ORGANIC TRANSITION

Conservation Management Effects on Soil Function in a Transitioning Organic Cotton - Peanut Rotation



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Conservation Management Effects on Soil Function in a Transitioning Organic Cotton - Peanut Rotation

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INTRODUCTION

Organic Agriculture in Texas

- Texas ranks 17th in the number of organic crop and livestock operations, 6th in total value of organic agricultural products sold, and 9th in total organic acreage.
- Texas grows over 90% of organic cotton, 95% of organic peanuts, and 41% of organic rice in the US.
- Continuous organic cotton systems are common, as a cover crop has been allowed to be considered as a rotation.
- Rye cover crops planted at low seeding rates (15 lb/ac) are commonly terminated via tillage in late winter during the vegetative stage, 2-3 months prior to cotton planting, to conserve soil moisture.

Cotton and Peanut Rotation

- Peanut is a common rotational crop with cotton under irrigated conditions.
- Peanut producers have expressed interest in soil health promoting practices (conservation tillage and cover crops).
- Digging peanuts is a destructive process, potentially limiting the benefits of conservation tillage alone (Figure 1).

Organic Challenges and Cover Crops

- **Weed control** and **nitrogen (N) management** are two main challenges.

Figure 1. Peanut digging.

- **Cover crops** offer a potential alternative or companion to mechanical tillage for weed control and can enhance soil fertility, soil organic matter, and soil structure.
- In semi-arid regions of Texas, the impact of cover crops on soil **moisture availability** is a major concern.
- Questions arise about species selection, seeding rate, and termination timing – which can subsequently affect weed control and nutrient cycling.

Objective

- The objective of this study was to identify management practices that enhance soil function in both conventional and organic agriculture and share successful practices between these systems.

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MATERIALS AND METHODS

The study was conducted during 2019-22 at Texas A&M AgriLife Research Extension Centers in Lubbock and Vernon (Figure 2 and 3).

- Lubbock – Olton clay loam, furrow irrigated
- Vernon – Miles loamy fine sand, pivot irrigated
- Study initiated with cotton planting in 2019
- Initial cover crop planting in November 2019 (Table 1).
- Study completed after peanut harvest in November 2022

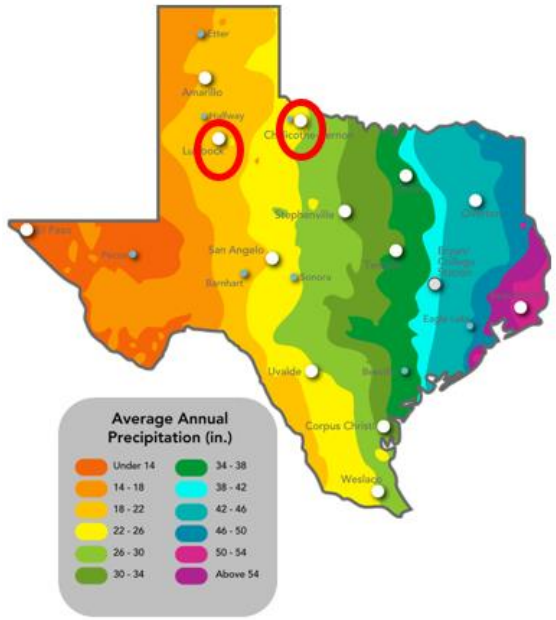


Figure 2. Study locations.

Methods

Measurements and Sampling

Pre-season and post-harvest soil sampling to 48'', and monthly soil sampling to 8''

Monthly moisture readings to 24''

Phospholipid-fatty acid analysis for microbial community composition (soil health indicator 1)

N-acetyl-β-D-glucosaminidase (NAG) activity for nutrient cycling analysis and mineralizable carbon for microbial activity (soil health indicators 2 and 3)

Crop harvest for yield estimation

Economic analysis of viability of organic production

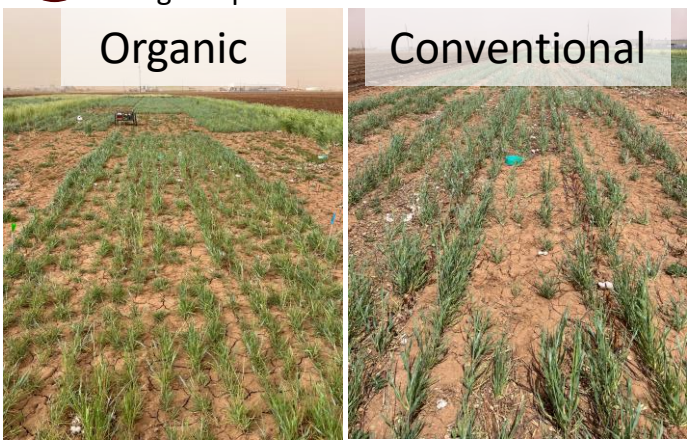


Figure 4. Cover crop stand in Lubbock by system (April 2022). No significant difference in biomass production among similar cover crop mixtures between conventional and organic systems.

