Reducing carbon footprint in agriculture through conservation and efficient nutrient management practices:
Evidence from Bangladesh

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RATIONALE

Climate change challenges and the role of agriculture

Bangladesh faces annual natural disasters such as floods, cyclones, and drought, largely due to climate change and global warming.

Climate change, driven by greenhouse gas (GHG) emissions from industries and agriculture, threatens the environment and global food security (Krupnik et al., 2022).

Agriculture is both a contributor to and a victim of climate change. Intensive farming, agrochemical use in high-yield systems—like rice-rice and rice-wheat, and rice-maize significantly contribute to greenhouse gas emissions. Crop production alone accounts for 27% of global emissions (Ritchie, 2019).

Conservation of agriculture and mitigation of climate change effects

Conventional Agriculture (CONA)

- Involves deep inversion tillage (200-300 mm), exposing soil to oxidation (Shepherd et al., 2001).
- Removes plant residues, increasing GHG emissions.

Conservation Agriculture (CA)

- Promotes minimum soil disturbance, crop rotation, residue retention (Mandal et al., 2021), and integrated pest management (Brown et al., 2021).
- Uses no-till/reduced-till practices for lower energy use and reduced GHG emissions.

Fertilizer Management in CA

- Requires complementary technologies (e.g., water, weed, and nutrient management (Majumdar et al., 2018).

CA Benefits

- Recognized for energy efficiency and as a climate change mitigation strategy (Islam et al., 2019; Gathala et al., 2020)

Objectives

Many studies have highlighted the potential benefits of CA, but its impact on GHG emissions and fertilizer efficiency in CA remains uncertain.

This study assesses the effects of alternative agricultural practices, specifically CA and nutrient-efficient farming on GHG emissions.

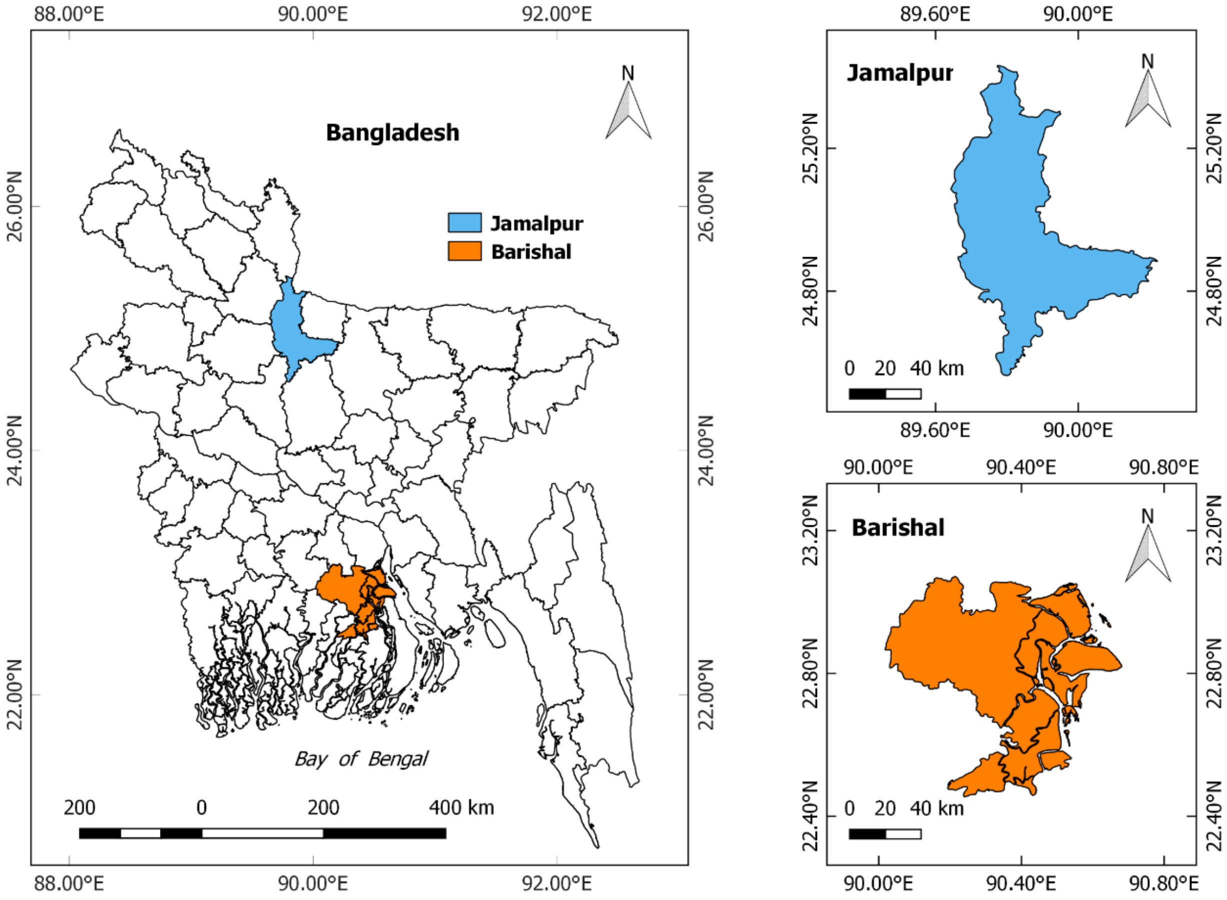
By examining these practices, we hope to provide insights into the potential of CA to mitigate the effects of climate change in agricultural systems

