Supplementary file

Organic Nitrogen Substitution Enhances Carbon Sequestration but Increases Greenhouse Gas Emissions in Maize Cropping Systems

Yanan Liu [1,2,3], Xiaoqing Zhao [2,3], Yuchen Cheng [2,3], Rui Xie [1,2,3], Tiantian Meng [1,2,3], Liyu Chen [2,3], Yongfeng Ren [2,3], Chunlei Xue [2], Kun Zhao [2,3], Shuli Wei [2,3], Jing Fang [2,3], Xiangqian Zhang [2,3,*], Fengcheng Sun [2,3,*] and Zhanyuan Lu [1,2,3,*]

[1] College of Agronomy, Hebei Agricultural University, Baoding 071000, China; 13384894790@163.com (Y.L.); xierui12358@163.com (R.X.); 15754882732@163.com (T.M.)
[2] Inner Mongolia Academy of Agricultural and Animal Husbandry Sciences, Hohhot 010031, China; zhaoxq204@163.com (X.Z.); ycch2024@163.com (Y.C.); cly@imaaahs.ac.cn (L.C.); renyongfeng_1984@163.com (Y.R.); xcl13474717283@163.com (C.X.); zhaokun_522@163.com (K.Z.); wslweishuli@163.com (S.W.); fangjing721@163.com (J.F.)
[3] Key Laboratory of Black Soil Protection and Utilization (Hohhot), Ministry of Agriculture and Rural Affairs of the People's Republic of China, Hohhot 010031, China
* Correspondence: zhangxiangqian_2008@126.com (X.Z.); sfcnmnky@sina.com (F.S.); lzhy2811@163.com (Z.L.)

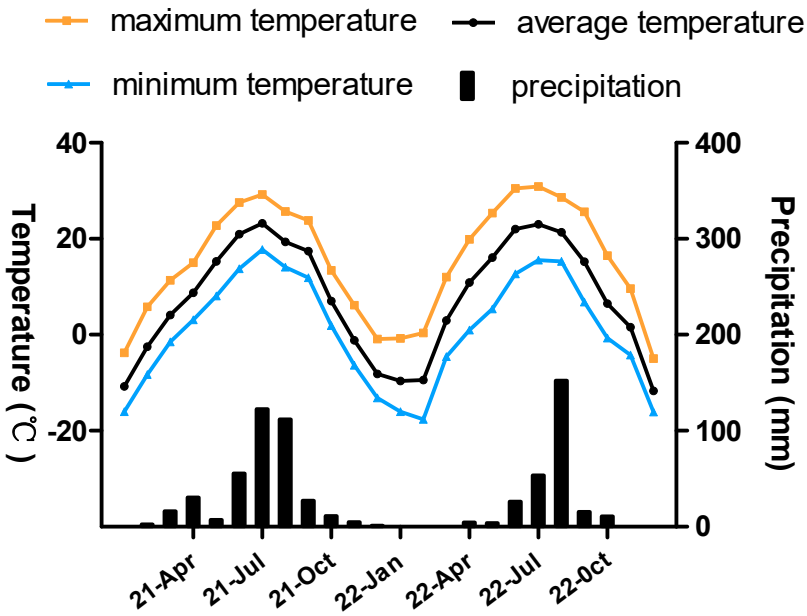

Fig S1. Monthly temperature and precipitation during the two-year experimental period.

Table S1 The emission factor of various agriculture inputs.

