Influence of Management and Temporal Crop Diversity on Soil Organic Carbon and Soil Structural Stability in Long-Term Integrated Nutrient Management Systems

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Background

- Understanding processes that ameliorate cropping system productivity and sustainability is particularly important in intensively managed row crop systems.
- Integrated nutrient management is perceived as one way of achieving sustainable intensification (Snapp et al., 2010).
- Soil organic carbon accrual and soil stabilization are among the key indicators of agro ecosystems health. However these have rarely been determined along a long term temporal crop diversity gradient in integrated nutrient management systems.

Fig. 1. The Living Field Laboratory Long-term trial, Kellogg Biological Research Station (KBS_LTER), Hickory Corners, Michigan

Objectives

The objectives of the study were to:

i) determine long term soil structure stability effects of crop bio-diversification in an integrated compost and integrated fertilizer management using water stable aggregates as indicators.

ii) quantify measures of labile C to determine long term responses of integrated nutrient management and temporal crop bio diversification.

iii) ii) examine relationship between labile C soil measures and structural stability in fine loamy mixed, semi active, mesic Typic Hapludalf soils of the long term trial.

Research Questions

Question 1: What are the long term effects of integrated nutrient management systems to soil structural stability?

Question 2: What effects does temporal crop biodiversity have on agro ecosystem function in integrated nutrient management systems?

Hypotheses

1. Integrated compost management will be associated with increased soil structural stability than integrated fertilizer management.
2. Increasing crop biodiversity will enhance soil C accrual reflected by labile C measures in both systems.

Methods

We investigated the role of management and temporal crop bio-diversification through the manipulation of crop diversity in a 20 year study located at Kellogg Biological Station, southwest Michigan.

Treatments included:

1. Continuous monoculture of corn (C)
2. Corn-soy bicultural (CS)
3. Corn-soy-wheat triculture (CSW)
4. Polyculture of corn-soy-wheat with a cover crop (CSWco)

We quantified Soil Organic Carbon (SOC), labile soil organic carbon (Permanganate Oxidizable Carbon – POXC) and water stable aggregates at 3 different depths (0-5, 5-20 and 20-25 cm) .

Experimental design

Split plot, randomized complete block with 4 replications

Main plots within blocks were Integrated Fertilizer (IF) and Integrated Compost (IC)

Results

Table 1. Influence of Management and Crop Diversity on Soil Characteristics in the LFL at KBS_LTER in 2013

Soil properties (mean ± standard error) of soils sampled to the depth of 0-25 cm in the LFL in 2013

Management	Crop Diversity	Description	pH	SOC %	POXC mg kg^{-1}	WSA %
Integrated Compost						(2000 µm)
	Monoculture	Continuous Corn (CC)	7.63 ± 0.06	0.90 ± 0.18	375 ± 56	19.23 ± 0.45
	Biculture	Corn-Soy (CS)	7.74 ± 0.03	1.01 ± 0.13	341 ± 48	21.13 ± 0.80
	Triculture	Corn-Soy-Wheat (CSW)	7.41 ± 0.15	1.02 ± 0.14	391 ± 46	24.43 ± 1.02
	Polyculture	Corn-Soy-Wheat+cover (CSWco)	7.77 ± 0.04	1.20 ± 0.13	438 ± 55	32.40 ± 0.85
Integrated Fertilizer						
	Monoculture	Continuous Corn (CC)	6.67 ± 0.10	0.64 ± 0.11	271 ± 37	16.21 ± 1.17
	Biculture	Corn-Soy (CS)	7.09 ± 0.09	0.75 ± 0.14	347 ± 27	18.23 ± 0.71
	Triculture	Corn-Soy-Wheat (CSW)	7.00 ± 0.08	0.93 ± 0.09	323 ± 31	21.71 ± 0.63
	Polyculture	Corn-Soy-Wheat+cover (CSWco)	6.89 ± 0.07	0.86 ± 0.12	348 ± 35	25.42 ± 0.69
ANOVA	*P-value*					
Management (M)			<0.0001	0.0198	0.0097	0.014
Diversity (D)			NS	NS	NS	<0.0001
M x D			0.0328	NS	NS	0.0225