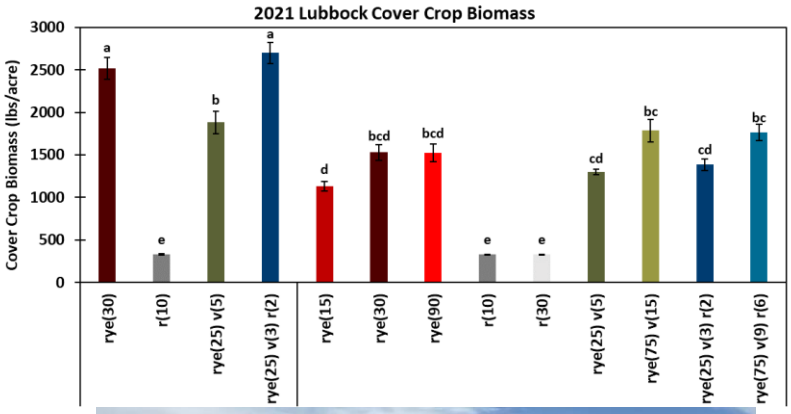
Figure 3. Cropping system treatment.

Table 1. Cover crop treatments by system. Treatment abbreviations in parathesis.

Conventional Only	Conventional and Organic	Organic Only
No Cover Control	30 lb/ac Rye (rye 30)	15 lb/ac rye (rye 15)
	10 lb/ac Radish (r 10)	90 lb/ac Rye (rye 90)
	25 lb/ac Rye + 5 lb/ac hairy vetch (rye25/v5)	30 lb/ac Radish (r30)
	25 lb/ac Rye + 3 lb/ac vetch + 2 lb/ac radish (rye25/v3/r2)	75 lb/ac Rye + 15 lb/ac vetch (rye75/v15)
		75 lb/ac Rye + 9 lb/ac vetch + 6 lb/ac radish (rye75/v9/r6)

RESULTS AND DISCUSSION

Cover Crop Biomass and Weed Counts



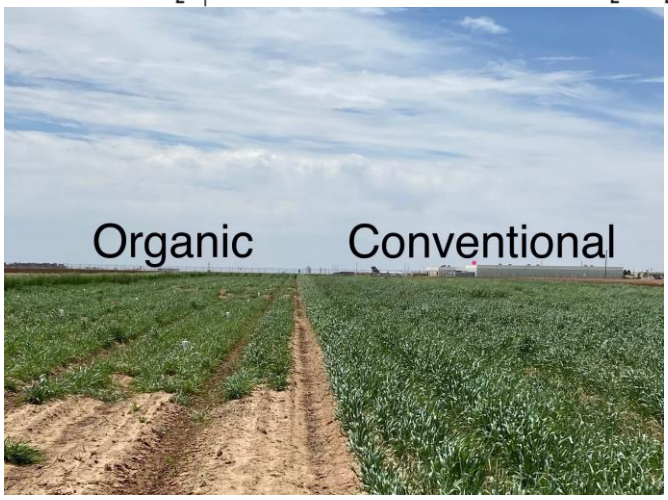


Figure 5 (top) & 6 (bottom). Figure 5: Cover crop herbage biomass in conv (left) and org (right) in Lubbock for 2021. For all figures, bars which share the same letters are not statistically different at P=0.05. Greater cover crop biomass in conventional likely due to increased residual inorganic nitrogen and seed variety differences between conventional and organic.

