The effect of soil cation balancing on soil properties and weed communities in an organic rotation

Linder, Katie[1], Mohseni-Moghadam, Mohsen[2], Doohan, Douglas[3]
[1]Graduate Student, [2]Postdoctoral Researcher, and [3]Professor
Department of Horticulture and Crop Science, 1680 Madison Avenue, The Ohio State University, Ohio Agricultural Research and Development Center (OARDC), Wooster, OH 44691.
THE OHIO STATE UNIVERSITY
COLLEGE OF FOOD, AGRICULTURAL, AND ENVIRONMENTAL SCIENCES

ABSTRACT

Many organic farmers in Ohio subscribe to soil balancing, or Base Cation Saturation Ratio (BCSR), to manage soil fertility, weeds and crops. BCSR calls for a balanced soil (~70% Ca, ~10% Mg, ~5%K). However, research has not substantiated this claim. An experiment was initiated in 2014 to evaluate the effect of BCSR on weed and crop communities, and soil properties in a 4-crop rotation. The experimental design is a randomized complete block, with 3 BCSR treatments, limestone, limestone with gypsum, GFF (a commercially-available blend from Green Field Farms Cooperative), plus a non-amended control. Soil was sampled in November 2013 and in September 2014, and analyzed for pH, base saturation and nutrient levels. Results of the 2013 samples were used for prescribing amendments applied in April 2014. Additional amendments were applied in fall of 2014. According to 2014 results, soil balance (defined above) was not achieved with the BCSR treatments. Soil pH, percent calcium and potassium were ideal in the gypsum and limestone plots, but magnesium was too high. In GFF plots, pH and percent calcium were too low, while magnesium was slightly elevated. Percent potassium was within the BCSR range, due to GFF's 0-0-50 component. Aluminum was lower in gypsum and limestone plots, because calcium in these amendments replaces aluminum on soil exchange sites leading to displacement from the root zone. In 2015, we will adjust amendment rates to further balance the soil in treatment plots, and observe the impacts on crop growth and weed communities.

Figure 1. According to practitioners of BCSR, giant ragweed indicates high Mg.

INTRODUCTION

Soil cation balancing is an approach to soil fertility method used by many organic farmers in Ohio. In fact, approximately 55% of the region's organic farmers claim that weeds represent an 'imbalance' in the soil (Zwickle 2011) (Fig. 1). The concept of soil balancing, or Basic Cation Saturation Ratio (BCSR), defines a 'balanced soil' as having a base saturation of 70-75% calcium (Ca), 6-12% magnesium (Mg), and 2-5% potassium (K) (Kopittke & Menzies 2007). Past research on plant nutrition has focused primarily on the "sufficiency level of available nutrients" (SLAN) concept, which guides soil fertility management according to crop requirements and has been shown to be less costly per acre than BCSR (Kopittke & Menzies 2007). However, due to the lack of peer-reviewed literature on soil balancing and the interest of Ohio's organic farmers to use BCSR to control weeds, additional scientific evidence is needed to determine the effects of soil balancing.

An experiment was initiated in spring 2014 to investigate the effects of three soil balancing regimes on soil properties and weed and crop communities in a 4-crop rotation. Our goal is to determine if soil balancing is an effective method of organic weed control. We hypothesize that balancing the soil according to BCSR method standards will provide crops with a competitive advantage over weed species. Only data on the impacts of BSCR on soil chemistry after one field season are presented here.

OBJECTIVES

- To measure the impact of soil amendments on soil base saturation of exchange sites and other soil parameters, such as soil pH, cation exchange capacity (CEC), and macro- and micronutrients.
- To determine how crop productivity and recruitment, growth and fecundity of weeds will be affected by crop rotation and soil amendment treatments.

MATERIALS AND METHODS

Location: OARDC, East Badger Farm.

Experimental design: Randomized complete block with factorial treatment design and 4 replications.

4 crops in rotation: Corn, soybeans, wheat and clover.

4 soil treatments (Table 1): Limestone (LS), gypsum plus limestone (GP+LS), Green Field Farms Cooperative proprietary amendments (GFF) and untreated control (CT).

Soil treatment application dates: 4/24/2014 (all plots), 10/24/2014 (soybean) and 12/5/2014 (remaining).

Soil sampling: 11/5/2013 and 9/18/2014 (Fig. 2).

Soil analyses: pH, base saturation and levels of macro- and micro-nutrients (via Mehlic-3 extraction).

Statistical analysis: PROC GLM, with Fisher's Protected LSD test (5%).

Table 1. List of BCSR treatments and application times and rates.

