DIVISION OF AGRICULTURE
RESEARCH & EXTENSION
University of Arkansas System

Agriculture and Natural Resources

FSA2219

Climate-smart Agricultural Practices for Cotton Production in Arkansas

Cassie Seuferling
Research Assistant - Crop, Soil & Environmental Sciences

Kristofor R. Brye
University Professor - Crop, Soil & Environmental Sciences

Diego Della Lunga
Post Doctoral Fellow - Crop, Soil & Environmental Sciences

Jonathan B. Brye
Research Assistant - Crop, Soil & Environmental Sciences

Michael B. Daniels
Distinguished Professor - Crop, Soil & Environmental Sciences

Kelsey Greub
Instructor - Crop, Soil & Environmental Sciences

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Introduction

The issue of climate change has recently become a topic of concern for agriculture, particularly considering the increased frequency of droughts, the prevalence of severe weather events and rising air temperatures that can affect crop yields. Intensively cultivated areas also represent a substantial direct and indirect source of greenhouse gases (GHG) that influence climate change. The three main GHGs emitted from soils are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). The quantities and rates of release of these gases from soils that are being used for row crop agriculture vary based on the management practices that are being used.

Evaluation of cultivation practices for row crops is critical to understanding potential climate-change mitigation strategies in the agricultural sector. Mitigation strategies include the use of conservation tillage and cover crops that may reduce soil surface GHG emissions, as well as reducing emissions from farm equipment by reducing the number of required trips across fields. Climate-smart practices aim to reduce direct and indirect GHG emissions and to encourage enhanced storage processes such as soil carbon (C) sequestration.

Examples of biological processes that produce GHGs in soil:

- **Carbon dioxide:** Released as a result of root respiration and aerobic microorganism respiration during organic matter decomposition. Emissions generally increase when soil is disturbed by cultivation (i.e., tillage).
- **Methane:** Released from microorganism respiration during organic matter decomposition under anaerobic (i.e., water-logged) soil conditions.
- **Nitrous oxide:** Released as a result of denitrification reactions under anaerobic (water-logged) soil conditions. Emissions generally increase after nitrogen (N) fertilizers are applied to fields.

Cotton Production

Upland cotton (*Gossypium hirsutum*) is often grown for lint for textiles and seeds for oilseed and cattle feed. The cotton plant requires adequate soil moisture, warm soil temperatures and a relatively long growing season, usually from mid-April to mid-October. In 2023, Arkansas produced 9 percent of the total cotton lint yield in the United States (USDA-FAS, 2024). The majority of cotton production in Arkansas occurs on soils of various textures in the eastern third of the state, near the Mississippi River, where the climate is humid and the winters are mild. Practices common in Arkansas cotton production include spring pre-plant tillage with multiple field passes to break down stalks and create or reform raised beds for planting, furrow or sprinkler irrigation and in-season N fertilization, along with herbicide and pesticide use as necessary. For more information on general cotton production practices in Arkansas, see Arkansas Cotton Quick Facts (Robertson et al., 2022).

Climate-smart Agriculture

The goal of climate-smart agricultural research is to identify management practices that enhance C and nitrogen (N) sequestration in the soil by reducing GHG emissions and enhancing direct sequestration of gases from the atmosphere into the soil. Climate-smart practices that have been shown to reduce GHG emissions and conserve soil and water resources include reduced tillage (conservation tillage and no-tillage (NT; Figure 1) and cover crops (Figure 2).

Most forms of reduced tillage, including NT, typically qualify as conservation tillage, defined as any tillage practice that leaves 30 percent or more of the soil surface covered with crop residue (USDA-NRCS, 2017). Cover crops can be used separately or in combination with conservation tillage to promote soil quality (i.e., the ability of the soil to function as a plant growth medium), by reducing soil erosion, improving water infiltration and promoting the buildup of soil organic matter (Teague et al., 2012).

Figure 1. Field in St. Francis County, AR with no-tillage (top panel) and conventional tillage (bottom panel) strips as experimental treatments in a wheat-soybean, double-crop study.