METHODOLOGY

Site description

The study was conducted from 2011 to 2014 at Bangladesh Agricultural Research Institute (BARI) stations: Jamalpur (24.9250° N, 89.9463° E) and Barisal (22.7010° N, 90.3535° E). Jamalpur is in the Active Brahmaputra-Jamuna Floodplain (AEZ-9), while Barisal lies in the Ganges Tidal Floodplain (AEZ-14).

Criteria	Jamalpur site	Barisal site
Maize growing season	Temperature: 10.5-33.5º C	10.56-36.05º C
	Total monthly rainfall: 0-308 mm	0-235 mm
Rice growing season	Temperature: 23-33.1ºC	23.3-33.3 ºC
	Total monthly rainfall:16-559 mm	66-398 mm
Soil type	Clay loam	Loam
pH	5.7	6.19
Soil organic carbon	0.65%	0.81%



Treatments

Treatments: Two factors

Factor A: Production system
- Conventional tillage (CONA)
- Conservation agriculture (CA)

Factor B: Fertilizer management
- +NPKZn
- -N+ PKZn
- -P+NKZn
- -K+NPZn
- -Zn+NPK

Design: Split-plot

Trial location:
- RARS, Mymensingh
- RARS, Barishal

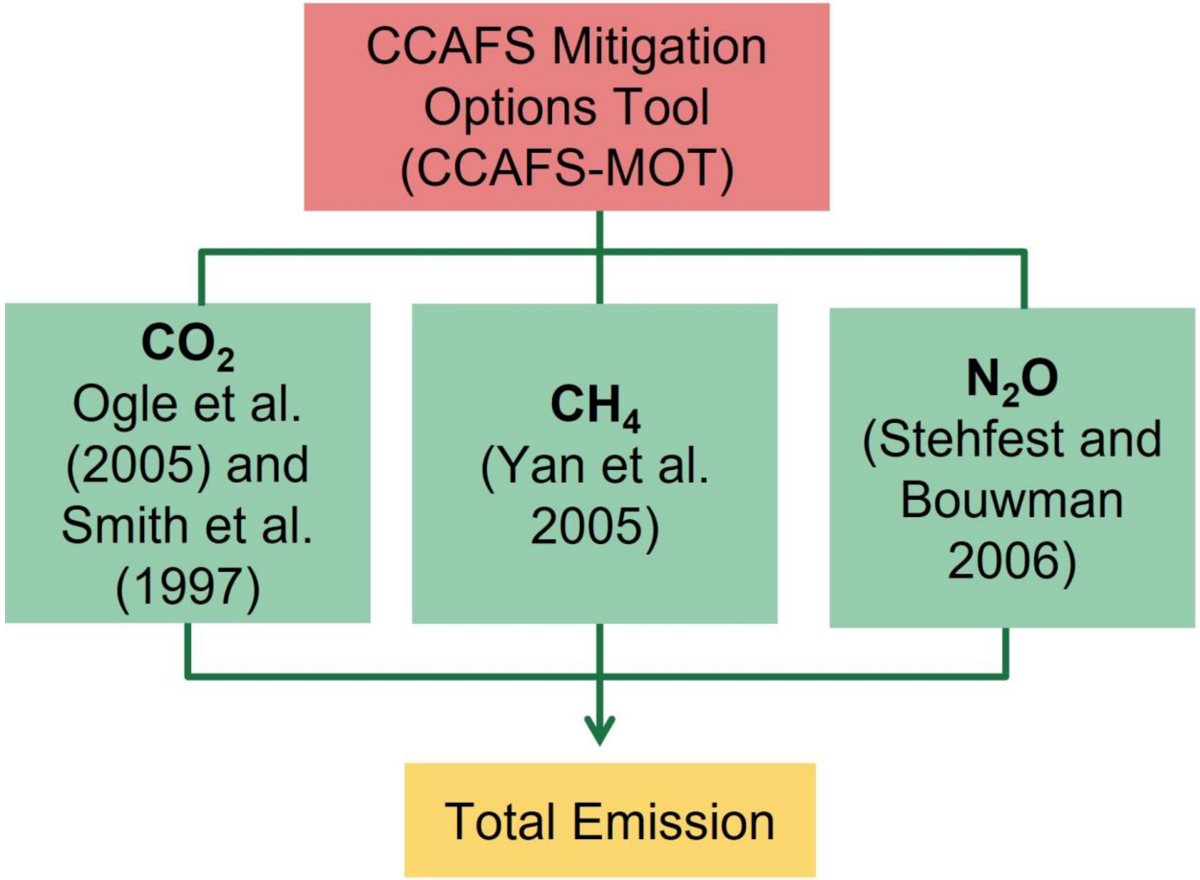
Rice: BINA 7

Maize: NK 40 Hybrid

Year of trial : 3 years

Data collection
- Soil and plant nutrients
- Yield and yield parameters

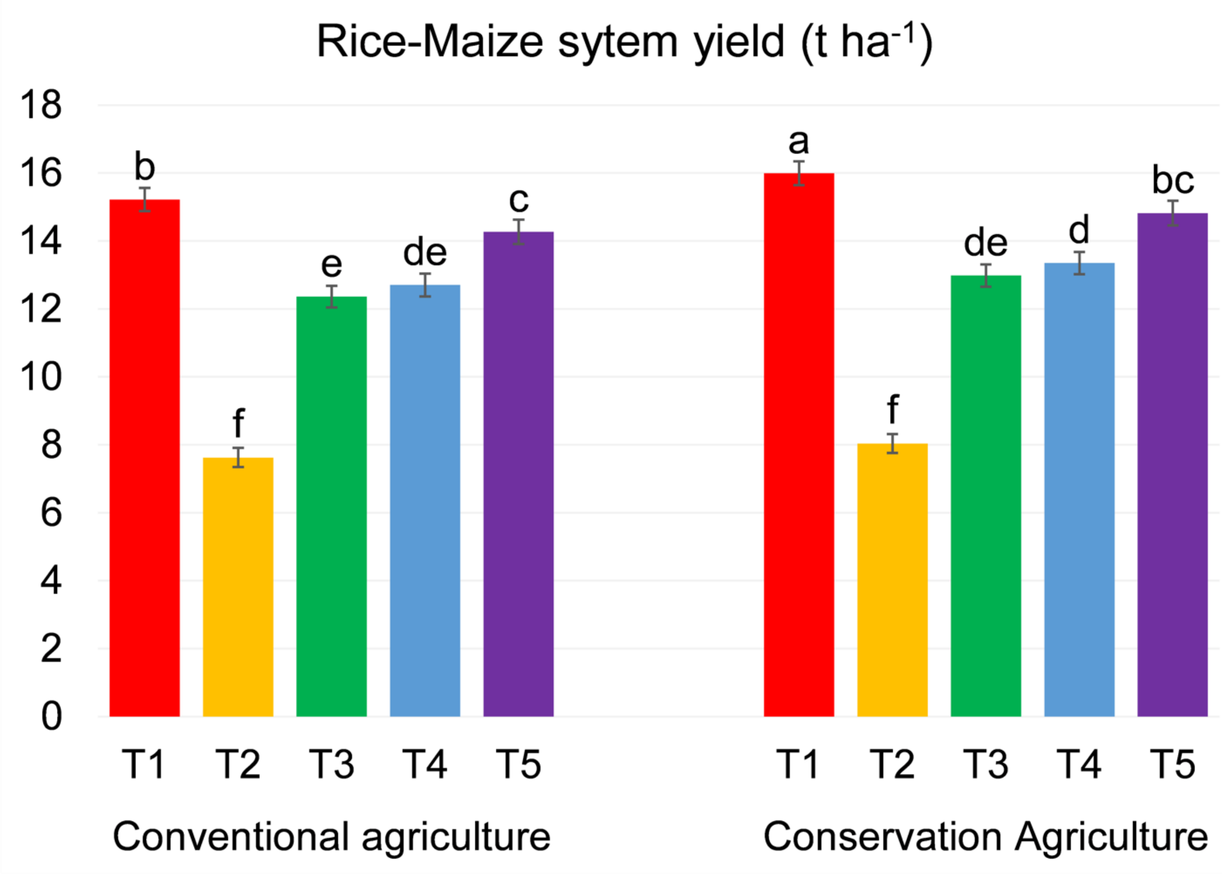
Energy, Global warming potential & GHG emissions



- **The CCAFS' Mitigation Options Tools** (CCAFS-MOT) are used to estimate GHG emissions associated with crop production systems until the farmgate level.
- **Calculated** R-M system yield, total energy use (TEU), global warming potential (GWP), and emission intensity (EI).
- **Statistical analysis:** An analysis was conducted using a two-factor repeated measures design with a split-plot approach (Gomez and Gomez, 1984).

