Evaluating *Brassica* Cover Crops and Reduced Tillage On-Farm for Soil-Borne Disease Mitigation and Soil Health Improvement

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INTRODUCTION

Certain Brassicaceae species produce glucosinolate compounds that have shown promise in laboratory studies to suppress a broad range of soil-borne crop pathogens ("biofumigation"; 1,2). Biofumigation can be facilitated in the field by 1) chopping *Brassica* cover crop biomass to release glucosinolates and myrosinase enzymes from plant cells, and then 2) incorporating it into moist soils where glucosinolates hydrolyze to produce isothiocyanate gas, a broad spectrum fumigant (Fig. 1). Consequently, *Brassica* cover crops and biofumigation are increasingly popular with growers looking to mitigate soil-borne crop disease issues.

Biofumigation field trial results to-date have been variable though (3,4), suggesting circumstantial and/or mis-management factors negatively interact with biofumigation potential. Other potentially beneficial default effects of these cover crops on soil health (5) are also not well understood. General soil health improvement is also generally recognized as a component of soil-borne pathogen mitigation; cover cropping and reduced tillage are fundamental approaches increasingly adopted by growers to help improve soil health.

In the northeastern US, many Cucurbitaceae and Solanaceae crop growers battle blight from the tenacious soil-borne pathogen *Phytophthora capsici* (Fig. 2, left); this pathogen thrives and spreads in water and can be devastating in wet years. Previous research by McGrath (6) illustrated that reduced tillage treatment (Fig. 2, center, right) significantly reduced fruit blight from *P. capsici*. We hypothesized that an integrated approach using biofumigation with *Brassica* cover crops and reduced tillage could have an additive effect on mitigating blight from *P. capsici*.

Biofumigation and reduced tillage treatments, on-farm trial site in NY, 2015

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MATERIALS AND METHODS

Figure 1. *From left to right- 'Caliente 199' biofumigation-specific mustard cover crop, flail chopped and incorporated mustard biomass, and roller-packed moist soils with mustard biomass for facilitating in-field biofumigation. Brassica-produced glucosinolates and enzymes are released from plant cells by chopping biomass, and incorporating into soils moist soils where contact with water produces fumigant isothiocyanate gases.*

We conducted a series of two-year field study in the Hudson Valley and Long Island regions of New York, USA to investigate the 1) soil-borne disease mitigation and 2) soil health management potential of *Brassica* cover crops used as a component of a two-year soil health management program that also integrated reduced tillage practices with rolled rye cover crops (Fig. 2, center, right).

Figure 2. *From left to right- Phytophthora capsici-infected pumpkin (Cucurbita pepo, fruit blight) following contact with soil-residing inoculum; pumpkins planted with reduced till methods into rolled rye (Secale cereale) cover crop; mature pumpkin atop rolled rye mulch in reduced till field.*

Four growers with widespread natural infestations of the soil-borne pathogen *P. capsici* established field-scale, on-farm "grower standard practice" control plots adjacent to plots where *Brassica juncea* (v. 'Caliente 199') cover crops were used for biofumigation in year 1 (Fig. 3, left), and reduced tillage (RT) into rolled rye (*Secale cereale*) cover crops was used in year 2. A plot-scale study with correspond -ding treatments was conducted simultaneously at Cornell's Long Island Horticultural Research and Extension Center.

Phytophthora capsici-susceptible cucurbit (*Cucurbita pepo*) cash crop yield response and cover crop biomass C and N was measured each year. Soil infiltration rates and Cornell Soil Health assays were taken after cucurbit harvest in year 2 (Fig. 3, center, right).

Figure 3. *From left to right- single on-farm replicate of biofumigation vs. "grower standard practice" control treatments; harvesting butternut squash yield (Cucurbita pepo) from on-farm reduced tillage plot; taking soil infiltration rates in reduced tillage plot.*

RESULTS AND DISCUSSION

In on-farm trials, evidence of treatment effects on yield and soil health parameters lacked ($p > 0.10$), with *P. capsici* blight incidence absent or very low in all treatments, sites, and years (Fig. 4).

