Carbon and nutrient cycling and beneficial microorganisms in organic and conventionally managed blueberry soils in Michigan, USA

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Introduction

Interest in organic blueberry production has increased in recent years due to price incentives and other reasons. Less than 0.3% of commercial blueberries in Michigan were certified organic in 2008. Some organic blueberry growers reported reduced vigor and yields immediately after the organic transition, followed by rebounding growth and productivity after several years. This response may be due to shifts in soil biology due to a change in management practices. In annual cropping systems, organic management promotes soil nutrient cycling and microbial abundance compared to conventional management. However, wet, acidic, high organic matter blueberry soils might not respond to organic and conventional management in the same way as other agricultural soils. Our objectives were to:

- Determine ecosystem-level responses of soil carbon and nutrient cycling and microbial communities to organic and conventional management practices.
- Assess mycorrhizal colonization in organic and conventional Michigan blueberry fields and their relation to other field characteristics.

Figure 1. Typical conventional (left) and organic (center) blueberry fields, and blueberries ready for harvest.

Materials and methods

Eight pairs of commercial organic blueberry fields were matched to conventional fields on the same soil series. Samples were collected in autumn of 2008 and on three dates in 2009. Labile and slow soil C pools, soil enzyme activity, short-term mineralizable soil C and N, total soil C and N, populations of cultivable beneficial soil microbes, and ericoid mycorrhizal colonization were determined using published methods.

Management, depth, and date effects were subjected to mixed-model repeated measures ANOVA. Pre-planned contrasts were used to compare the effects of management at each soil depth interval. Principal component analysis was performed on all measured biological variables and specific (per unit SOM) enzyme activities using mean values of each field at 0- 30-cm soil depth across sampling dates.

Results

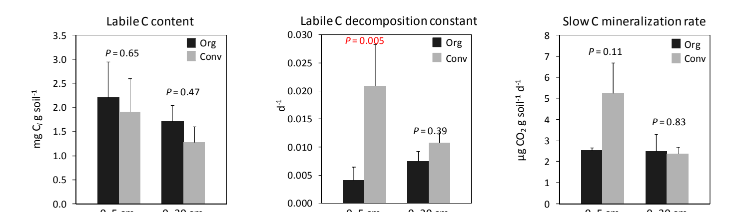


Figure 2. Labile C content, decomposition constant and slow C mineralization at 0-5 and 0-30 cm soil depth. Significant ($p < 0.05$) differences between organic and conventional fields at each soil depth interval are highlighted in red.

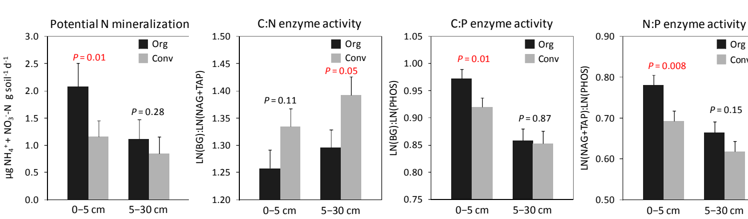
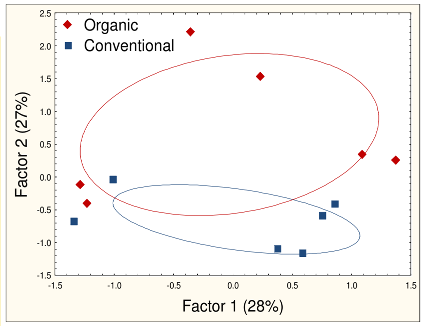
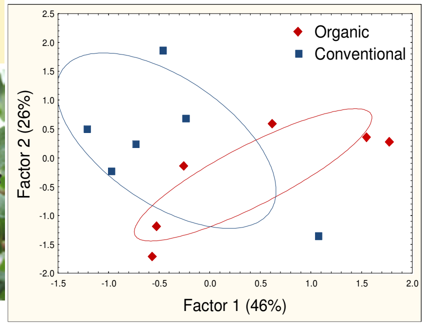


Figure 3. Potential N mineralization rate and C:N, C:P, and N:P enzyme allocation ratios at 0- 5- and 5- 30-cm soil depth. Significant ($p < 0.05$) differences between organic and conventional fields at each soil depth interval are highlighted in red.



