TEXAS A&M AGRILIFE EXTENSION

Challenges and Opportunities of Organic Cotton in Southern Texas

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What is organic cotton?

Organic cotton is a way of growing cotton fiber that minimizes the environmental impact of chemical use in cotton production. Cotton is most often produced with heavy inputs of pesticide chemicals and synthetic fertilizers. Among the row crops grown in the U.S., cotton uses the most pesticide chemicals per acre of production (USDA-NASS, 2023). On the other hand, organic cotton production avoids these environmentally harmful chemicals altogether. Instead, it requires adopting cultural practices such as cover crops, timely tillage, crop rotation, adjustment in planting date, cutting off irrigation targeting harvest, and organic fertilizers.

Synthetic fertilizers such as urea, ammonium nitrate, diammonium phosphate, potassium chloride, etc., can't be used for organic cotton production. Instead, organic sources of nutrients such as animal manure or compost are used. Genetically modified seeds such as Bt cotton are also prohibited, and reliance on conventional varieties is mandatory. Conventional cotton varieties also need to be genetically modified organism (GMO)-free. The tolerance level for GMOs in organic cotton production is less than 5%. Any seed treatment before planting must also be organic, meaning synthetic fungicides, insecticides, or nematicides are allowed to treat the seed before planting. Together, these regulations make organic cotton production environment-friendly and pose serious challenges for farmers.

Why organic cotton?

Cotton is one of the most pesticide-intensive commodity crops grown in the U.S. The pesticide load for cotton production is expensive for farmers and harms the environment. The chemicals include herbicides to control weeds, pesticides to control bollworms and other insects, and defoliants to aid cotton harvest. Production, storage, and application of these chemicals require energy consumption, contributing to greenhouse gas emissions. Often, these pesticides can enter the ecosystem through soil, plant, and aquatic

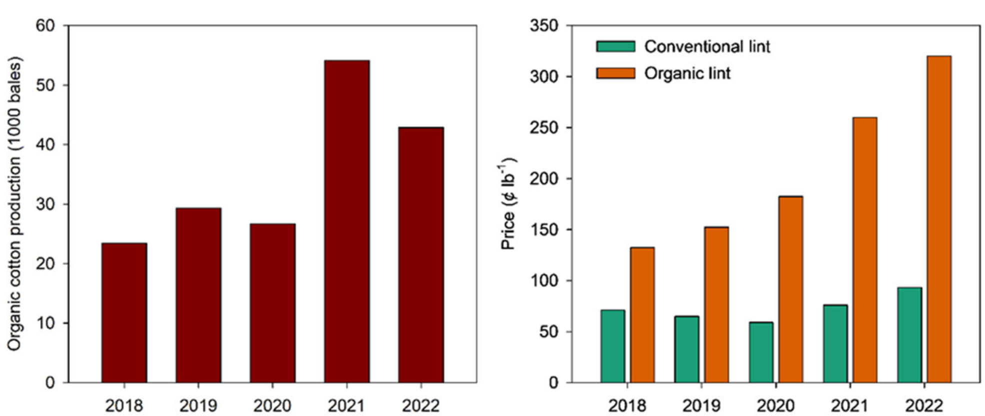

Figure 1: Organic cotton bale production in the U.S. (left), and conventional vs. organic cotton lint prices (right) from 2018 to 2022 (USDA-AMS, 2023).

contamination, threatening the overall ecosystem. Therefore, these practices threaten the sustainability of the world's leading fiber crop production.

The international market for organic cotton products has grown dramatically in the last few years. The U.S. produces only 3% of the global organic cotton production (Textile Exchange, 2022). However, organic cotton production is increasing in the U.S., motivated by the price premium for organic cotton fiber. Organic lint prices have been increasing consistently over that of conventional cotton. In 2022, organic lint prices were almost 2.5 times higher than conventional lint prices (Figure 1).

What are the challenges of organic cotton in southern Texas?

Without the use of chemical pesticides and synthetic fertilizers, there are many challenges to growing organic cotton. Because chemical herbicides are removed from the organic grower's toolbox, weed pressure is one of the most important challenges in organic cotton production. Organic farmers mostly rely on cultivation to control weeds. In the east-central to southern part of Texas, however, frequent rainfall earlier in the growing season prevents farmers from cultivating due to wet fields. In this case, weeds can dominate a field within a week after significant rain. Later in the season, special tillage equipment or hand-weeding is often required to control within-row weeds after cotton germination.

