Soil Health 2024 Japan Workshop
「土壌の健康」についての国際ワークショップ

Soil health assessment in Kanto, Japan: A long-term study of conservation agriculture trials

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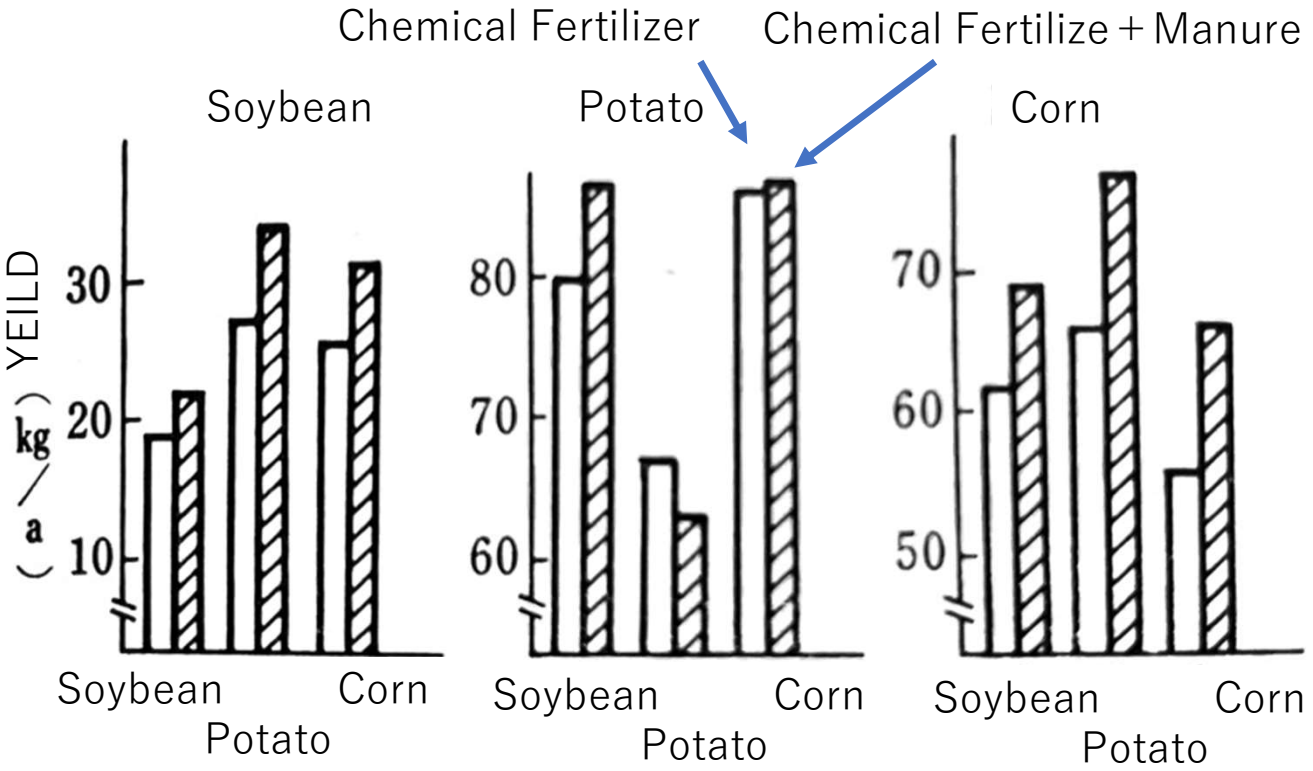
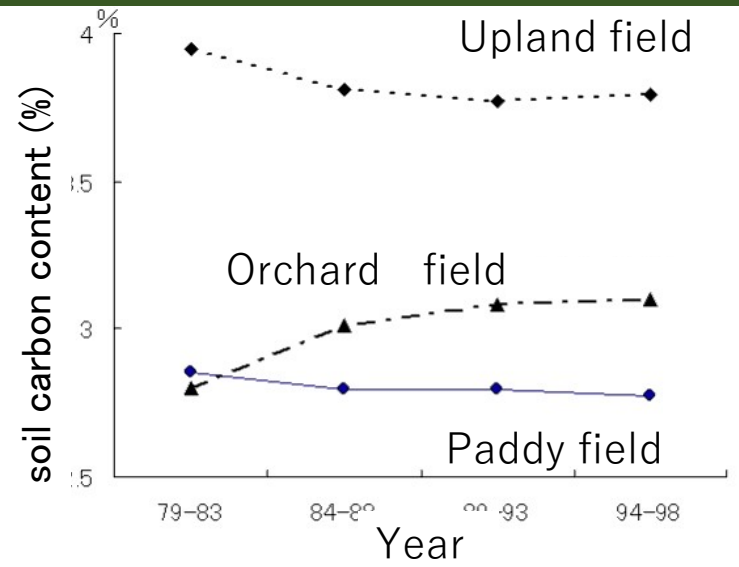
Soil management and Soil Health in the Past

Soil health has been intensely discussed within the context of traditional crop rotation and the use of compost in Japan from the 1950s to 1970s.

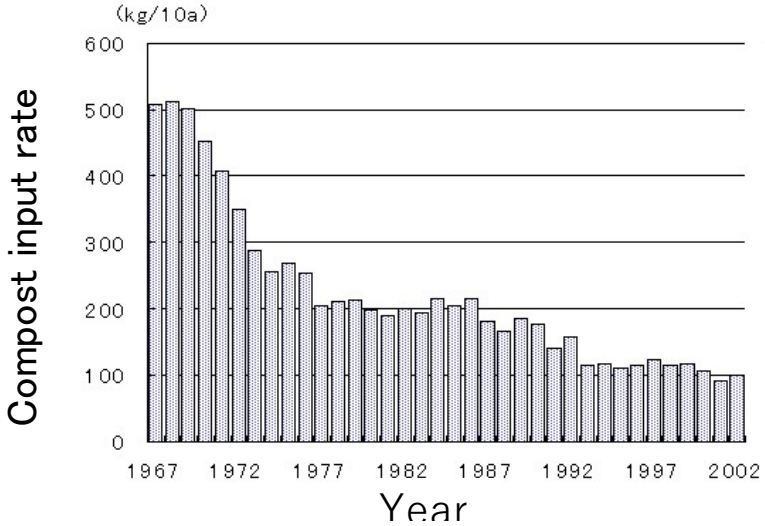


Data from Okubo (1976)

Soil management and Soil Health Update



Changes in soil carbon content



- **Soil carbon content tends to decrease in Upland fields due to decline of compost input.**
- In the paddy fields almost did not change due to flooding.
- In orchard, there was a tendency for soil carbon to increase due to the minimizing soil disturbance.

Data From MAFF (2007)

Soil management and soil degradation

Through agriculture, we are causing problems such as the degradation of soil resources and global warming（Ronald Amundson et al.Science 348, 1261071,2015).

