

Supplementary information for

Soil properties, carbon inputs, and climate combine to control the stable soil carbon saturation deficit dynamics over different 17-year fertilizations

Jiaying Di^{1,2}, Minggang Xu^{1,*}, Wenju Zhang¹, Xiaogang Tong³, Xinhua He^{4,5},
Hongjun Gao⁶, Hua Liu⁷ & Boren Wang¹

¹ *National Engineering Laboratory for Improving Quality of Arable Land, Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences, Beijing 100081, China*

² *Key Laboratory of Agro-information Services Technology of Ministry of Agriculture, Agriculture Information Institute of Chinese Academy of Agricultural Sciences, Beijing 100081, China*

³ *College of Resources and Environment, Northwest A & F University, Yangling, Shannxi 712100, China*

⁴ *College of Resources and Environment, Southwest University, Chongqing 400715, China*

⁵ *School of Plant Biology, University of Western Australia, Crawley, WA 6009, Australia*

⁶ *Centre of Agricultural Environment and Resources, Jilin Academy of Agricultural Sciences, Changchun 130033, China*

⁷ *Institute of Soil and Fertilizer, Xinjiang Academy of Agricultural Sciences, Urumqi, China*

***Corresponding authors.**

E-mail address: xuminggang@caas.cn (M.G. Xu)

Table S1. Coefficient values of the 13 predictor variable of the lasso regression model at the three long-term experimental sites. TOC, total soil organic content; TN, total soil nitrogen; AN, available nitrogen; TP, total phosphorus; AP, available phosphorus; BD, bulk density; pH, soil pH; MAP, mean annual precipitation; MAT, mean annual temperature; Cum_T > 10°C, effective cumulative temperature >10°C; Cum_C input, cumulative C input amount C input_R, crop residue-C input amount; C input_M/S, the extra organic C input amount (i.e., manure or straw).

Category	Predictor variable	Coefficient value		
		Gongzhuling	Qiyang	Urumqi
Soil properties	TOC	-4.63	-4.19	-11.82
	TN	-4.18	0.00	0.00
	AN	0.00	0.00	0.00
	TP	10.13	0.00	0.00
	AP	-11.30	0.00	0.00
	BD	2.23	0.00	0.00
	pH	0.00	0.00	4.02
Climate	MAP	0.00	0.00	0.00
	MAT	-1.21	0.00	-3.53
	Cum_T	-0.24	2.77	0.00
C inputs	Cum_C input	0.00	0.00	0.00
	C input_R	-5.28	0.00	0.00
	C input_M/R	0.00	-15.05	-9.72

Table S2. Application rates of mineral fertilizers at the three long-term experimental sites. N, mineral nitrogen; NP, mineral N and phosphorus; NPK, mineral N, phosphorus, and potassium combination; NPKS, NPK plus crop straw return; NPKM, NPK plus livestock manure; hNPKM, higher rates of mineral fertilizer and manure input.

Site	Crops	N/NP/NPK	NPKS	NPKM	hNPKM
		Mineral N-P-K (kg ha ⁻¹ yr ⁻¹)			
Gongzhuling	Corn	165-36-68	112-36-68	50-36-68	75-54-103
Qiyang	Corn	210-36-70	210-36-70	63-36-70	94-54-105
	Wheat	90-15-30	90-15-30	27-15-30	40-23-45
Urumqi	Corn/wheat/wheat	241-59-48	217-50-42	85-22-10	150-39-15

Table S3. Sources and application rates of organic amendments in various fertilizer treatments at the three long-term experimental sites. NPK, mineral N, phosphorus, and potassium combination; NPKS, NPK plus crop straw return; NPKM, NPK plus livestock manure; hNPKM, higher rates of mineral fertilizer and manure input.

Site	NPKS	NPKM/hNPKM	NPKS	NPKM	hNPKM
	Source		Application rate (Mg ha ⁻¹ yr ⁻¹)		
Gongzhuling	CS	PM	7.5	23	34.6
Qiyang	WS	PM	Half ^{&}	29	44
	CS	PM	Half ^{&}	13	19
Urumqi	CS/WS	GM	All ^{&}	30	60

CS: corn straw, WS: wheat straw, PM: pig manure, GM: goat manure. [&]: Half or all crop straw of the previous season was returned back to the soil.

Table S4. The 13 predictor variables of the lasso regression model at the three long-term experimental sites.