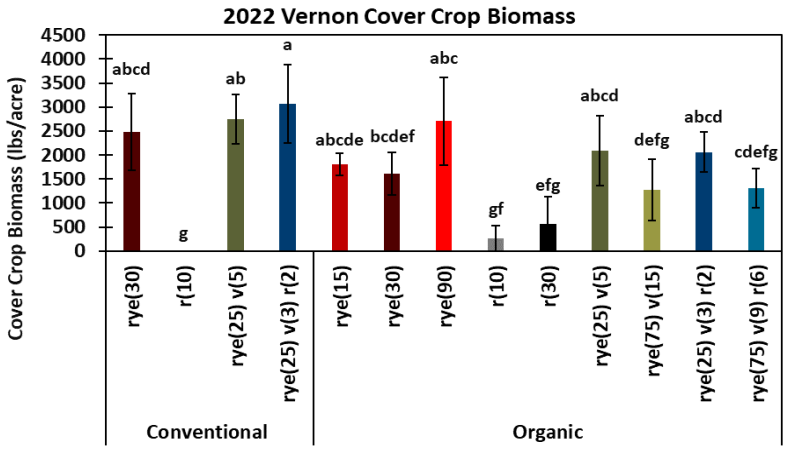


Figure 7. Cover crop herbage biomass in Vernon in 2022. Rye biomass similar across systems.

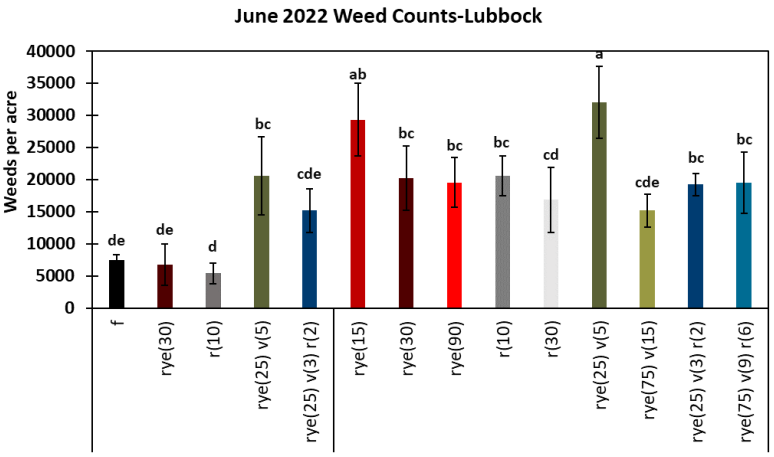
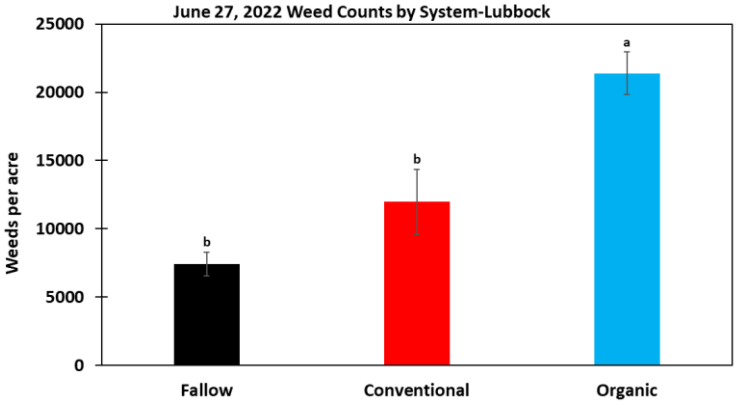


Figure 8. Weed counts in conv (left) and org (right) in Lubbock (2022) by cover crop treatment. Within management systems, cover crop mixtures including rye reduced weed pressure compared to other mixtures or rye alone. Seeding rate had no consistent effect on weed populations within the organic system.



Figures 9. Weed counts in Lubbock (2022) by management system. Conventional and conventional fallow had lower weed pressure than organic.

Figure 10. Weed infestation was greater in organic versus conventional treatments.