RESULTS

Rice-Maize system yield

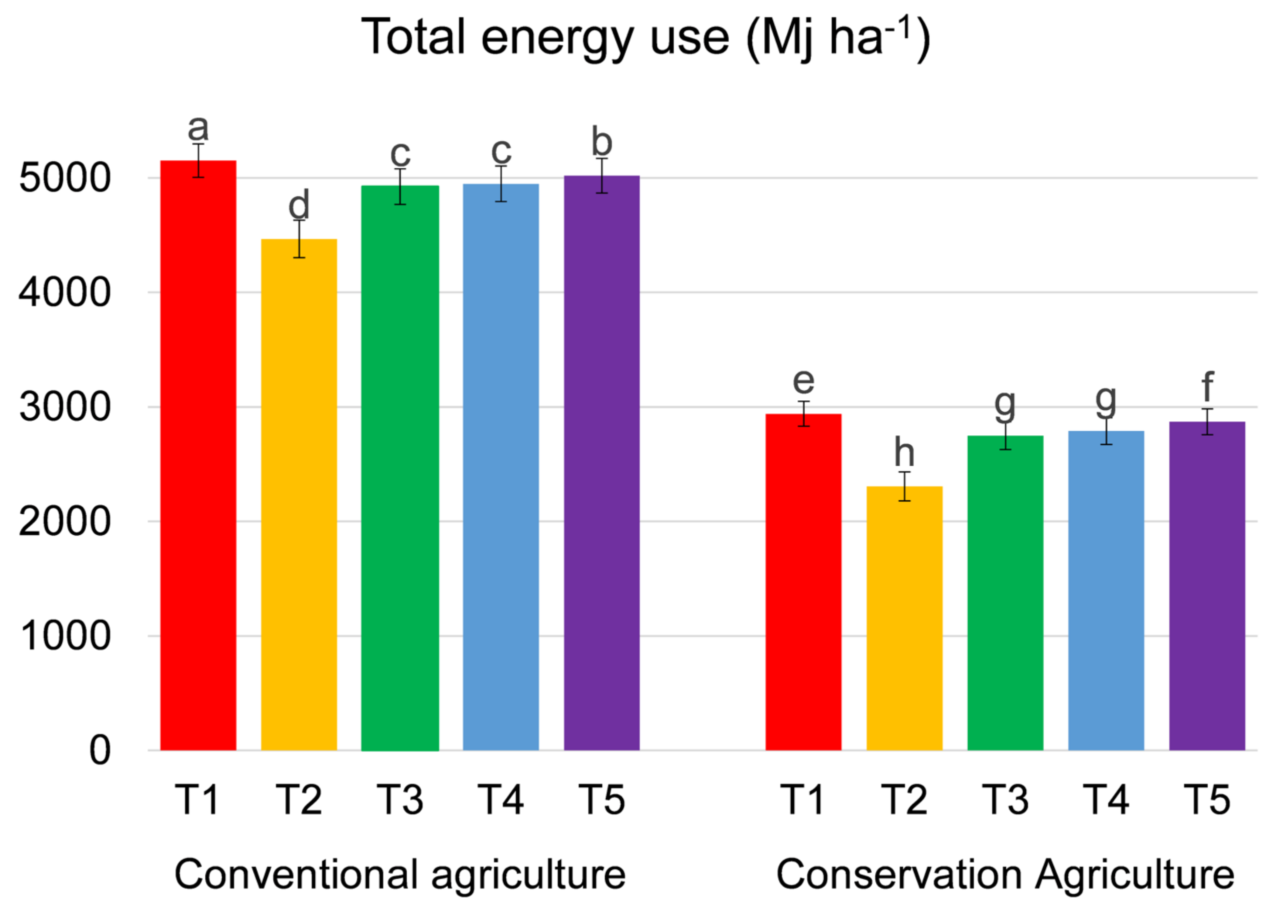


Source	P value
Production systems (PS)	<0.01
Fertilizer management (FM)	<0.01
PS × FM	0.815

CA had a 5.10% yield increase compared to CONA.

