Soil organic matter-C stock and sequestration of China's croplands

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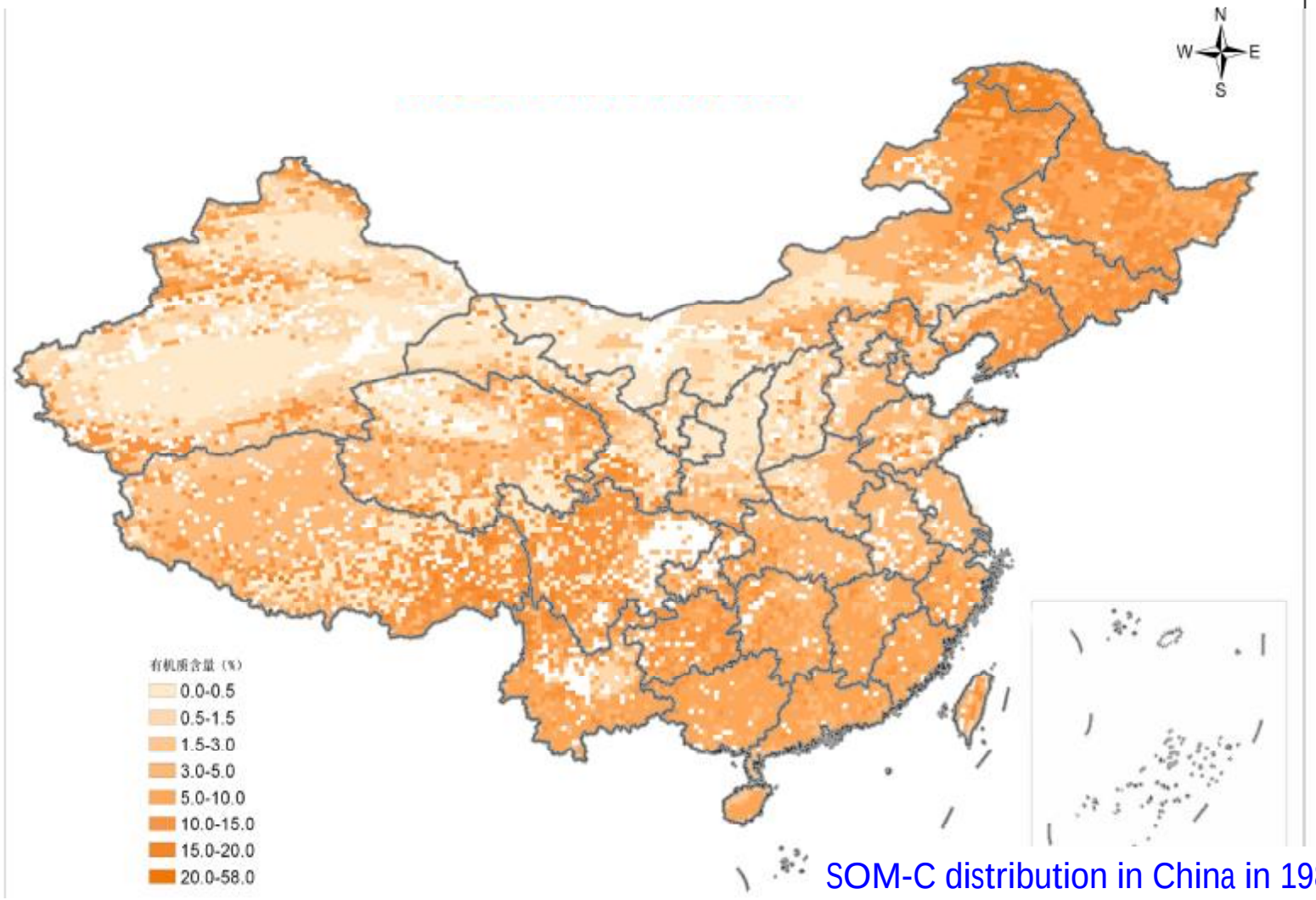
Highlights

- China’s Great biophysical potential of C sequestration in croplands
- C sequestration have much benefits in agriculture
- Soil SOM-C stock increase in China’s croplands
- Data available for potential estimation
- Major approaches for SOM-C enhancement

Biophysical potential

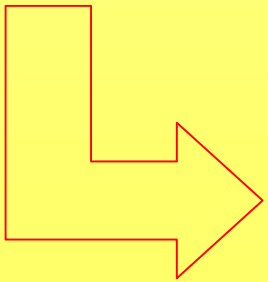
Low background SOM-C with much spatial variability in China's croplands



SOM-C distribution in China in 1980's

Background C storage of China

- **Whole soil (100cm):90Pg (Xiangshan Conference,2004);**
- **Topsoil (~25cm): 38Pg;**
- **Cropland whole soil: 15Pg;**
- **Cropland topsoil: 5Pg**



Topsoil C density (tC/hm^2)

- **Non-cultivated: 49.84 ± 46.69**
- **All cultivated: 38.46±31.22**
- **Rice paddies: 46.91±25.73**
- **Dry croplands: 35.87±32.77**

(Song et al., 2005; Pan et al., 2003)

Topsoil SOC storage

Topsoil OC stock of China:

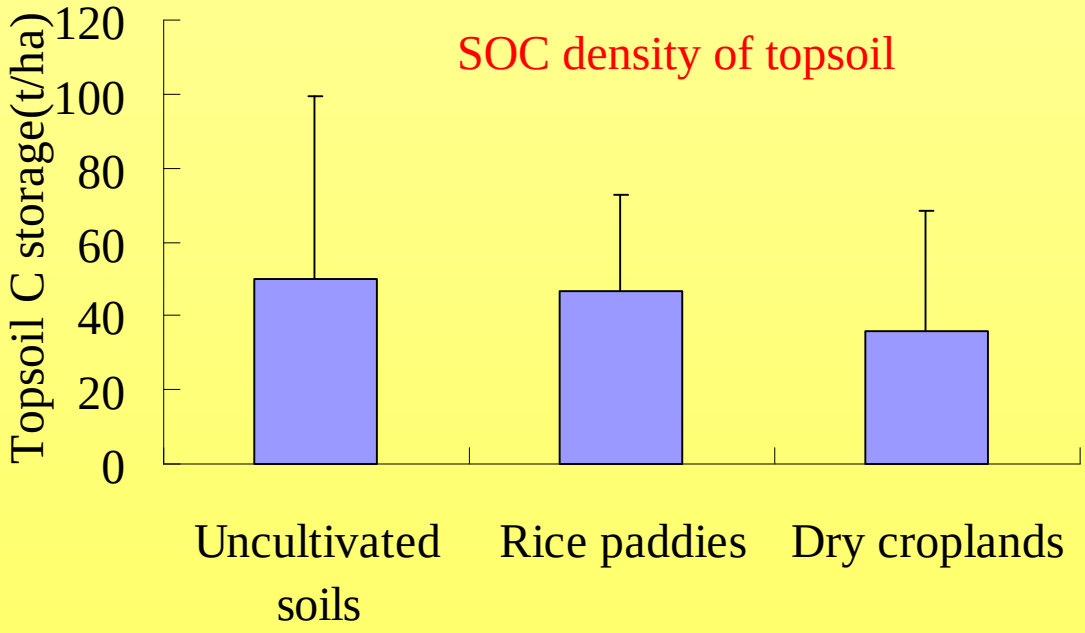
All soil: 38 Pg

Cultivated soil: 5.1 Pg

Rice Paddies:1.3 Pg

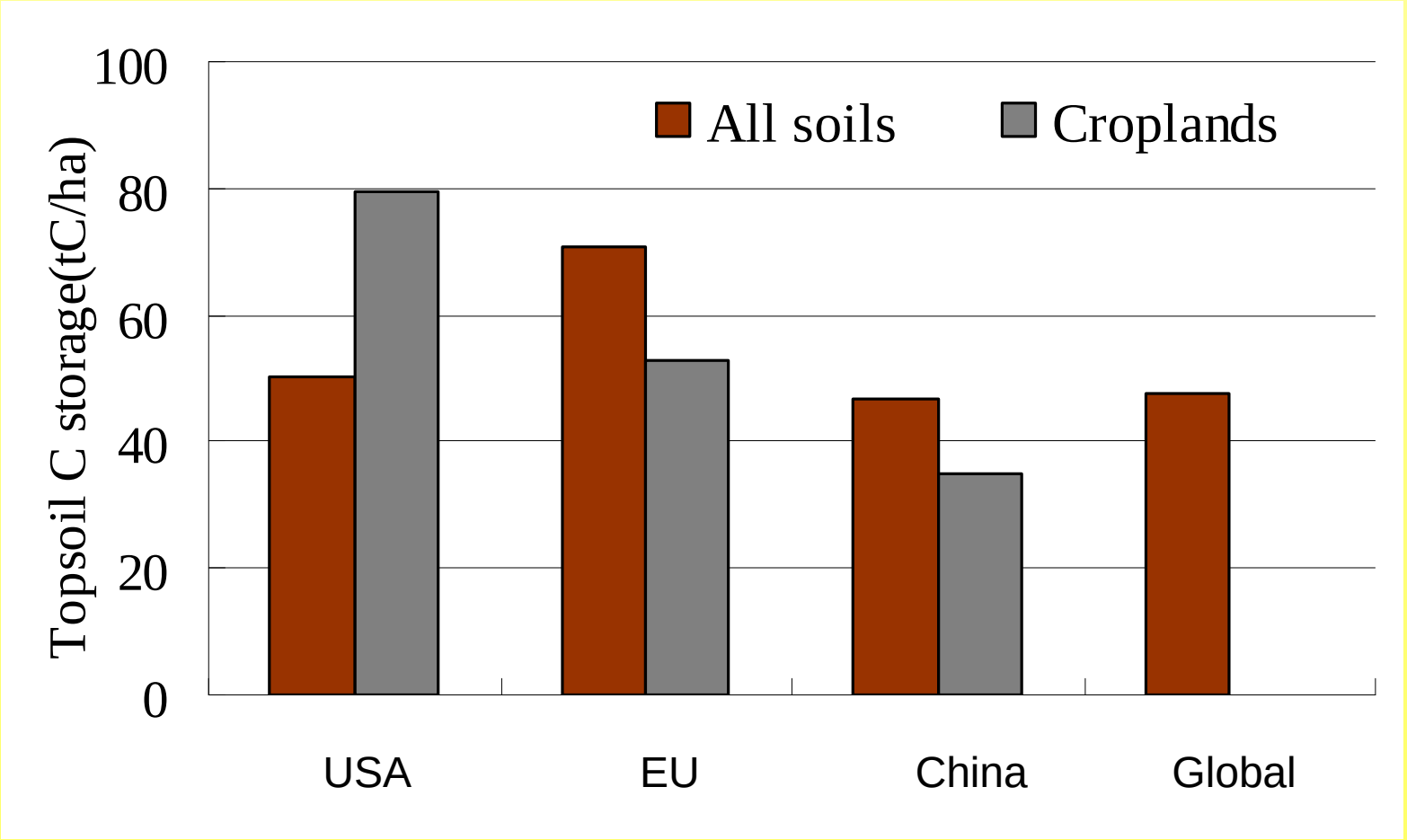
Dry croplands: 3.8 Pg

Data from Pan,G.,2008.



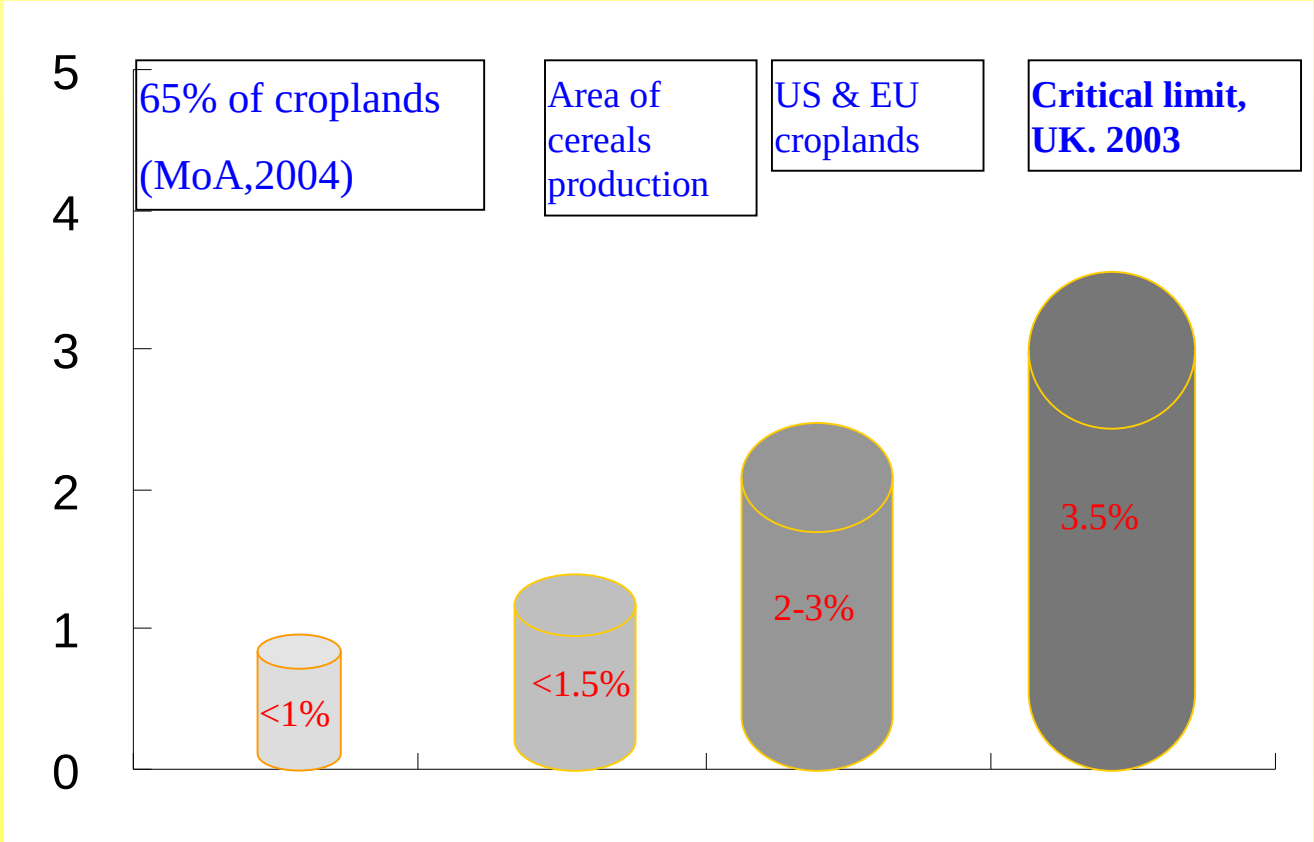
Data from Pan et al., 2004; Song et al., 2005

Is China a low-C (stock) country?