From an encounter with an Best Practice farmer

Learning to improve the soil through agriculture

Food and Agriculture Organization of the United Nations

保全農業

Conservation Agriculture

3 basic soil management strategies

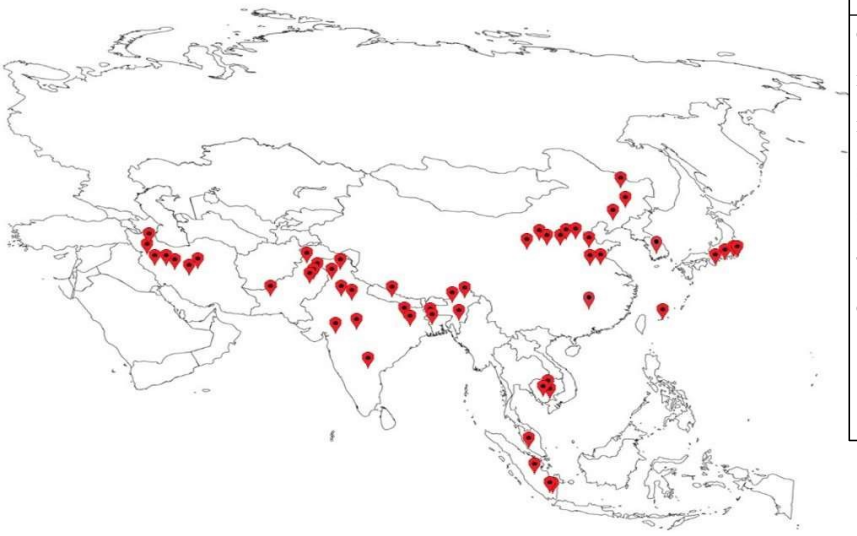
土壌のかく乱を最小限とする・不耕起栽培
Minimum mechanical soil disturbance

土壌を植物などで被覆する・草生栽培
Permanent soil organic cover

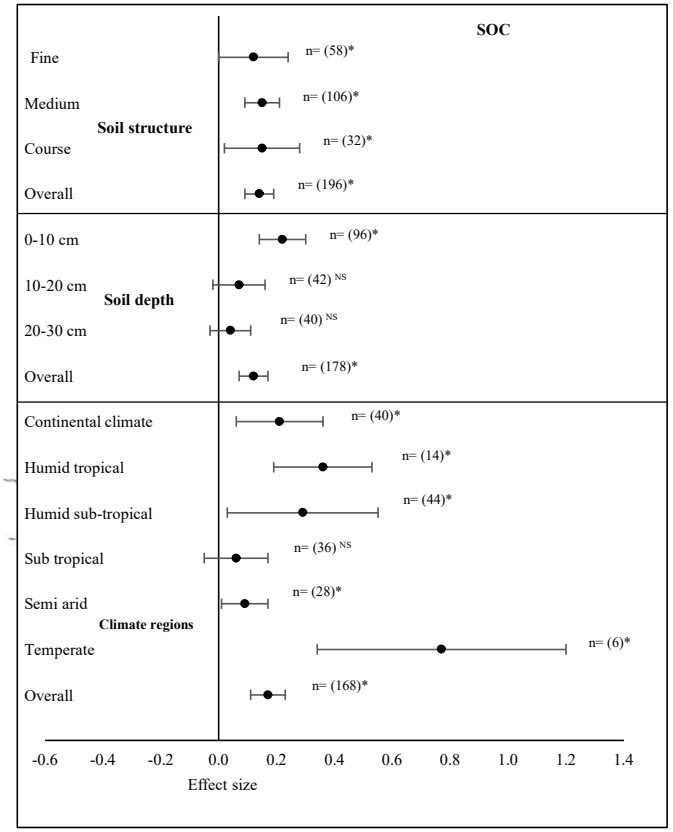
圃場での生物多様性を確保する・輪作/混作
Species diversification

Possibilities for no-till cultivation in the Asian region

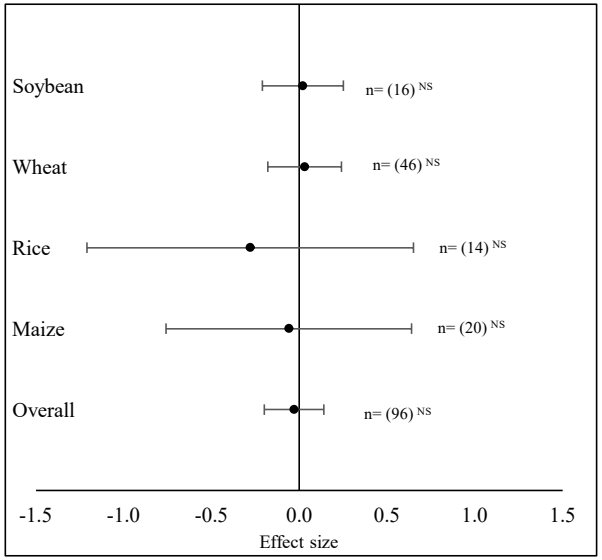
A meta-analysis was conducted on scientific research papers on comparative experiments between tillage and no-till conducted in the Asian region.
68 papers from 11 countries (peer-reviewed)



Soil carbon sequestration



Crop yield

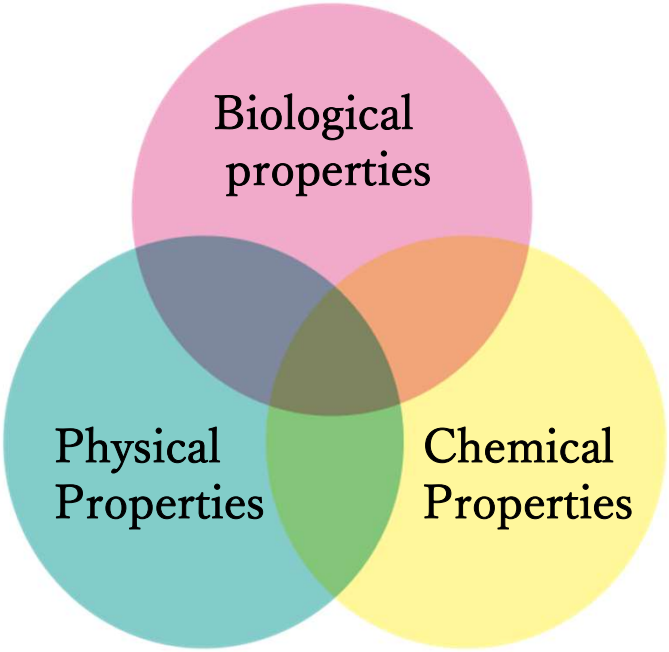


Improved carbon sequestration through no-till
Yield stability is important

Hashimi et al. 2022 Land Degradation & Development

Hypothesis of soil health

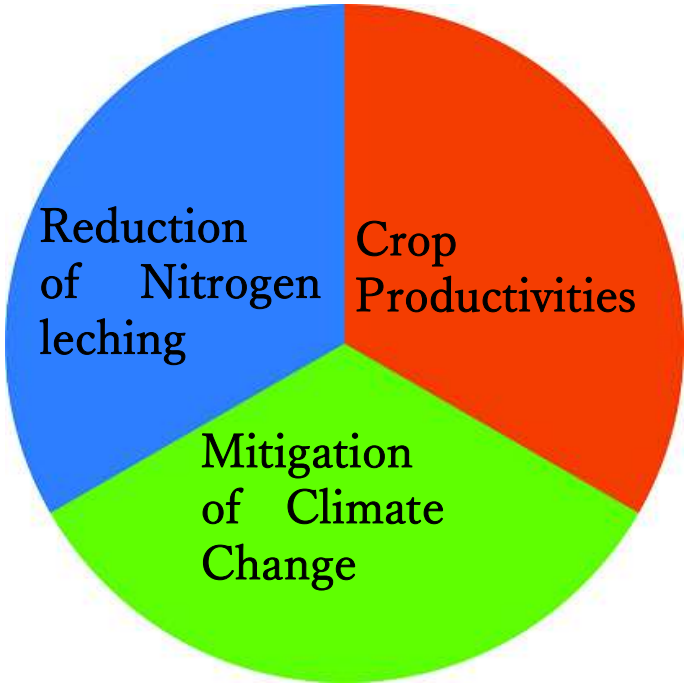
Soil attributes



Measurement Minimum Data Set

Scaling (Z score)
Soil Health Index

Soil Ecosystem service



Long-term crop rotation experiment with cover crops and tillage methods

The experiment has been ongoing in the Hong-stacked plateau field (soil: CL, LiC) of the International Field Agricultural Science Center, Faculty of Agriculture, Ibaraki University from October 2002 ~ the present