RESULTS AND DISCUSSION continued

Stored soil moisture

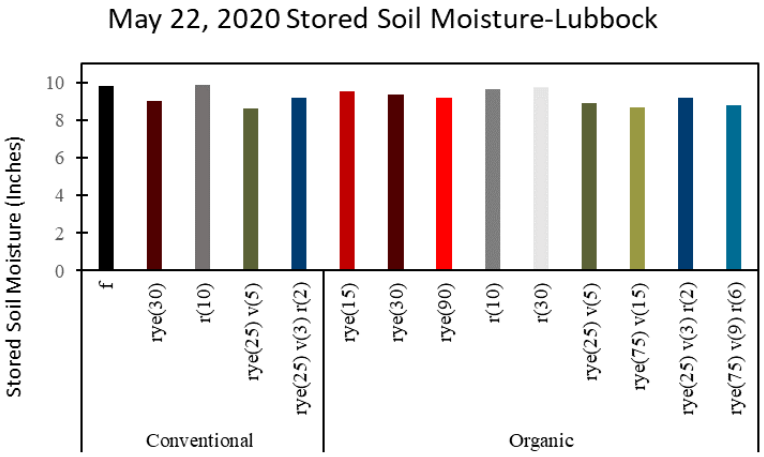


Figure 11. Stored soil moisture at 0-24 inch depth. Moisture data was taken on May 22, 2020, 23 days after cover crop termination (April 29, 2020).

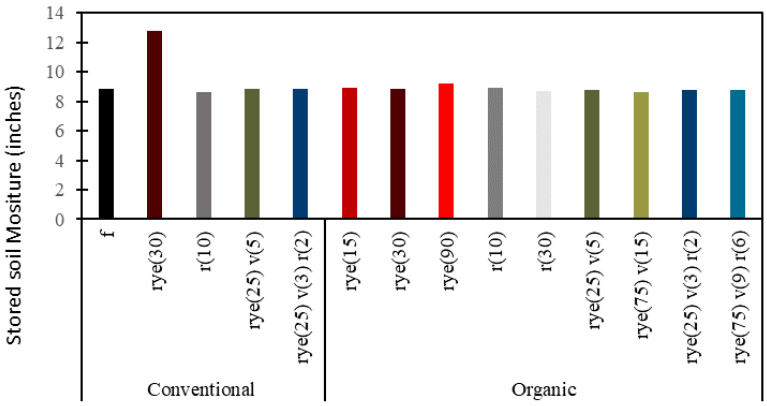


Figure 12. Stored soil moisture at 0-24 in. Moisture data was taken on August 28, 2020, 111 days after cover crop termination (April 29).

Cover crop use in semi-arid environments has been shown to reduce soil water content after cover crop termination however this may be offset later in the season due to increased infiltration and reduced evaporation resulting from increased ground cover. The same phenomenon was observed in this study. Fallow control plots had higher soil water content early in the season (Figure 11), but moisture levels increased to and in some cases eclipsed levels seen in fallow plots (Figure 12). Results from this study show again that cover crops increase mid and late season soil water content.

Phospholipid fatty acids (PLFAs)

- Phospholipid-fatty acids are compounds in the cell membranes of soil microorganisms which can be analyzed quantitatively and qualitatively to estimate microbial community size and composition. Healthier soils are generally thought to contain a larger, more diverse microbiological community.

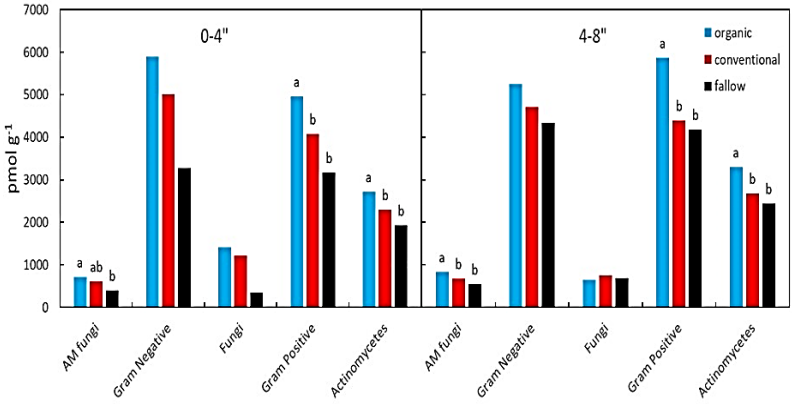


Figure 13. Phospholipid fatty acids (PLFAs) at 0-4 and 4-8 inches at Vernon, TX (2020).

Community Composition

- Community composition remained unchanged between systems at both depths after 2 years of organic management (Figure 13). In all systems, the community was dominated by gram-positive and gram-negative bacteria, both of which play a large role in nutrient cycling in soils.

Community Size

- Organic management generally increased the relative abundance of all categories of microbes, likely due to the application of manure which is a food source for microorganisms.

Figure 14. Peanuts with and without rye cover crop. Peanuts grown after rye cover provide more soil surface coverage due to a denser stand.