Adv. Clim. Res., 2008, 4(5):277-284

Enhancement of SOM in China's croplands urged



State project of SOM enhancement in croplands, MoA since 2003!

Does China have a low SCS potential? (Inventory and Counting)

Region	**SCS potential**	Methods	Literature
Global	**0.4~2 Pg/a,**	Extrapolating from case data	4: Lal, 1999; Metting et al., 2001
EU	**16~120 Tg/a**	Scenario analysis and up-scaling	5: Smith et al., 1998; 2000
USA	**60~208 Tg/a**	IPCC inventory method	5: Lal, et al., 1998,1999; Sperow et al., 2003; Meeting et al, 2001; Bruce et al., 1999
China	**25~37 Tg/a** **0.7~3.2 Pg** **-0.97 Pg**	Up-scaling of Case study data Up-scaling of LTSE data DNDC modeling	3: Lal, 2004; Pan et al, 2003; Han B, et al,2005

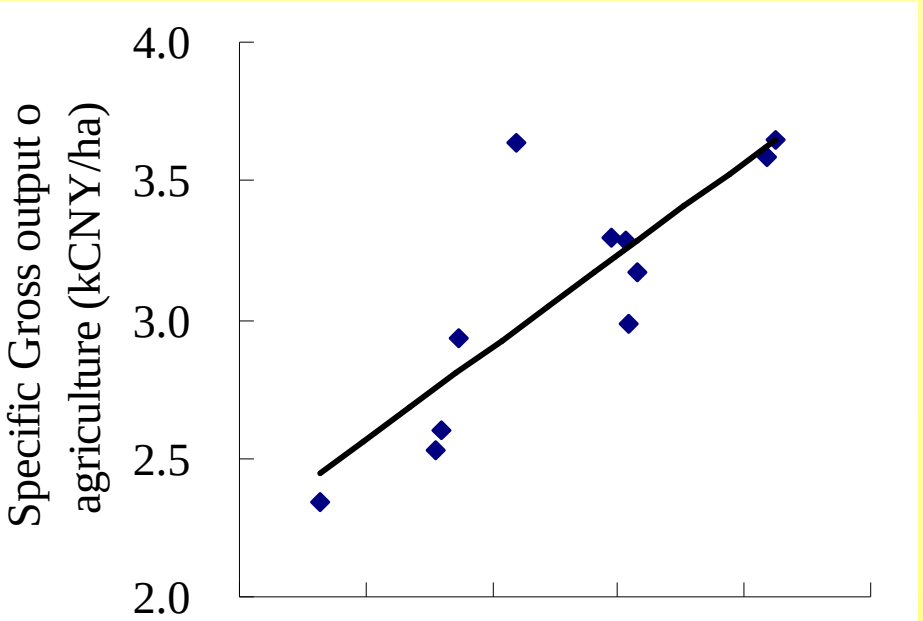
After Sun et al., 2008

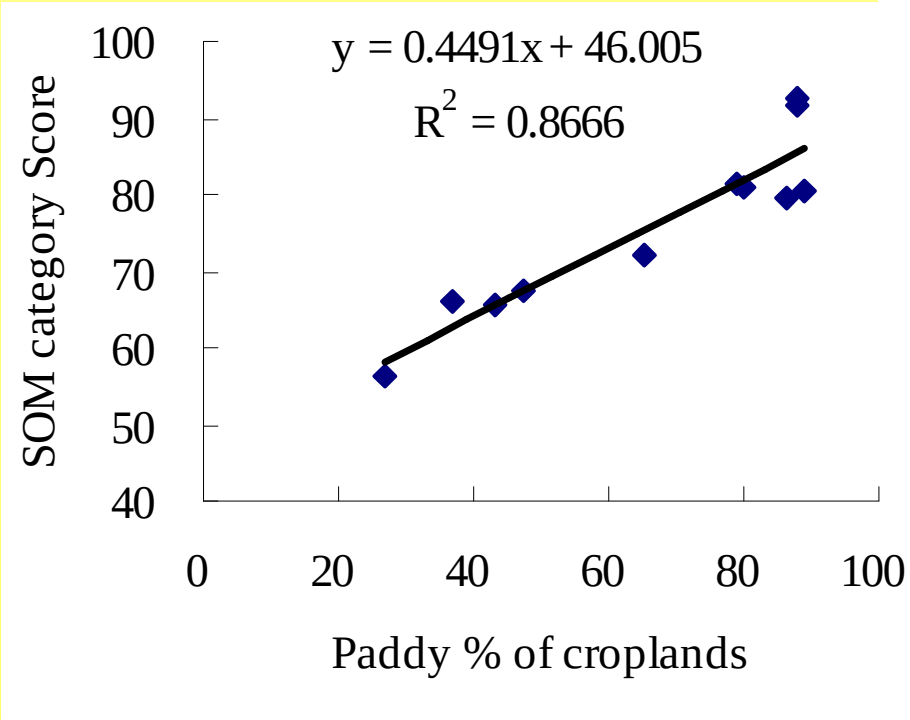
SOM-C sequestration benefits

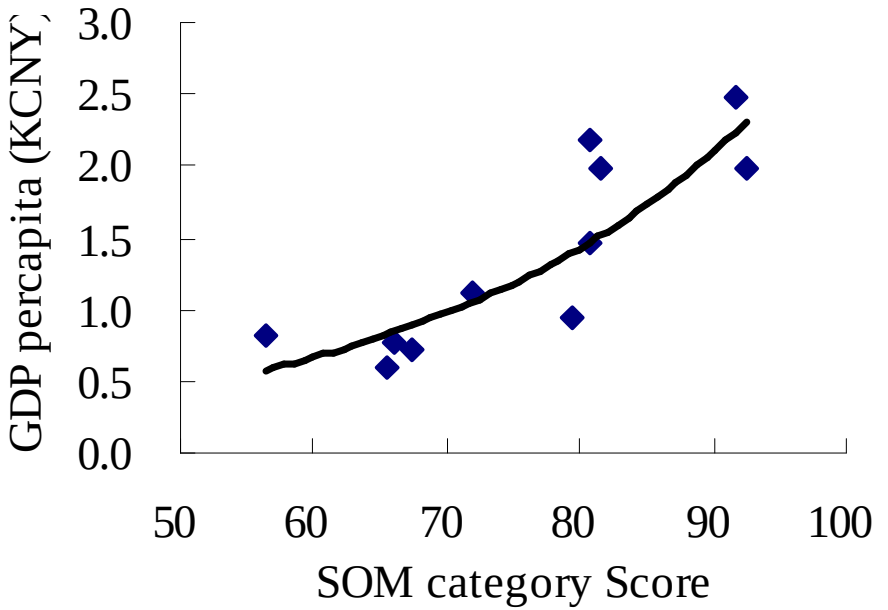
SOM: Vital to terrestrial ecosystem functioning and land sustainability

- Key soil quality indicator (Royal Commission of Environmental Pollution,1996);
- One of most valuable natural resource next to fresh water (Brown,1999);
- Greatest OC pool of Earth Surface system (Batjays,2000);
- Most important soil factor (global questionnaire, Macaulay Institute for Soil Research.,2008)