Changes in SOC along the depth profile in integrated compost and fertilizer management systems at KBS

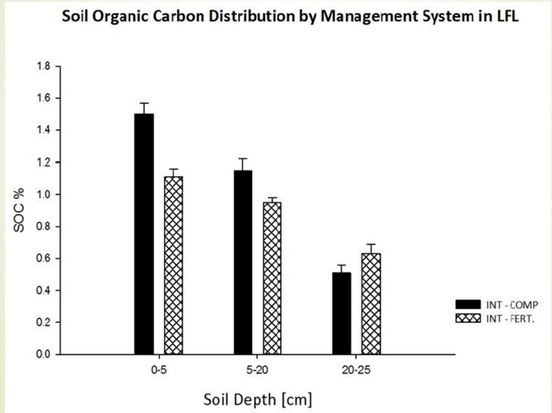

Fig. 2. SOC distribution across Management systems in the LFL (KBS_LTER), Michigan

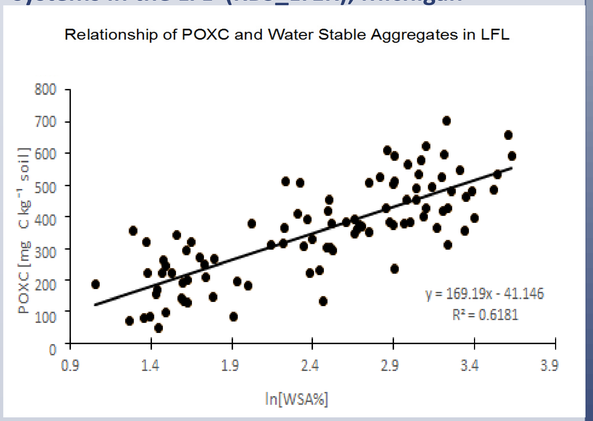

Fig. 3. Relationship of POXC and WSA (2000µm)

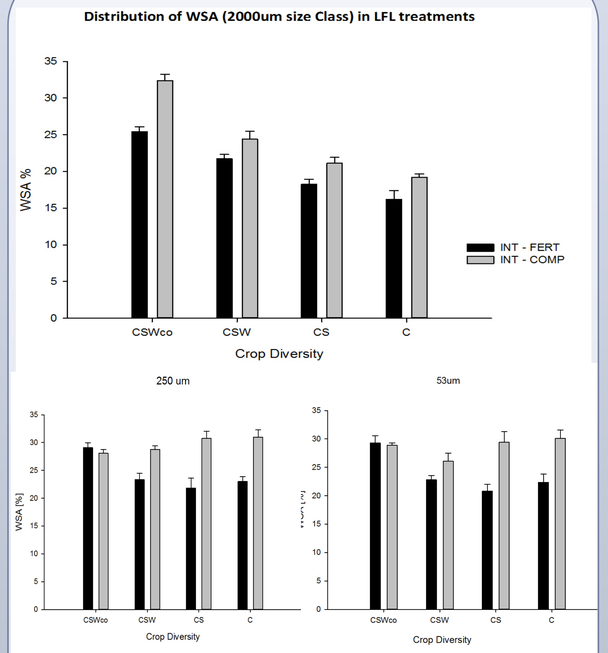

Figure 3A-C. Distribution of WSA in different aggregate class sizes in LFL treatments (0-5 cm Depth).

Conclusion

Results indicated that POXC and water stable aggregate size fractions responded to long-term treatment differences . Over the 20 year period, the least diverse system (C) had reduced macro aggregate stability compared to the polyculture, in both management systems. Of all measures when compared at the same depth, POXC and intra-aggregate carbon were moderate predictors of water stable aggregation across all size fractions (r^2 =0.62 , 0.42 respectively).

References

Snapp, S.S., L.E. Gentry and R. Harwood. 2010. Management intensity - not biodiversity - the driver of ecosystem services in a long-term row crop experiment. *Agriculture, Ecosystems & Environment* 138(3-4):242-248

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