	Factor 1	Factor 2
β-D-1,4-glucosidase	0.96	0.07
β-D-1,4-cellobiosidase	0.92	0.21
β-1,4-N-acetylglucosaminidase	0.73	0.56
Tyrosine aminopeptidase	0.16	-0.18
Acid phosphatase	0.62	-0.57
Phenol oxidase	0.11	-0.30
Peroxidase	0.69	-0.18
Soil respiration	0.80	0.46
Ericoid mycorrhizae	-0.69	0.61
Dark septate endophytes	0.31	-0.04
Streptomyces spp.	0.14	0.75
Bacillus spp.	0.16	0.73
Trichoderma spp.	0.06	0.75
Fungi	-0.17	0.55
Bacteria	0.12	0.72
Fluorescent *Pseudomonas* spp.	0.14	0.63

Figure 4. Principal component analysis of biological variables at 0-30-cm soil depth in organic (red) and conventional (blue) fields. Ellipses include 95% of values on each axis. Factor score coefficients contributing > 0.6 to a factor are highlighted in red..



	Factor 1	Factor 2
β-D-1,4-glucosidase	0.89	0.34
β-D-1,4-cellobiosidase	0.88	0.21
β-1,4-N-acetylglucosaminidase	0.86	0.12
Tyrosine aminopeptidase	0.64	0.02
Acid phosphatase	0.29	0.61
Phenol oxidase	-0.10	0.90
Peroxidase	0.40	0.81
Soil respiration	0.86	0.26

Figure 5. Principal component analysis of specific (per unit SOM) enzyme activity at 0-30-cm soil depth in organic (red) and conventional (blue) fields. Ellipses include 95% of values on each axis. Factor score coefficients contributing > 0.6 to a factor are highlighted in red. The conventional outlier is a field with a heavy layer of wood mulch.

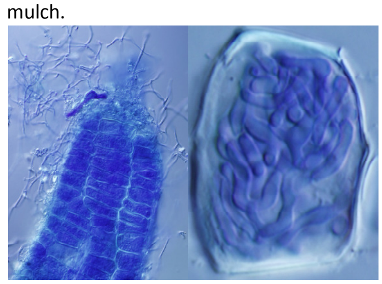


Figure 6. Left: blueberry root. Colonized by ericoid mycorrhizal fungi Right: coiled fungal hyphae within a mycorrhizal cell.

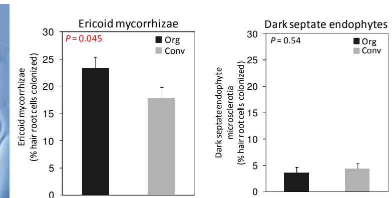


Figure 7. Ericoid mycorrhizal (left) and dark septate endophyte (right) colonization of organic (black bar) and conventional (grey bar) blueberries in Michigan, mean of three dates in 2009.

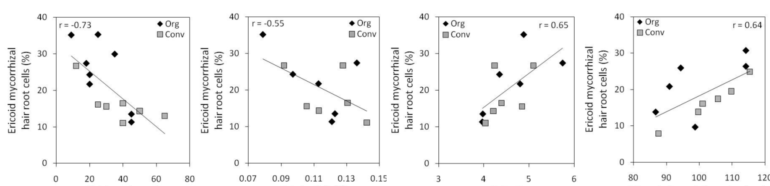


Figure 8. Correlations between ericoid mycorrhizal colonization (y-axis) and field characteristics (x-axis).

Conclusions

- Organic and conventional blueberry soils do not differ significantly in labile C content but conventional management accelerates decomposition of labile C and tends to enrich slower cycling soil C pools.
- Although management did not affect the activity of individual soil enzymes, transition to organic management shifted N:P enzyme allocation towards acquisition of N and increased the rate potential N mineralization by two-fold.
- Microbial communities in organic and conventional fields tend to diverge with as biological activity increases. Patterns of specific C, N, and P enzyme activities between management types suggest alteration in soil organic matter quality and resource availability occurs following the transition to organic management.
- Ericoid mycorrhizal colonization is generally higher in organic fields, inversely related to field age and total soil N, and positively associated with soil pH and mean hair root diameter in commercial blueberry fields in Michigan. The causative factors underlying these relationships are not completely understood and need further study.

Acknowledgements

We acknowledge the support of grower collaborators and USDA NCR-SARE.