Main crop: 2003~2008 Okabo

Soybeans since 2009, organic since 2010

Experimental design: 4 iterations

Key Factor: Tillage Method

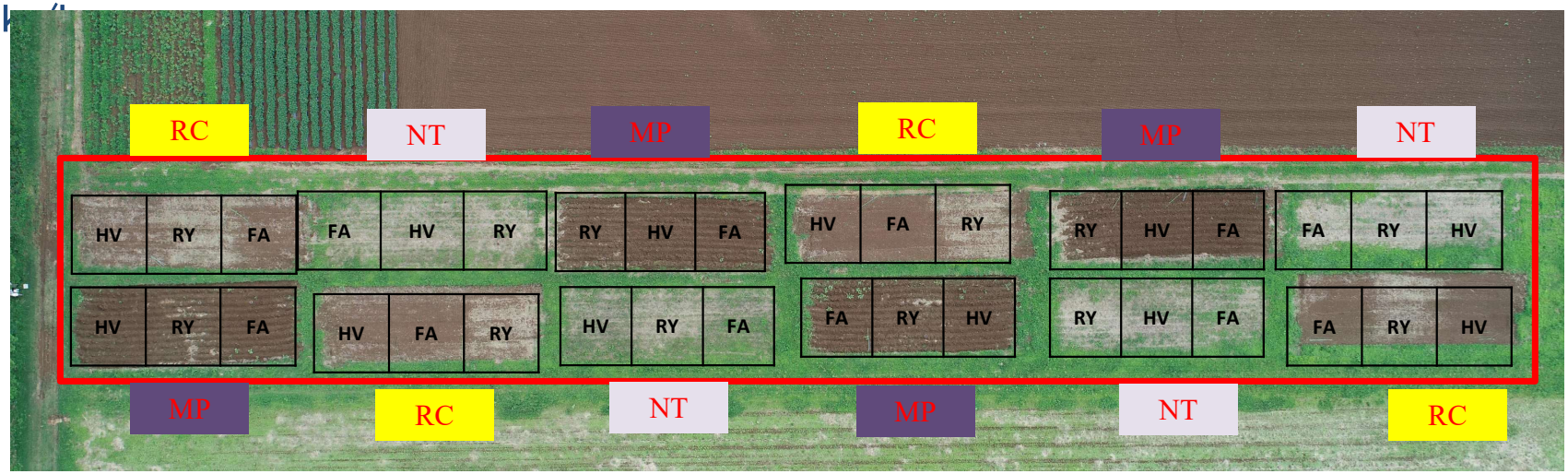
1. Plough (MP) 2. Rotary plough (RC) 3. No-till (NT)

Secondary Factors: Cover Crop Type

1. Hairy vetch (HV) 2. Rye (RY) 3. Bare ground (FA)

Application of rice husk smoked coal (from 2021)

0:0 kg/ha 1:8,000 k



Mesurement

Cover crop dry matter , soybean dry matter, yield, soil carbon storage, GHGs emissions

Rotary plowing (15 cm depth)

Plow (27 cm depth)

No-till sowing (non-disturbing)

Carbon supply by cover crop

No-till cultivation has a high weed risk

Weed suppression effect of cover crop

Development of a new no-till weeding machine

Weeding work using a prototype

Field efficiency improved 2.6～2.9 times

This machine is the result of joint research between Patagonia Japan Branch, Kobe University, and Ibaraki University. Since it is still in the research stage, information on where it can be used, its operational limitations, durability, and performance is not yet available. Also, please note that safety considerations are not sufficient

ANOVA analysis of soil carbon content between farming system

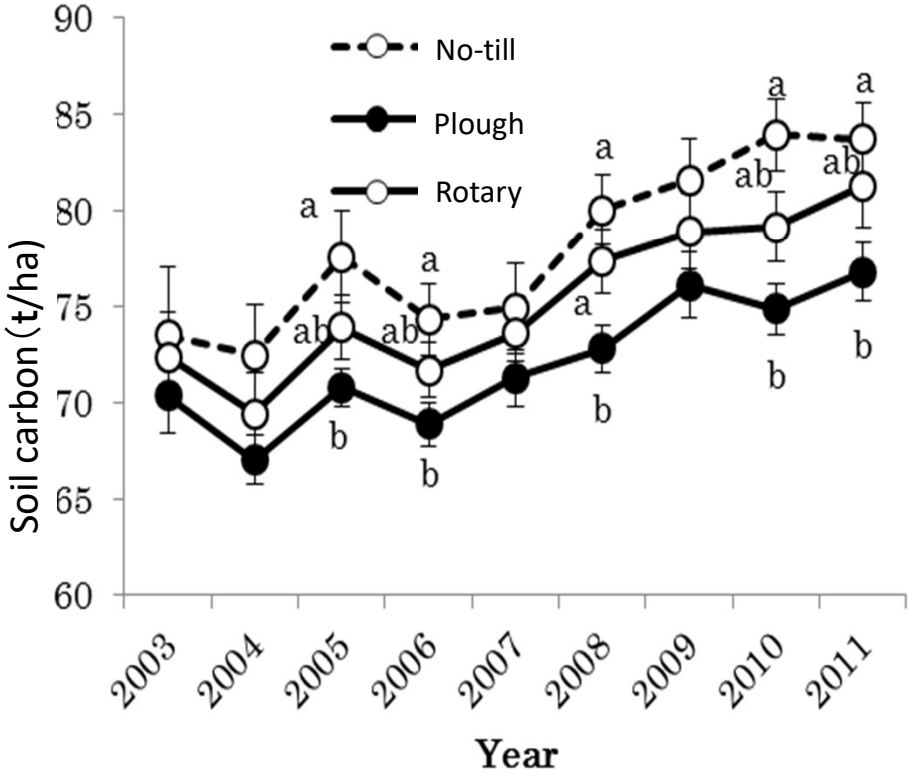
Depth(cm)	Factor	2003		2004		2005		2006		2007		2008		2009		2010		2011	
		4月.	10月.	4月.	10月.	4月.	10月.	4月.	10月	4月.	10月	4月.	10月	4月.	10月	4月.	10月.	4月.	10月.
	Tillage	NS	NS	NS	**	***	***	*	***	*	***	***	***	***	***	***	***	***	***
	Cover crop																		
0-2.5	Tillage	NS	NS	*	NS	**	**	*	***	**	***	***	***	***	***	***	***	***	***
	Cover crop																		
	Tillage	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Cover crop																		
	Tillage	NS	NS	NS	NS	NS	*	NS	**	NS	*	***	***	**	***	**	***	***	**
	Cover crop																		
2.5-7.5	Tillage	NS	NS	NS	NS	NS	NS	NS	***	NS	***	***	**	***	***	**	***	***	***
	Cover crop																		
	Tillage	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Cover crop																		
	Tillage	NS	NS	*	NS	NS	NS	NS	NS	NS	NS	*	**	**	**	NS	**	**	*
	Cover crop																		
7.5-15	Tillage	NS	NS	NS	NS	NS	*	NS	**	NS	***	***	NS	***	***	***	***	**	***
	Cover crop																		
	Tillage	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Cover crop																		
	Tillage	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	*	NS	NS
	Cover crop																		
15-30	Tillage	NS	NS	NS	NS	NS	NS	NS	NS	NS	**	**	NS	*	***	**	**	NS	**
	Cover crop																		
	Tillage	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Cover crop																		

