Strategies to Transition to Organic Grain: Impacts on Soil Health and Crop Productivity

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Introduction

Organic transition? USDA National Organic Program (NOP) requires three years of organic management (no synthetic chemicals) prior to organic certification.

- Compared to conventional farming, organic may be more profitable and ecological due to 2-3 times (Langemeier and O'Donnell, 2020) higher prices and less toxic (natural) amendments.

Challenges? Farmers must manage soil fertility, weeds, diseases, and pests without synthetic products (Delate and Cambardella, 2004) and learn new techniques (often requiring new equipment) while receiving only conventional

Typical organic grain farmers	"Conventional" Maryland grain farmers
Tillage for weed control, making seedbeds	No-till (74% of cropland)
Animal manures, legumes for soil fertility	Strict nutrient management plans, Cover crops including legumes (41% of the cropland)

- Switching to traditional organic farming methods could increase soil disturbance, likely followed by greater erosion, and runoff losses.

Research need: Identify organic transition strategies that can match or exceed the soil health benefits of the no-till with cover crops grain production system it would be replacing, while also providing acceptable productivity, economics and practicality for transitioning farmers.

Research objectives:

To investigate the effects of four organic transition strategies on:

1) Soil health 2) Crop productivity

Research hypotheses:

Strategies with less soil disturbance, and higher cover crop biomass will result in:

1) Increased soil health metrics 2) Higher grain crop productivity

Four organic transition strategies

Treatment 1: Traditional full-tillage. Spring oat (2020)–Corn (2021)-Soybean(2022)-Organic corn (2023)
Concept: Standard organic tillage, cultivation for weeds, maximize harvestable crops, minimal cover crops.

Treatment 2: Reduced-tillage. Spring oat (2020)–Corn(2021)-Soybean(2022)-Organic corn (2023)
Concept: Medium disturbance, reduced tillage. Moderate cover crop intensity and biomass.

Treatment 3: Minimum-till with precision-zoned high biomass diverse cover crops.
Spring oat (2020)–Corn (2021)-Soybean(2022)-Organic corn (2023)
Concept: Minimum tillage disturbance, maximum cover crop biomass and roots.

Treatment 4: Perennial alfalfa-grass hay, untilled. Organic corn in 2023.
Concept: Perennial hay. Initial preparation of clean seedbed with tillage. No soil disturbance after initial establishment. Multiple hay harvests per year.

Methodology

- Organic transition initiated in May 2020 and completed in May 2023
- RCBD with 4 replications of each treatment at each study location.

Farm name	Location	Soil description	Individual plot size	Treatments
CMREC (UMD research station)	PG county, MD	Moderately well drained sandy loam	30 ft x 100 ft	1,2,3,4
LESREC (UMD research station)	Wicomoco county, MD	Moderate-well drained silty loam	15 ft x 250 ft 30 ft x 250 ft	1,2,3,4
Commercial farm – A	Frederick county, MD	Poorly-well drained silt loam	60 ft x 150 ft	1,2,3
Commercial farm - B	Wicomoco county, MD	Moderately-poorly drained sandy loam	30 ft x 300 ft	1,2,3

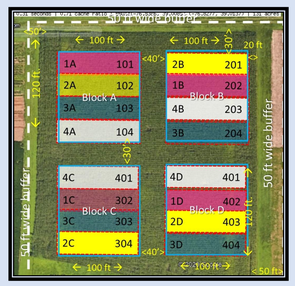


Fig 1: Experimental plot design at CMREC Beltsville, UMD research farm

Sample/data collection and analyses

Soil sampling:

- Top 30 cm soil sampling in fall 2020 (baseline), fall 2022 (during transition) using 3.1 cm diameter soil probes.
- Top 30 cm soil sampling during V4-V5 stage of corn for Pre-sidedress nitrate test (PSNT) analysis (June-July 2023).