Treatment	Product	Spring rate (kg ha-1)	Fall rate (kg ha-1)
LS	Calcium magnesium carbonate*	2152	0
GP+LS	Calcium sulfate	2578	2241.7
	Calcium magnesium carbonate*	2152	0
GFF	Soft rock phosphate (0-3-0)	560.4	560.4
	Sulfate of potash (0-0-50)	224.2	0
	Aragonite	448.3	224.2
	Flora-Stim (microorganisms)	448.3	448.3
	Compost	1120.9	1120.9
	Calcium carbonate**	0	0
	Calcium sulfate	0	448.3
	Kelp	0	56
	Molasses	0	56
	Boron	0	22.4
	Zinc	0	11.2
	Copper	0	5.6

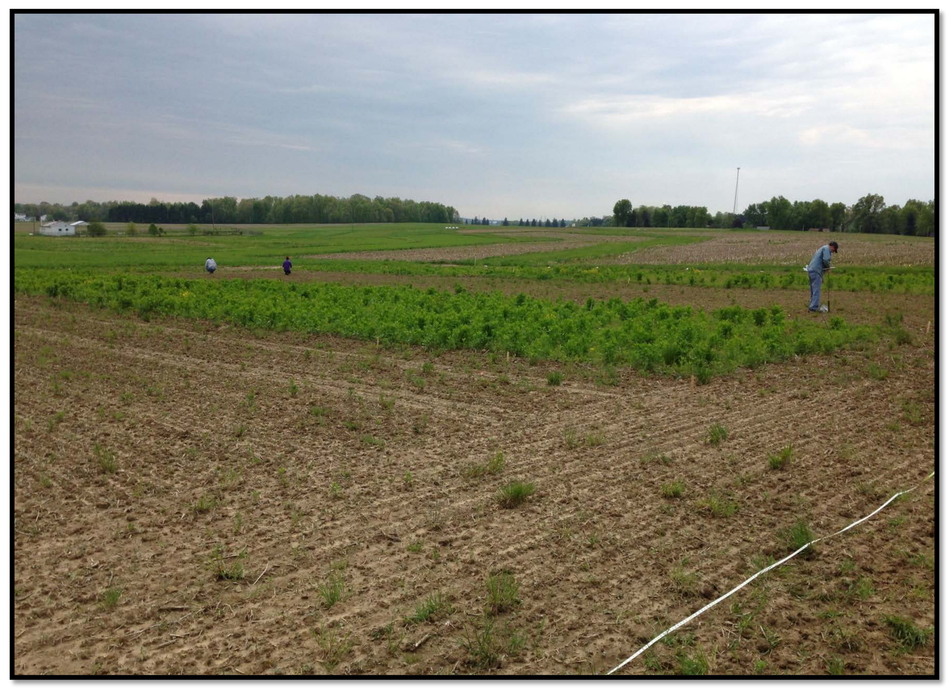

Figure 2. Soil samples being taken at the East Badger field in Wooster, OH.

RESULTS

Table 2. pH, CEC and base saturation of fall 2014 soil samples.

Treatment	pH	CEC	Ca (%)	K (%)	Mg (%)
CT	6.05 c	7.34 a	59.41 b	3.65 b	17.74 b
GFF	6.09 c	7.29 a	60.01 b	5.06 a	17.98 b
GP+LS	6.44 b	6.86 a	72.14 a	3.54 b	22.66 a
LS	6.63 a	6.48 a	69.61 a	4.14 b	25.45 a

Soil pH and base saturation (Table 2):

- Soil pH was highest in the LS treatment and lowest in the GFF and control treatments.
- % Ca was near or within BCSR range (~70%) in LS and GP+LS plots, but below range in the GFF and control plots.
- % Mg was above the BCSR range (~10%) in all plots, but was highest in the plots treated with dolomitic limestone (LS).
- % K was within the BCSR range (~5%) for all plots, and was highest in the GFF plots due to the added sulfate of potash (0-0-50).

Table 3. Macro- and micro-nutrient concentrations in fall 2014 soil samples.

Treatment	P (ug/g)	S (ug/g)	Al (ug/g)	Fe (ug/g)	Zn (ug/g)
CT	46.89 a	34.04 c	783.03 a	135.61 a	3.84 a
GFF	46.74 a	37.61 b	797.59 a	134.24 a	3.73 ab
GP+LS	30.78 b	60.67 a	707.15 b	117.44 b	2.96 c
LS	41.74 ab	34.84 bc	722.34 b	128.68 a	3.20 bc

Macro- and micro-nutrients (Table 3):

- Aluminum (Al) was lowest in the GP+LS and LS plots.

Macro- and micro-nutrients (Table 3) (cont'd.):

- Phosphorus (P), iron (Fe) and zinc (Zn) were lowest in the GP+LS plots and highest in GFF and CT plots.
- Sulfur was highest in GP+LS plots and lowest in CT plots.

CONCLUSIONS AND DISCUSSION

- Soil balancing levels have not yet been achieved in any of the treatments.
  - Calcium levels were closest to BCSR levels in the plots treated with gypsum plus limestone, or limestone alone.
  - Potassium levels were within the BCSR range in the GFF plots.
  - However, magnesium levels were too high for the BCSR in all of the treatments.
- Aluminum levels are likely lower in the gypsum plus limestone plots due to calcium's ability to displace aluminum from soil exchange sites, which removes aluminum from the root zone.
- Due to the on-going status of this research, it is too soon to draw conclusions about soil balancing on weed and crop populations.

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