Influence of Nutrient Management and Rotational 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.
- Cropping system productivity and sustainability are highly dependent on soil organic matter dynamics (Snapp et al., 2010).
- Soil organic carbon accrual and soil stabilization are among the key indicators of agro ecosystems productivity. However, these have rarely been determined in long term rotational crop diversity gradients in integrated nutrient management systems. This study conducted in LFL of the KBS_LTER in 2013 aimed at addressing this research gap.

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) 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 rotational crop diversity have on agro ecosystem function in integrated nutrient management systems?

Hypotheses

1. Integrated compost management will be associated with increased soil structural stability compared to integrated fertilizer management.

2. Increasing rotational biodiversity will enhance aggregate stability and soil C accrual reflected by various 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 biculture (CS)

3.Corn-soy-wheat triculture (CSW)

4.Polyculture of corn-soy-wheat with two cover crops (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}
Integrated Compost					
	Monoculture	Continuous Corn (CC)	7.63 ± 0.06	0.90 ± 0.18	375 ± 56
	Biculture	Corn-Soy (CS)	7.74 ± 0.03	1.01 ± 0.13	341 ± 48
	Triculture	Corn-Soy-Wheat (CSW)	7.41 ± 0.15	1.02 ± 0.14	391 ± 46
	Triculture+cover	Corn-Soy-Wheat+cover (CSWco)	7.77 ± 0.04	1.20 ± 0.13	438 ± 55
Integrated Fertilizer					
	Monoculture	Continuous Corn (CC)	6.67 ± 0.10	0.64 ± 0.11	271 ± 37
	Biculture	Corn-Soy (CS)	7.09 ± 0.09	0.75 ± 0.14	347 ± 27
	Triculture	Corn-Soy-Wheat (CSW)	7.00 ± 0.08	0.93 ± 0.09	323 ± 31
	Triculture+cover	Corn-Soy-Wheat+cover (CSWco)	6.89 ± 0.07	0.86 ± 0.12	348 ± 35
ANOVA	P-value				
Management (M)			<0.0001	0.0133	0.0097
Diversity (D)			NS	NS	NS
M x D			0.0328	NS	NS