Insects and diseases such as bollworm and root rot are also major concerns in organic cotton production. The use of farm equipment in an insect-infested field can also transfer the infestation to the organic field. Therefore, farm equipment needs to be cleaned thoroughly before being used in an organic field. Without the use of chemical defoliants, organic cotton growers depend on cutting off irrigation early to facilitate defoliation and aid cotton harvest. Organic defoliants such as vinegar can be used before harvest. However, they are less efficient and require a higher amount than conventional defoliants. The requirement for a higher amount of active ingredients also increases the cost of application for these defoliants. Organic cotton often produces reduced yields compared with conventional cotton. and sometimes, complete losses are observed. Cotton pickers or strippers are challenged when harvesting the cotton due to incomplete defoliation, leading to reduced lint recovery efficiencies.

Do cover crops help in organic cotton production?

Cover crops can be a valuable component of organic management practices. They are crops grown between the main crop seasons for multiple benefits. Cover crops suppress weeds during the fallow season and early in the cotton season. Before they mature and start flowering, they are incorporated into the soil by disking or may be rolled and crimped or shredded to lay on the soil surface. The decomposition of cover crop biomass releases nutrients such as nitrogen from legumes and improves soil function (Blanco-Canqui et al., 2015; Osipitan et al., 2019). Cover crops increase soil organic matter (Poeplau & Don, 2015). Although cover crops can take up soil water during their growing period, after termination, soils can store more plant-available water (Burke et al., 2021; Rankoth et al., 2021).

Findings from a cover crop study

Different winter cover crops were tested in organic cotton systems at the Texas A&M University research farm near College Station, Texas. The cover crops tested were oats, purple top turnip, Austrian winter peas (AWP), and a mix of all three (Figure 2). These cover crops were evaluated for weed suppression efficiency, cotton growth, cotton yield, soil greenhouse gas emissions, soil water, and soil temperature. Details of these findings are in Salehin et al. (2024); Salehin et al. (2025) and Salehin et al. (2025). The major findings of the study are:

- Turnip cover crops were most efficient in reducing weed pressure in the early cotton season. The weed biomass recorded in turnip cover crop plots was similar to winter fallow, with multiple tillage and hoeing throughout the fallow and cotton seasons (Figure 3).
- The high nitrogen content of Austrian winter peas reduces the targeted manure application

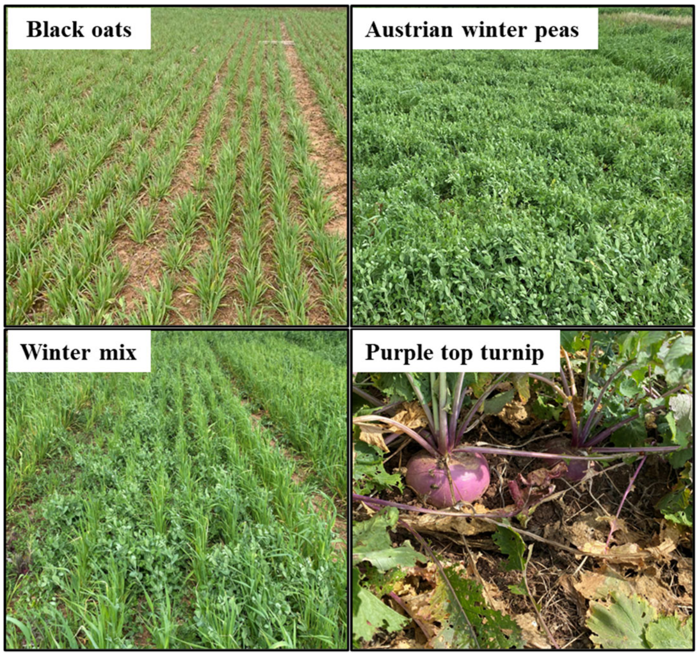

Figure 2: Black oats, Austrian winter peas, purple top turnip, and winter mix cover crops grown in an organic cotton field trial at Texas A&M University research farm near College Station, Texas.

rate by half without compromising the cotton lint yield.

- Cover crop biomass incorporation increased soil carbon and nitrogen content, especially Austrian winter peas and mixed species.
- Cover crops can take up stored soil water in spring. However, the decomposition of turnip, Austrian winter peas, and mixed species biomass results in the storage of more plant-available water during cotton seasons (Figure 4). Root channels left behind increase infiltration and capture of rainfall.
- Turnip and Austrian winter peas, with a half-rate of poultry litter, reduced soil carbon dioxide (CO_2) in the first year of organic transition (Figure 5A).
- Reducing the poultry litter application rate with Austrian winter peas and non-legume cover crops such as oats and turnips can reduce the nitrous oxide emissions during cotton season (Figure 5B).
- A turnip cover crop with reduced weed pressure yielded similar cotton lint to a winter fallow practice with multiple tillage and hand weeding throughout the season for both experimental years (Figure 6). This indicates that cover crop practices like turnips and Austrian winter peas can reduce the expenses and labor required for tillage and hoeing without compromising cotton lint yield.

