THEME 2

Manure application increased grain yield and SOC across China's agricultural land

Guiying Jiang, Wenju Zhang, *Minggang Xu*, Jinzhou Wang, Daniel V. Murphy
National Engineering Laboratory for Improving Quality of Arable Land; Institute of Agricultural Resources and Regional Planning; Chinese Academy of Agricultural Sciences; Soil Biology and Molecular Ecology Group; School of Geography and Environmental Sciences; Institute of Agriculture; University of Western Australia

INTRODUCTION

China has 20% of the world population but only 8% of the total arable land and uses more inorganic fertilizer than any other country; accounting for 90% of the global increase in use and consuming 36% of total global production. Soils in China account for 7 to 12% of the global SOC stock under arable production systems. This SOC stock reflects additions of organic waste to agricultural soils over a period of thousands of years aiding the stabilization of SOC. If China continues to maintain self-sufficiency in food production, then arable lands will need to increase productivity without causing loss of SOC and associated problems of soil degradation and greenhouse gas (GHG) emissions.

OBJECTIVES

Our aim was to quantify the contribution of manure application to gain crop yield and SOC sequestration in agricultural soils across China. This was achieved through use of climate and field trial data to measure long-term historical yield and SOC values and to use this data to calibrate climate change (HadGEM2-ES, based on RCP4.5 scenario) and SOC models (RothC 26.3) to predict the future contribution of manure to SOC stocks by the end of the century.

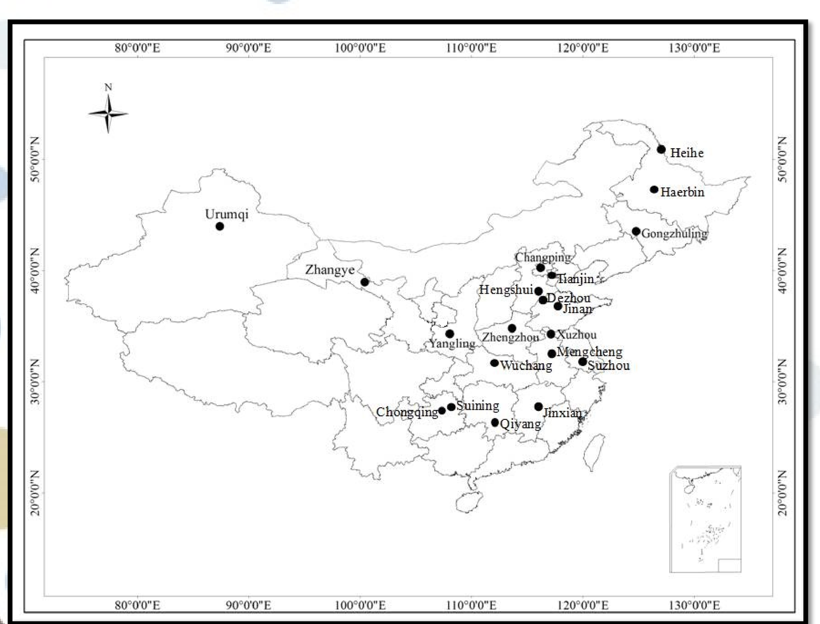

Fig. 1: Location of the 20 long-term experimental sites in China.

MAIN RESULTS

The effect of chemical and/or manure fertilizer effect on the grain yield and SOC content.

During the past three decades inorganic fertilizers (37-450 kg N $ha^{-1}yr^{-1}$) have increased grain yield (91-183%) but with little contribution to SOC sequestration (4-17%). In contrast manure (2010 rates; 0.4-4.0 t C $ha^{-1}yr^{-1}$) when applied with inorganic fertilizer provided a small benefit to grain yield (6-19%) but doubled SOC sequestration (8-41%)(Fig.2) . According to the relationship between SOC change rate and mean annual C input, we estimated the manure required to maintain the current SOC content at each site. Results showed that a manure application of 17.1, 6.0, and 13.2 t $ha^{-1}yr^{-1}$ in single-, double- and paddy-upland rotation cropping systems, respectively is needed (Table 1).

