Nutrient cycling on organic farms across a gradient of soil organic matter in Yolo Co., California: On-farm research to improve nitrogen availability and retention

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I. Supplying N and building SOM on organic farms

- By increasing renewable organic matter inputs to soil, organic farming can store carbon, support an active microbial community, and increase nitrogen retention, decreasing NO_3^--N pools and limiting potential greenhouse gas emissions. Active soil microbes also liberate nitrogen and other nutrients from SOM and make them available for crops to increase yields. (Fig 1)
- In practice, however, achieving higher SOM, high N availability, N retention and high crop yields, can be challenging, given the complexity of plant-soil-microbe N cycling. On-farm research is needed to improve the knowledge capacity required to manage these complex systems.
- Research at the landscape scale (i.e. across many farms) is particularly important because farms differ according to soil type, management practices, and market influences. Here, we examine organic Roma-type tomato fields across a gradient of soil organic matter in Yolo County, CA.

- Question 1: In planning for climate change, what benefits are provided by reliance on renewable inputs (not based on fossil-fuels)?
- Question 2: How does landscape-level variation in nutrient cycling on organic farms inform the potential for reliance on renewable inputs?

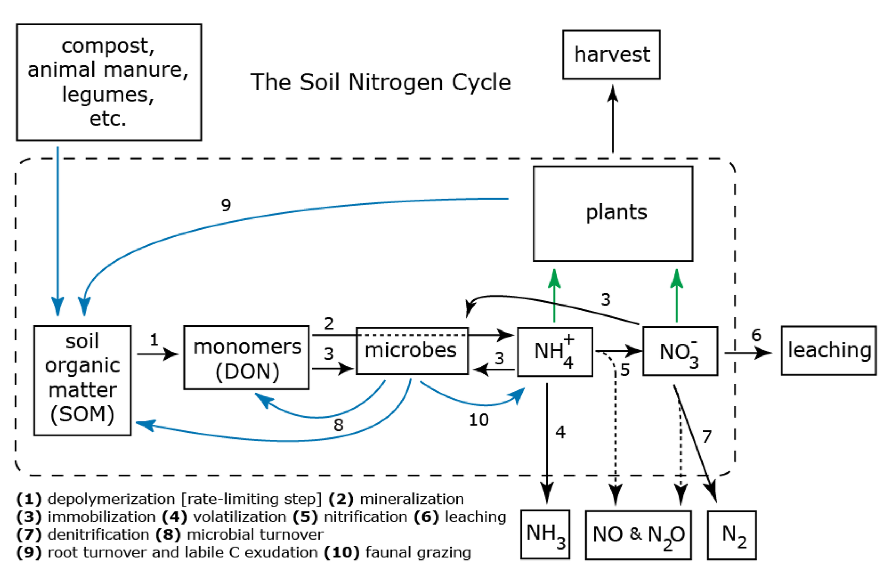

Fig 1: Microbial activity liberates N from organic matter and makes it available for plants. Microbial activity can also contribute to N retention and building SOM.

II. Study design

- 13 organic fields in Yolo Co. growing Roma-type tomatoes were sampled during summer 2011.
- At tomato flowering stage, indicators of microbial activity and nutrient cycling (e.g. microbial biomass, soil inorganic N), plant nutrient status (e.g. shoot N), and soil physicochemical characteristics were measured. Tomato yield was measured at harvest.
- Management practices were ascertained through interviews with growers.