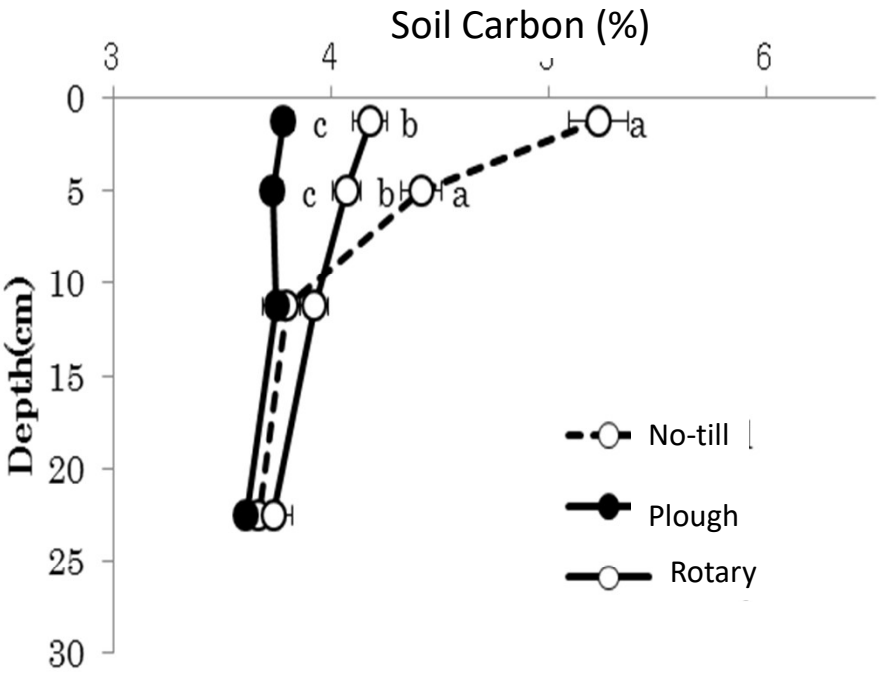
T: Tillage system, CC: Cover crop, T × CC: Tillage system × Cover crop.

,**,* The significance levels are 0.1%, 1%, and 5%, respectively. The no significant difference.

Higashi et al. (2014)
Soil & Tillage Research

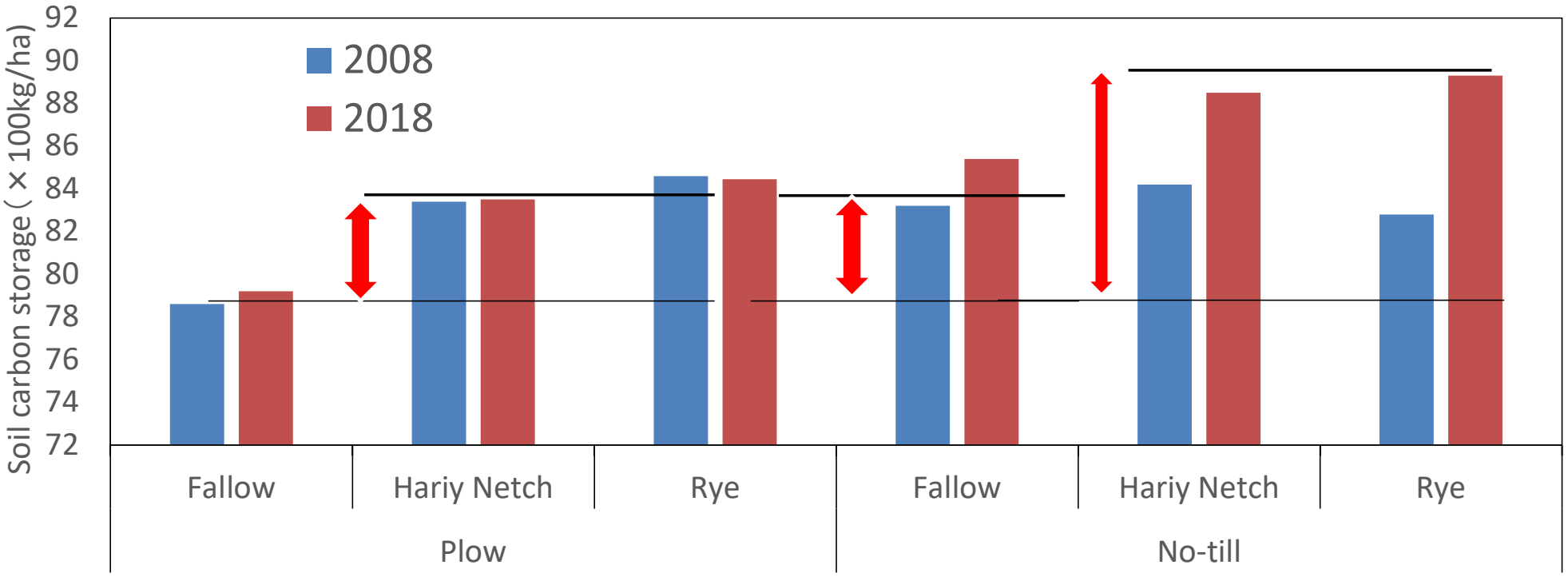
Changes in Soil Carbon Sequestration





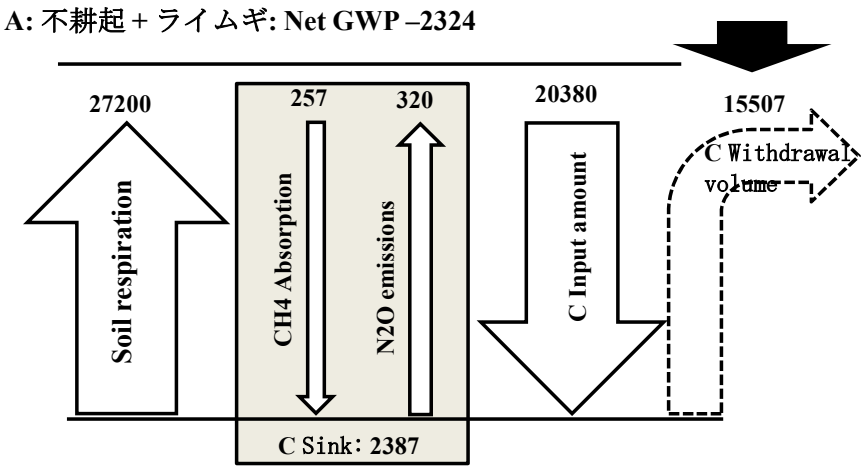
Higashi et al. 2014 Soil & tillage Research