The effect of manure application on carbon budget in agricultural system in China

Under current NPP + no climate change, the relative increase of SOC content in 2099 varied from 26-150%, 39-140%, and 11-61% in single-, double-, and paddy-upland rotation system area (Table 1). We estimated that if locational amount of manure under NPK plot from 2011 is added, there will be 2089.54 Tg (37%) and 2493.97 Tg (27%) from manure in 2099 under current NPP + no climate change and increased NPP + climate change scenarios, respectively. They were equaled to 7661.63 and 9144.56 Tg CO_2 which can be mitigated by manure application under these two scenarios in 2099 (Fig. 3). However, there will be 19584.92 (39%) and 19716.43 (46%) Tg CO_2 released from the manure application until 2099.

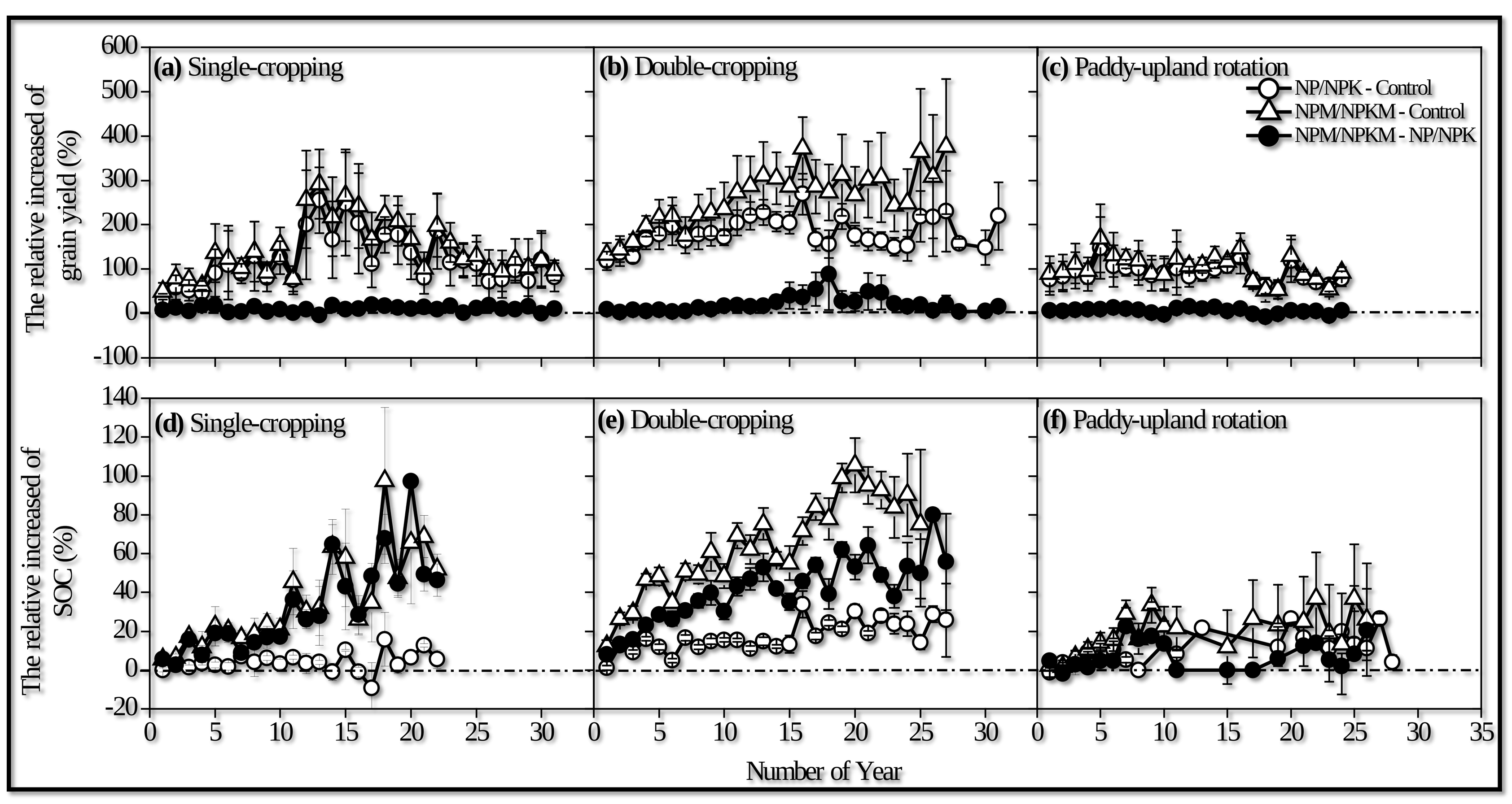

Fig. 2: The relative increase of grain yield and SOC concentration between NP /NPK vs. Control plots, NPM/NPKM vs. Control plots, and NPM/NPKM vs. NP/NPK plots in single-cropping (a, d), double-cropping (b, e), and paddy -upland rotation (c, f)

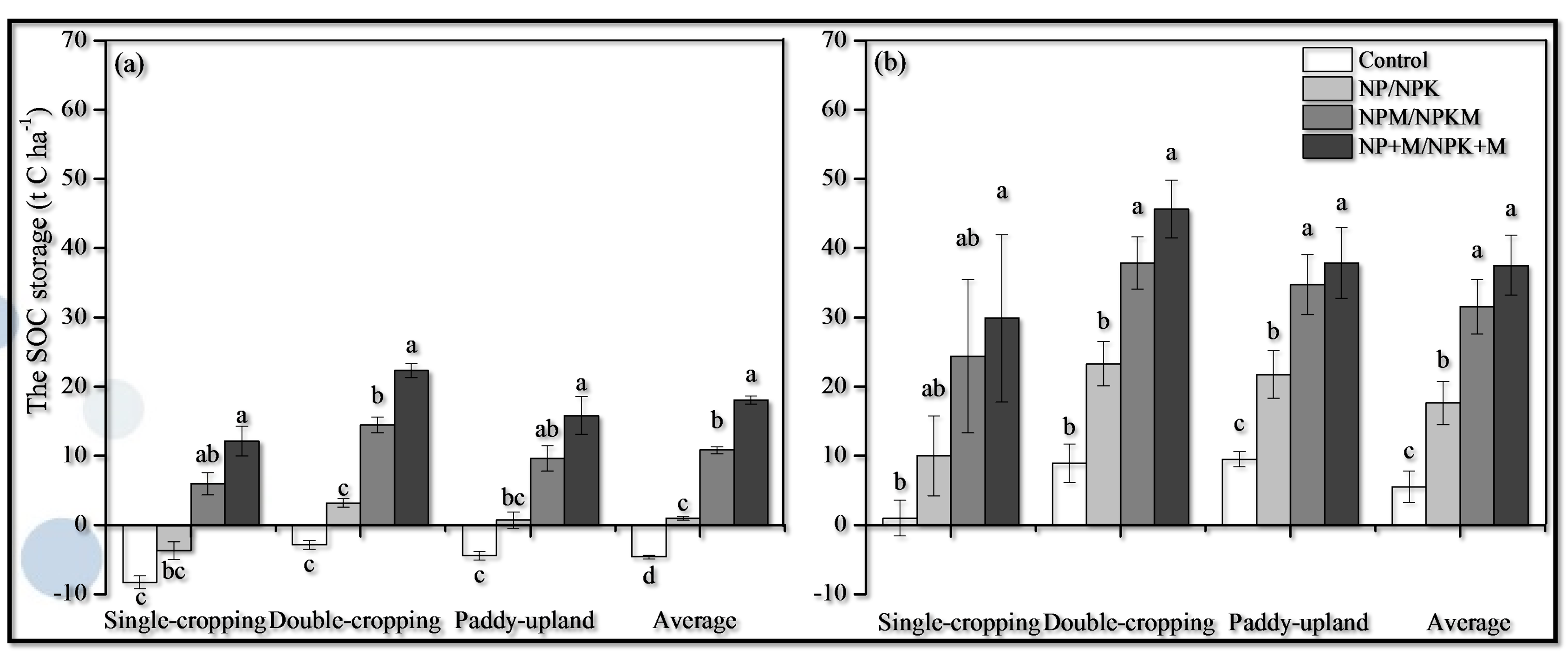

Fig. 3: Modelled difference of SOC storage under different plot in among single-, double-cropping, upland and paddy rotation and all site the average under current NPP + no climate change (a) and increased NPP + climate change (b) scenario in 2099