SOM in agricultural production

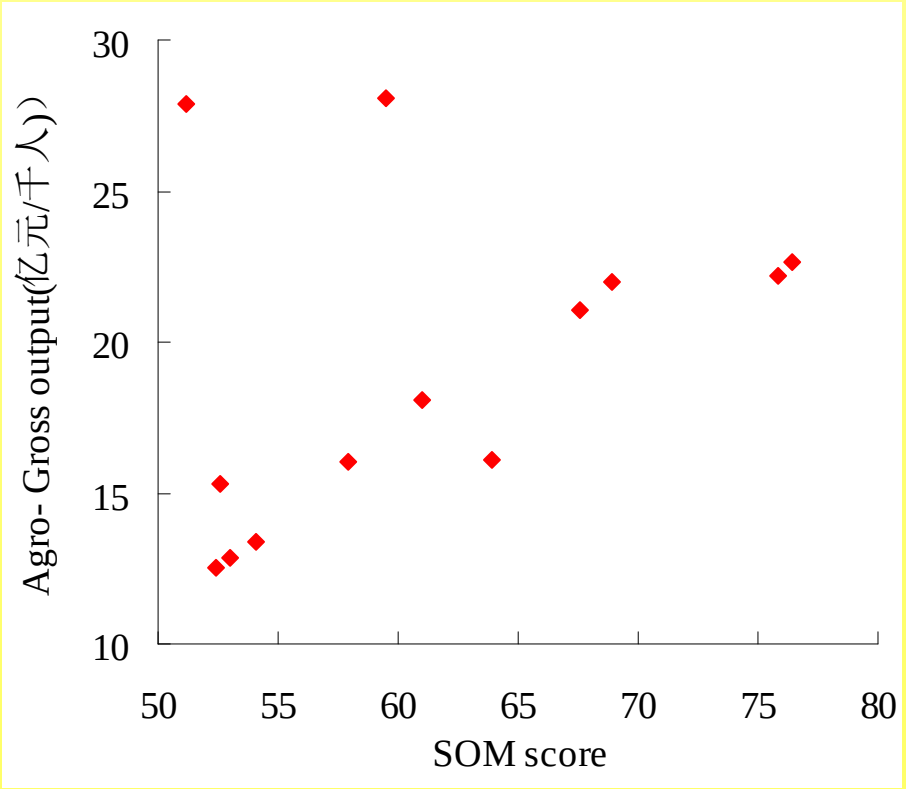


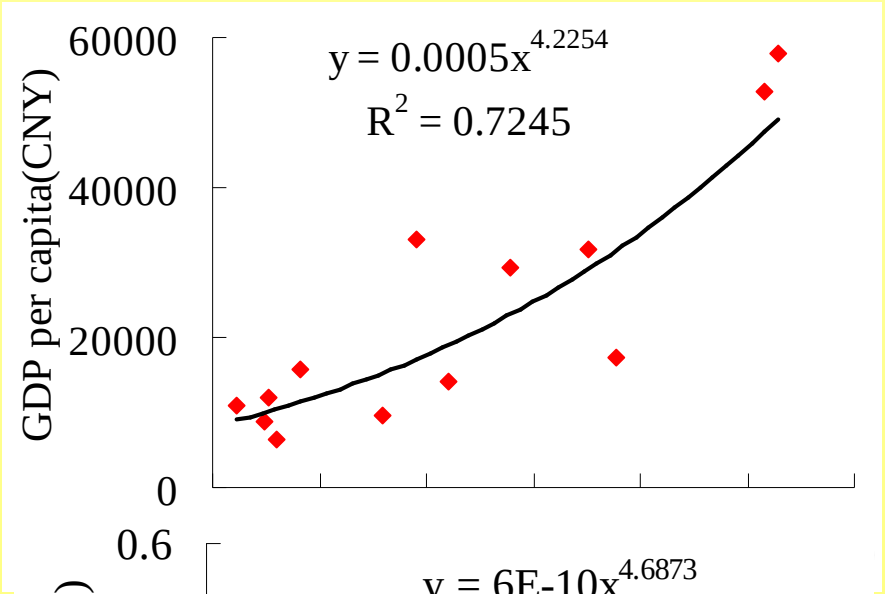


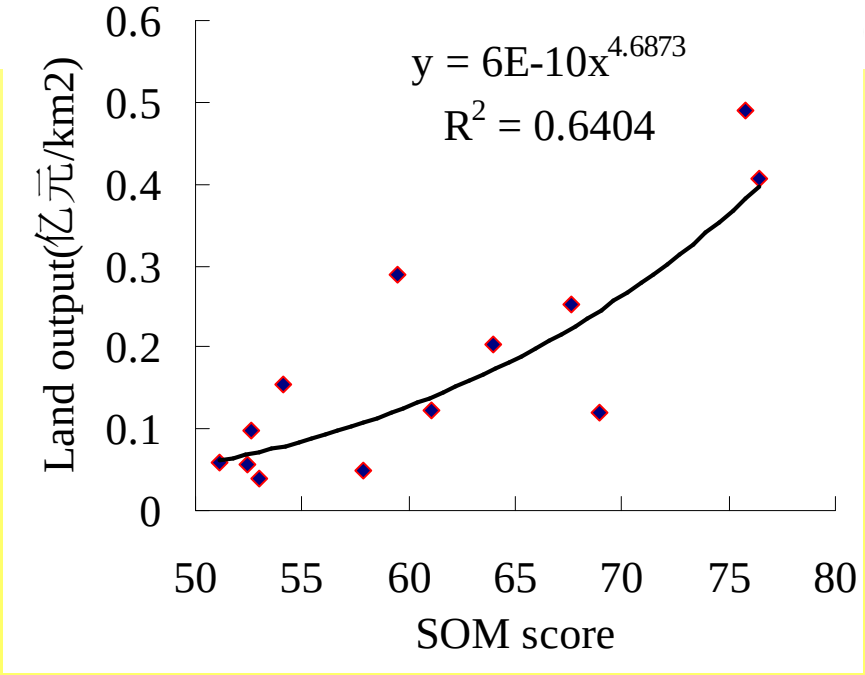


据1982年江苏11个省辖市统计资料计算（江苏统计局,1982）

SOM in agricultural production

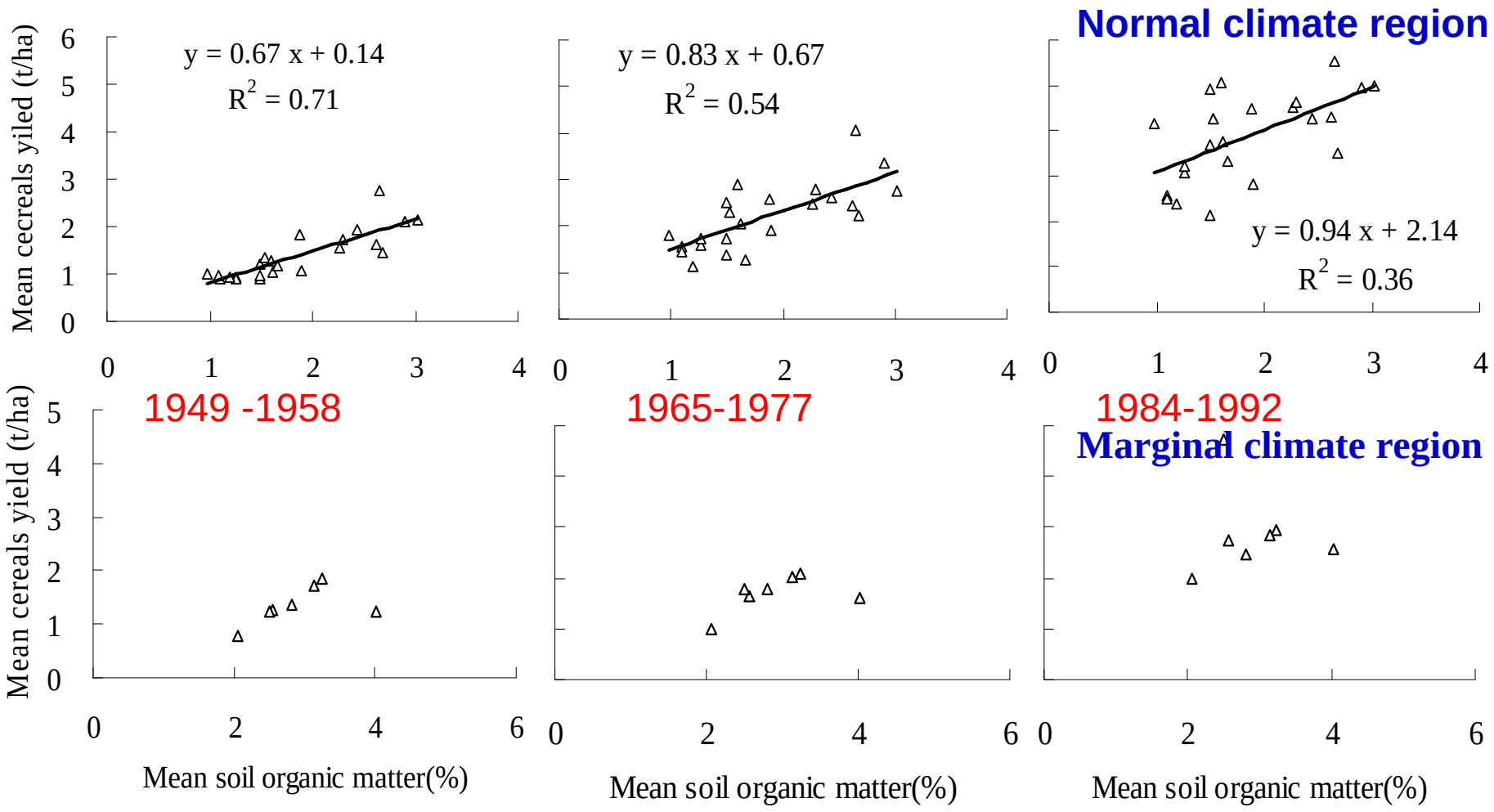






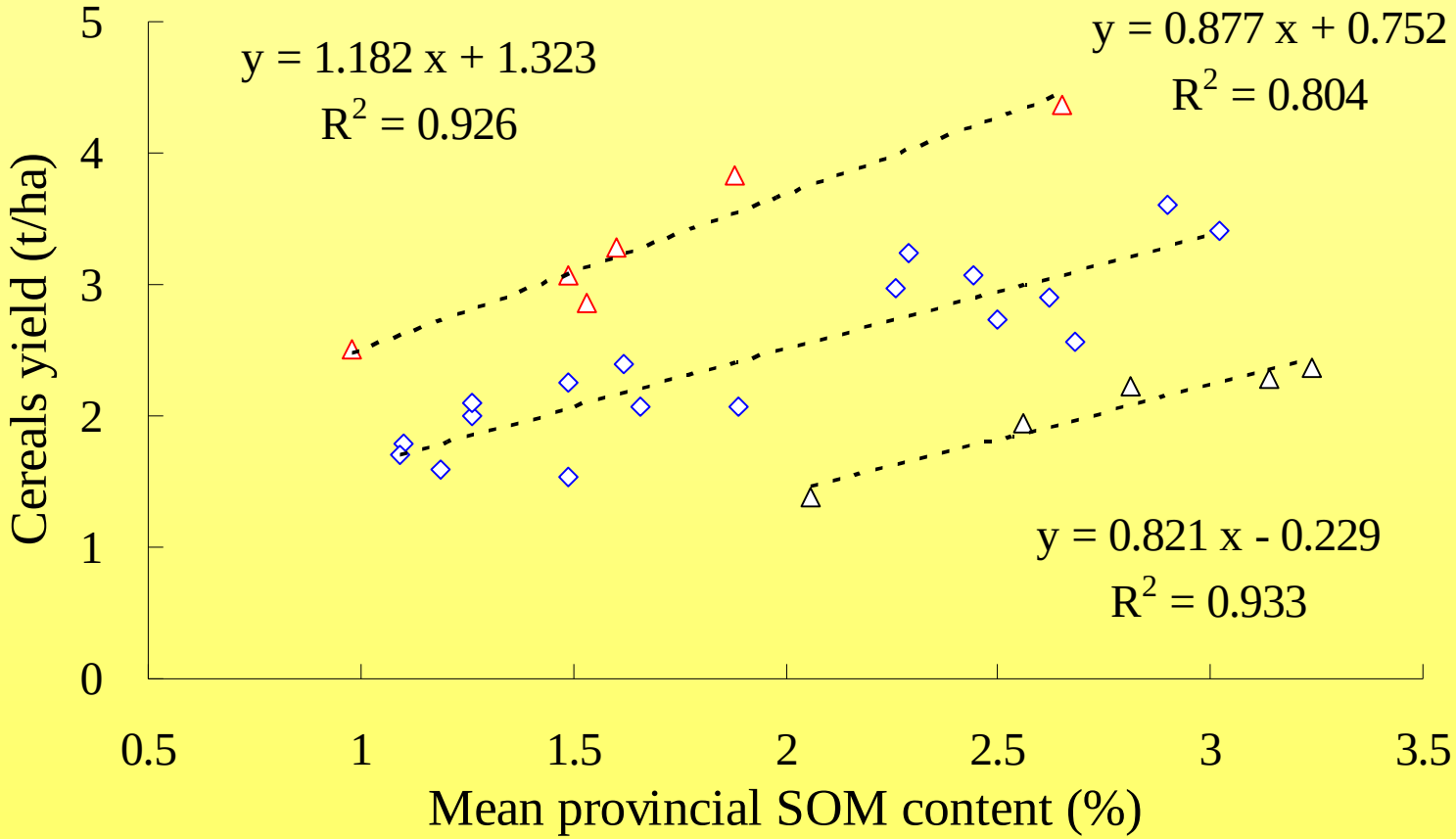
据2004年江苏11个省辖市统计资料计算（江苏统计局,2004）

SOM and cropland productivity



Cereals productivity of croplands varied with their mean SOM contents: Statistical data from “50 years of PRC: 1949-1998. Pan et al., 2009. AGEE

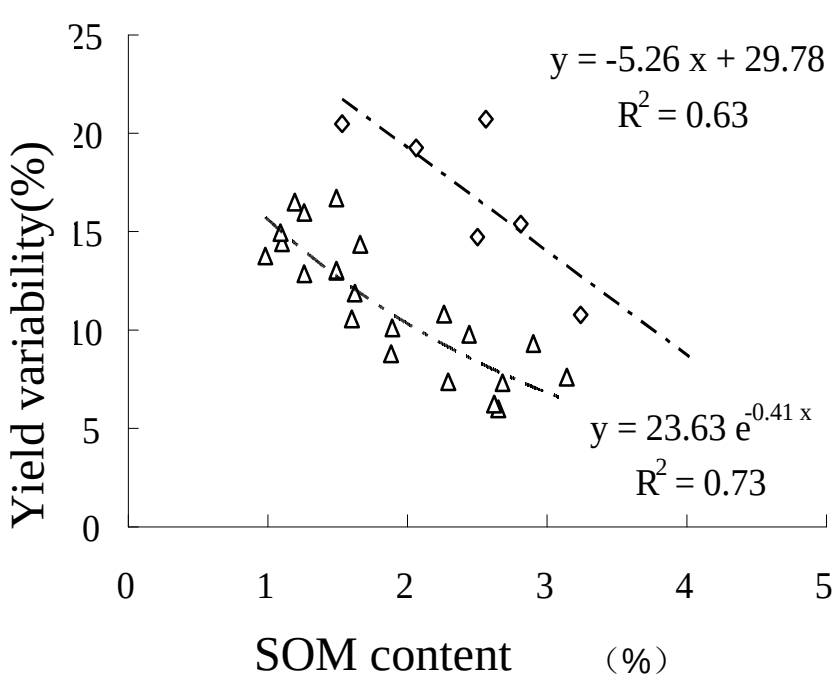
SOM impacts cropland productivity

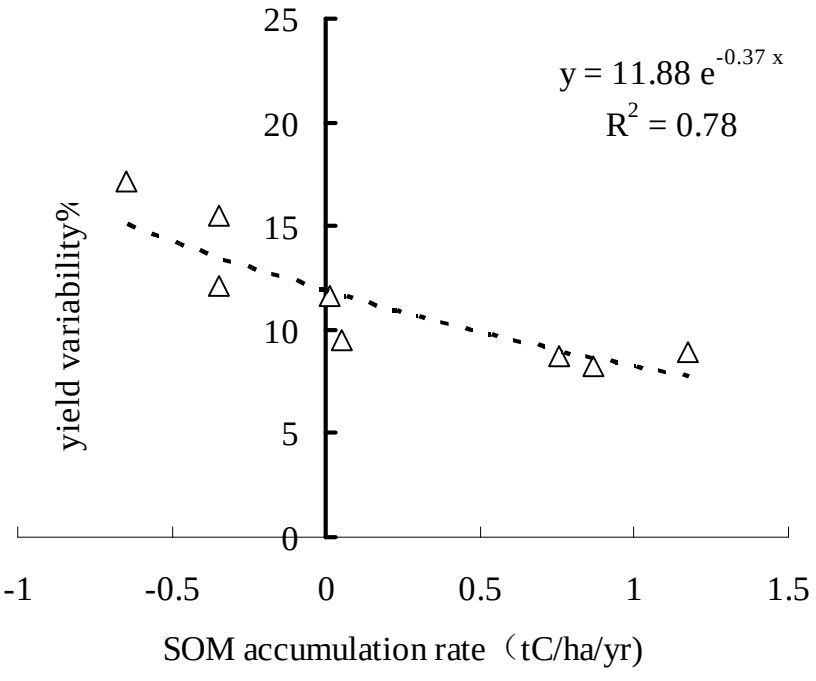


Cereals productivity of croplands varied with their mean SOM contents: Statistical data from “50 years of PRC: 1949-1998. Pan et al., 2009. AGEE

有机质增加1%,单产平均增加0.8-1.2t/hm²!

SOM impacts sustainability of productivity

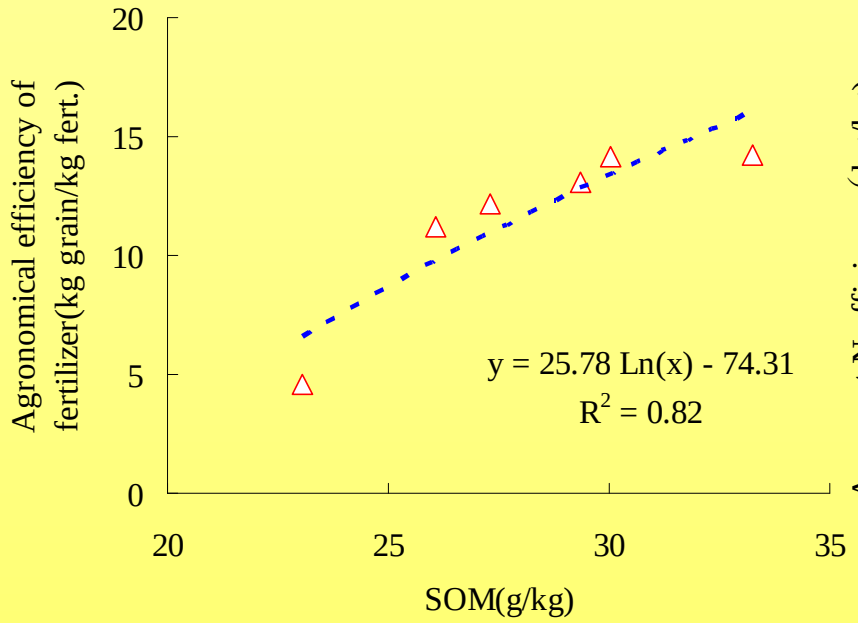


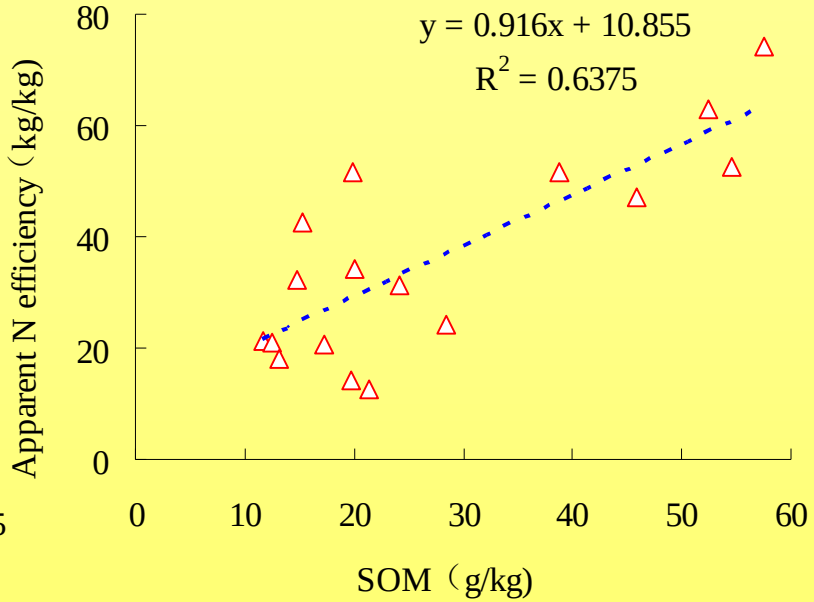


Cereals yield variability of croplands against the mean SOM contents: Statistical data from “50 years of PRC: 1949-1998. Pan et al., 2009. AGEE