Category	Predictor variable	Description	Unit
Soil properties	TOC	total soil organic carbon	g kg ⁻¹
	TN	total soil nitrogen	g kg ⁻¹
	AN	available nitrogen	g kg ⁻¹
	TP	total phosphorus	g kg ⁻¹
	AP	available phosphorus	mg kg ⁻¹
	BD	bulk density	g cm ⁻³
	pH	soil pH	
Climate	MAP	mean annual precipitation	mm
	MAT	mean annual temperature	°C
	Cum_T	effective cumulative temperature >10°C	°C
C inputs	Cum_C input	cumulative C input amount	Mg ha ⁻¹
	C input_R	crop residue C input amount	Mg ha ⁻¹
	C input_M/R	extra organic C input amount include manure or straw	Mg ha ⁻¹

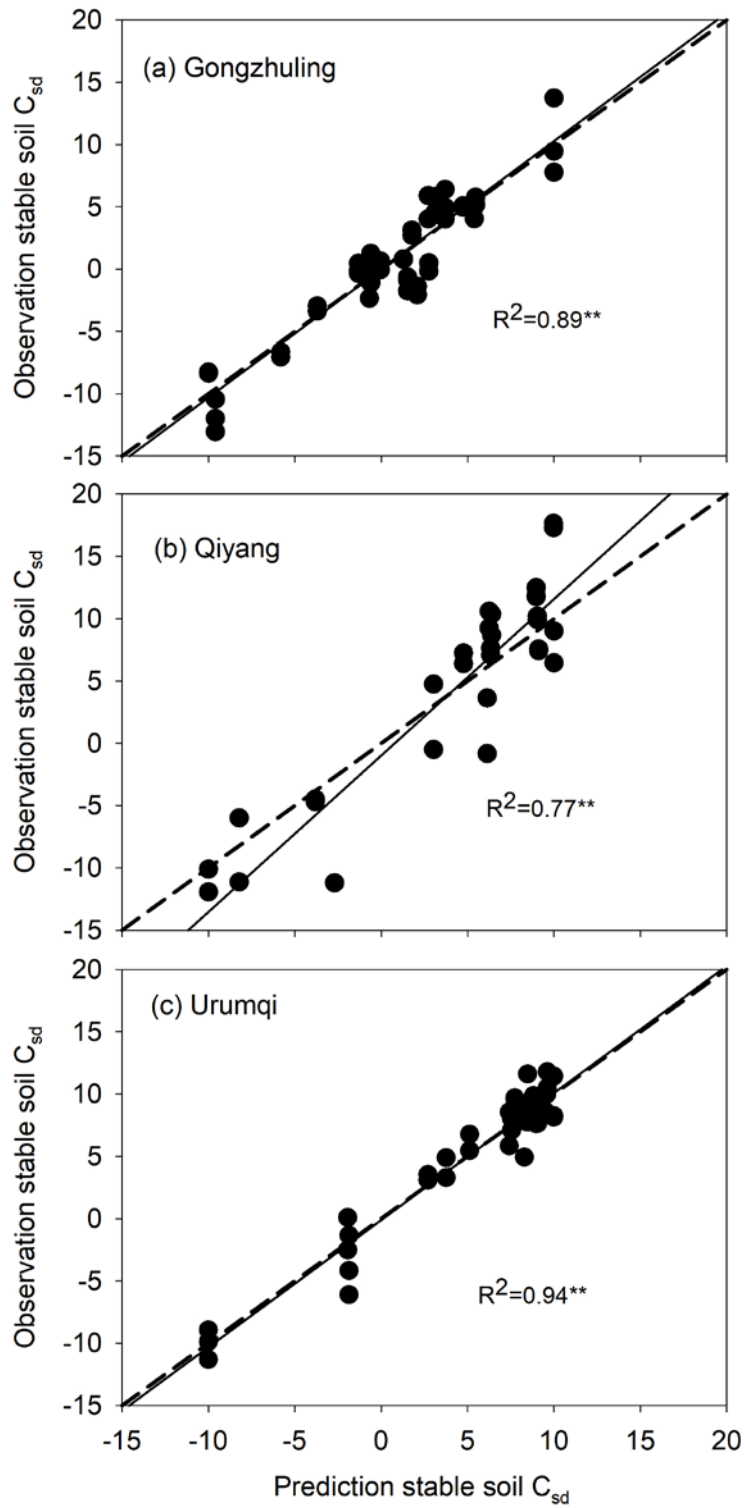


Figure S1. Observed values and values predicted by the lasso linear regression model using the predictors shown in Fig. 3. The dashed line shows the 1:1 line (in all sites $P < 0.01$, denoted by two asterisks).