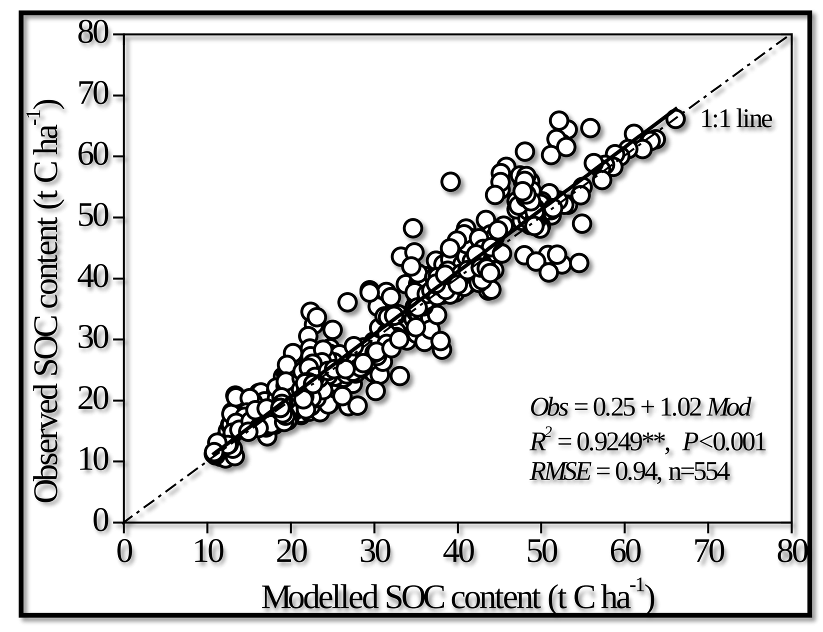

Fig. 4: The relationship between modelled SOC content and observed SOC content in all the sites in this study

Tab. 1: The organic materials to maintain initial SOC level at different sites

Cropping system	Site	C input to maintain SOC (t C ha^{-1})	Organic materials to maintaining SOC (t ha^{-1}): Fresh manure	Organic materials to maintaining SOC (t ha^{-1}): Air-dried Straw
Single-cropping	Heihe	4.2	24.96	11.01
	Haerbin	3.85	22.87	10.09
	Gongzhuling	2.2	13.06	5.76
	Zhangye	2.66	15.79	6.96
	Urumqi	1.52	9.04	3.99
	Mean±SE	2.89±0.20	17.14±2.98	7.56±1.32
Double-cropping	Changping	0.62	3.68	1.62
	Wujing	0.81	4.8	2.12
	Hengshui	0.67	3.96	1.75
	Xinji	2.75	16.35	7.21
	Dezhou	0.79	4.69	2.07
	Jinan	0.24	1.43	0.63
	Mengcheng	0.62	3.7	1.63
	Zhengzhou	1.08	6.44	2.84
	Xuzhou	2.86	17.01	7.5
	Yangling	0.211	1.25	0.55
	Qiyang	0.49	2.92	1.29
	Mean±SE	1.01±0.08	6.02±0.50	2.65±0.22
Paddy-upland rotation	Beibei	2.55	15.12	6.67
	Wuchang	2.13	12.68	5.59
	Suzhou	-	-	-
	Suining	1.97	11.72	5.17
	Mean±SE	2.22±0.10	13.17±0.58	5.81±0.26

CONCLUSION

In this study, we qualified that when manure is applied in combination with inorganic fertilizer, there was little contribution to grain yield (12.6%), but contribute 27.1% to SOC. If we continue using manure with chemical fertilizer at current application rates, there will be increase in SOC sequestration of 2493.97 Tg t C, and an increase of 43% compared to inorganic fertilizer only by the end of this century in arable land in China.