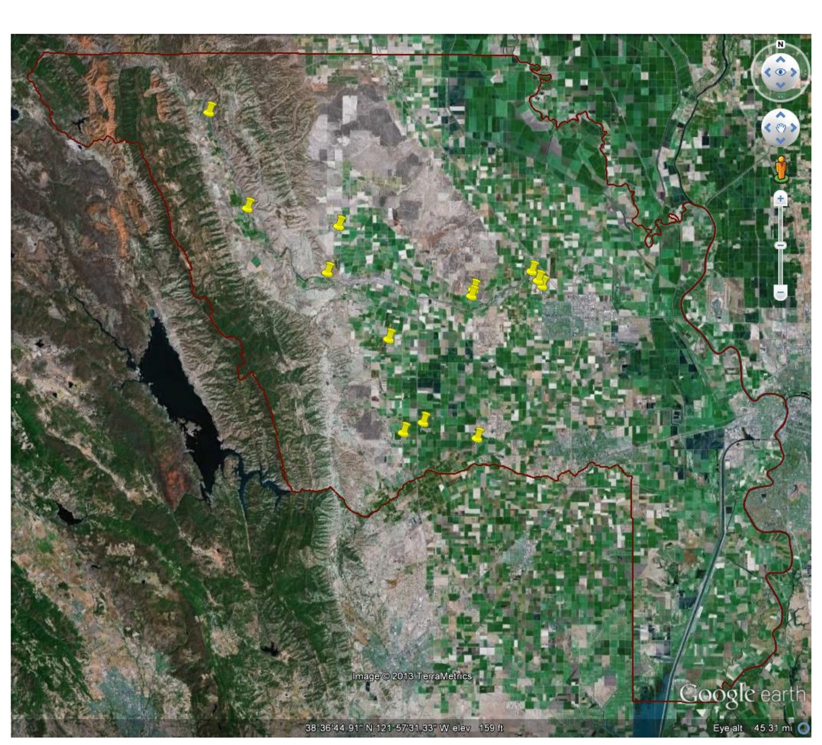

Fig 2: Satellite view of Yolo Co. showing locations of organic Roma tomato fields sampled over the 2011 growing season. Organic farms growing both processing and fresh market tomatoes were identified using the California Certified Organic Farmers (CCOF) directory in winter 2011. Growers were contacted to assess interest in the project and to ascertain plans for growing Romas. Eight growers, managing a total of 13 fields, agreed to participate in the research. Selected fields were transplanted within a two-week period in early April, 2011.

III. Indicators of nutrient cycling across organic farms in Yolo County

Key indicators of nutrient cycling across organic Roma tomato fields in Yolo County