Table 1: Percent of cover crop and poultry litter (PL) residues mineralized as carbon dioxide (CO_2) during a 90-day soil incubation. Residues were incorporated into the soil to simulate conventional tillage or left on the soil surface to simulate minimal tillage after cover crop termination.

Tillage	Cover Crop Practices	Residue carbon mineralized (%)
Minimal	PL+Turnip	52
	PL+Oat	51
	0.5PL+Austrian winter peas	57
	PL+Mix	52
Conventional	PL+Turnip	44
	PL+Oat	35
	0.5PL+Austrian winter peas	45
	PL+Mix	36

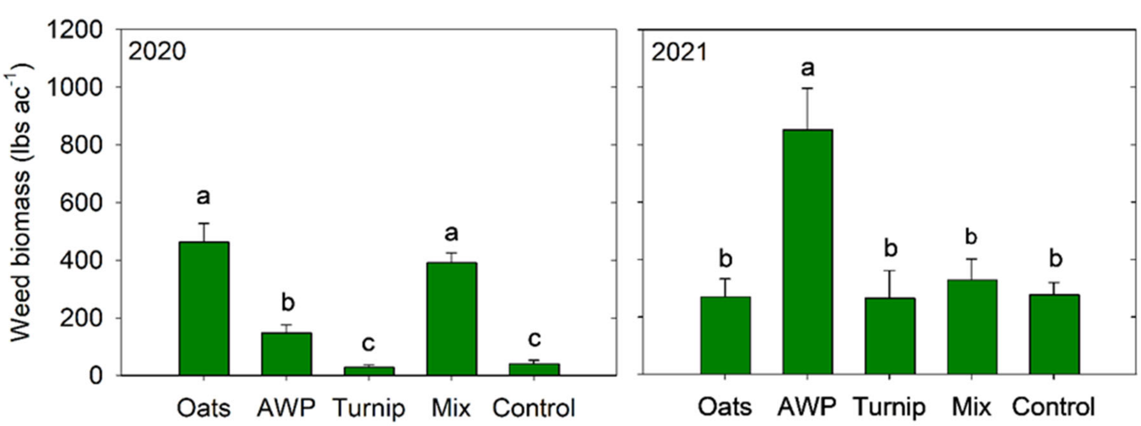

Figure 3: Weed biomass in the early cotton seasons in response to cover crop practices compared to winter fallow with multiple tillage and hand weeding (control) in 2020 and 2021 experimental years.