T1= +NPKZn, T2= -N+PKZn, T3= -P+NKZn, T5= -K+NPZn, T6= -Zn+NPK

R-M system energy use

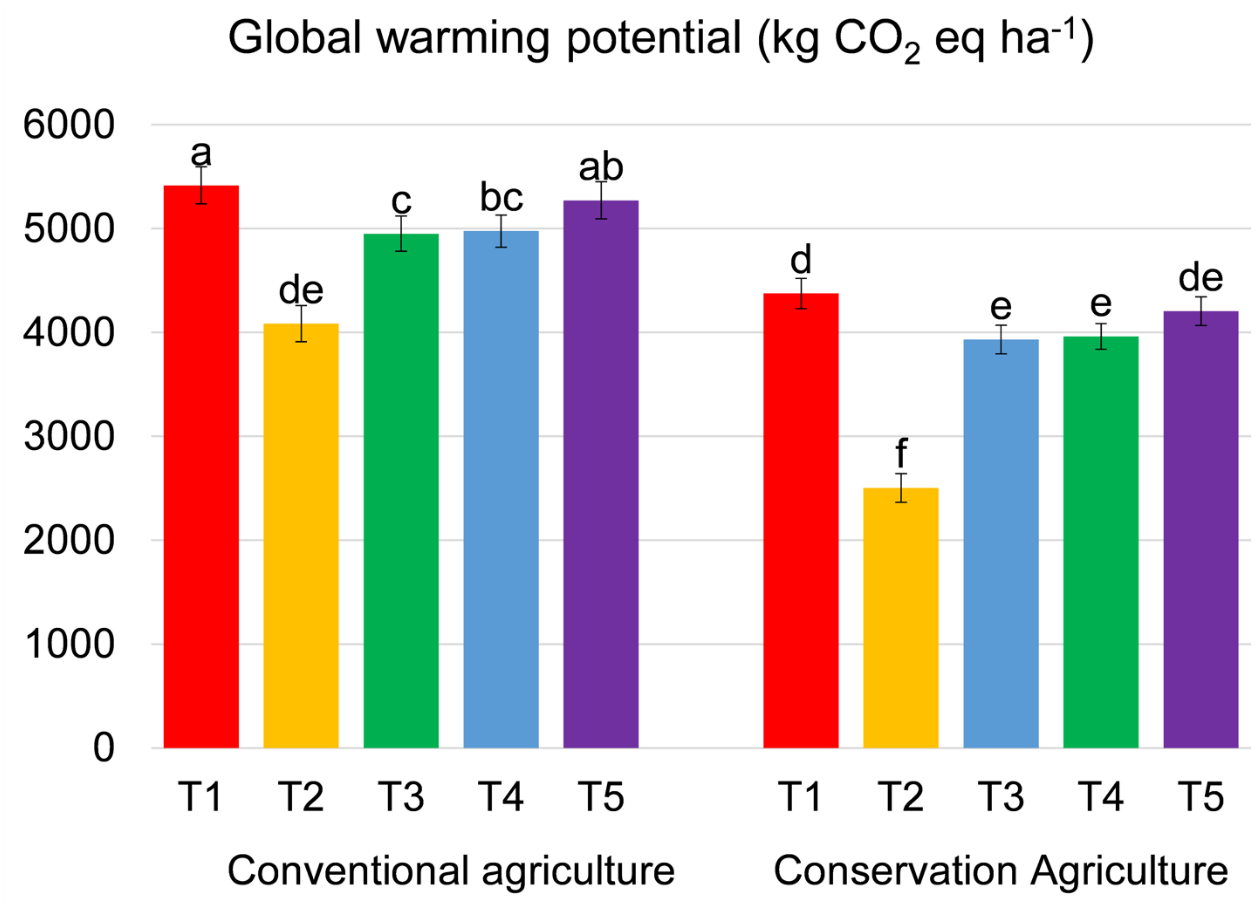


Source	P value
Production systems (PS)	<0.01
Fertilizer management (FM)	<0.01
PS × FM	0.99

CA required 44.28% less energy compared to CONA.