Yield variability of rice paddies under different fertilization in a over 20years long term experiment, Jiangxi, China

SOM impacts nutrient use efficiency

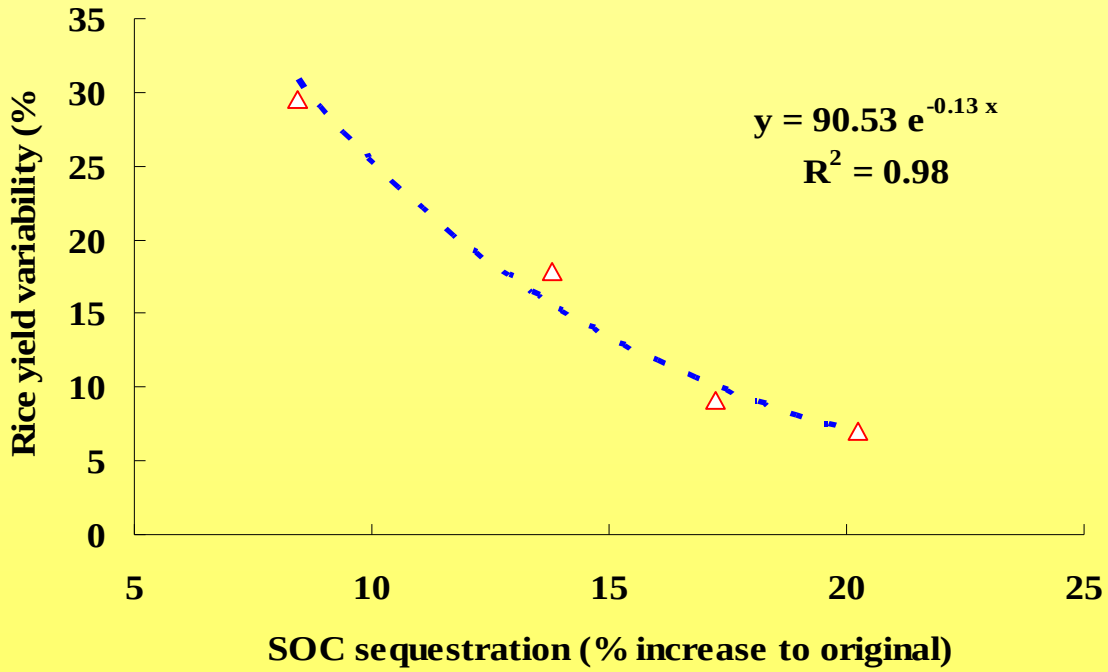




Rice paddies under long term different fertilization experiments from Jinxian, Jiangxi, China)

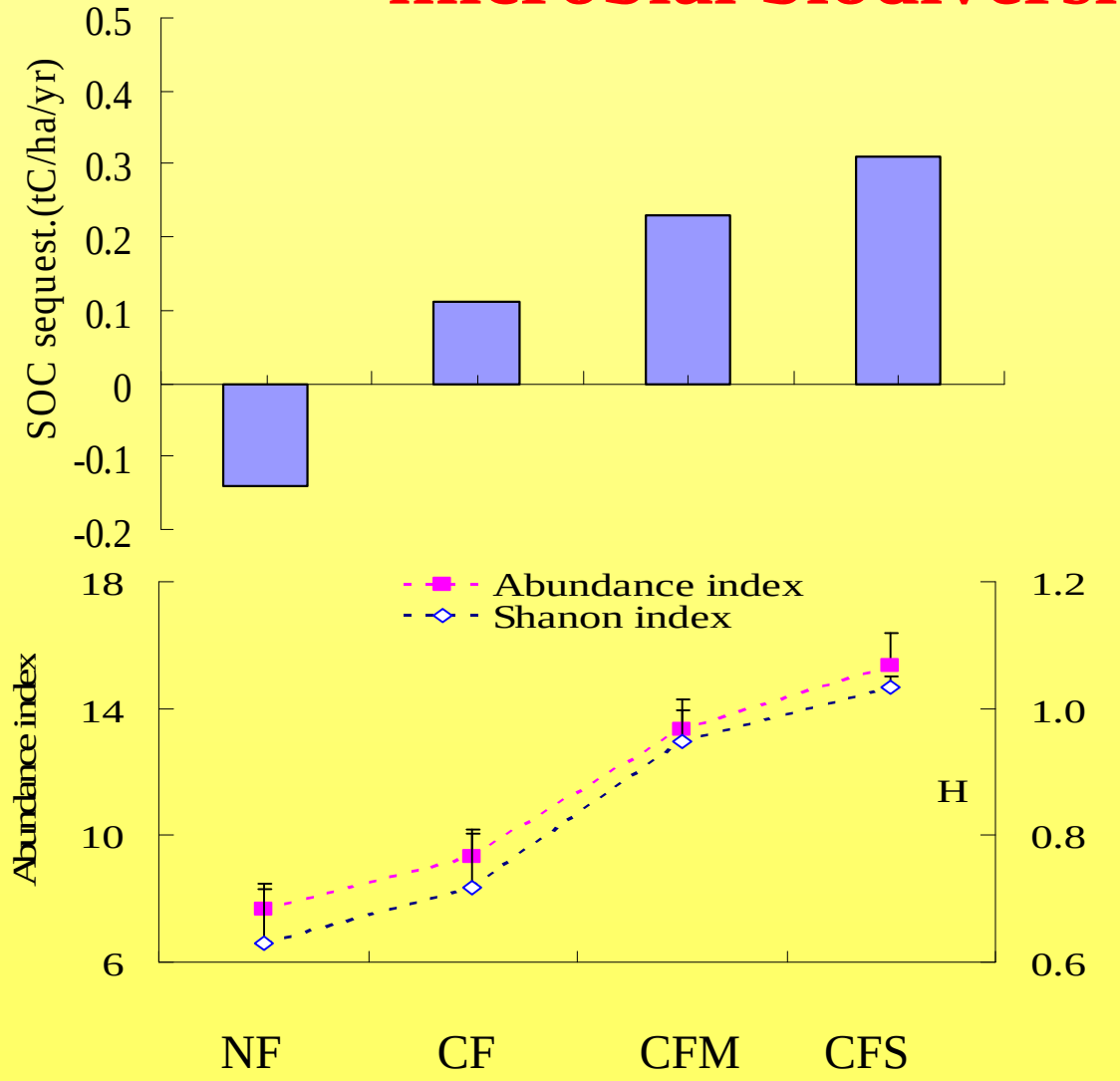
Data from Cropland monitoring network of East China, MoA, 2004

SOM and cropland sustainability



SOC sequestration favors sustainability of rice yield under different fertilization experiments since 1987.

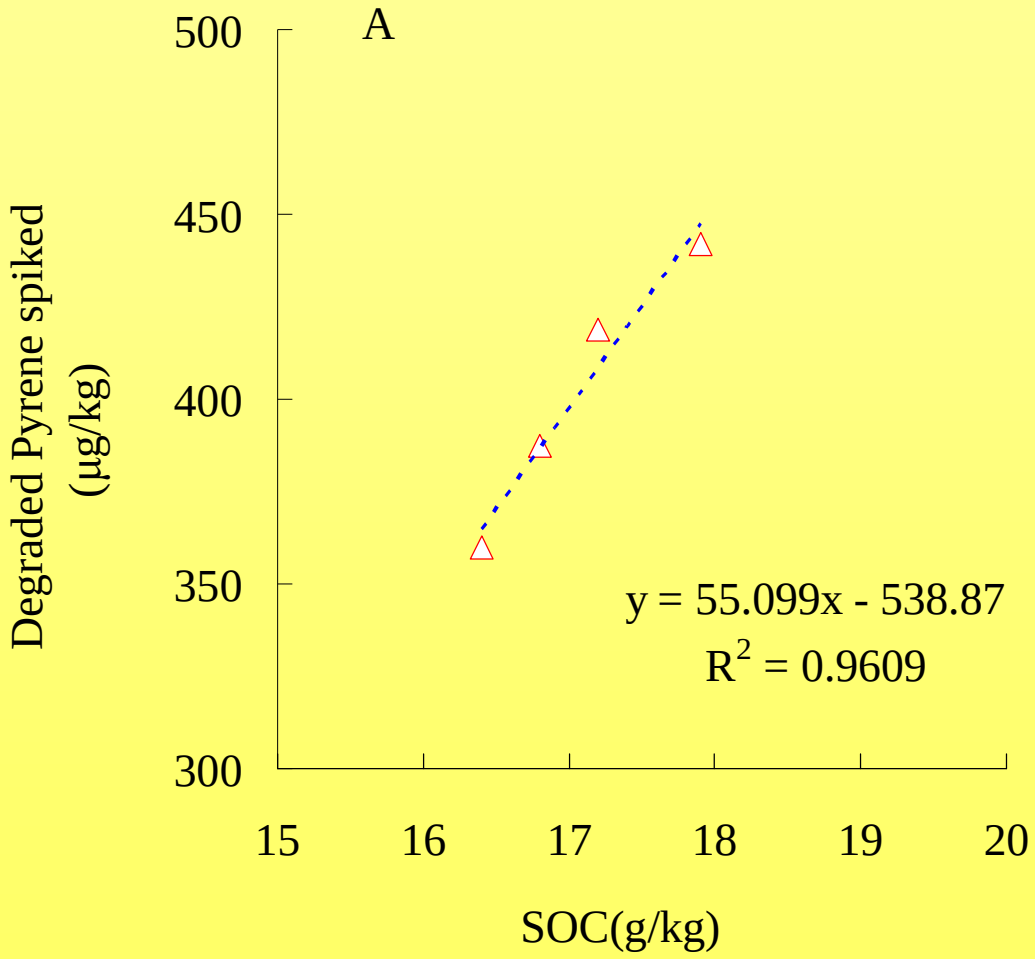
SOM accumulation enhanced microbial biodiversity



PCR-DGGE analysis evidenced microbial gene biodiversity in a rice paddy under longterm different fertilization from Tai Lake regio, China

Zhang et al., 2004. Ecologica Sinica

Higher SOM favors biodegradation of POPS



Biodegradability of spiked pyrene correlated with SOM in topsoil samples from a Hydroagric Anthrosol under different fertilization in Tai Lake region, China.

Han Xiaojun, et al.,2009

Soil SOM-C stock increase in China's croplands

SOM-C dynamics of China's croplands

As estimated by C modeling, soil SOM-C has been gained in China's ecosystems

Vol 458|23 April 2009|doi:10.1038/nature07944 nature

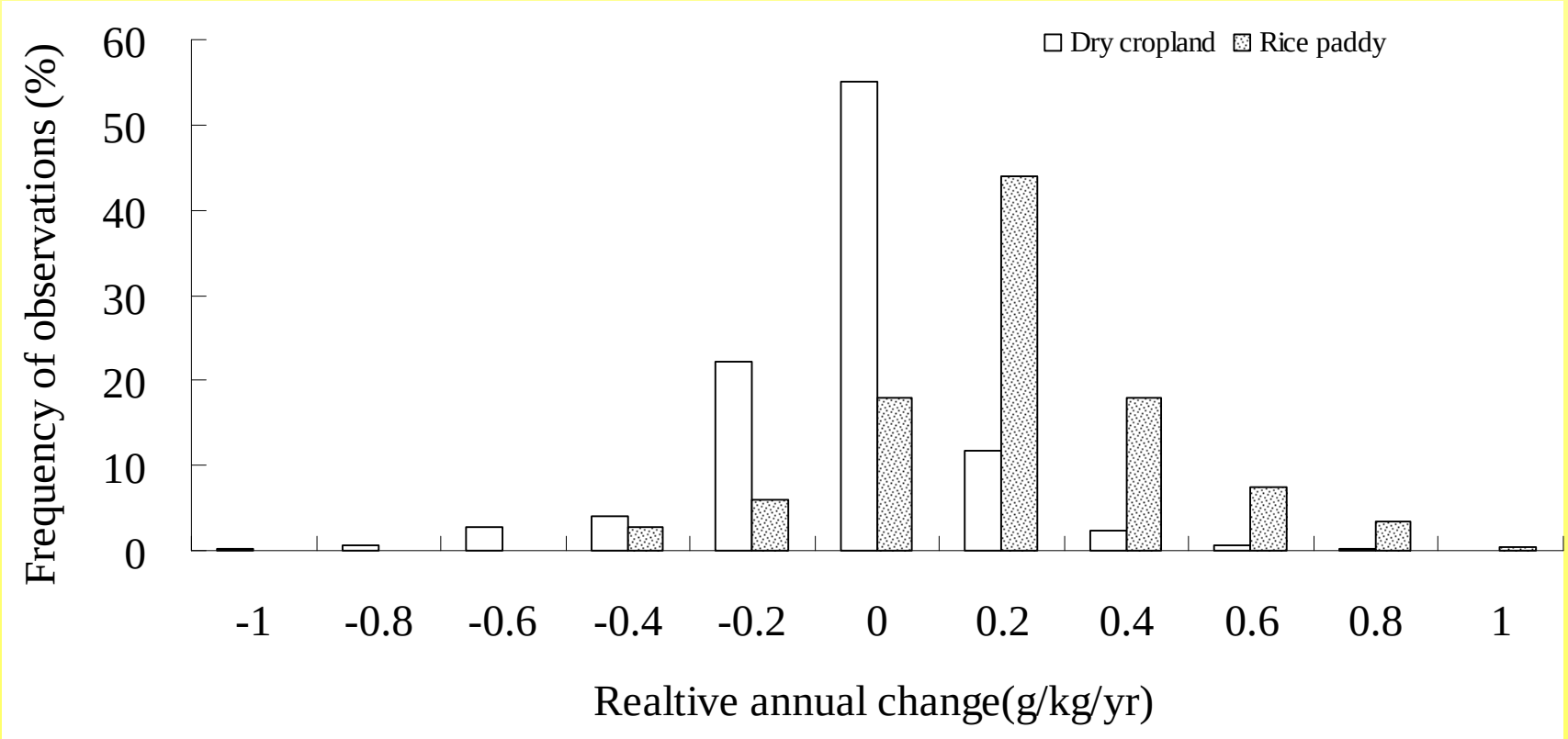
LETTERS

The carbon balance of terrestrial ecosystems in China

Shilong Piao[1], Jingyun Fang[1], Philippe Ciais[2], Philippe Peylin[3], Yao Huang[4], Stephen Sitch[5] & Tao Wang[1]