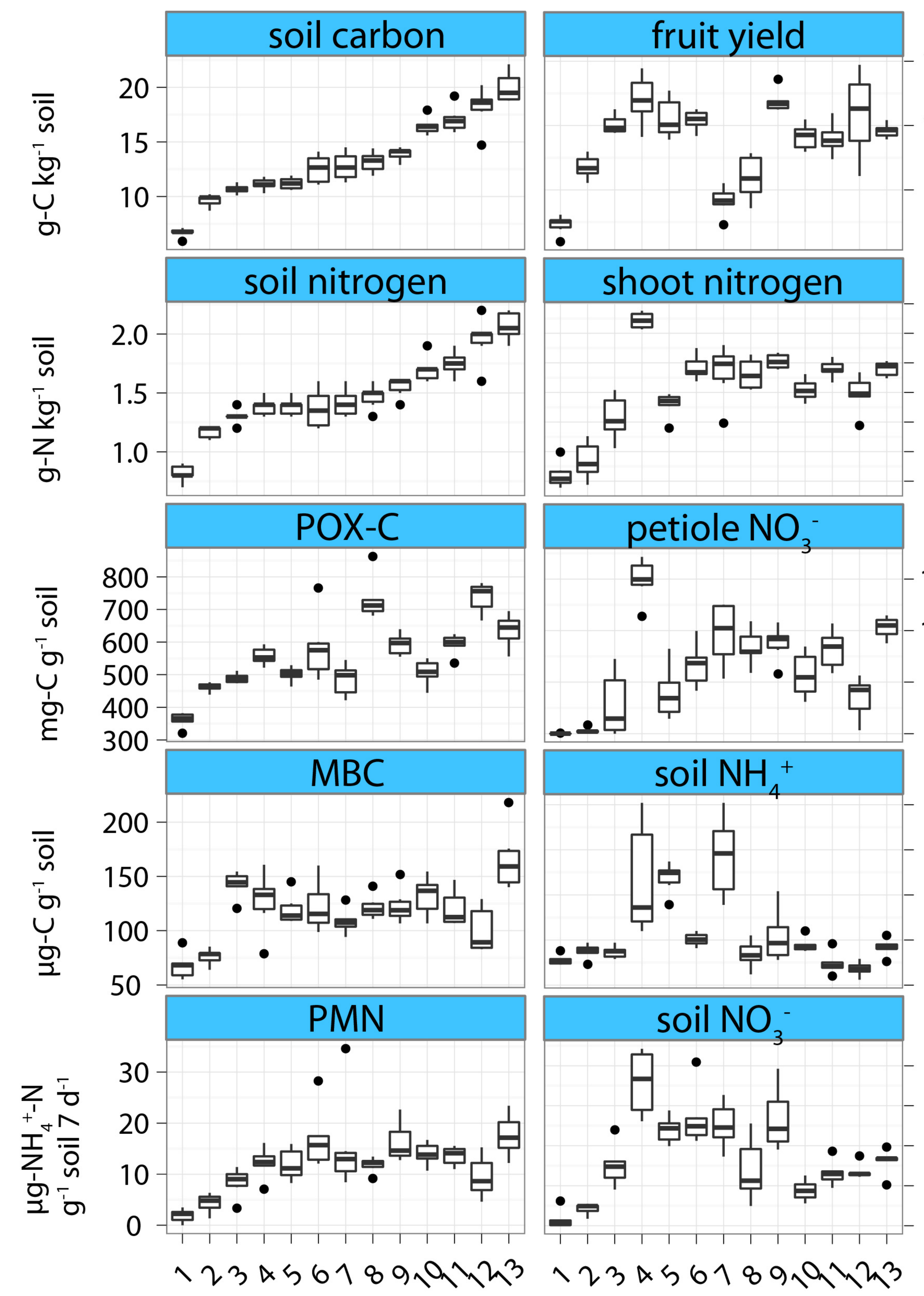

Fig 3: Key indicators of nutrient cycling across Roma-type tomato fields in Yolo Co., measured in flowering stage during summer 2011. This stage corresponds to peak nutrient demand in tomatoes. Shown are box plots (n = 6). Soil measurements are from surface soil (0-15 cm). The horizontal line is the mean; upper and lower "hinges" are the first and third quartiles; upper and lower whiskers extend 1.5 times the inter-quartile range (the distance between the first and third quartiles); data beyond this range are plotted as points. **POXC**: permangante oxidizable carbon; **MBC**: microbial biomass; **PMN**: potentially mineralizable nitrogen.

Management and soil types of selected fields

field	primary organic inputs	secondary inputs	soil series
1	poultry/cow manure (fall)	none	Tehama loam
2	poultry/cow manure (fall)	none	Tehama loam
3	poultry/cow manure (fall)	none	Capay silty clay
4	vetch winter cover crop	guano, soluble	Tehama loam
5	poultry manure (spring)	none	Capay silty clay
6	poultry litter (fall), vetch winter cover crop	guano	Brentwood silty clay loam
7	composted green waste (fall), vetch winter cover crop	pellets, soluble	Yolo silt loam
8	composted green waste (fall)	pellets, soluble	Yolo silt loam
9	poultry litter (fall), vetch winter cover crop	guano	Yolo silt loam
10	composted green waste (fall)	Chilean nitrate	Yolo silt loam
11	composted green waste (fall)	Chilean nitrate	Yolo silt loam
12	composted green waste (fall)	soluble	Yolo silt loam
13	composted green waste (fall)	Chilean nitrate	Yolo silt loam

Table 1: Organic matter inputs and soil series of fields in the study. Management information was derived from interviews with growers. Clay content in surface soil (0-15 cm) varied between 10 and 21%, with an average of 16%.

