Shandong Agricultural University

Effects of residue management strategies on greenhouse gases and yield under double cropping of winter wheat and summer maize

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KEYWORDS:

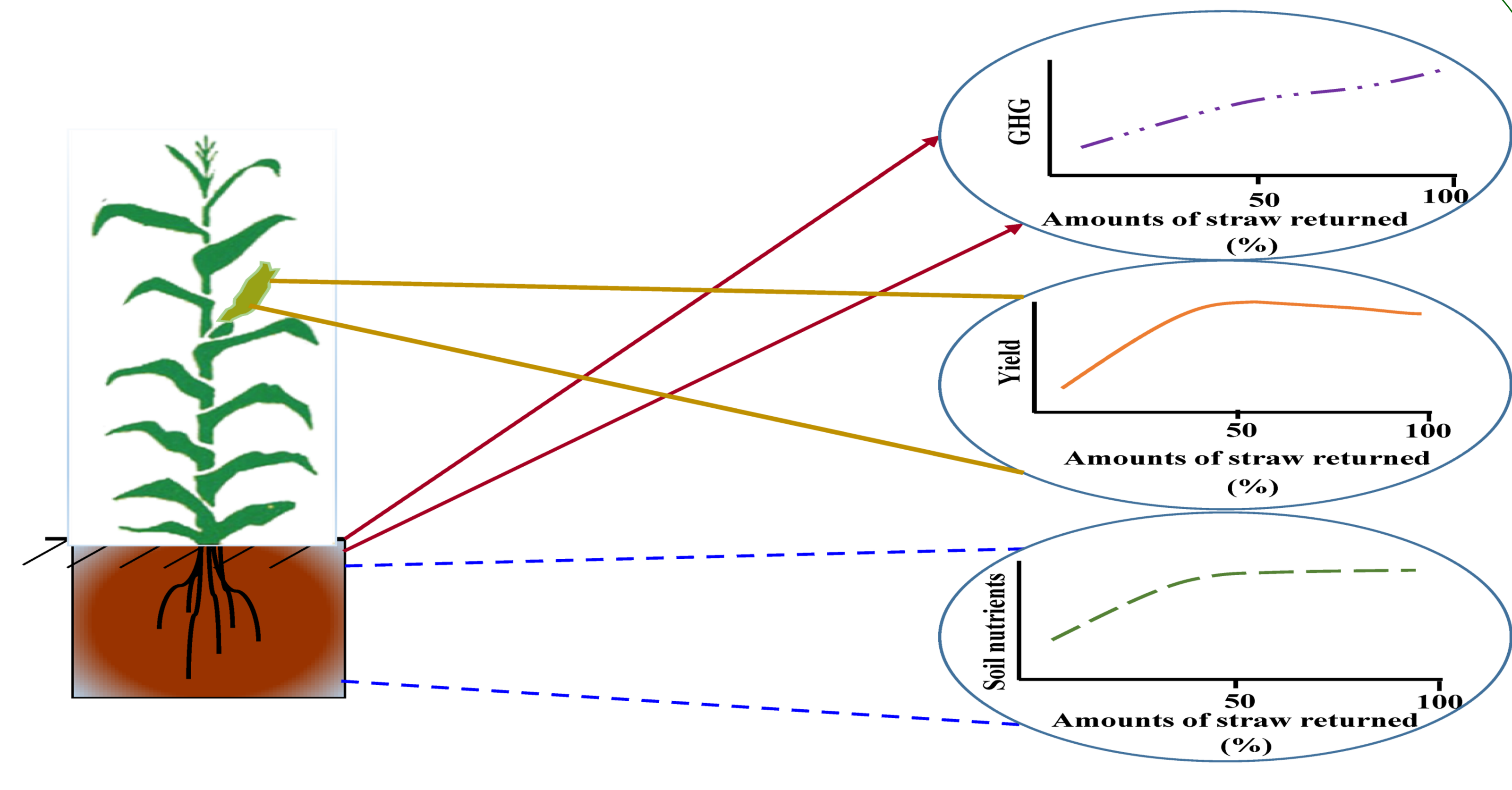
Double cropping system

Summer maize

Stover returned

Greenhouse gas emissions

Graphical Abstract:



Comprehensive effect of straw returned to field on soil – crop - atmosphere

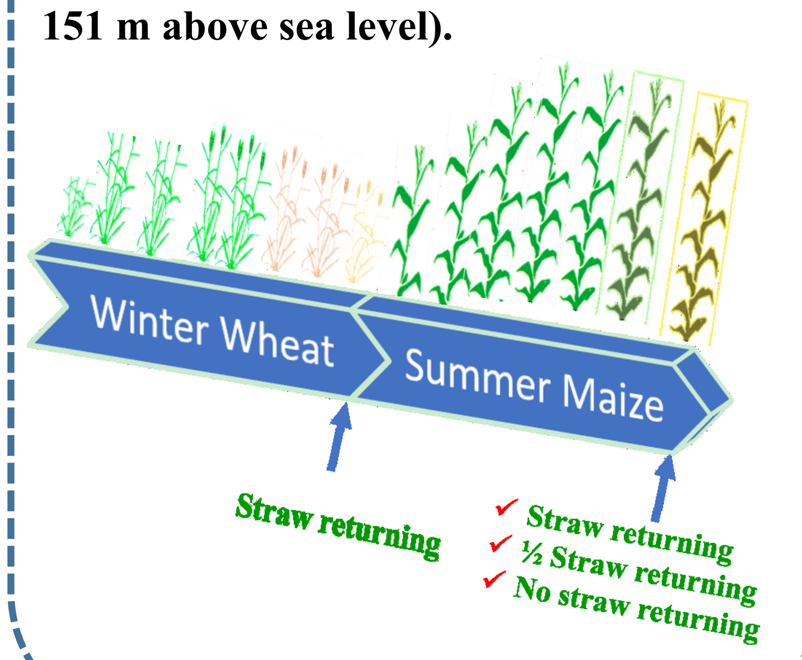
Introduction:

The North China Plain (NCP) is typically cropped using a winter wheat–summer maize double cropping system, which has huge potential for straw production. The region also experiences atmospheric pollution caused by straw burning, which has become an important contributor to global warming.

Straw return in a double cropping system is expected to increase greenhouse gas efflux; however, there is a risk of increasing greenhouse gases with the amount of straw returned. The decomposition of straw is closely related to soil texture, tillage mode and climate change. We look forward to finding a reasonable amount of straw returned to the field that reduces greenhouse gas emissions while ensuring yield does not decline and thus achieving a win-win for yield and the environment. The effect of the decomposition of different amounts of summer corn straw returned to the field on yield and greenhouse gas emissions for many years is unknown under the conditions of the region. The goals of this study were to (i) quantitatively study greenhouse gas emissions during years when various amounts of summer maize straw were returned to the field and (ii) describe the relationships among greenhouse gas emissions, soil interactions, and straw returned with the aim of optimizing farmland management measures to mitigate the climate impacts of maize production.

Materials and Methods:

This study was conducted during 2011–2017 at the State Key Laboratory of Crop Biology and Experimental Farm of Shandong Agricultural University, China (36°11′ N, 117°06′ E, 151 m above sea level).



Gas flux calculation

$$F = \left(\frac{\Delta G}{\Delta t}\right) \times \left(\frac{V}{A}\right) \times \left(\frac{m}{Vm}\right)$$

$F = Gas\ emissions\ flux,\ \ CO_2\ (g\ m^{-2}\ h^{-1}),\ \ CH_4\ (mg\ C\ m^{-2}\ h^{-1}),\ \ N_2O\ (mg\ N\ m^{-2}\ h^{-1})$

$\frac{\Delta G}{\Delta t}$ = Increment of gas concentration in unit time

$V = Volume;\ \ A = Surface\ area$

$m = Molecular\ mass\ of\ greenhouse\ gases$

Global warming potential

$$GWP = CO_2 + (CH_4 \times 25) + (N_2O \times 298)$$

Greenhouse gas intensity

$$GHGI(kg\ kg^{-1}) = \frac{GWP\ (kg\ ha^{-1})}{Yield(kg\ ha^{-1})}$$

Results:

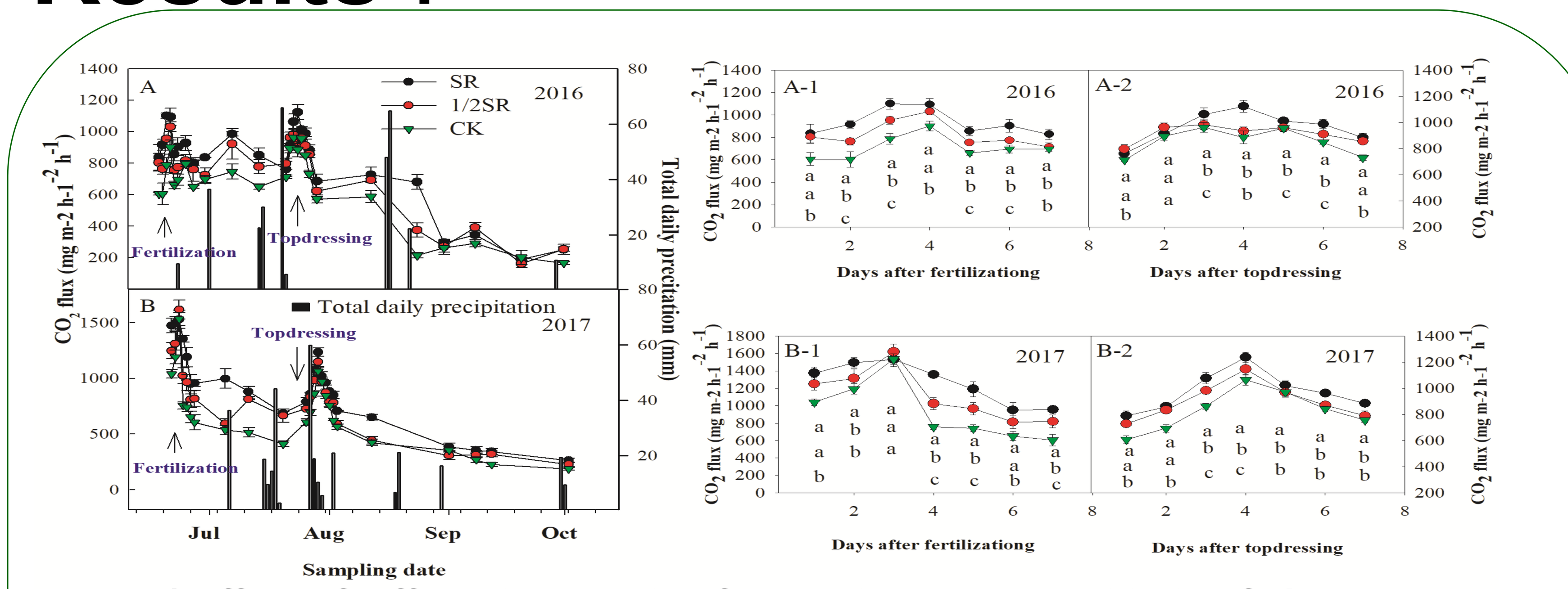


Fig. 1 Effect of different amounts of corn stover returned to the field on variations in CO_2 emission fluxes during maize growth in 2016 and 2017.

SR, all winter wheat straw and all summer maize stalks returned to the field; 1/2 SR, all winter wheat straw and one-half of the summer maize returned to the field; CK, all winter wheat straw returned to the field, whereas all summer maize stalks were completely removed.

A: CO_2 emission fluxes during maize growth in 2016; A-1: CO_2 emission fluxes a week after fertilization during maize growth in 2016; A-2: CO_2 emission fluxes a week after topdressing during maize growth in 2016.

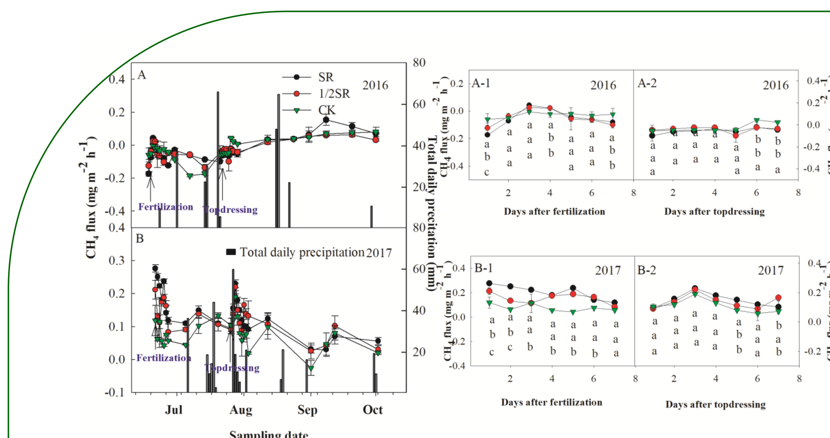


Fig. 2 Effect of different amounts of corn stover returned to the field on variations in CH_4 emission fluxes during maize growth in 2016 and 2017.