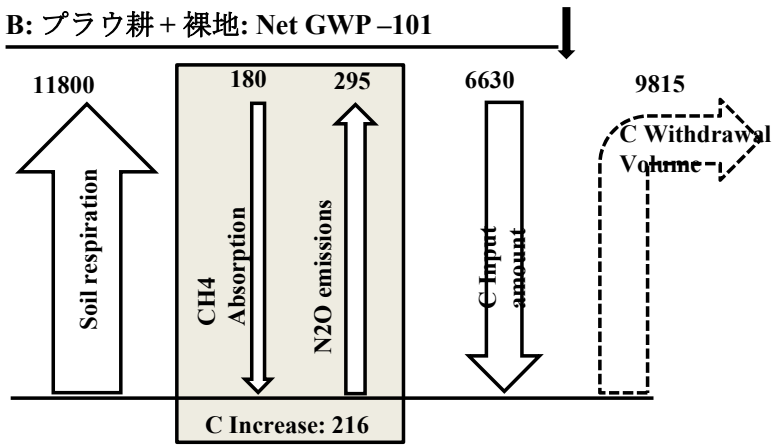
No-till with rye cover crop Increased carbon storage



Gong et al. 2021 Soil & tillage Research

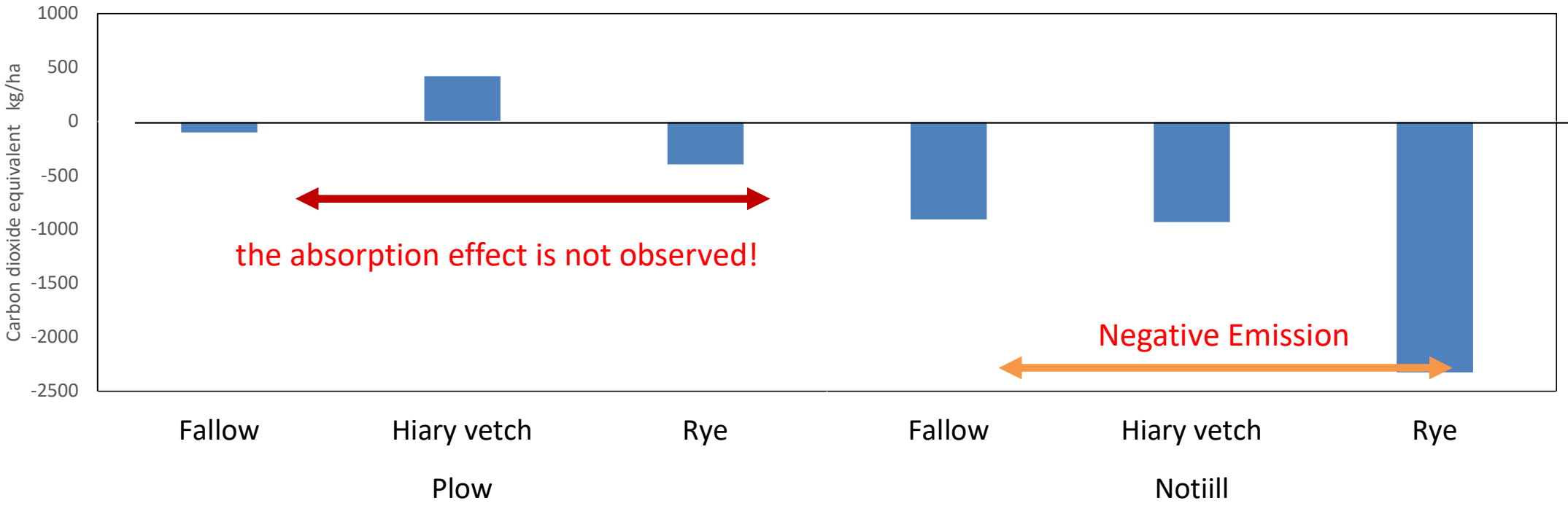
Cover crop + no-till cultivation is effective in mitigating global





Gong et al. 2021.
Soil & tillage Research

Global warming mitigation through the No till wiy Rye



Effects of tillage methods and the use of cover crops on global warming potential (GWP). The global warming potential was determined by converting nitrous oxide and methane emissions and changes in soil carbon storage into carbon dioxide (Gong et al. 2021)

Gong et al. 2021 Soil & tillage Research

Plough + Fallow

Water stagnation due to torrential rain (July 2021)

No-till + cover crop

Concentrated heavy rain でも drainage is good (July, 2021)

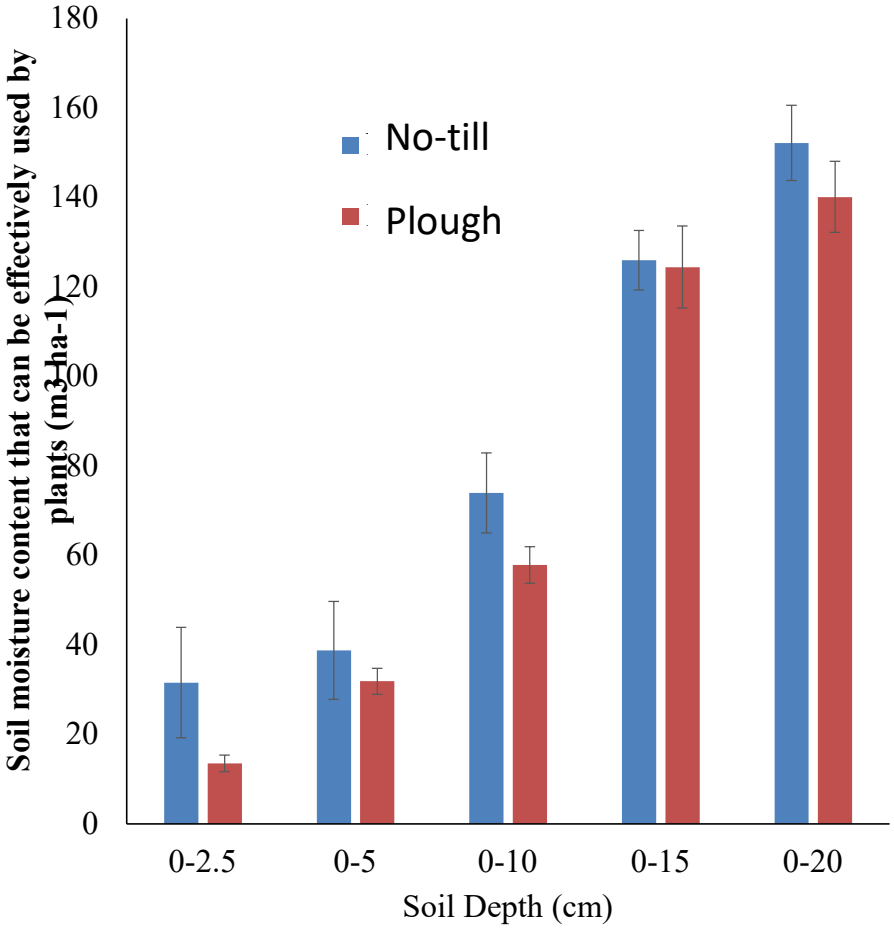
Plough + Fallow

Growth delay due to high temperature and soil drying (August 2022)