Soil health metrics:

- Soil respiration by incubating soil samples for 24 and 72 hours
- Soil wet stability (Slaking test)
- Soil nitrate analysis
- Permanganate oxidizable carbon (POXC)

Crop productivity measurements:

- Stand establishment (Counts) at V5 stage and maturity (Fall 2023)
- Crop yield by hand harvest (October 2023)
- Weed biomass at V5 stage and maturity (Fall 2023)

Statistical analyses:

- Rstudio v1.1.463
- Analysis of Variance (ANOVA)
- Tukey's HSD at a=0.05

Fig 2: Soil profile from top 30 cm divided into three separate depths for analyses.

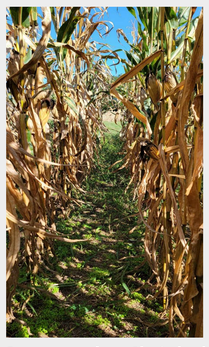


Fig 3: Corn row (trt 4) right before hand harvest (October 2023 CMREC).

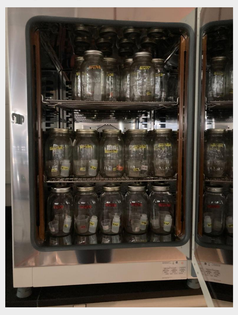


Fig 4:Mason jars in incubator set at 29°C for soil respiration test.

Results

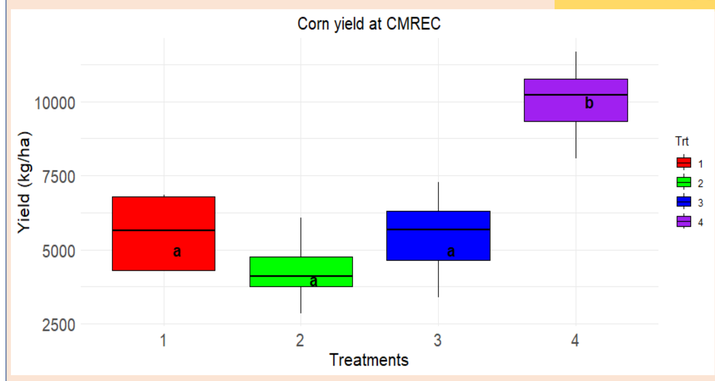


Figure 5. Hand harvest corn yield in kilograms/ha at CMREC. Treatment 4 had significantly higher yield than other treatments. Treatments labeled with the same letter do not differ significantly at p<0.05.

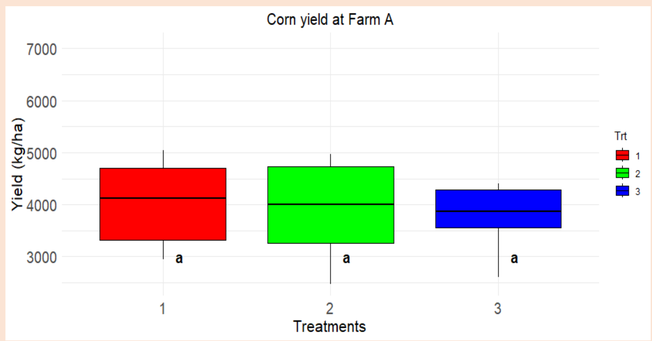


Figure 6. Hand harvest corn yield in kilograms/ha at Farm A. Treatments labeled with the same letter do not differ significantly at p<0.05. Hand harvest yields did not differ significantly.

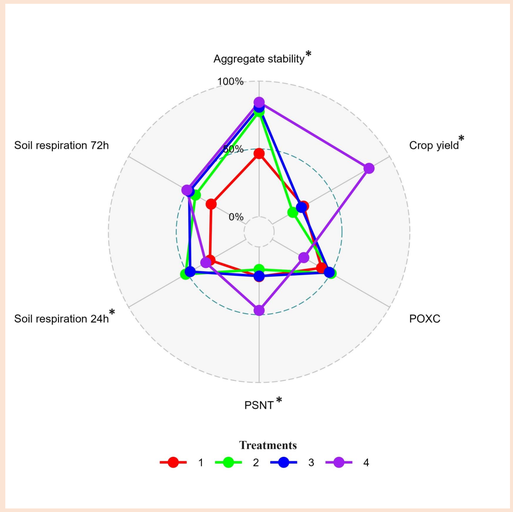


Figure 7. Radar plot showing the impacts of the four treatments on different soil health parameters. All the parameters were standardized at the same scale (0 to 1). Higher values indicate greater(positive) impact. Parameters with asterisk (*) sign denote significant difference between treatments.