Achieving high yields and tightly-coupled N cycling

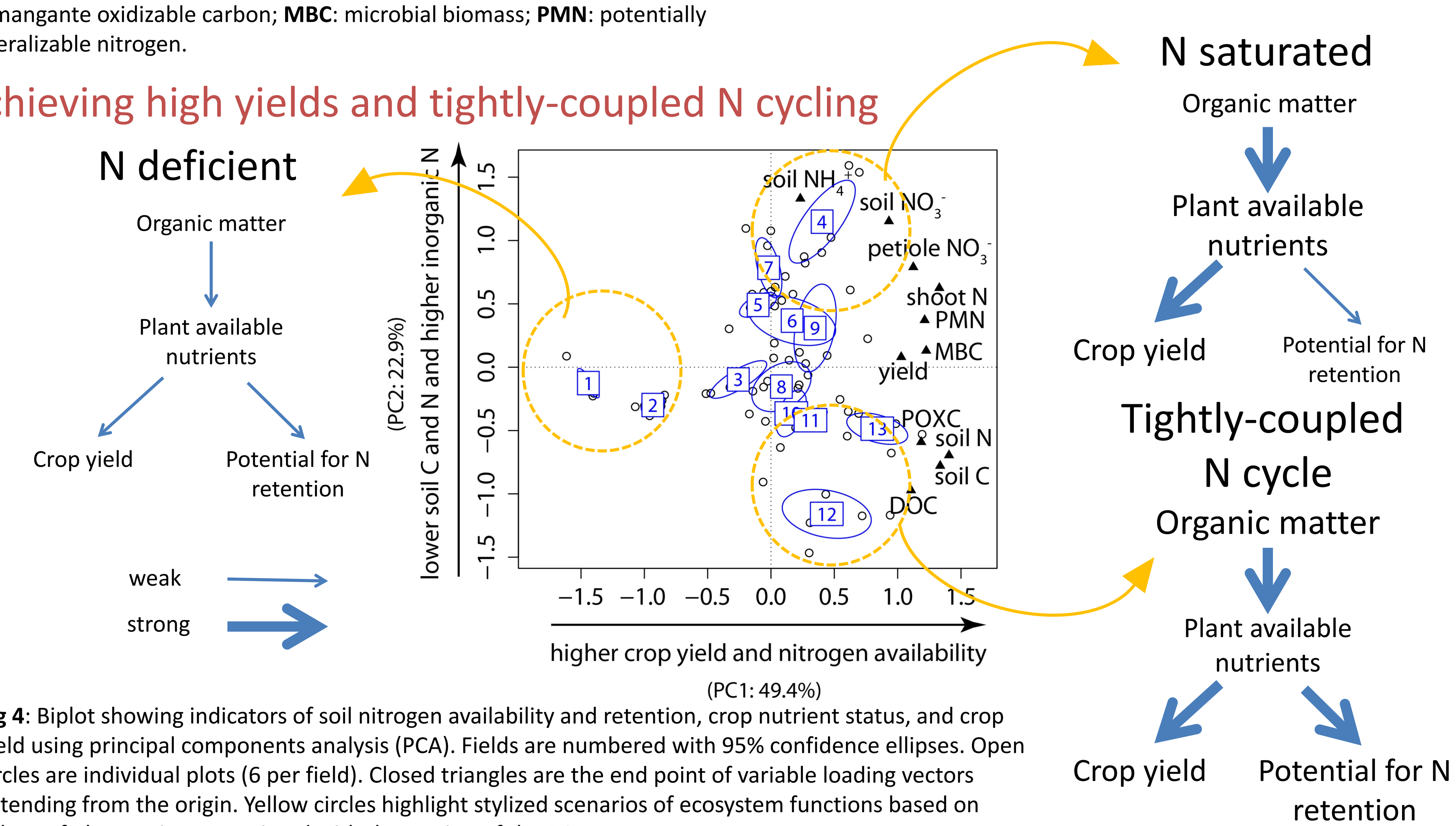

Fig 4: Biplot showing indicators of soil nitrogen availability and retention, crop nutrient status, and crop yield using principal components analysis (PCA). Fields are numbered with 95% confidence ellipses. Open circles are individual plots (6 per field). Closed triangles are the end point of variable loading vectors extending from the origin. Yellow circles highlight stylized scenarios of ecosystem functions based on values of observations associated with that region of the PCA.

IV. Implications for climate change mitigation and adaptation

- Question 1: Organic farms rely primarily on renewable organic matter inputs (Table 1). Production alone of synthetic N fertilizer can generate nearly 1 kg CO_2e for every kg of N produced (West and Marland 2002). Since farms often apply ~150 kg N ha^{-1}, this represents a substantial potential reduction in GHG emissions while maintaining generally high yields (Fig. 3). Additional life cycle research analysis research is needed to better quantify these changes.
- Question 2: In this study, higher SOM was associated with higher measures of nitrogen availability and crop yield - up to a point. While fields with mid to high levels of SOM had similar yields, fields with the highest SOM showed more potential for nitrogen retention. (Figs. 3 and 4)
- Research at LTRAS shows that organically-managed soil in Yolo Co. can accumulate as much as 0.56 Mg C ha^{-1} yr^{-1} (Kong et al 2005). But differences in management and soil type will make this outcome highly variable across farms (Fig. 5). Building and utilizing SOM will require adaptive management approaches.

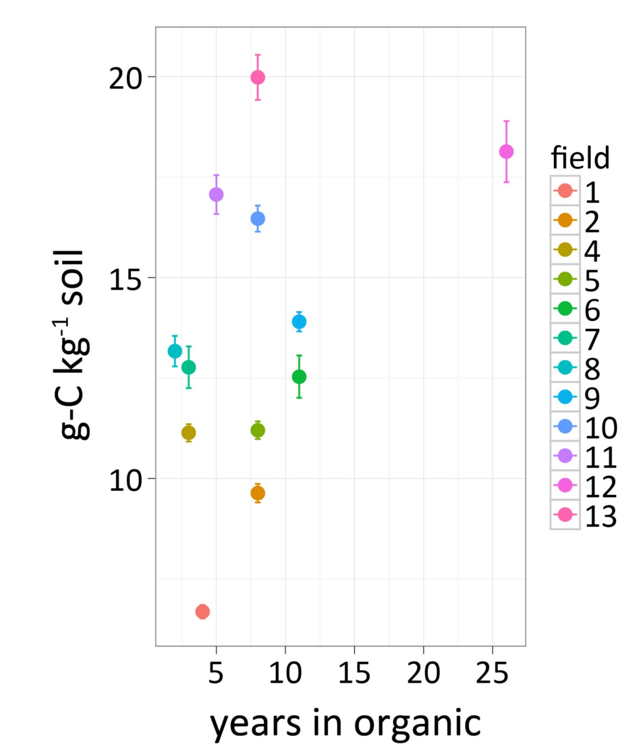

Fig 5: Soil organic carbon (0-15 cm) in relation to years in organic management. Shown are means ± standard error (n = 6) for each field. While there is a trend of increasing SOM with years in organic, it is highly variable, reflecting the heterogeneous landscape

Funding and Acknowledgments

Funding for this project came from a USDA OREI grant and an NSF Graduate Research Fellowship. The authors would like to thank other members of the Jackson lab and especially the growers who worked with us on this study and made it possible.