Enzyme Activity

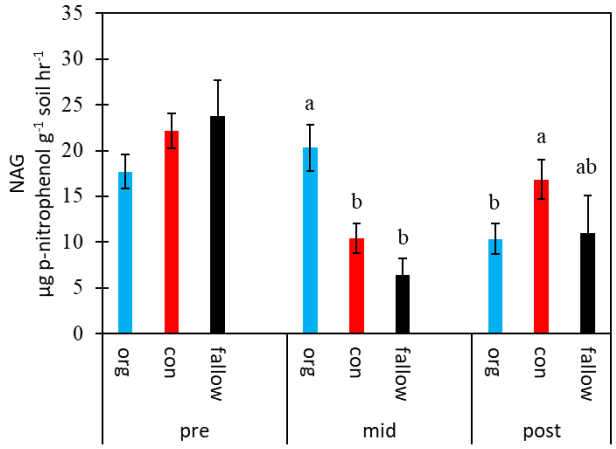


Figure 15. NAG activity by system in Vernon (2020).

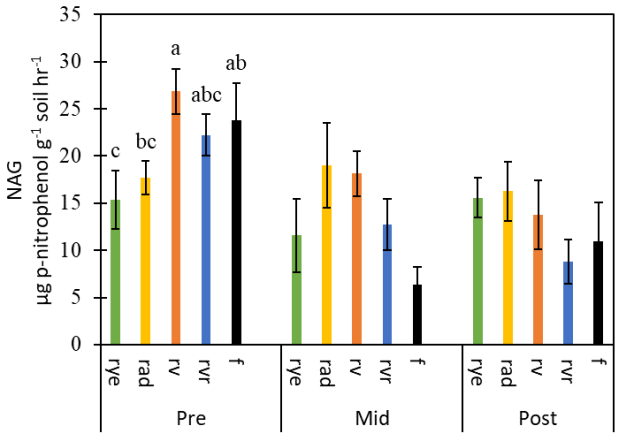


Figure 16. NAG activity by cover crop (averaged over seeding rate) in Vernon (2020).

Management System

- NAG enzyme activity in the organic system was significantly greater than conventional and fallow during mid-season but lower than conventional post-season (Figure 15).
- Increased NAG activity represents increased N cycling, an important process in organic systems which do not receive inorganic N input.

Cover Crop Selection

- Mixtures including vetch significantly increase NAG activity over rye only likely due to the presence of a legume (vetch) in the mixtures (Figure 16).

Mineralizable Carbon

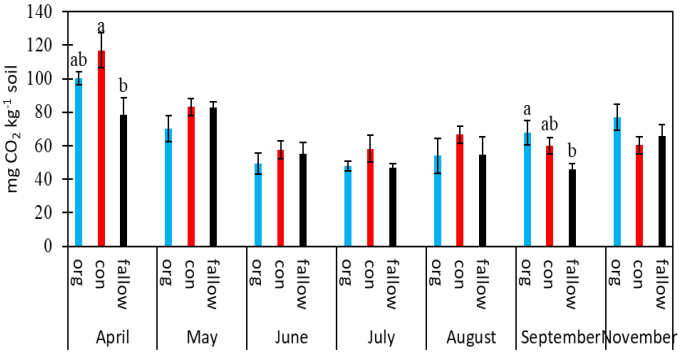


Figure 17. Carbon mineralization by system in Lubbock (2020).

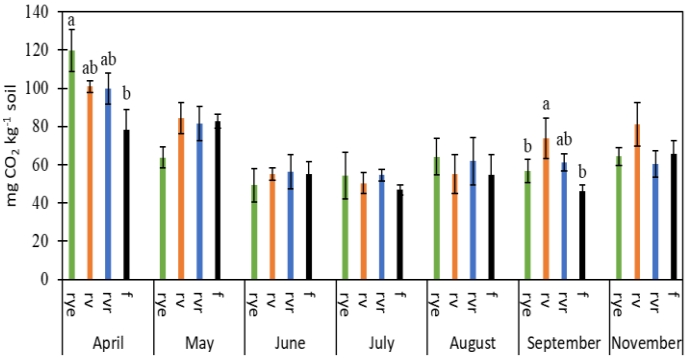


Figure 18. Carbon mineralization by cover crop (averaged over seeding rate) in Lubbock (2020).

Management System

- Management system (organic vs conventional) had a limited effect on mineralizable carbon (Figure 17).
  - Organic was never significantly different from conventional
- Conventional was significantly greater than fallow in April, while organic was significantly greater in September.