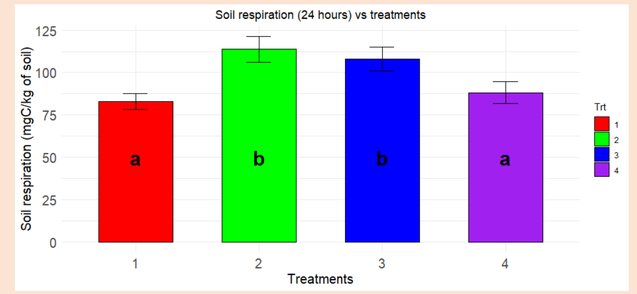


Figure 8: Total CO_2-C evolved under different treatments during 24 hour incubations. Treatments labeled with the same letter do not differ significantly at p<0.05. Treatments 2 and 3 had significantly higher CO2-C produced during the incubation period.

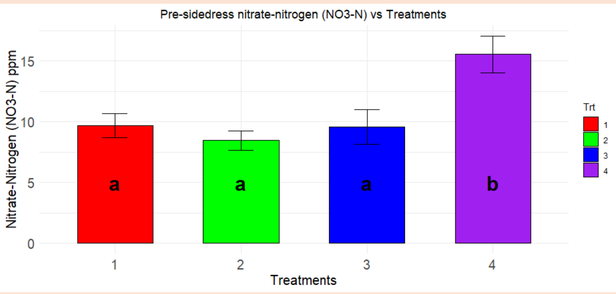
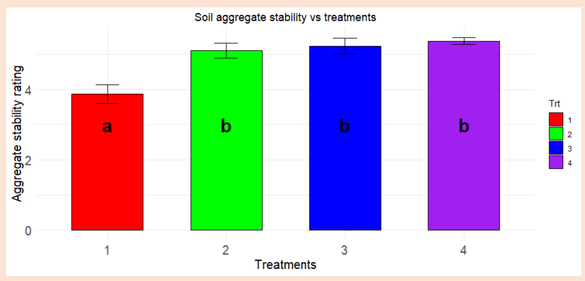


Figure 9: Pre-sidedress nitrate level (ppm NO3-N) at different treatments. Treatments labeled with the same letter do not differ significantly at p<0.05. Treatment 4 had significantly higher NO3-N, likely contributed by the alfa-alfa hay and legume cover crops in the previous seasons.



← Figure 10: Average stability scores for each treatment. Trt 1 (with highest soil disturbance) had significantly lower stability score than the other three treatments.

Conclusion

- Treatment with perennial alfalfa-grass hay yielded almost double than the other treatments, likely contributed by higher nitrate-nitrogen released after two year of alfalfa hay crop, and lower weed competition. Other parameters with possible effect on the yield will be analyzed in the future.
- Reducing soil disturbance had positive impact on soil health metrics such as aggregate stability, respiration rate, and crop yield.
- Planter down pressure, coulter, and press wheel adjustments critical to high crop yields, especially in organic grain with cover crops and without soil disturbance.

References:

Delate, K., & Cambardella, C. A. (2004). Agroecosystem Performance during Transition to Certified Organic Grain Production. Agronomy Journal, 96(5), 1288-1298. doi: 10.2134/agronj2004.1288

Langemeier, M. and M. O'Donnell. (2020). "Conventional and Organic Enterprise Net Returns." Department of Agricultural and Consumer Economics, University of Illinois at Urbana Champaign. Farm doc daily (10):161, September 4, 2020.

NORTHEAST SARE Sustainable Agriculture Research & Education

FUTURE HARVEST Chesapeake Alliance for Sustainable Agriculture

USDA NIFA United States Department of Agriculture National Institute of Food and Agriculture