T1= +NPKZn, T2= -N+PKZn, T3= -P+NKZn, T5= -K+NPZn, T6= -Zn+NPK

Global warming potential

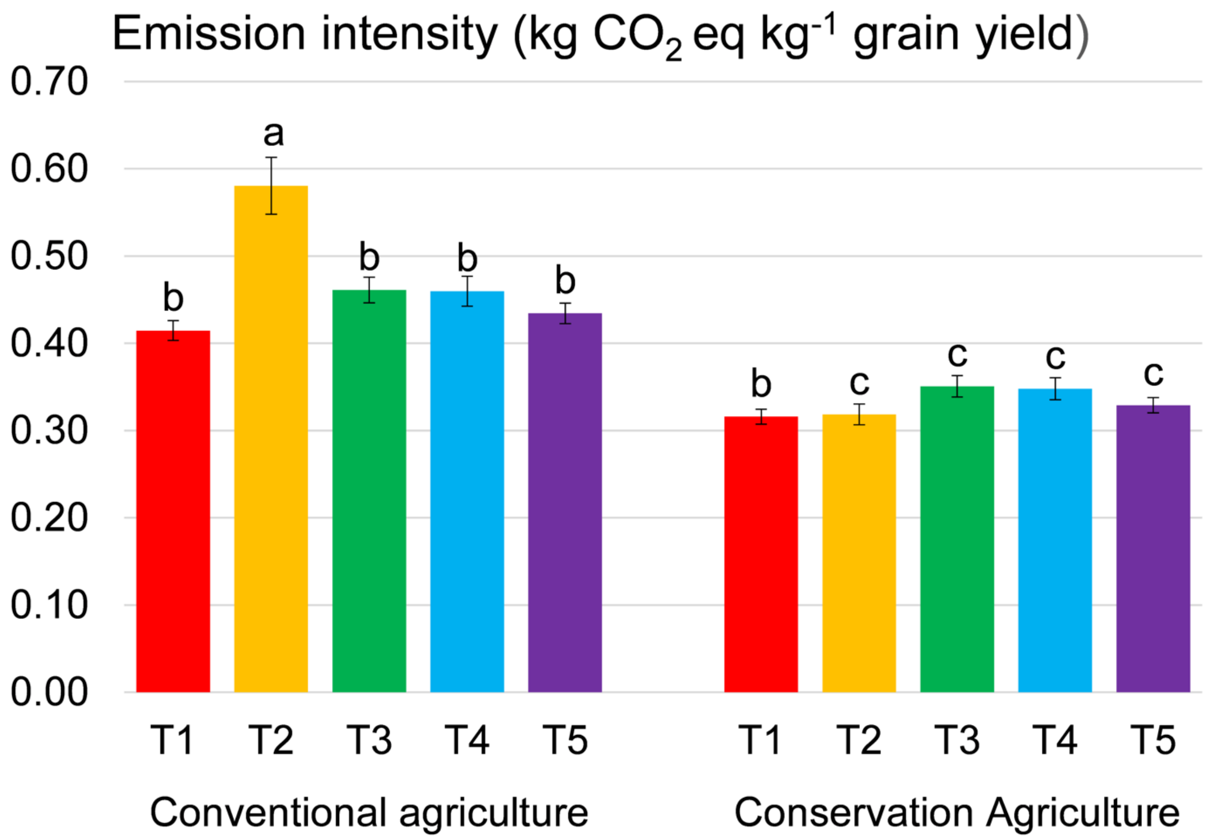


Source	P value
Production systems (PS)	<0.01
Fertilizer management (FM)	<0.01
PS × FM	0.0015

In CA 24.48% of GHG emission was reduced compared to CONA.

T_1= +NPKZn, T_2= -N+PKZn, T_3= -P+NKZn, T_4= -K+NPZn, T_5= -Zn+NPK

Emissions intensity



Source	P value
Production systems (PS)	<0.01
Fertilizer management (FM)	<0.01
PS × FM	<0.01

CA had 28.51% less emission intensity compared to CONA.

T1= +NPKZn, T2= -N+PKZn, T3= -P+NKZn, T5= -K+NPZn, T6= -Zn+NPK

IMPLICATIONS

Implications

The study examined balanced nutrient application with CA, particularly the "+NPKZn" treatment, which significantly enhances yields while achieving the lowest carbon footprint compared to CONA, highlighting the importance of addressing deficiencies in N, P, K, and Zn.

CA reduces energy use by 44.28% and the carbon footprint by 24.48% compared to CONA, demonstrating its potential to achieve high yields with lower environmental impact.

The study concludes that CA with balanced nutrient use enhances productivity, reduces emissions, and conserves energy, offering a sustainable approach to mitigating climate change and developing climate-resilient farming systems.

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