SOM dynamics as monitored during 1982-2006: higher increase in rice paddies than in dry croplands

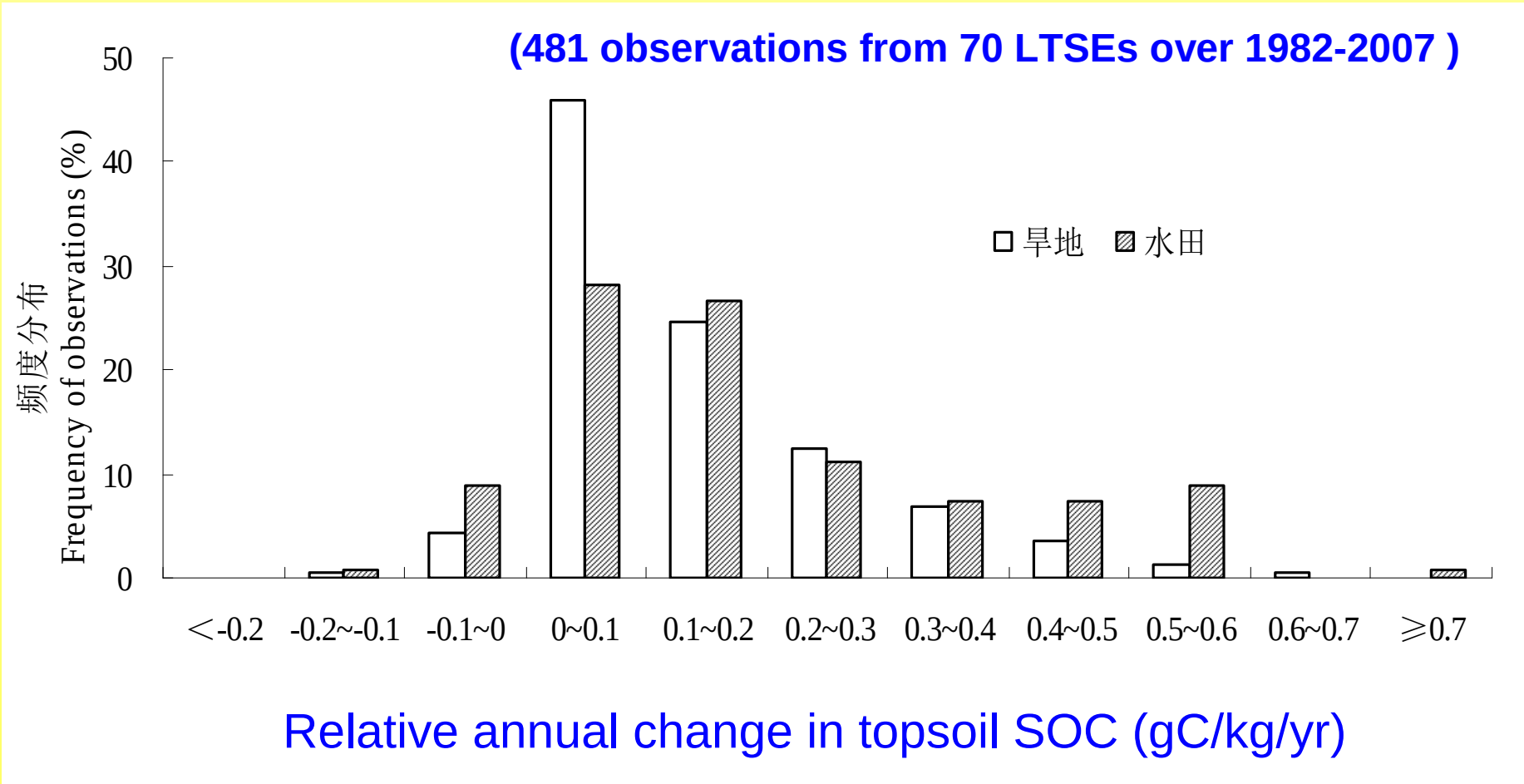
(1081 observations from monitoring works)



Mean increase, rice paddies of 0.110g/kg/yr versus dry croplands of 0.056g/kg/yr)

(Pan et al., to be submitted)

SOM dynamics under LTSEs of fertilization: Higher increase in rice paddies than in dry croplands

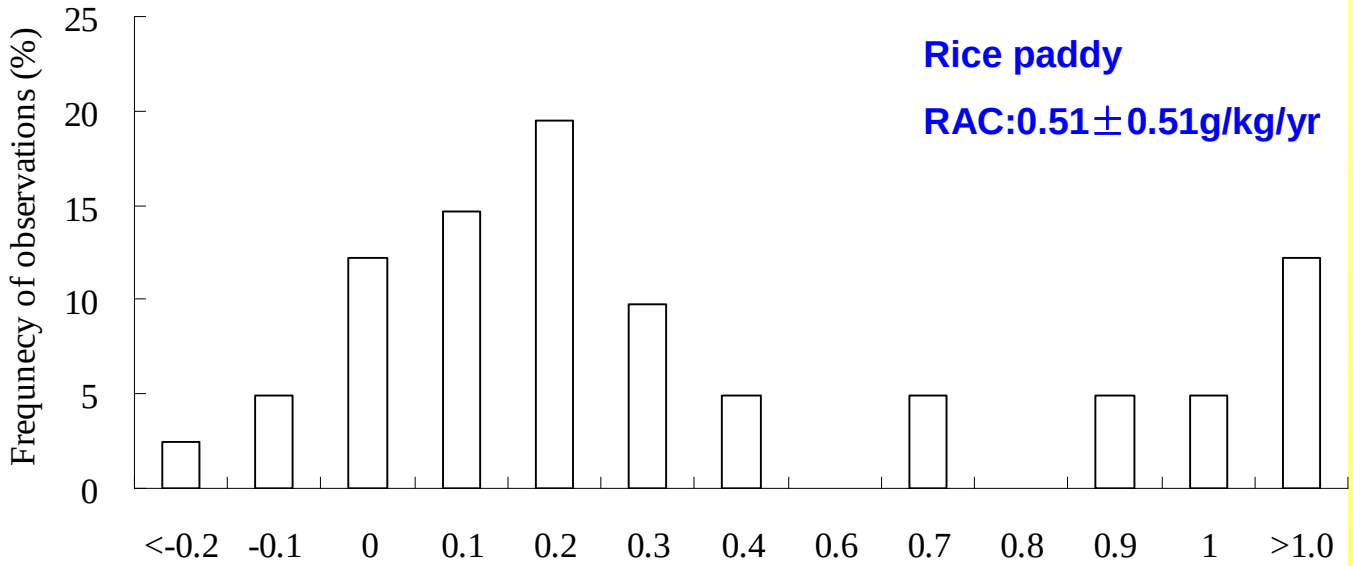


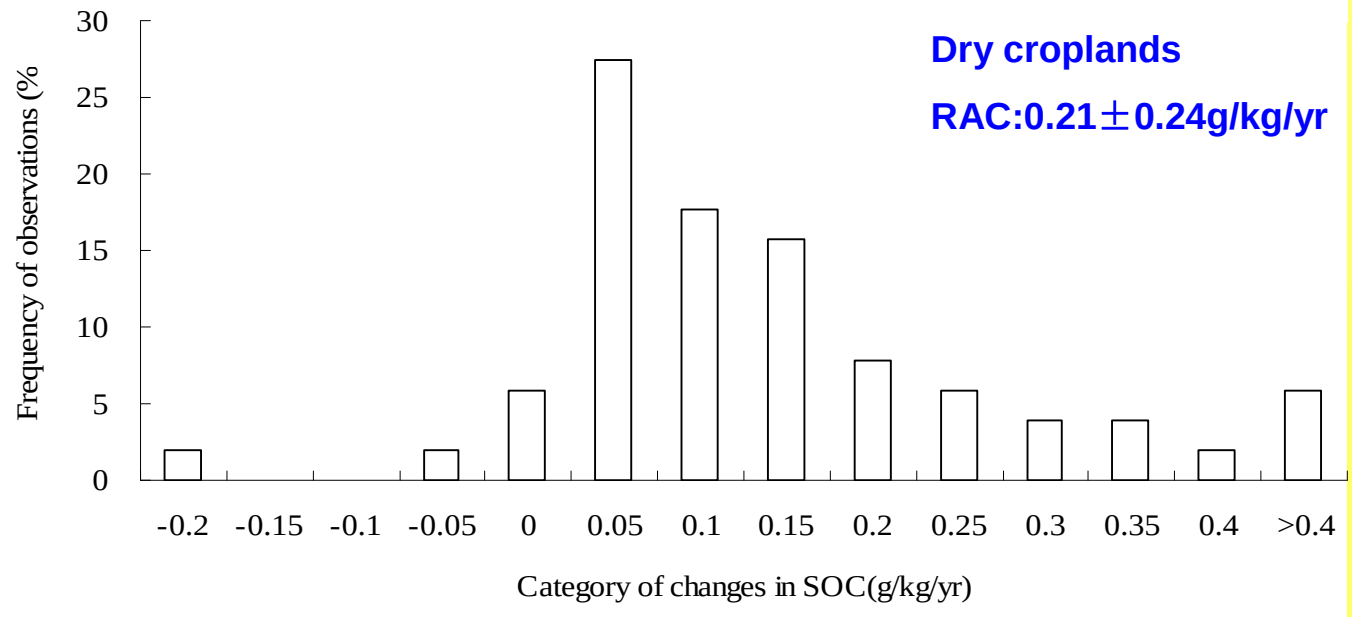
Rice paddies: 0.19±0.18gC/kg/yr; dry croplands:0.13±0.13gC/kg/yr)

To be resubmitted to AGEE,2009

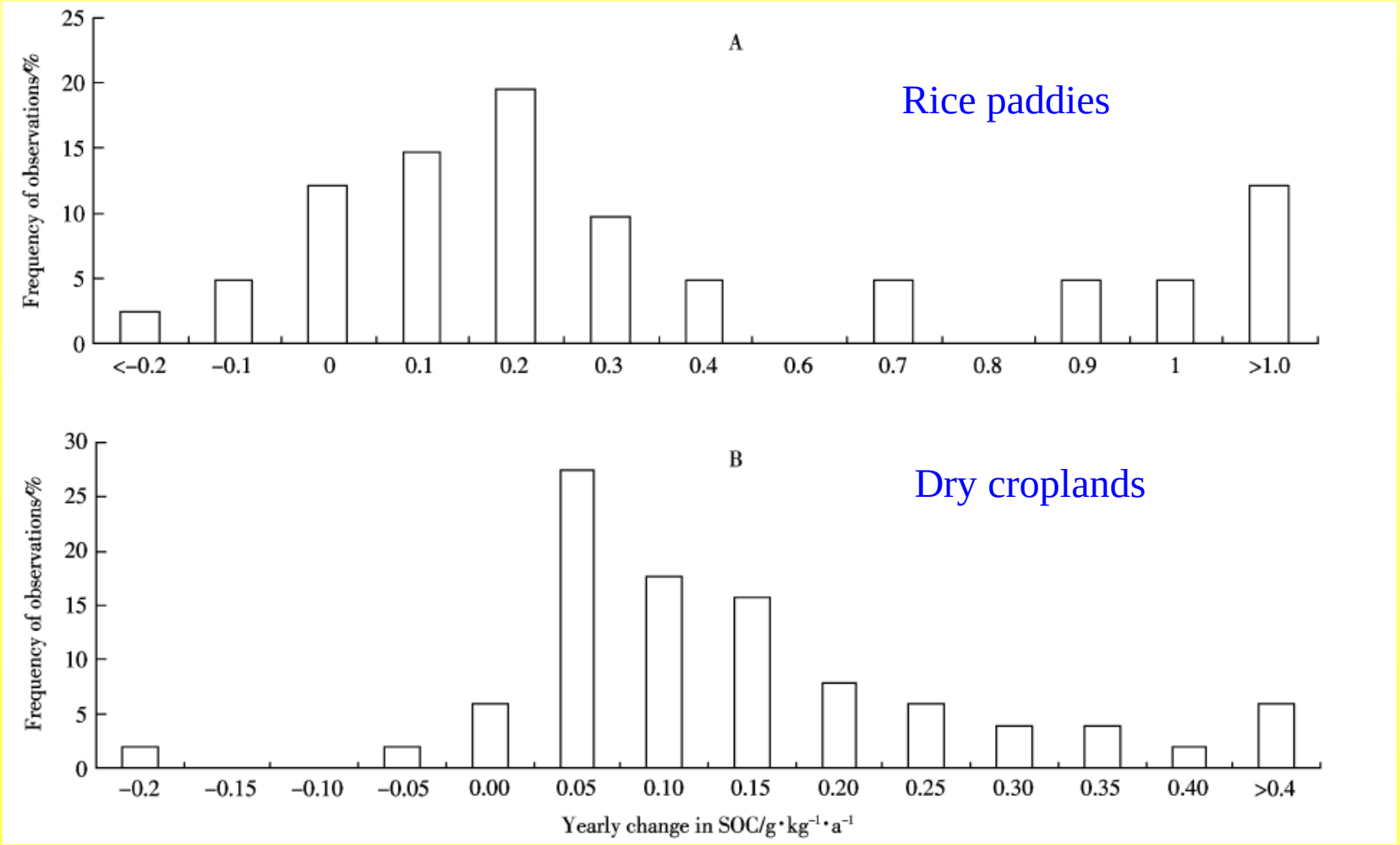
SOM accumulation can be doubled in rice paddies as in dry croplands under conservation tillage.

