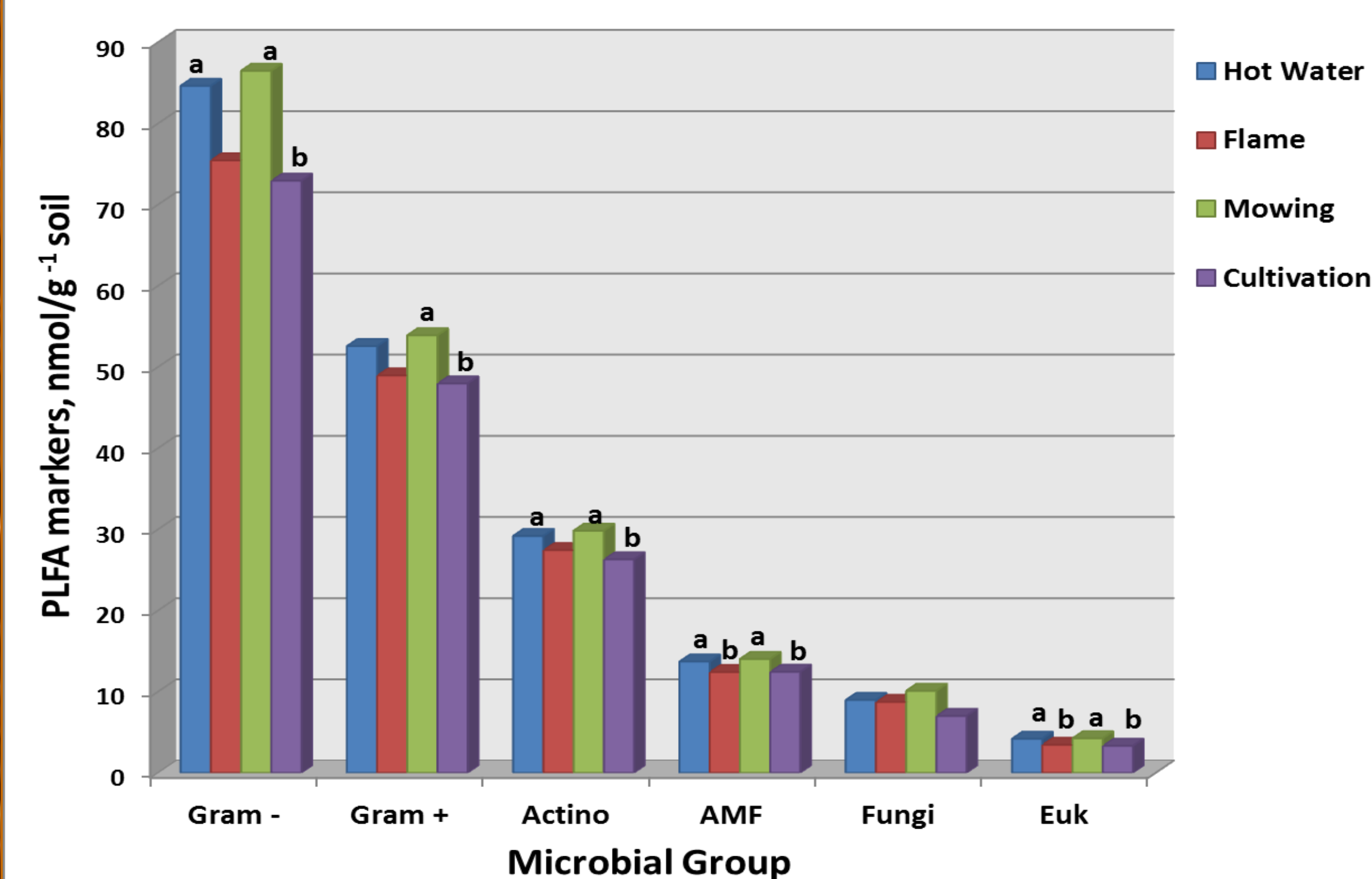


Table 1. Mean soil health properties across yrs. 2015-2016. Values followed by a different lowercase letter within each column are significantly different ( $\alpha=0.05$ )

	2015		2016	
	$\beta$ -glucosidase	Acid Phosphatase	$\beta$ -glucosidase	Acid Phosphatase
	- $\mu$ g PNP g soil <sup>-1</sup> hr <sup>-1</sup>			
Propane Flamer	141.00	288.75 a	184.92	256.25
Between-row Cultivator	143.46	286.02 a	180.29	237.53
Hot Water Sprayer	155.57	328.20 ab	197.29	279.53
Between-row Mower	158.54	356.82 b	188.25	262.52