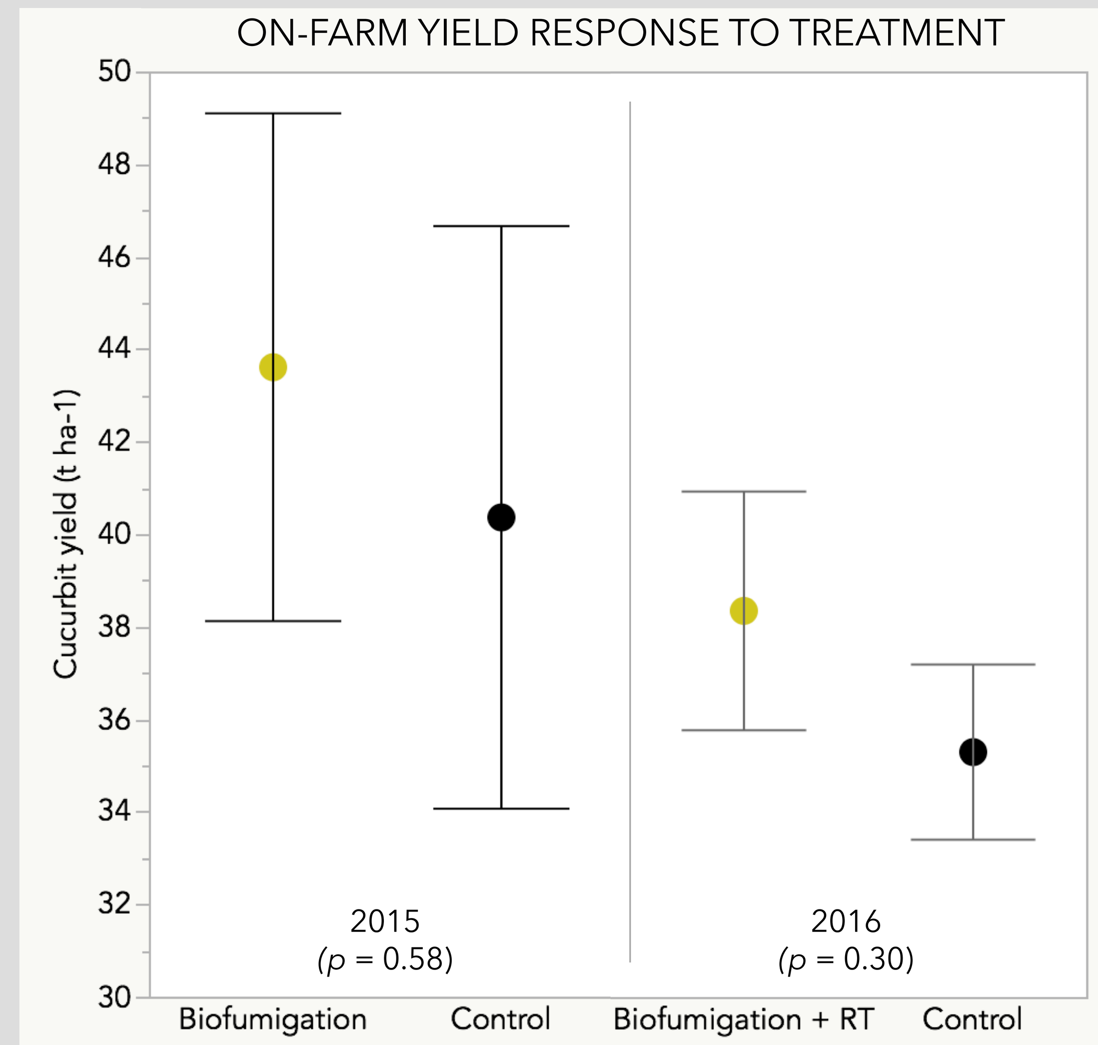

Figure 4. *On-farm cucurbit cash crop (Cucurbita pepo) yield response to biofumigation treatment alone in 2015 (n=4) and integrated biofumigation + reduced tillage treatment 2016 (n=8) vs. grower standard control treatments.*

In corresponding plot-scale trials on Long Island, treatment differences in year 2 were evident but were attributed to reduced weed control in RT plots rather than blight, which was absent.