Year	Input	Units	CK	NPK	OF1	OF2	OF3	PK
2021	N fertilizer (N)	kg ha^{-1} yr^{-1}	0	240	160	160	0	0
	P fertilizer(P_2O_5)	kg ha^{-1} yr^{-1}	0	150	62.9	84.5	0	150
	K fertilizer(K_2O)	kg ha^{-1} yr^{-1}	0	112.5	18.39	0	0	112.5
	Diesel fuel	kg ha^{-1} yr^{-1}	128	128	128	128	128	128
	Electricity	kW · h ha^{-1} yr^{-1}	750	750	750	750	750	750
	Pesticide	kg ha^{-1} yr^{-1}	1.8	1.8	2.07	2.07	2.3	1.8
	Labor	d ha^{-1} yr^{-1}	105	240	204	204	180	180
	Seeds: maize	kg ha^{-1} yr^{-1}	25.5	25.5	25.5	25.5	25.5	25.5
	total		1248.21	3650.46	2735.4	2773.61	1316.00	1736.46
2022	N fertilizer (N)	kg ha^{-1} yr^{-1}	0	240	160	160	0	0
	P fertilizer(P_2O_5)	kg ha^{-1} yr^{-1}	0	150	73.7	97	0	150
	K fertilizer(K_2O)	kg ha^{-1} yr^{-1}	0	112.5	19.3	7.1	0	112.5
	Diesel fuel	kg ha^{-1} yr^{-1}	128	128	128	128	128	128
	Electricity	kW · h ha^{-1} yr^{-1}	750	750	750	750	750	750
	Pesticide	kg ha^{-1} yr^{-1}	1.8	1.8	2.07	2.07	2.3	1.8
	Labor	d ha^{-1} yr^{-1}	105	240	204	204	180	180
	Seeds: maize	kg ha^{-1} yr^{-1}	25.5	25.5	25.5	25.5	25.5	25.5
	total		1248.21	3650.46	2761.1	2807.42	1316.00	1736.46

Note: CK is No fertilizer, NPK is Chemical fertilizer, OF1 is 1/3 nitrogen fertilizer substitution by sheep manure, OF2 is 1/3 nitrogen fertilizer substitution by 1/6 sheep manure and 1/6 straw nitrogen, OF3 is Complete chemical nitrogen fertilizer substitution by sheep manure, PK is only phosphorus and potassium fertilizer.