Cover Crop Selection

- Cover crop selection also had a limited effect on mineralizable carbon, although rye was significantly greater than fallow in April and rye/vetch and rye/vetch/radish mixtures were significantly greater in September. (Figure 18).
- Overall, cover crops can increase soil health parameters and have not shown negative impacts on soil health.

RESULTS AND DISCUSSION continued

Yield

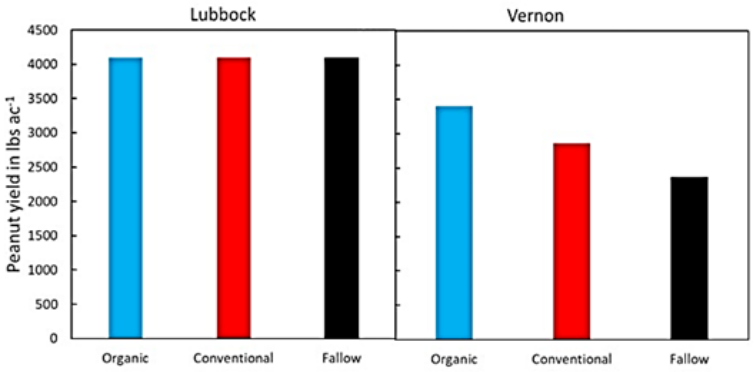


Figure 19. 2020 peanut yields. No statistical differences among the systems were observed.

In the first year of transitional peanuts at Lubbock (2020), there was no difference in yield between conventional, organic and fallow systems (Figure 19). In Vernon, results were similar although, organic yields were slightly higher than conventional, followed by the fallow. system. This shows there is little yield differentiation after two years of organic management.

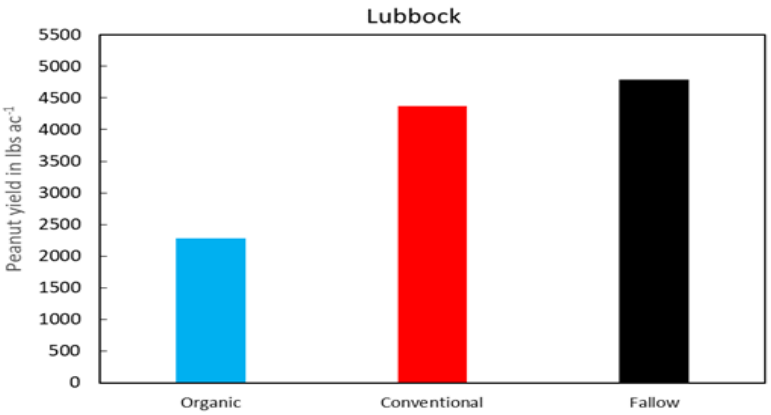


Figure 20. 2022 peanut yields.

In the first year of fully transitioned organic production, peanut yields were greatly affected by management system (Figure 20). Conventional and fallow treatments averaged 4,371 and 4,793 lb/ac, respectively, while organic averaged 2,283 lb/ac.

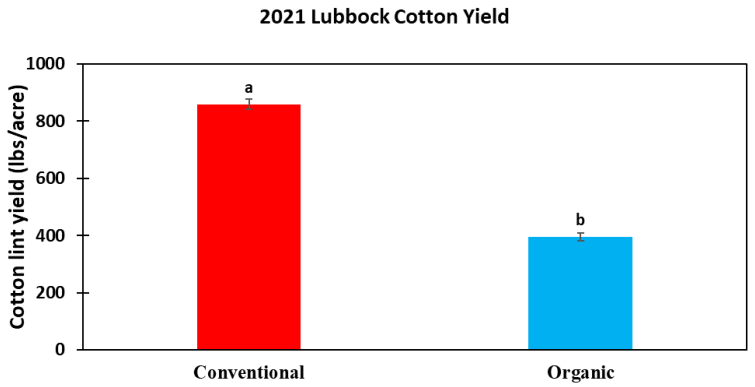


Figure 21. 2021 Cotton yield at Lubbock.