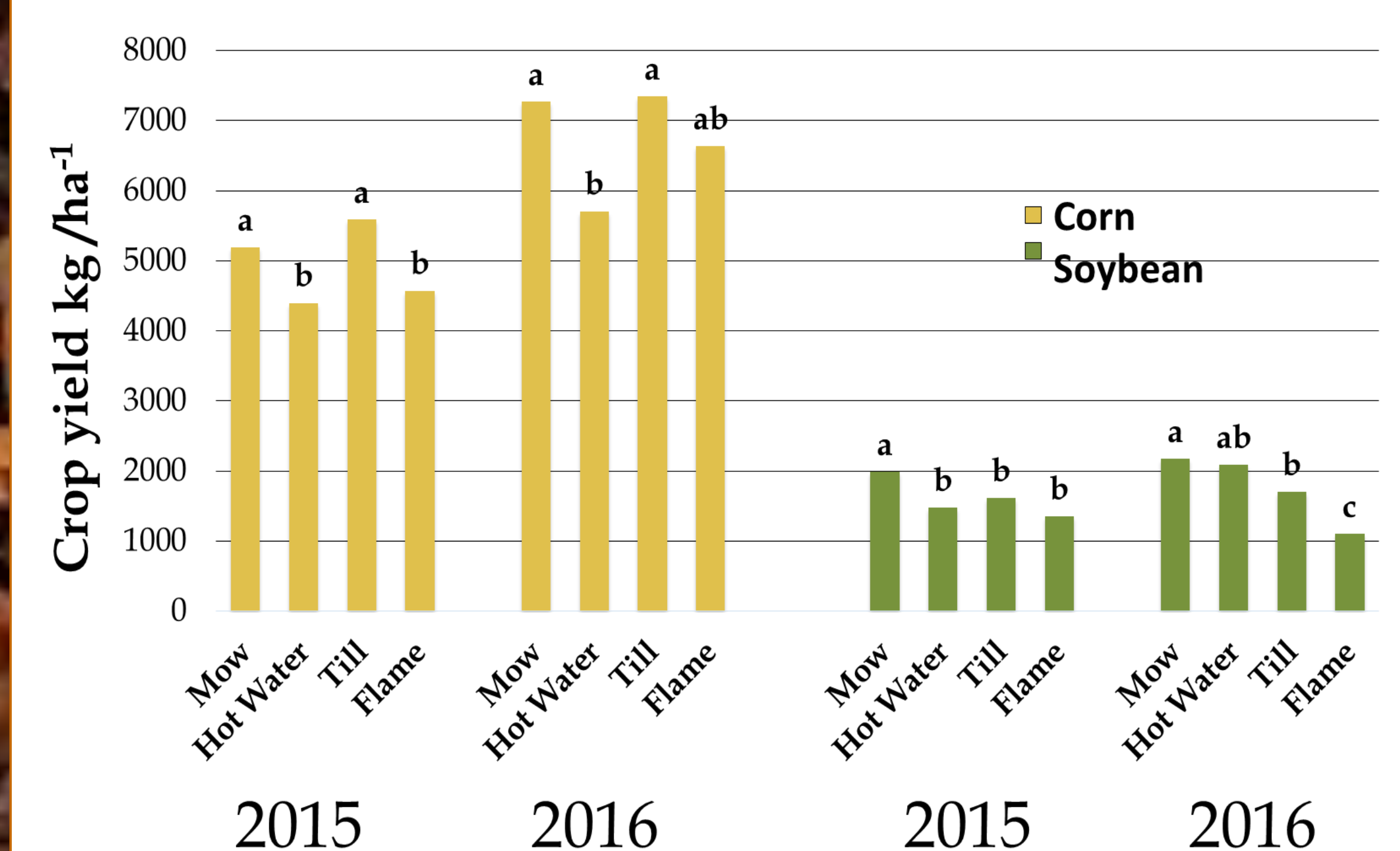
  

	2015		2016	
	POXC	Aggregate Stability	POXC	Aggregate Stability
	g kg soil <sup>-1</sup>	%	g kg soil <sup>-1</sup>	%
Propane Flamer	0.72 a	66.73	0.95	31.17 ab
Between-row Cultivator	0.72 a	63.81	0.97	26.51 b
Hot Water Sprayer	0.74 ab	68.23	1.00	34.63 a
Between-row Mower	0.79 b	69.71	1.02	35.97 a

## Results

- **Weed Treatment Effects on Microbial Community Structure**
  - Significant differences were found for most microbial groups between weed treatment type (Fig. 3).
  - Mowing and hot water treatments consistently had higher concentrations of microbe groups. Total PLFA biomass in hot water and mowing had higher values (15%-20% respectively) compared to cultivation (Fig. 3).
- **Weed Treatment Effects on Soil Enzymes**
  - No significant differences in BG were detected between weed treatments for both years (Table 1).
  - Mowing and hot water treatments had higher values of AP activity (20%-13% respectively) compared to cultivation in 2015 (Table 1).
- **Weed Treatment Effects on Soil Structure**
  - A drastic unexpected decrease (52%) in overall aggregate stability was observed after the first year, which may reflect first year additional and end of season tillage.
  - Cultivation and flame treatments had decreased their Ag.Stab. values by 56% for the second year (Table 1).
- **Weed Treatment Effects on Oxidizable Carbon**
  - No significant differences in POXC were detected for the second year of the study as all treatments increased values 25%-30%, and were relatively similar (Table 1). Probable cause was increased compost rate.
  - Flame and cultivation had the same value for POXC in 2015.
- **Weed Treatment Effects on Crop Yield**
  - Hot water spray had significant yield results in soybeans (2,098 kg ha<sup>-1</sup>), a 22% increase from cultivation (Fig. 4).
  - Flame treatment in corn had a crop yield (6,643 kg ha<sup>-1</sup>) similar to cultivation with only a 10% difference (Fig. 4).

Figure 4. Effect of weed treatment on corn and soybean crop yield (kg ha<sup>-1</sup>) across both years



## Conclusions

- Hot water spray in conjunction with a crimped cover crop had the highest overall soil health indicator values. When a crimped cover crop was absent between row mowing had optimal soil health values.
- Propane flame had decreased soil quality indicator values, and was similar to the cultivation treatment values. However, when a high rate of compost is applied some soil health properties can be increased.
- Mowing with a crimped cover crop had the highest crop yields in both corn and soybeans. Crop species must be considered when applying thermal weed control; as propane flame treatment can be devastating to soybean seedlings, and hot water treatment wasn't as effective in corn.

## Acknowledgements

This project was funded by the USDA program: Organic Agriculture Research and Extension Initiative (OREI). Soil analysis was facilitated by the USDA-ARS Soil Quality lab Midwest cropping unit. Field operations were conducted by the dedicated, and organic passionate Dr. Kerry Clark, Mrs. Kimberly Griffin, and Ricardo Costa Silva.