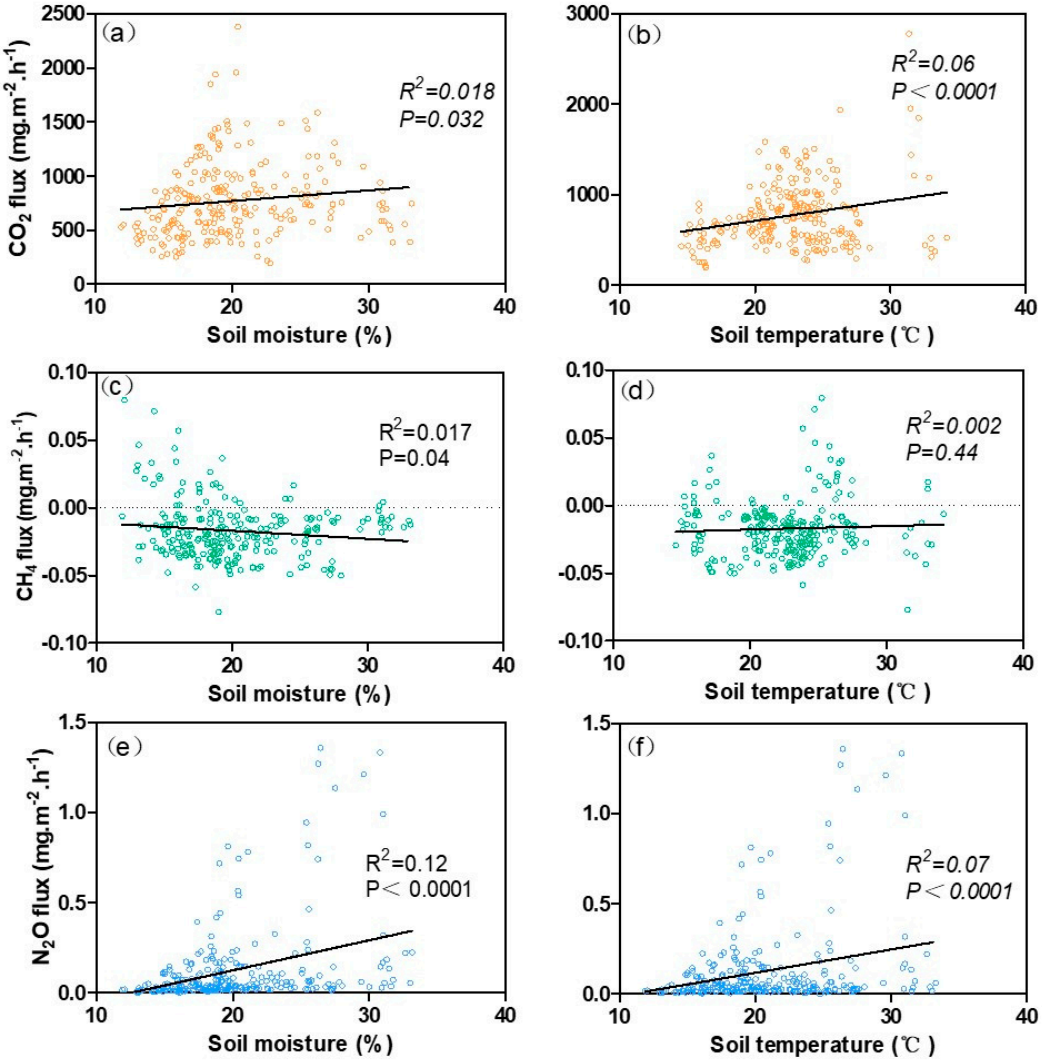

Fig **S2**. (a) The correlation between CO_2 fluxes and soil moisture. (b) The correlation between CO_2 fluxes and soil temperature. (c) The correlation between CH_4 fluxes and soil moisture. (d) The correlation between CH_4 fluxes and soil temperature. (e) The correlation between N_2O fluxes and soil moisture. (f) The correlation between N_2O fluxes and soil temperature.

Table S2. The impact of different fertilization treatments on soil physicochemical properties.

Year	Treatment	TN（g/kg）	NN (mg C kg^{-1})	AN (mg N kg-1)	AP (mg/kg)	AK (mg/kg)	BD(g cm^{-3})	PH
2021	CK	1.27±0.12d	14.93±0.59d	13.98±0.6c	3.47±0.24d	15.96±1.28d	1.39±0.2a	7.34±0.34b
	NPK	1.37±0.16c	46.88±3.71a	19.34±0.92a	18.27±2.85c	47.22±4.02c	1.43±0.06a	7.41±0.25ab
	OF1	1.53±0.21b	37.2±3.94b	16.96±0.58b	22.91±2.03ab	57.94±3.16b	1.37±0.08a	7.60±0.18a
	OF2	1.42±0.1c	25.86±4.64c	16.72±0.73b	19.55±1.68bc	37.04±3.02c	1.33±0.17a	7.42±0.05ab
	OF3	1.64±0.23a	27.73±3.78c	14.34±0.55c	29.67±3.06a	72.16±5.59a	1.27±0.04b	7.52±0.21a
	PK	1.22±0.08d	13.96±0.115d	13.39±0.39c	13.64±1.74c	24.84±1.45d	1.42±0.09a	7.39±0.24ab
2022	CK	1.23±0.11c	15.84±0.77d	12.09±0.69c	2.28±0.18d	9.55±1.28d	1.36±0.16a	7.41±0.18ab
	NPK	1.32±0.16ab	53.32±7.7a	26.21±10.22a	22.56±2.19b	35.12±2.02c	1.41±0.07a	7.29±0.16b
	OF1	1.41±0.06b	32.39±7.41b	21.48±9.04ab	26.61±2.65ab	42.74±3.51b	1.38±0.06a	7.55±0.34a
	OF2	1.40±0.07b	34.35±6.31b	19.4±9.38ab	18.95±2.13c	31.18±2.42c	1.36±0.07a	7.38±0.24b
	OF3	1.52±0.17a	26.51±7.31c	16.53±1.87bc	34.57±3.68a	62.88±4.09a	1.29±0.03b	7.40±0.16ab
	PK	1.20±0.017c	16.01±0.7d	11.51±1.54c	16.41±1.29c	26.34±1.82d	1.38±0.04a	7.35±0.31b
Year		＜0.0001	0.031	＜0.242	＜0.0001	＜0.0001	0.164	0.042
Treatment		＜0.0001	＜0.0001	＜0.0001	＜0.0001	＜0.0001	0.027	0.138
Year*Treatment		＜0.0001	＜0.024	＜0.083	＜0.0001	＜0.0001	0.342	0.622