Data from a synthesis of LTSEs of conservation tillage. Wang et al.2009.



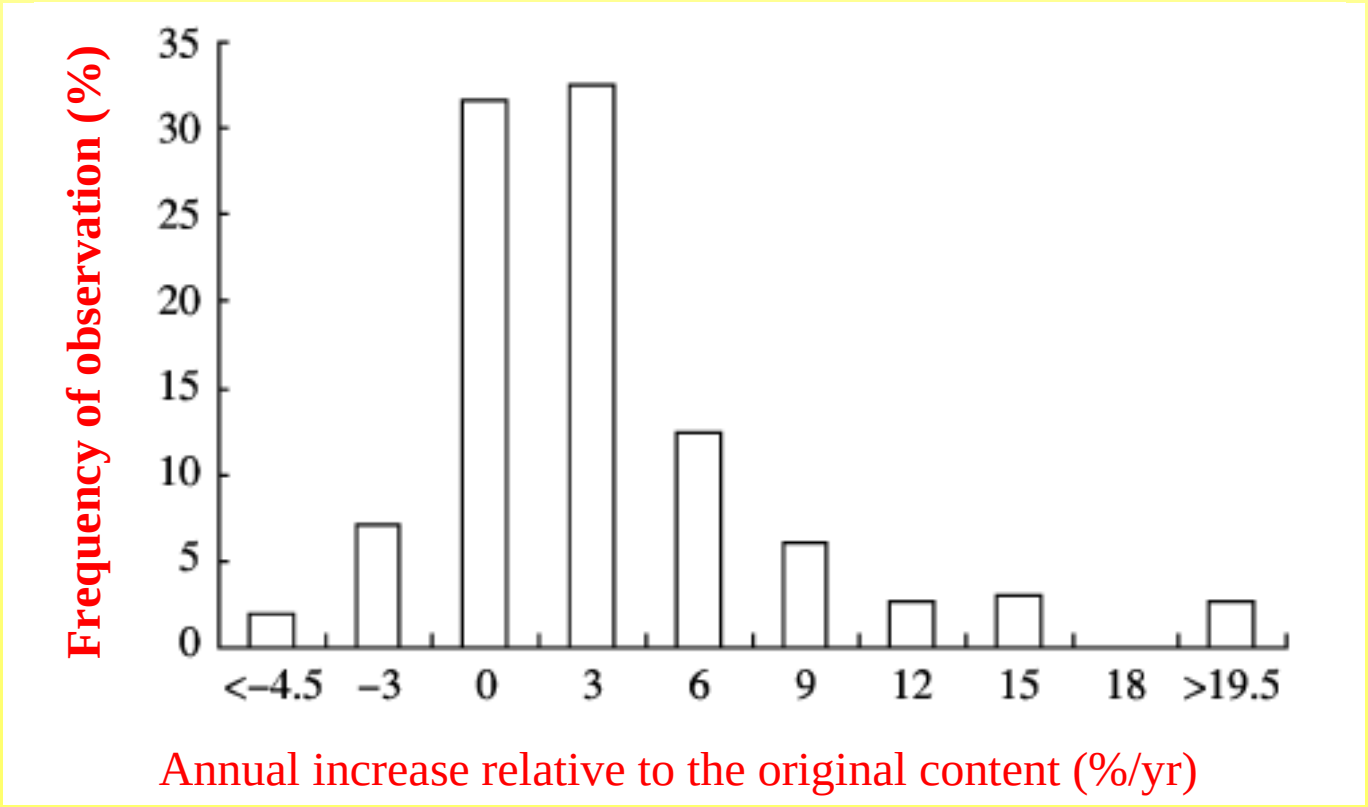


SOM-C increase in croplands: evidence from tillage experiment sites



Wang et al., 2003

An overall increase in SOM-C validated



Topsoil SOM-C changes in croplands since 1990's . Data source: the National Cropland productivity monitoring network, MoA, 2004

Cheng Kun, et al., 2009

The increase validated by a re-sampling of topsoil of Jiangsu soils in a provincial geological survey, 2004

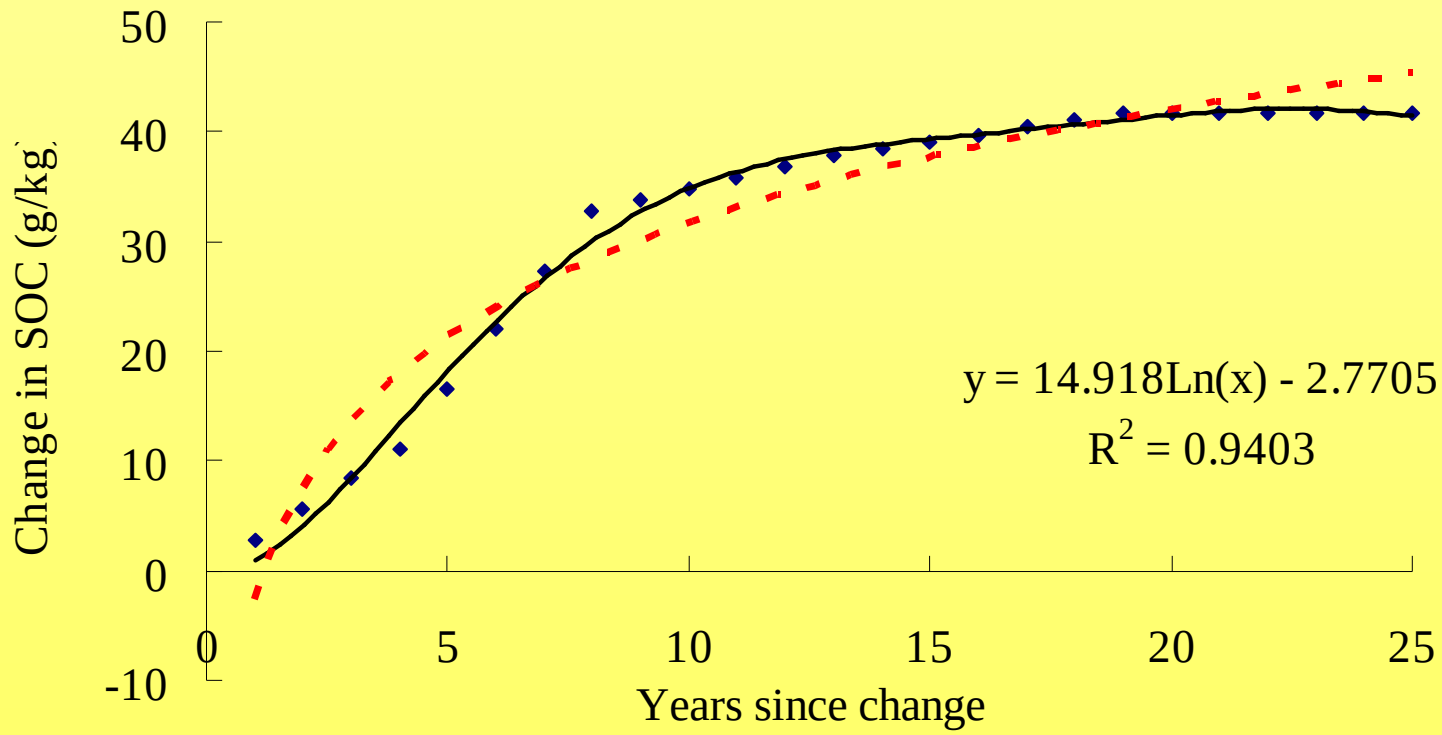
Sampling year	Single sample individual	Composite of soil type	Composite of eco-regions	Composite of municipal counties	Overall
1982	149.8 ±68.0	156.5 ±65.4	145.1 ±49.9	144.5 ±49.2	149.0 ±58.1
2004	171.6 ±59.8	177.4 ±51.3	171.4 ±49.2	172.5 ±45.3	173.2 ±51.4

Evidenced C stock increase estimated by C modeling by Huang et al., 2007 & 2009

Estimation of C sequestration in China's croplands over 1985-2005

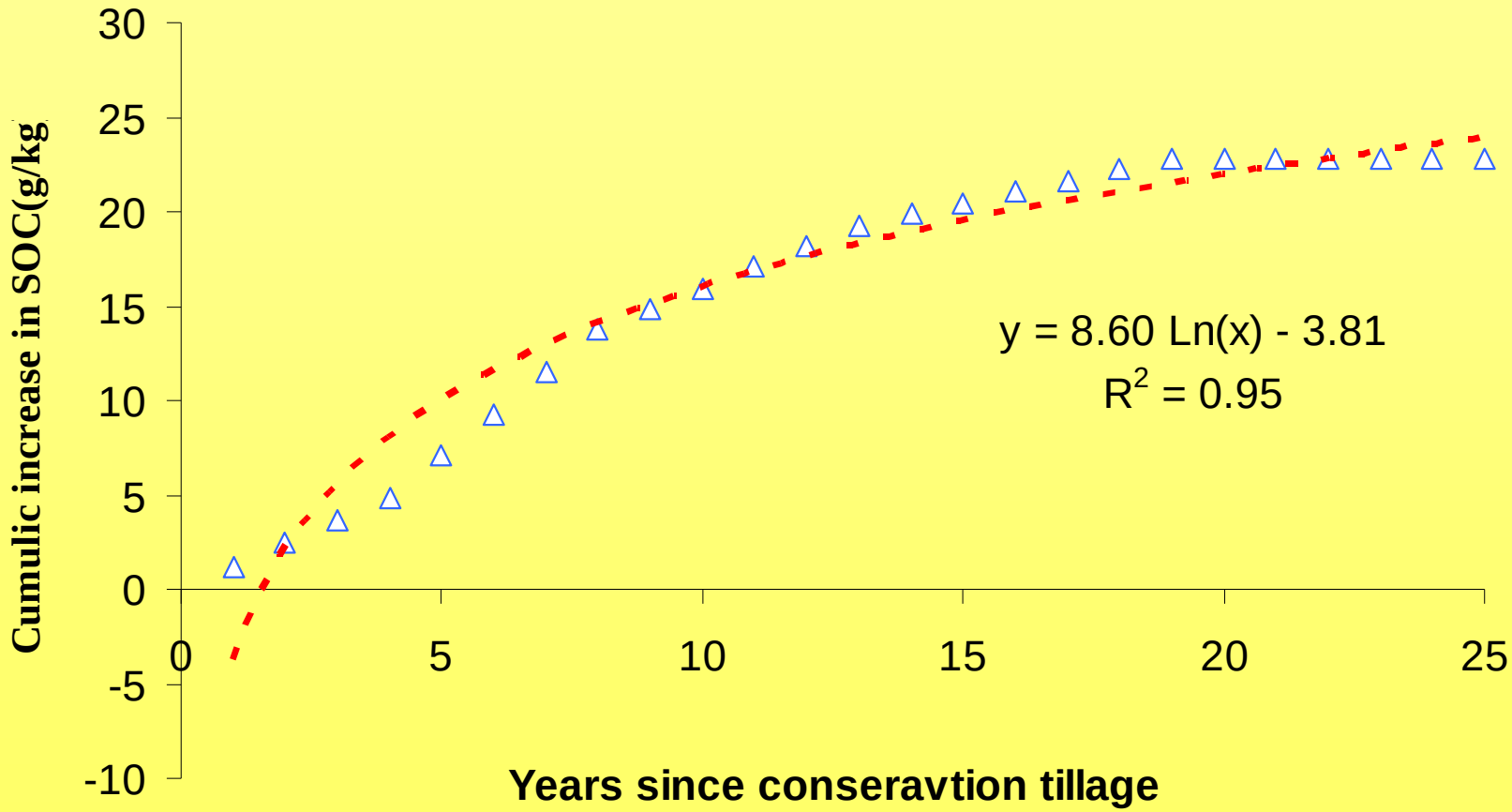
- Bulk topsoil C stock increase estimated: 100- 400 Tg; (Xie et al., 2007; Huang and Sun, 2006)
- Bulk topsoil C stock increase quantified: 25.5Tg C/yr (7.3 for rice paddies and 18.2 for dry croplands (this study)