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

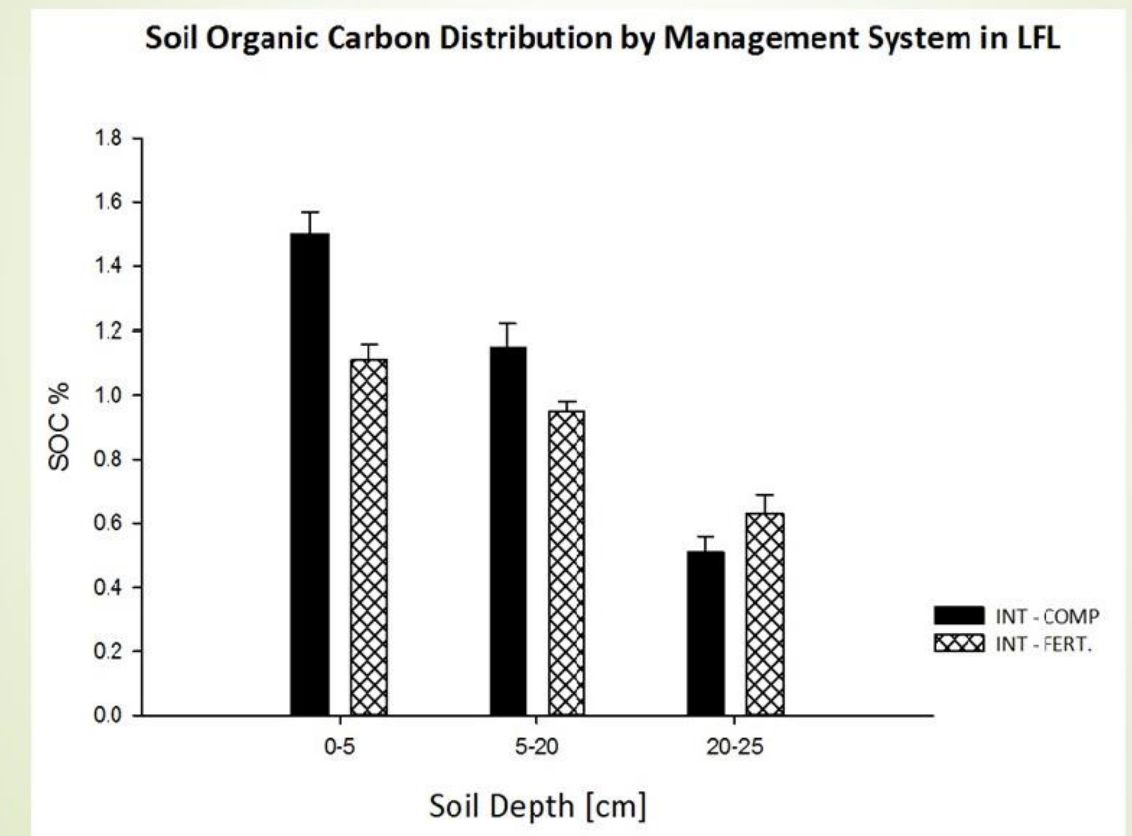

Fig. 2. SOC distribution across Management systems in the LFL (KBS_LTER), Michigan

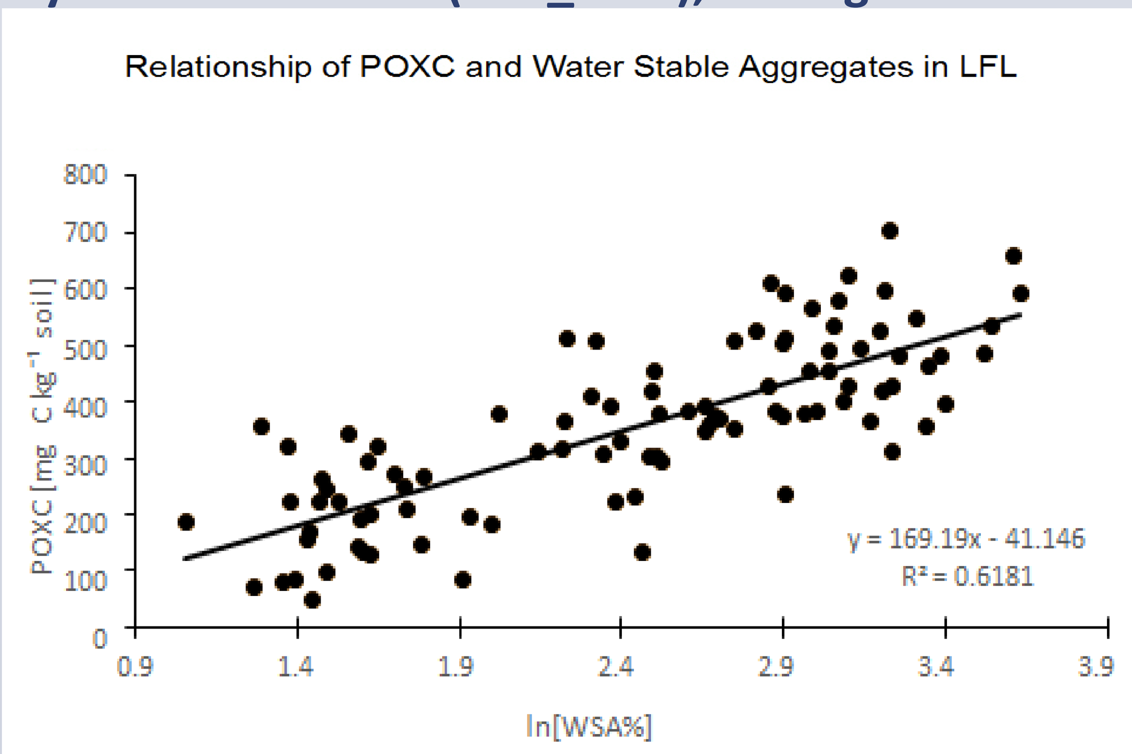

Fig. 3. Relationship of POXC and WSA (2000µm)