No-till + cover crop

Ensuring growth even at high temperatures and dry soil (August 2022)

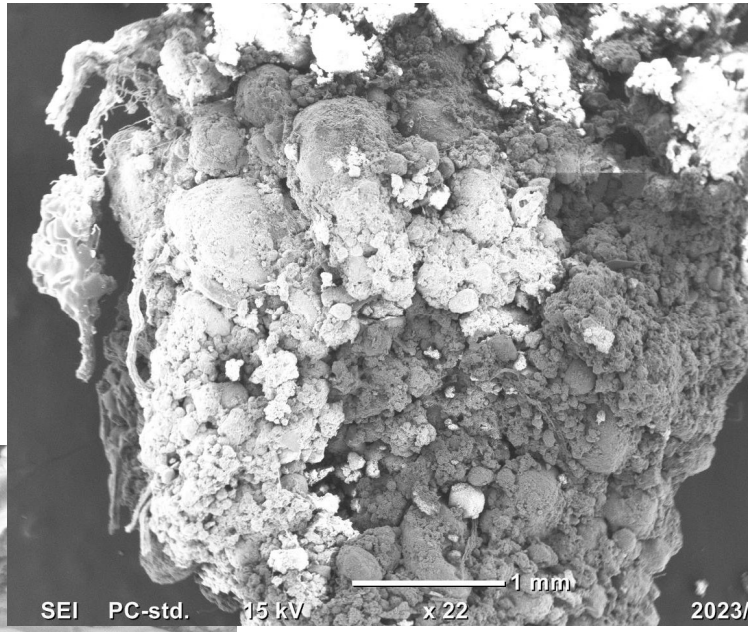
The tillage method changes the moisture retention capacity of the soil!

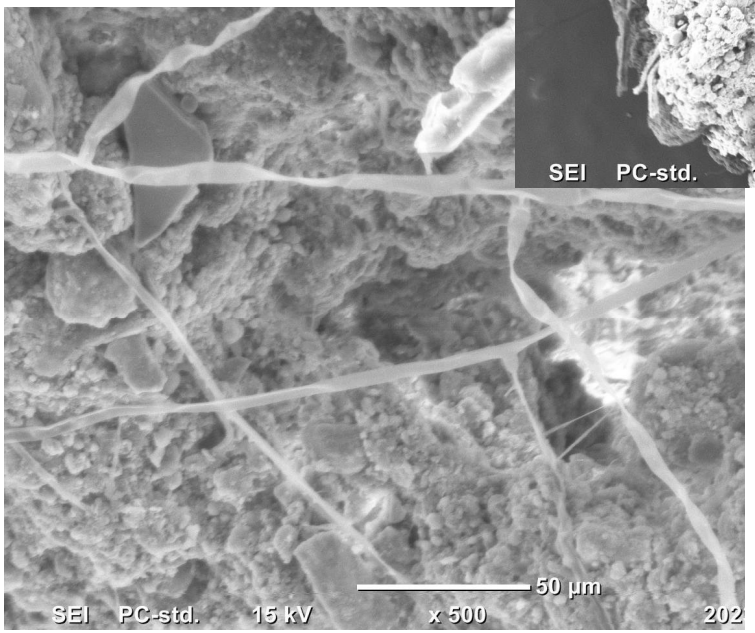


No-till allows plants to use water per 1 ha
Can hold 20 tons more water

Hashimi et al. 2023 submitted

Macro aggregate
(4 mm or more)

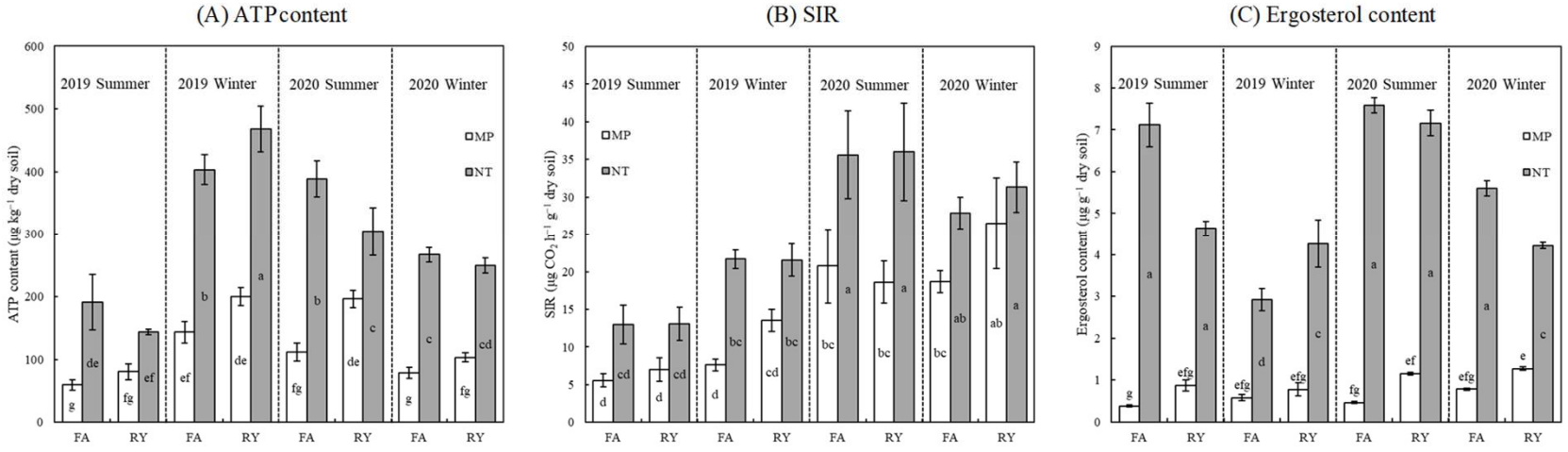




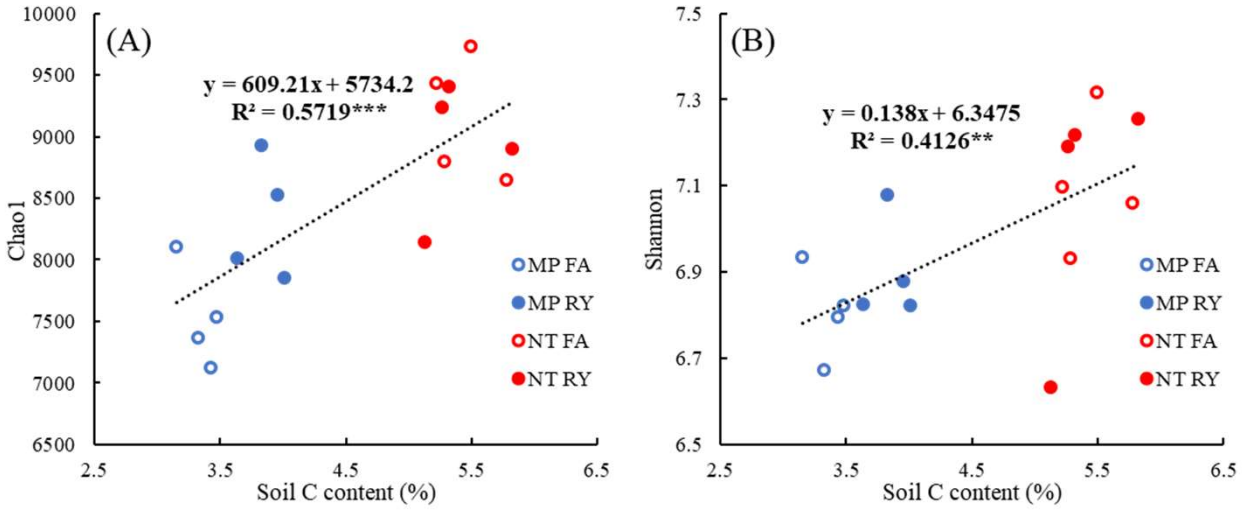
In the Macro Aggregate volcanic ash is tied together to create voids