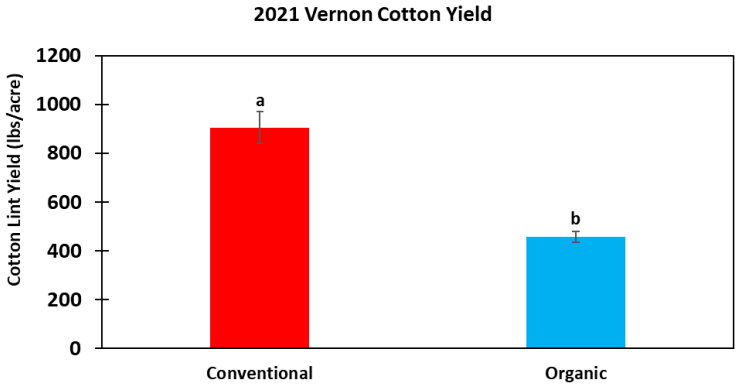


Figure 22. 2021 Cotton yield at Vernon.

In 2021, cotton yields were significantly lower under organic management at both locations, likely due to genetic potential of conventional and organic cotton varieties (DP 2143NR and UA48, respectively), increased weed pressure and reduced fertilizer input in the organic system (Figures 21 and 22). However, there was little variability in yield among cover crop treatments within the same management system. This indicates that yield effects do not need to be considered when selecting a cover crop mixture and seeding rate. Significant yield reductions and high production costs in 2021 resulted in a net loss of $411/acre in Lubbock, while in Vernon net return was $311 less than conventional.

Table 2. Economic analysis

Management System	Gross Revenue			System Costs			Net Return			
	2019	2020	2021	2019	2020	2021	2019	2020	2021	Average
	$/A			$/A			$/A			
Organic-LBB	1140	1039	743	1191	1335	1154	-52	-296	-411	**-253**
Conv.-LBB	812	747	803	417	635	411	395	112	392	**288**
Organic-VRN	1096	1823	854	653	1086	631	443	737	223	**492**
Conv.-VRN	870	768	850	319	311	315	551	457	534	**514**

RESULTS AND DISCUSSION continued

Economic analysis

- Prices for conventional cotton were determined using loan value plus $0.25 premium for lint and $200/ton for cottonseed. Organic cotton prices were calculated using loan value plus $1.00 premium for lint and $400/ton for cottonseed. Conventional peanuts prices were $550/ton and organic peanuts were $1,100/ton. Producers moving to organic production must undergo a transition period prior to receiving organic price premiums, but this study is comparing an established organic production system to a conventional system.
- All production expenses were determined based on 2021 input (seed, fertilizer, compost, herbicide) prices and 2020 custom rates survey responses for tillage, harvesting, and application expenses.
- In Lubbock, the average gross return across the three-year period was $541/A higher for the conventional system. The organic system was more competitive at the Vernon site, with the conventional system only generating a higher net return of $22/A. This is largely due to organic peanuts outyielding the conventional during year 2. The conventional system resulted in greater yields in all years of the study at Lubbock and two out of the three years at Vernon.
- The higher revenues received due to higher prices in the organic system were offset by substantially higher weed control costs, both tillage operations and hand weeding activities.

CONCLUSION

Cover crop production was similar among treatments and seeding rates.

Under conventional management, stored soil moisture was lower for cover crop treatments but recovered by early season.

Stored soil moisture was similar among organic treatments, including varying seeding rates and termination timing.

PLFA's indicated improved trends for microbial activity in organic system at Vernon, likely due to recent compost application.

Nutrient cycling and soil health was improved under organic management and increased organic matter inputs from manure application.

There was no peanut yield loss due to organic management until after transition. Organic cotton yield was reduced compared to conventional likely due to variety selection.

Higher production expenses and lower yields associated with the organic system may negate price premiums received for organic crops leading to higher net returns for conventional crops.

An optimal system would combine the soil health benefits of reduced mineral fertilizer dependence of organic management with the benefits of chemical weed control and reduced tillage in conventional systems.

Recommendations for Organic Transition

- Transition a small number of acres each year, rather than all planned organic acres at the same time, to minimize risk.
- Seek alternative certifications during transition period to increase revenue until organic price premium can be received after the final year of transition (QAI Certified Transitional, Non GMO Project, Certified Naturally Grown).
- Utilize rye in cover crop mixtures to reduce weed pressure, which reduces tillage requirements, ultimately resulting in further improvement in soil health and reduced weed control costs.
- Increasing cover crop seeding rate does not provide additional weed control or soil health benefits due to similar biomass production among seeding rates, therefore, current seeding rate recommendations can be used rather than high seeding rates to reduce costs.

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