Dynamics of SOC accumulation in rice paddies: Implication for multiple processes

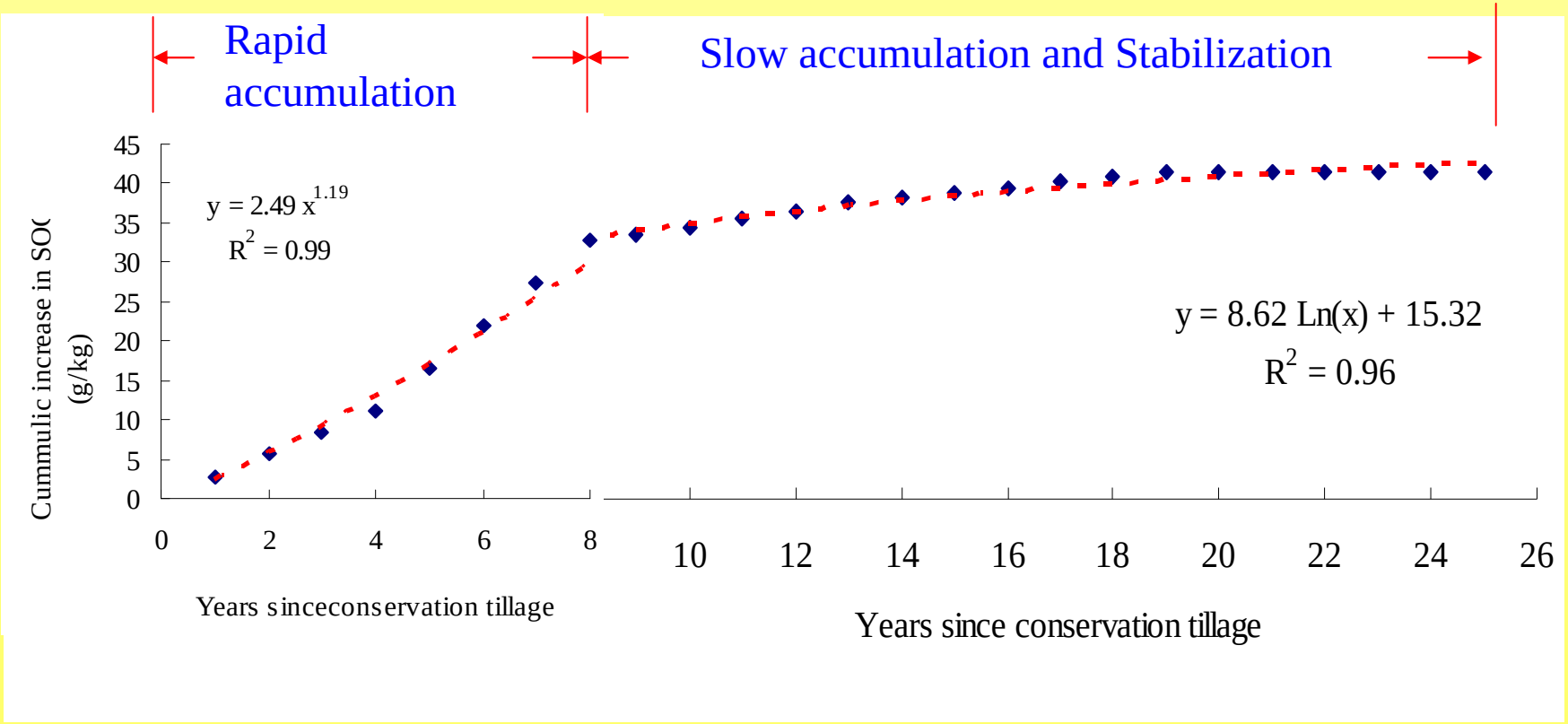


Based on the data of conservation tillage experiments. Wang et al., 2009. in Chinese

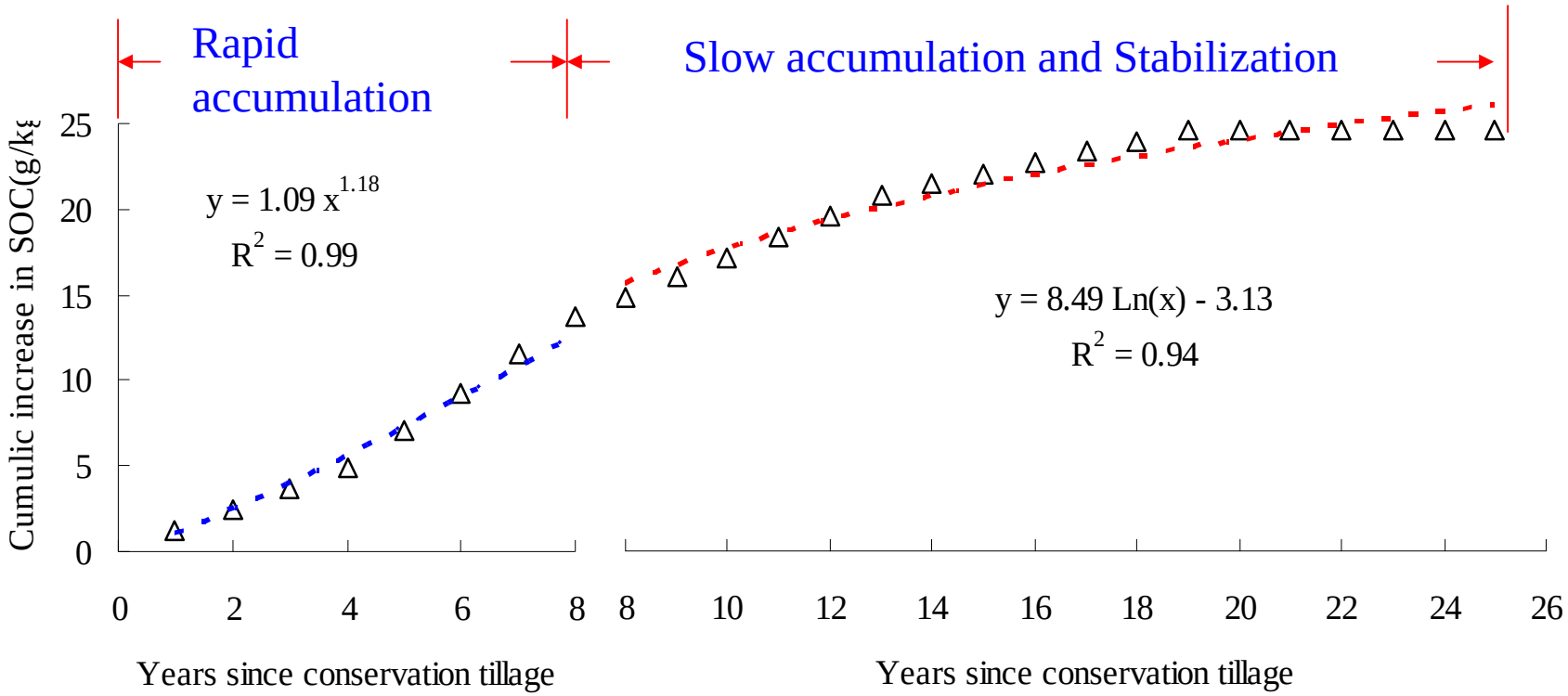
Dynamics of SOC accumulation in dry croplands: Implication for C stabilization



Dynamics of accumulation: Significance in C sequestration potential



Dynamics of accumulation: Significance in C sequestration potential



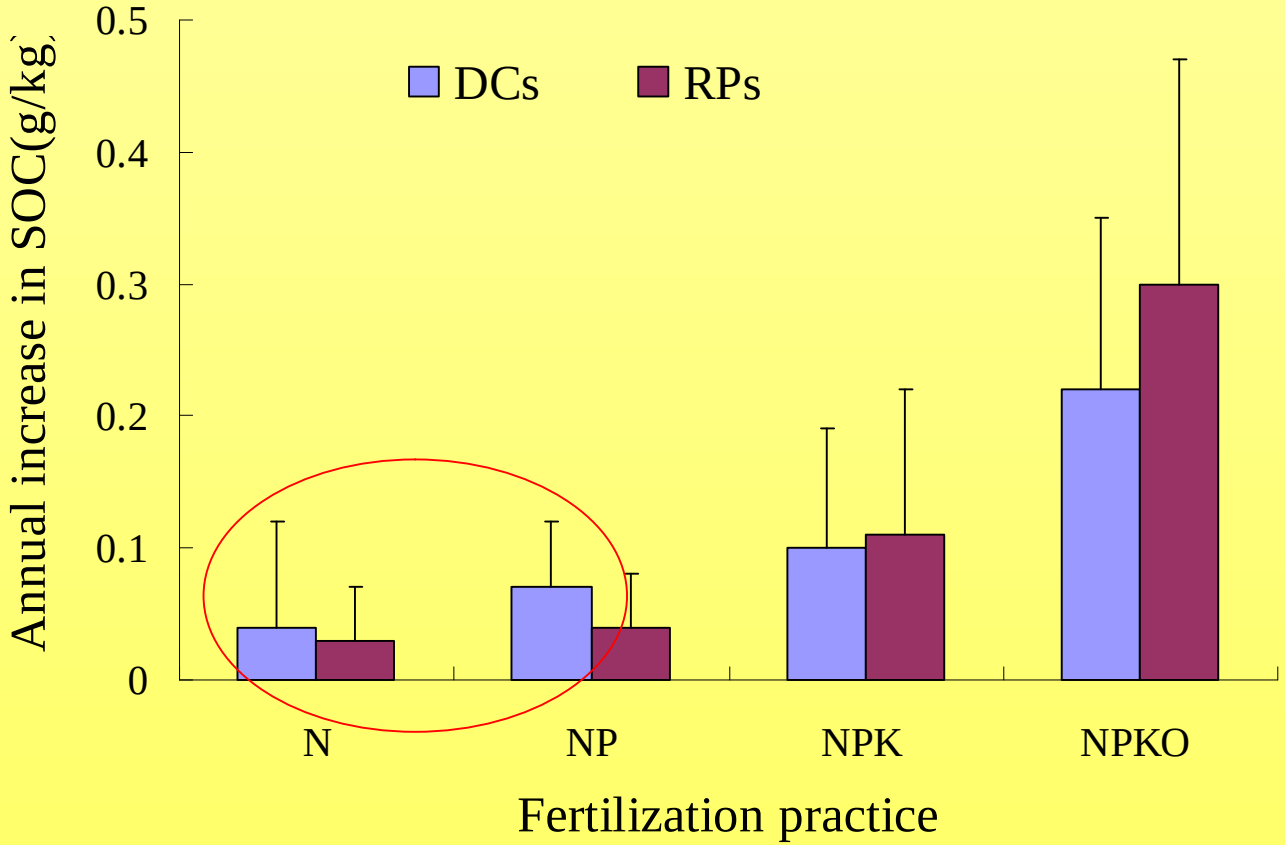
Major approaches for enhancing C sequestration

Improving crop management

Good/ rational fertilization practices

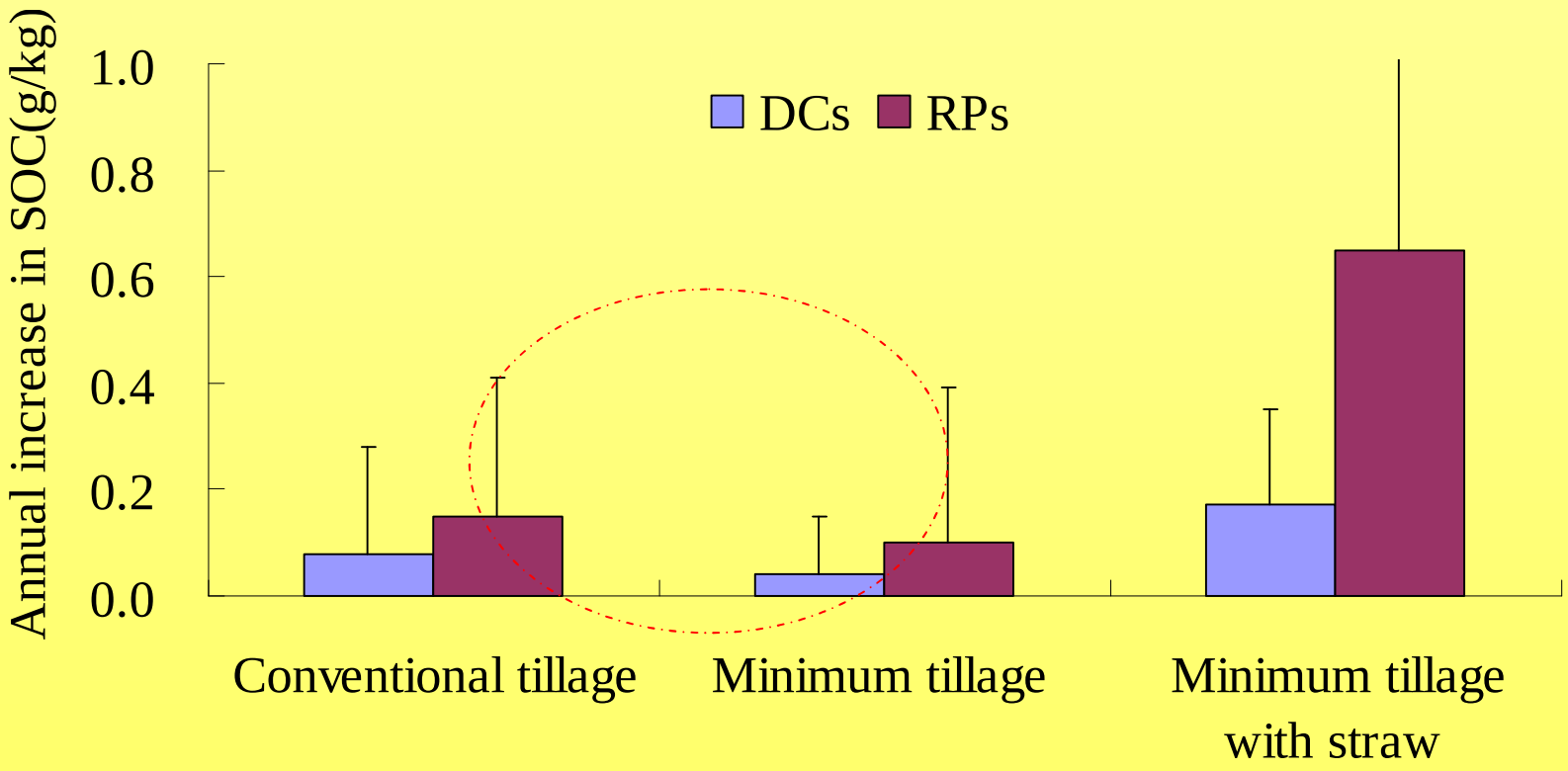
Biochar application from crop straw

Balanced fertilization favor C sequestration



Meta analysis of topsoil SOC under different fertilization experiments across China. —Wang et al., 2010. Science in China. Series C. in press

Conservation tillage incorporating straw facilitates C sequestration



Meta analysis of topsoil under long term tillage treatments across Mainland China. Wang, et al., 2009

1982-2003吴江市土地利用变化

土地利用类型	农田土壤面积(ha)	
	1982	2003
稻田	63691.50	18293.33
林地（花卉苗木地）	212.65	5340.00
果园	/	700.00
桑园	4560.45	4106.67
菜地（商品菜地）	/	1946.67
旱作物地	4292.82	700.00
总计	72757.41	31086.67

Proper land use keeps SOM-C stock

土地利用类型 Land use	样本数 n	范围 /g•kg^{-1} Range	有机碳/g•kg^{-1} Organic C
稻田Paddy field	110	8.58~24.71	16.95±3.13a
林地Woodland	33	3.64~22.50	14.37±4.00b
果园Orchard	10	4.76~18.67	13.15±4.44b
桑园Mulberry yard	26	6.24~24.76	15.53±4.37b
菜地Kale yard	15	8.12~19.66	14.68±3.20b
旱地Dry crop	84	3.64~24.76	14.91±4.04b