Note: CK is no fertilizer, NPK is chemical fertilizer, OF1 is 1/3 nitrogen fertilizer substitution by sheep manure, OF2 is 1/6 nitrogen fertilizer substitution by sheep manure and 1/6 by straw nitrogen, OF3 is complete chemical nitrogen substitution by sheep manure, PK is phosphorus and potassium fertilizer only. TN is total nitrogen, NN is nitrate nitrogen, AN is ammonium nitrogen, AP is available phosphorus, AK is available potassium, BD is soil bulk density. Data are presented as mean ± standard deviation, n = 3. Different letters within the same column indicate significant differences among fertilization treatments at $P < 0.05$ level (one-way ANOVA).

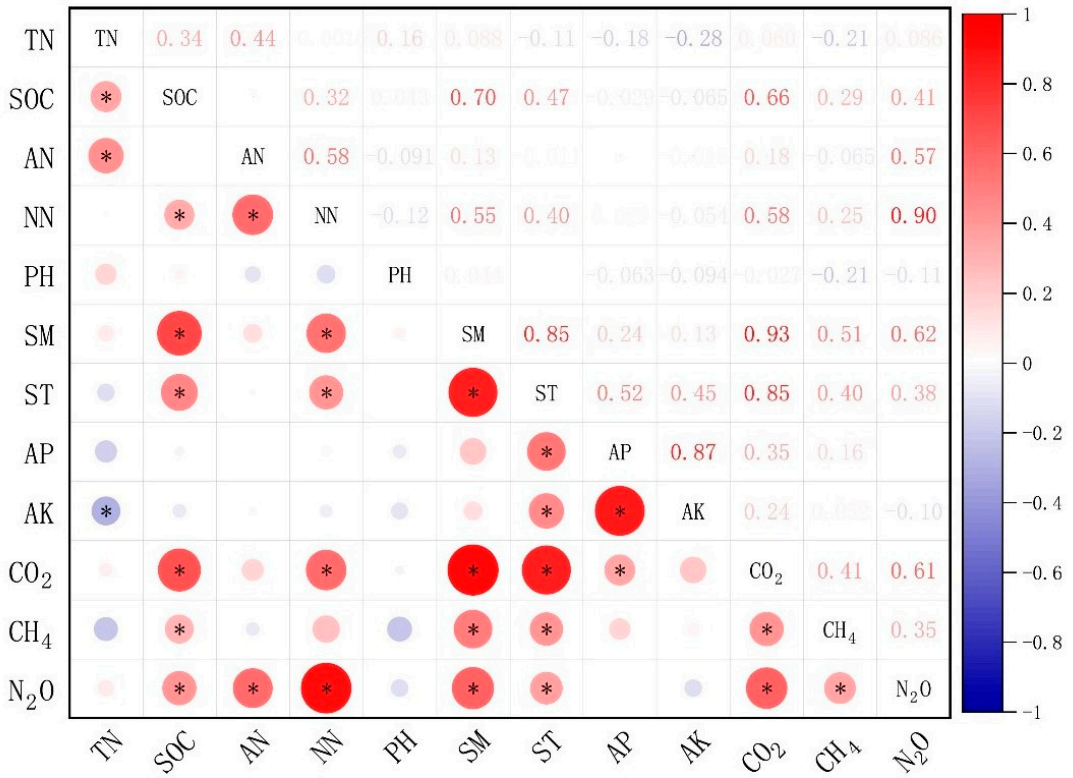

Fig S3. The relationship between CH_4, CO_2, and N_2O emissions and soil physical and chemical properties TN is total nitrogen, SOC is soil organic carbon, AN is ammonium nitrogen, NN is nitrate nitrogen, PH is soil pH, SM is Soil moisture content, ST is Soil temperature, AP is available phosphorus, AK is available potassium, BD is soil bulk density. * represents the P values less than 0.05