Mean cover crop nitrogen and carbon returned to soils following biofumigation and rolled rye cover crops in RT treatments were ~3.5-5x greater than controls (Fig. 5).

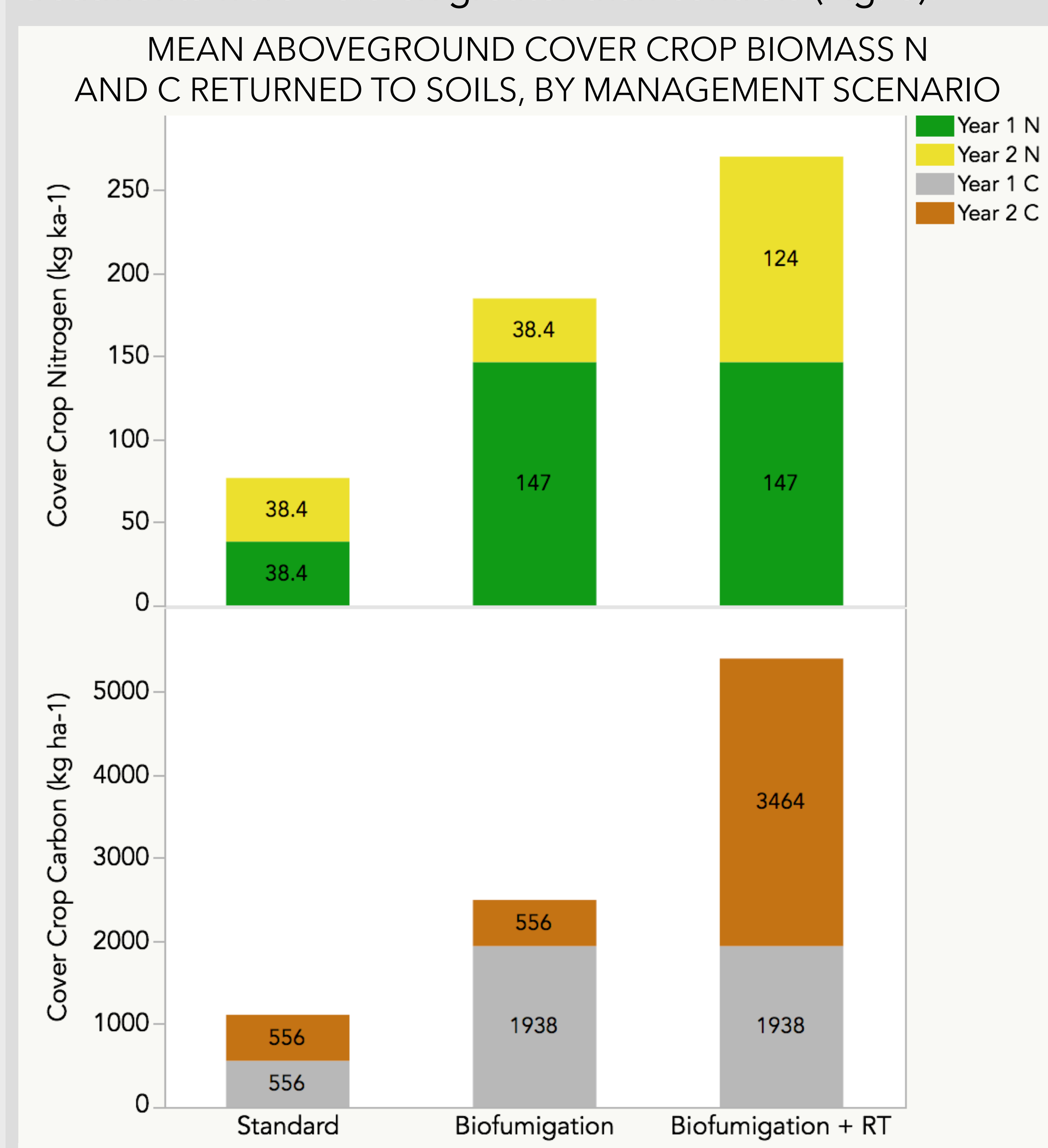

Figure 5. *Average aboveground cover crop N and C returned to soils, by different 2-year cover crop management scenarios; 1) standard overwinter rye (Secale cereale) cover crop (Oct.-April); 2) Brassica cover crop biofumigation in year one followed by standard overwinter rye; 3) Brassica cover crop biofumigation followed by rye cover crops grown for a rolled mulch (Oct-May) for a reduced tillage planting.*