全市表土有机碳库：2.20±0.22 Tg (1982); 0.82±0.07Tg(2003)

侯鹏程，等.2006. 南京农业大学学报

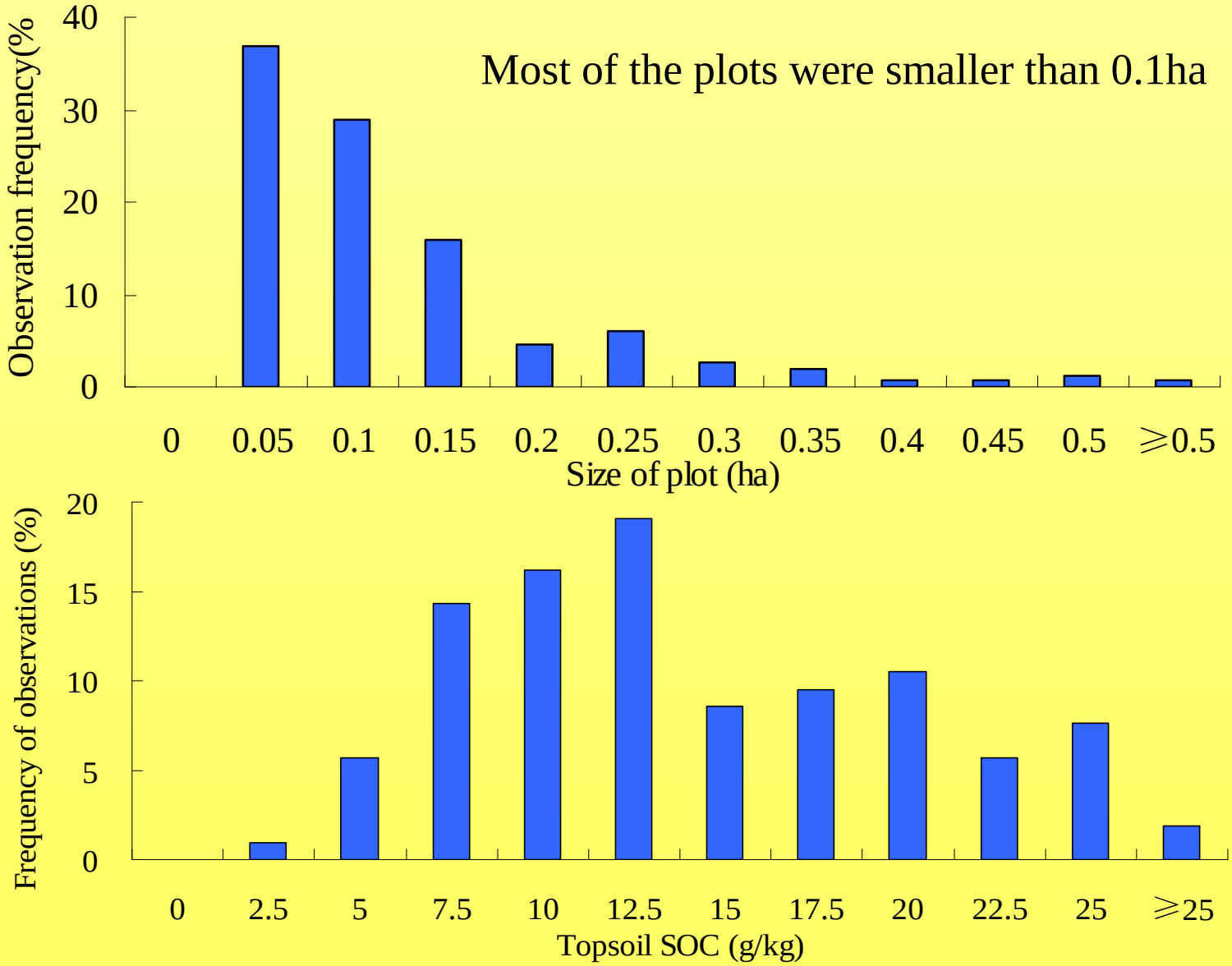
Land use changes and C stock-Village scale survey

	Rice paddy $g \cdot kg^{-1}$	Samples	Dry cropland $g \cdot kg^{-1}$	Samples
Gangyan	22.50±4.84	118	19.39±7.22	12
Shanzhu	24.71±5.72	85	25.00±3.00	8
Baniqao	13.96±5.73	82	7.98±5.08	23
Total/Mean	20.67±6.93	282	14.33±8.93	43

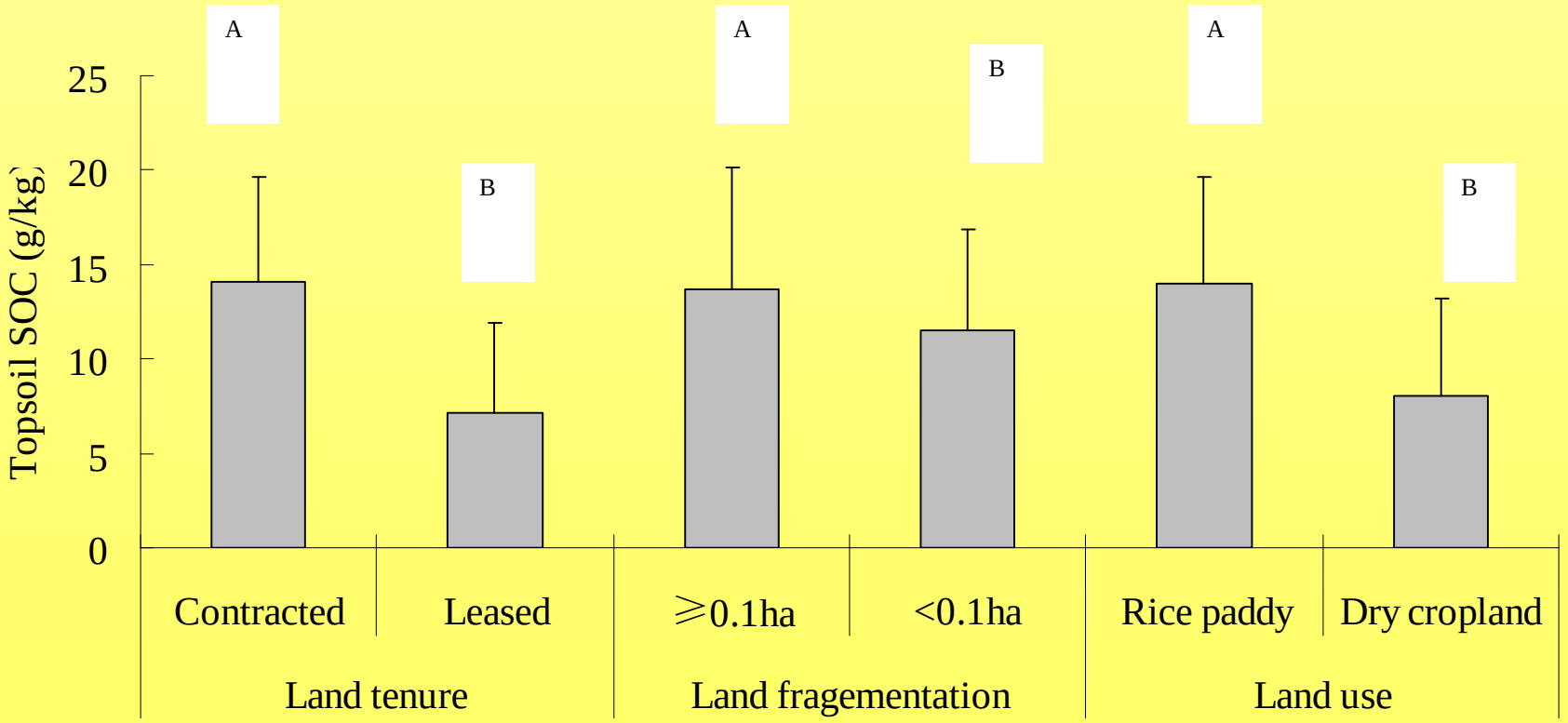
105 plots of the 15 households surveyed

Item	Measurement value		
Number of plots endowed	⩽7		>7
Total farm size (ha)	<0.7	⩾0.7	⩾0.7
Number of households	6	7	2
household land endowment (ha)	0.41±0.06B	0.94±0.18A	1.43
Topsoil SOC (g/kg) in 1985	12.17±1.97A	10.38±1.81B	11.10
Topsoil SOC (g/kg) in 2003	13.11±2.67B	16.51±0.97A	9.27
Mean SOC increase (g/kg)	0.95±2.10B	6.12±2.02A	-1.80

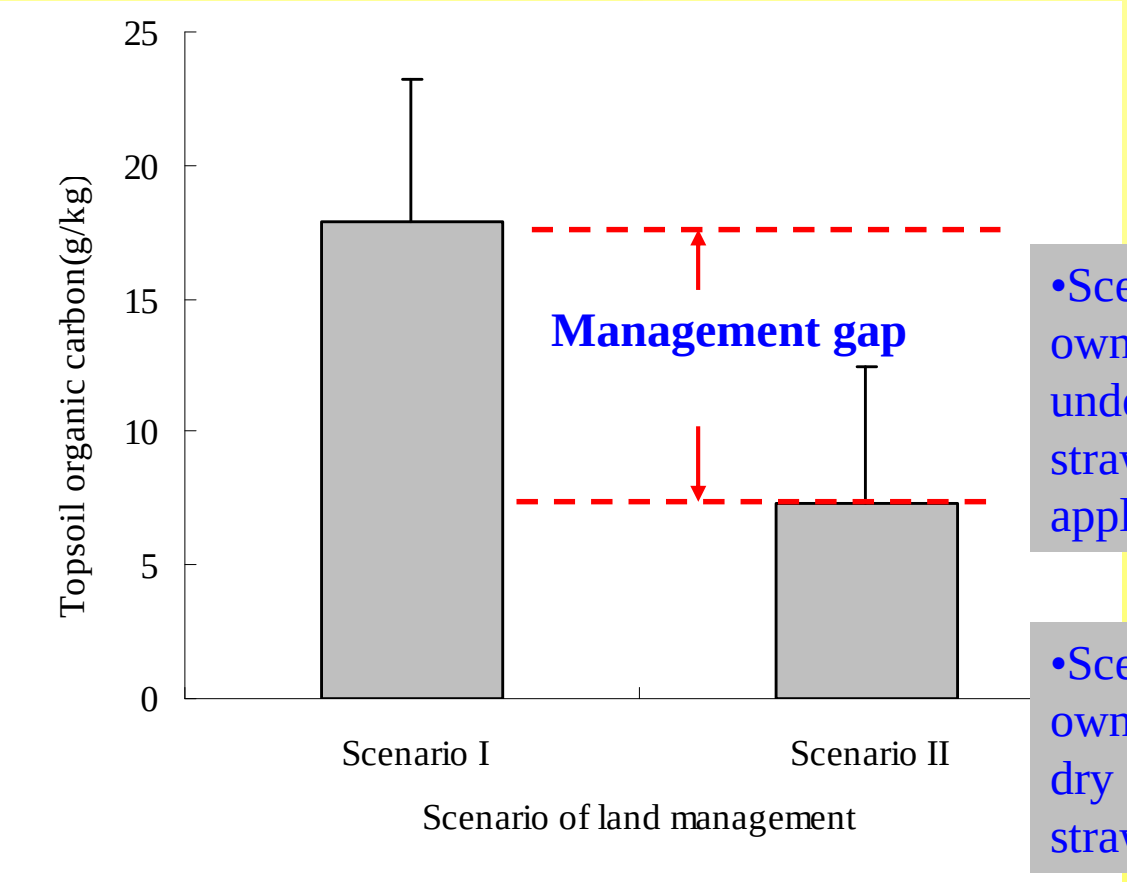
Land fragmentation and SOC variability



Wide variation with land use and management



Gap or Potential ?



•Scenario I: plots with contracted land ownership and in size larger than 0.1ha under double cropping of rice with straw return or green manure application;

•Scenario II: plots with subcontracted ownership and in size beyond 0.1ha of dry croplands without green manure or straw return).

•Differences in topsoil SOC content between scenarios of land managements of the household plots surveyed from the village, Jiangxi, South China

Biochar from crop straw

Biomass waste from agriculture of China：

- Straw biomass: 0.7 Pg/yr
- Municipal biomass waste: 0.2 Pg
- Animal waste：2Pg (fresh)
- May offsetting emission, eg. From burning
- Enhance C stock while decrease N2O emission
- Low temperature pyrolysis technique available without external energy

Potential and options for SOM-C sequestration and stock enhancement in China's croplands

- Great potential of returning bio-waste to soil;

  eg: biochar from biomass conversion of municipal waste, straw, and husbandry waste;
- Conservation tillage with straw return;
- Well designed fertilization scheme
- Optimizing land management

Data available for potential estimation

C dynamics under long term Agro-experiments

- Fertilization treatments: across Mainland;
- Conservation Tillage and/or straw return;

Wang et al.,2009;

C dynamics by soil monitoring

- Monitored sites for soil fertility;
- Different time of report;
- Meta-Analysis of a relative changes
- Estimation of a total topsoil C stock increase
- Pan et al., 2010

C dynamics by soil monitoring

- National cropland productivity monitoring system consistently since 1980’s;
- 299 sites of representative farms over provinces;
- Meta- Analysis of yield and SOC
- Cheng et al., 2009;

Soil C dynamics from soil sample record in publications using analysis

- Publications of research using soil samples collected;
- Record of SOM(SOC) contents retrieved;
- Comparison between land use and with different decades (1990's and 2000's)
- to be completed soon

A network of rice paddy experiments

Layouts and experience sharing through cooperation-expected

- Estimation methodology development;
- Organization of networking and data synthesis
- Available experiences and techniques of mitigation in UK;
- GMP strategy and framework, including C trading in agriculture
- ?

Acknowledgements:

- China National Science Foundation : Several key project funding on C sequestration and stability;
- China Ministry of Agriculture: Key project funding on climate change mitigation in agriculture;
- China Ministry of Education : Key project funding on Soil C stock changes
- China Ministry of Sci. and Technology: GHGs mitigation in rice paddies
- SAIN WG3….. Bilateral partners

Thanks!