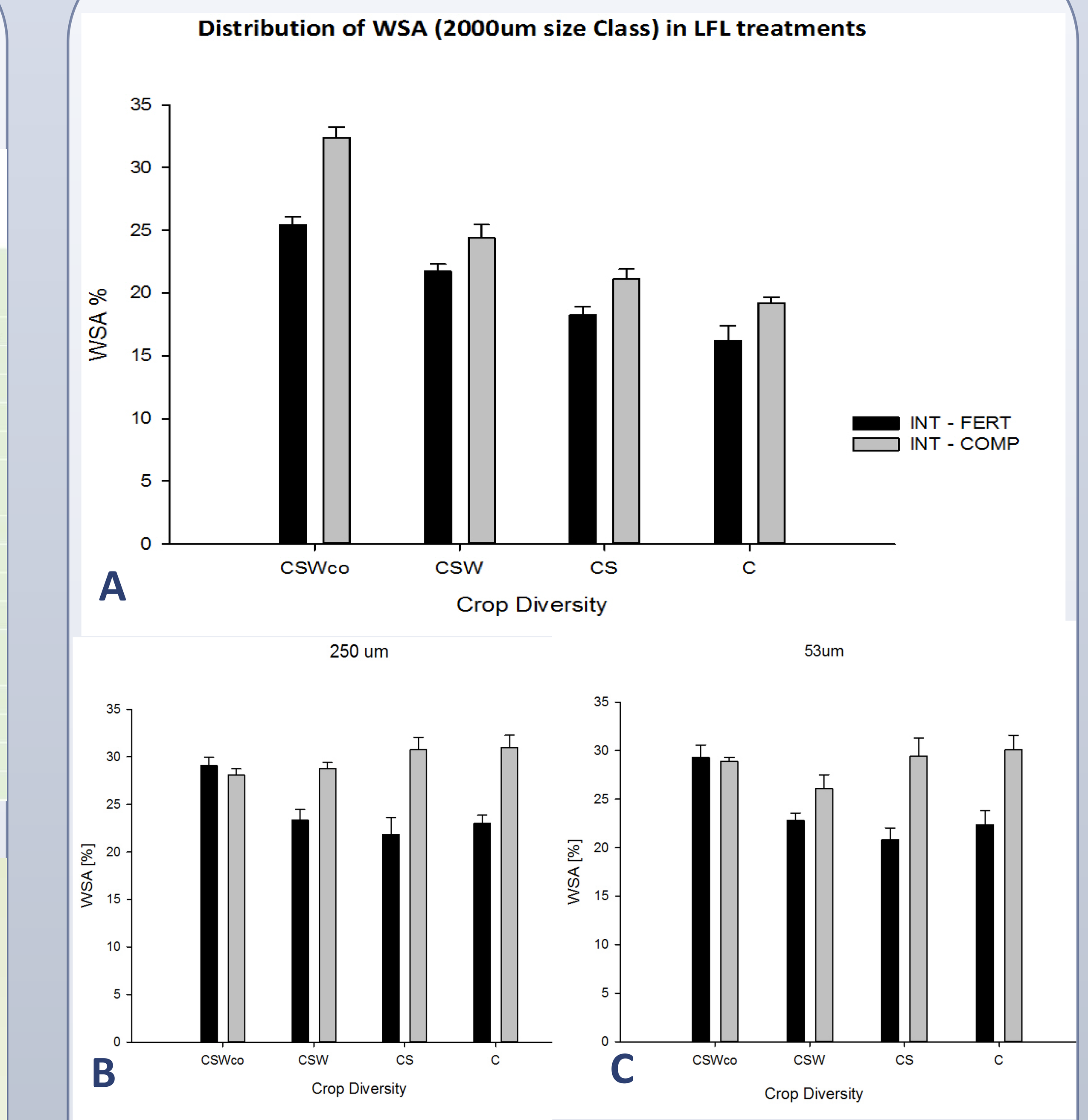

Figure 3A-C. Distribution of WSA in different aggregate class sizes in LFL treatments (0-5 cm Depth).

Conclusion

Results indicated that POXC and water stable aggregate size fractions responded to long-term treatment differences. Over the 20 year period, management had a greater influence with IC as the better system. The least diverse system (C) had reduced macro aggregate stability compared to rest of the treatments, in both management systems. Of all measures, SOC and POXC were moderate predictors of aggregate stability across the plow depth profile (0-25 cm).

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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