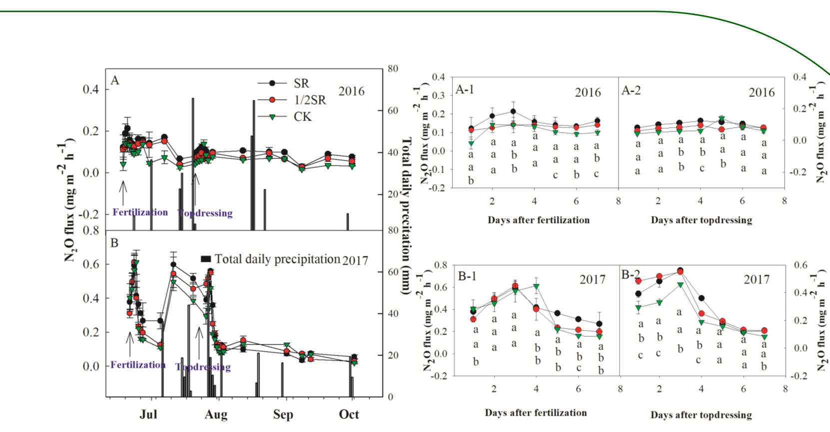


Fig. 3 Effect of different amounts of corn stover returned to the field on variations in N_2O emission fluxes during maize growth in 2016 and 2017.

Table 1 Effect of different amounts of corn stover returned to the field on GWP and GHGI during maize growth in 2016 and 2017.

Year	Treatment	Cumulative CO_2 emissions ($kg\ CO_2\ ha^{-1}$)	Cumulative CH_4 emissions ($kg\ CH_4\ ha^{-1}$)	Cumulative N_2O emissions ($kg\ N_2O\ ha^{-1}$)	GWP ($kg(CO_2$-eqv$)\ ha^{-1}$)	GHGI ($kg\ kg^{-1}$)
2016	SR†	15303a‡	1.01a	2.37a	16035a	1.23a
	1/2SR	13808b	0.83b	2.09b	14454b	1.09b
	CK	12220c	0.67c	1.85c	12788c	1.09b
2017	SR	14875a	0.98a	5.17a	16440a	1.37a
	1/2SR	13088b	0.89a	4.65b	14495b	1.18b
	CK	10634c	0.67b	4.01c	11845c	1.04b
Y		**	NS	**	NS	NS
T		**	**	**	**	**
Y*T		NS	NS	**	NS	*

GWP: Global warming potential. GHGI: Greenhouse gas intensity.

‡Different letters in each column indicate significant differences at $P < 0.05$ (LSD).

NS: Not significant.

*: Significant at the 0.05 probability level.

**: Significant at the 0.01 probability level.

Conclusion:

Compared with the SR treatment, the 1/2 SR treatment provides a significant reduction in greenhouse gas emissions, while also ensuring soil sustainability. The unused straw resources can be used for biomass energy, which ensures the utilization efficiency of the straw resources and makes an additional contribution to the mitigation of global greenhouse gas emissions and global climate change.

Published papers:

Fei Gao, Jiwang Zhang *et al.*, Response of maize root growth to residue management strategies. *Agronomy Journal*, 2018, 110(1): 1-8. (5-IF=2.095)

Fei Gao, Jiwang Zhang *et al.*, Effects of residue management strategies on greenhouse gases and yield under double cropping of winter wheat and summer maize. *Science of the Total Environment*, 2019, 687, 1138-1146. (5-IF=6.4)

Fei Gao, Jiwang Zhang *et al.*, Improving soil properties and yield under residue management strategies. *Agronomy Journal*, 2020. (5-IF=2.095)