Hashimi et al. 2023 Soil & Tillage

No-till agriculture stores soil carbon and increases soil microbial diversity



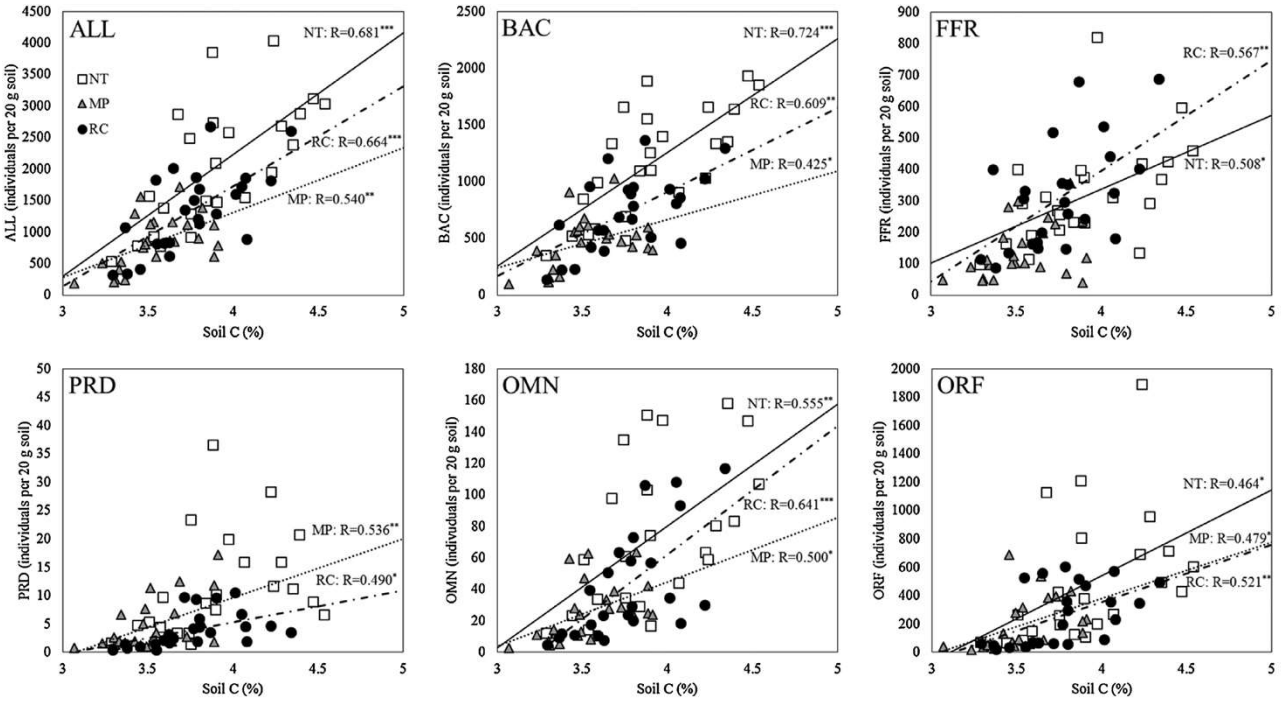
Differences between plough (MP) and no-till (NT) and winter-cropped bare ground (FA) and winter-grown rye (RY) on ATP (adenosine triphosphate) content (A), substrate-induced respiratory rate (SIR) (B), and ergosterol content (C) in summer and winter soils.



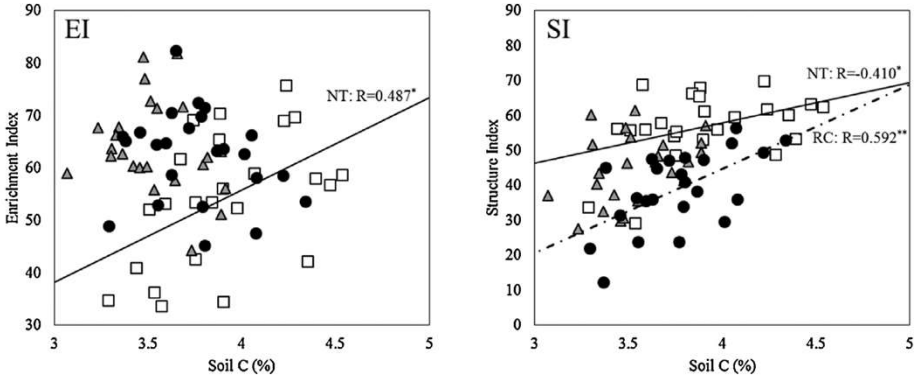
Relationship between soil carbon content and soil microbial diversity index (Chao1: right, Shannon: left). The notation ** and *** of the coefficients of determination indicate the significance levels of $p < 0.01$ and $p < 0.001$, respectively. The points in the figure show plow-tillage (MP) and no-till (NT) tillage methods and combinations of winter bare ground (FA) and winter rye (RY), respectively.

Gong et al 2022. *European Journal of Soil Science*

Soil carbon is stored to increase the diversity and structure of soil nematodes.