These returns to soils may be noteworthy due to a positive association found between soil infiltration rates and soil organic matter (SOM) levels (r^2=0.87, $p < 0.0001$, Fig. 6) in the soil health assay data. In corresponding plot-scale trials in Long Island, biofumigation + RT treatments had greater ($p < 0.10$) soil respiration ratings than treatments with conventional tillage.

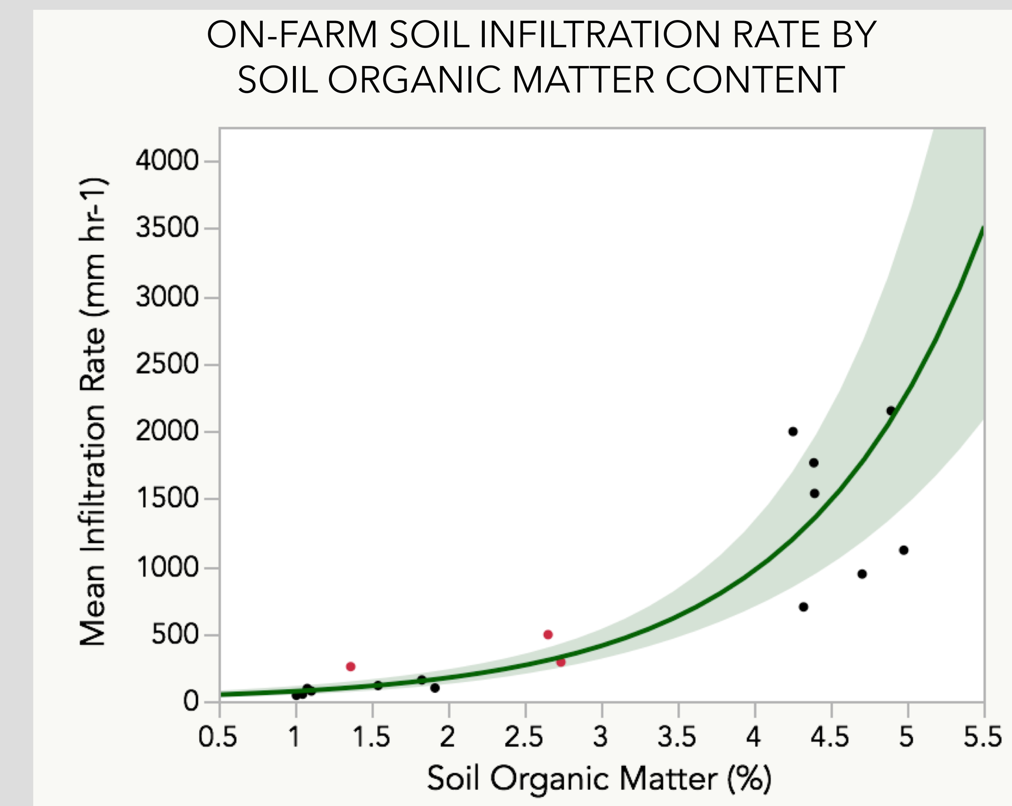

Figure 6. *Positive relationship between measured average on-farm soil infiltration rates and soil organic matter content from soil health assay data (transformed log fit, r^2 = 0.87, $p < 0.0001$). An inverse, negative relationship between infiltration rates and % sand in soils was also evident (transformed log fit, r^2 = 0.83, $p < 0.0001$).*

CONCLUSIONS

Refined cover crop management and longer-term system studies may be in order. Both cucurbit growing season conditions were not conducive to *P. capsici* infection, and soil health parameters were largely unaffected by only two years of treatments. The latter is despite promising biomass C and N returns to soils from cover crops in biofumigation + RT treatments, which could increase SOM over time to benefit soil infiltration rates. Rye cover crop biomass thresholds may also be important in the RT component, as blight was only found in plots with < 3000 kg ha^{-1} biomass C.

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