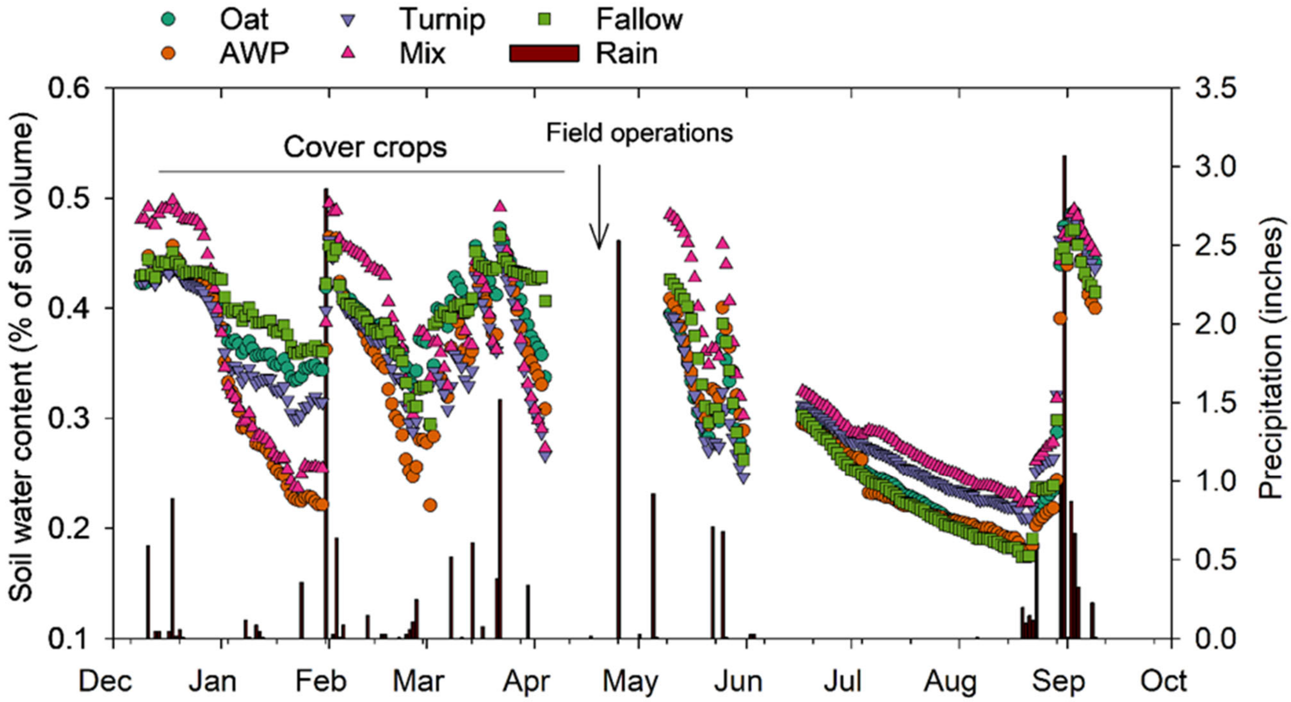

Figure 4: Soil water content during cover crops and cotton growing period in 2022 in response to different cover crop practices in organic cotton production. The cover crops depleted soil moisture during their growing season. However, during the cotton growing season, Austrian winter pea (AWP) and mixed species cover crop plots retained more soil water compared to no cover crop plots (Fallow).

- Tilling the soil after oats and winter mix cover crop termination is recommended to prevent oats from growing back as weeds. Moreover, tilling the soil after cover crop termination can also reduce the decomposition of cover crop and poultry litter residues compared to leaving them on the soil surface (Table 1). This indicates that tillage can also help store soil organic matter for a longer period in the organic cotton systems.

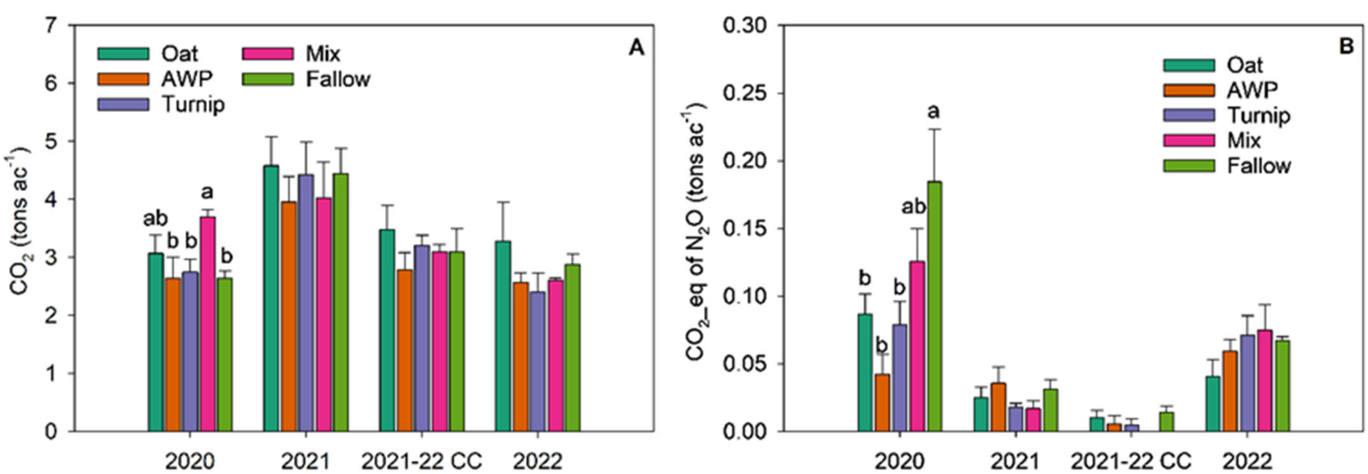

Figure 5: Cumulative soil CO_2 (A) and CO_2 equivalent (CO_2_eq) of N_2O (B) emissions or uptake for 100 days in 2020, 2021, 2022 cotton seasons and 2021-22 cover crop season in response to different cover crop practices. The letters above the error bars indicate significant differences among the cover crop treatments ($P < 0.05$), if any, within a crop season. No letters are present if there is no significant difference for a crop season. The cover crop treatments were oats, Austrian winter pea (AWP), purple-top turnips (Turnip), the mix of oats, AWP, and turnips (Mix), and no cover crop control (Fallow).

How often and when to apply tillage?