Cover crops are typically non-harvested crops planted during the off-season or fallow period to improve soil health by increasing water infiltration and reducing soil erosion (Roberts et al., 2018). Common cover crops in Arkansas agricultural systems include winter cereals such as cereal rye (*Secale cereale*), winter broadleaves such as tillage radish (*Raphanus sativus*) and winter legumes such as clovers (*Trifolium*; Roberts et al., 2018).

Using conservation tillage or NT practices in conjunction with cover crops can theoretically reduce CO_2, CH_4, and N_2O emissions by reducing the number of tillage passes across a field, reducing the risk of compaction and emissions from fuel combustion, thus often improving soil quality. Reduced tillage enhances aggregate stability, decreases the level of soil disturbance and the breakdown of organic material, therefore reducing CO_2 emissions. Improved water infiltration from reduced tillage and use of cover crops may lead to less standing water in fields after rainfall or irrigation events, leading to reduced CH_4 and N_2O emissions. Cover crops can scavenge leftover soil N, which both reduces the amount of N potentially denitrified by soil microorganisms and decreases the amount of fertilizer N required for the cash crop when the cover crop is terminated and nutrients are returned to the soil, thus reducing N_2O emissions.

In 2022, more cropland in Arkansas was managed under conservation tillage than under conventional tillage, however less than 5 percent of Arkansas cropland presently uses cover crops (USDA-NASS, 2022). Using conservation tillage practices alongside cover crops in cotton production can increase cotton lint yield while increasing water infiltration and water retention (Nouri et al., 2019).

Studies evaluating GHG emissions from climate-smart practices used in cotton production

Figure 2. Field in Desha County, AR in fall 2024, using no-tillage and planted with cereal rye cover crop (right), and a standard tillage strategy without cover crops (left). Field was planted with soybean during the 2024 growing season.

in Arkansas are ongoing. However, reductions in GHG emissions resulting from implementation of climate-smart management practices in other uplands crops have already been reported. In Arkansas soybeans (*Glycine max*), it was determined that the use of NT reduced CO_2 emissions compared to conventional tillage practices (Brye et al., 2006; Smith & Brye, 2014). A 15-year study in a corn (*Zea mays*)-soybean rotation in South Dakota concluded that CO_2 and N_2O emissions were reduced when cover crops were planted after crop harvest (Wegner et al., 2018). Reduced CO_2 emissions under conservation tillage have been attributed to slower decomposition of organic matter left on the soil surface, (Brye et al., 2006), as well as to reduced land cultivation directly influencing the release of CO_2.

However, similar studies with soybeans in the mid-southern United States noted that CO_2 and N_2O emissions were not affected by tillage or cover crops (Firth et al., 2022; Watts et al., 2023), and it is often observed that CH_4 emissions are unaffected by conservation tillage and cover crop practices (Wegner et al., 2018; Watts et al., 2023).

Though reduced tillage and/or cover crops may not always reduce GHG emissions, a potential secondary benefit to reduced tillage and/or cover crop use may be the increase in soil C over time (i.e., soil C sequestration). Differing results from multiple studies indicate a need for additional research quantifying GHG emissions from Arkansas row-crop agroecosystems and evaluating mitigation strategies with reduced tillage, cover crops or a combination thereof, particularly in cotton.

Summary and Conclusion

Greenhouse gas mitigation through agricultural practices is becoming an important strategy to reduce adverse effects of global climate change. The three main GHGs of concern in agriculture are CO_2, CH_4, and N_2O. The quantities of these GHGs emitted from the soil surface are determined by a variety of factors, including soil management practices. Using conservation tillage and/or cover crops improves soil quality and may reduce GHG emissions. Therefore, these practices should be considered for implementation as climate-smart agricultural practices for cotton production in Arkansas.

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CASSIE SEUFERLING is a research assistant, **KRISTOFOR R. BRYE** is a university professor, **DIEGO DELLA LUNGA** is a post doctoral fellow, **JONATHAN B. BRYE** is a research assistant, **MIKE DANIELS** is a distinguished professor, and **KELSEY GREUB** is an instructor . All are with Crop, Soil and Environmental Sciences at the University of Arkansas System Division of Agriculture.

FSA2219-PD-1-2025