In organic management systems, tillage is the primary means of weed control after weed germination. The organic cotton study at Texas A&M University tried two different tillage practices in the organic cotton system, such as conventional tillage and minimum tillage. The conventionally tilled plots received multiple tillage passes, such as disking after harvest, before cotton planting, and two to three interrow cultivation during cotton seasons. While minimum tillage plots only received disking after cotton harvest. The major findings from the study are:

- A single tillage operation after cotton harvest is not sufficient to control weeds before cotton planting.
- Grass species cover crops such as oats require disking after termination to stop them from growing back during the cotton season.
- Timely tillage earlier in the cotton season is critical to avoid weed pressure and achieve a good cotton stand (Figure 7).

How to choose the right land for organic cotton production?

Selecting the right land is essential for successful organic cotton production. One of the key factors to consider is low weed pressure and a minimal weed seed bank. Fields with high weed pressure or a large weed seed bank can significantly complicate weed control, especially in the absence of chemical herbicides. To mitigate these challenges, it's often advisable to manage weeds by growing both summer and winter cover crops. Some good summer are Sunn hemp, buckwheat, and Sudan grass. On the other hand, oats, cereal rye, Austrian winter peas, and hairy vetch are suitable winter cover crops in south Texas. The cover crops need to be plowed down to soil before they reach the flowering stage. Moreover, frequent plowing for at least two years before transitioning to organic production is necessary. This approach not only reduces existing weed pressure but also helps to minimize the seed bank, creating a more manageable environment for organic production.

Additionally, it is important to avoid selecting fields situated in low-lying areas of the landscape. These areas are prone to waterlogging after heavy rainfall, which can promote rapid weed growth, particularly in regions like southeastern Texas. In these areas, weeds can grow quickly after rain, making timely weed control essential to prevent them from overtaking the crop. Choosing land located on higher ground facilitates quicker field access after rain, improving the ability to implement timely weed control measures.

Are there organic defoliants for organic cotton production?

Defoliation before cotton harvest is one of the all-time major challenges in organic cotton production. In the southern high plains region, farmers wait for the early frost in the season to kill the plants and help the cotton harvest. However, in the southern part of Texas that is not an option. A combination of management techniques such as adjusting planting time and water stress can be used to help harvest organic cotton. Cutting off the waters supply earlier can help mature and stimulate the opening of the bolls.

Figure 7: Weed pressure with minimum (left) and conventional tillage (right) in an organic cotton field near College Station, Texas.

There are not many choices for organic-approved defoliants. However, the Organic Materials and Review Institute (OMRI) has approved some organic products that can be used as organic defoliants. However, it is advisable to consult a certifier before using any of these products to ensure their approval of the product in organic production. Acetic acid and citric acid are the two most commonly used active ingredients for organic defoliants. Other organic herbicides include citrus oil, clove oil, cinnamon oil, lemon grass oil, capric acid, and caprylic acid. Some OMRI-approved organic defoliants, their active ingredients, and commercial product names are listed in Table 2.

Summary

Organic cotton production in the humid subtropical climate of southern Texas is challenging. However, there are opportunities for success through use of management practices such as cover crops, timely tillage, and water management. Cover crops not only improve soil function but also help control weeds, reduce soil greenhouse gas emissions, and conserve soil water during drought. Careful observation of weed pressure and timely cultivation is the most critical practice for organic cotton production. Together, these practices can help overcome the challenges and tap into the promising opportunities of organic cotton production in the region.

Table 2: List of potential organic defoliants approved by Organic Materials and Review Institute (OMRI).

Type	Active ingredient(s)	Example product(s)
Botanical	Clove oil - 70%, soaps	Herbor-G
Botanical	d-Limonene (citrus oil)	AG Optima Burndown Herbicide, Avenger
Botanical	Acetic acid, Citric acid	AllDown
Botanical	Eugenol	Demize
Botanical	soybean oil, citric acid	EcoBlend Weed Killer
Botanical	Acetic acid	Vinegar, Green Gobbler, Vinagreen
Botanical	Clove, cinnamon oils	Weed Zap, Burnout
Biological	*Colletotrichum gloeosporioides f. sp aes-*	LockDown XL
Oils/Soaps	Ammonium Nonanoate	Axxe, Mirimichi Green, Biosafe Weed, and
Oils/Soaps	Ammoniated soap of fatty acids	Final-San-O, Weed Warrior, Finalsan
Oils/Soaps	Capric acid 36% and caprylic acid 44%	Homeplate, OHP Fireworxx
Oils/Soaps	Capric acid 32% and caprylic acid 47%	Suppress

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