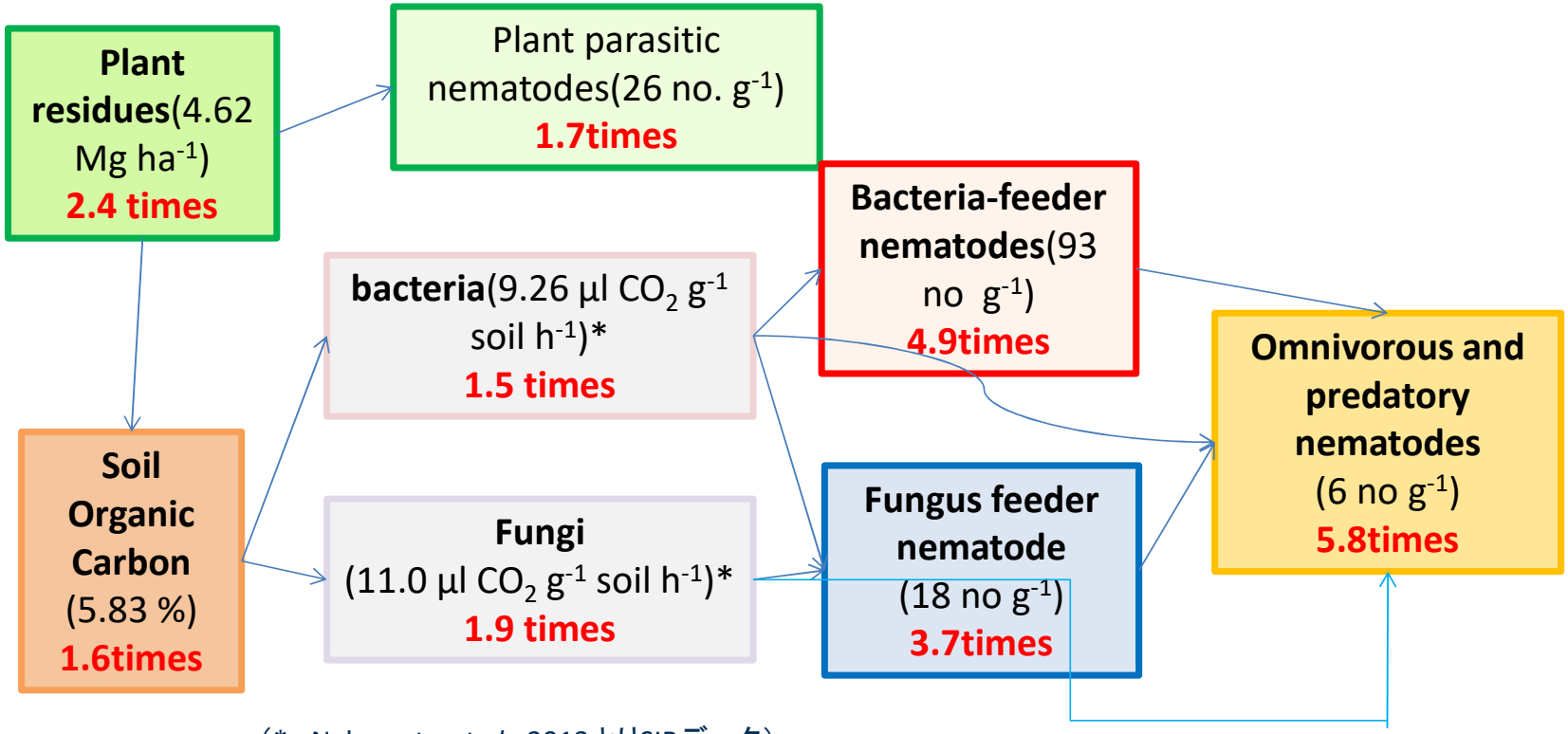
The relationship between nematode density and soil carbon concentration by food group in the autumn season from 2003 to 2011. All, A LL: total density of nematodes, BAC: bacterial diet, FFR: mycophagogy and PRD: predators, OMN: omnivores, ORF: plant food. NT, no-till; MP, moldboard plow; RC, rotary cultivator. *, **, and *** indicate significant P<0.05, P<0.01, P<0.001.



Relationship between nematode index and soil carbon concentration in autumn from 2003 to 2011. Note: It was carried out in a long-term tillage system research project in Ibaraki Prefecture. EI, fertility index;SI, structural index; NT, no-till; MP, moldboard plow; RC, rotary cultivator. *, **, and *** are P<0.05, P<0.01 and P<0.001, respectively.

Ito et al 2015. *Applied Soil Ecology*

No-till with cover crops and soil ecosystems



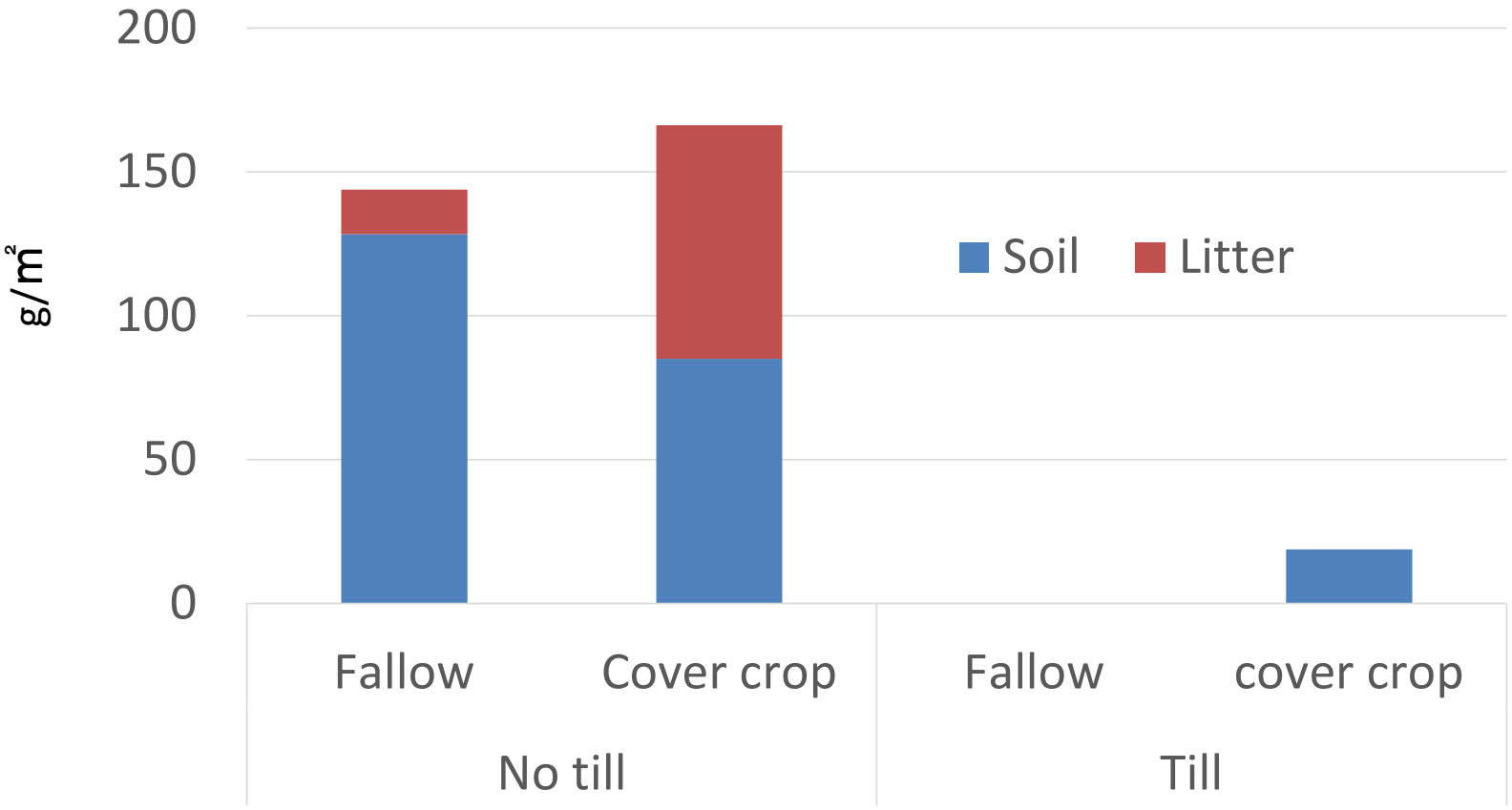
（* : Nakamoto *et al.*, 2012よりSIRデータ）

No-till cultivation provides a sustained supply of large amounts of org anic matter derived from rye and recharges the soil ecosystem

→Improved structure and size of soil ecosystems

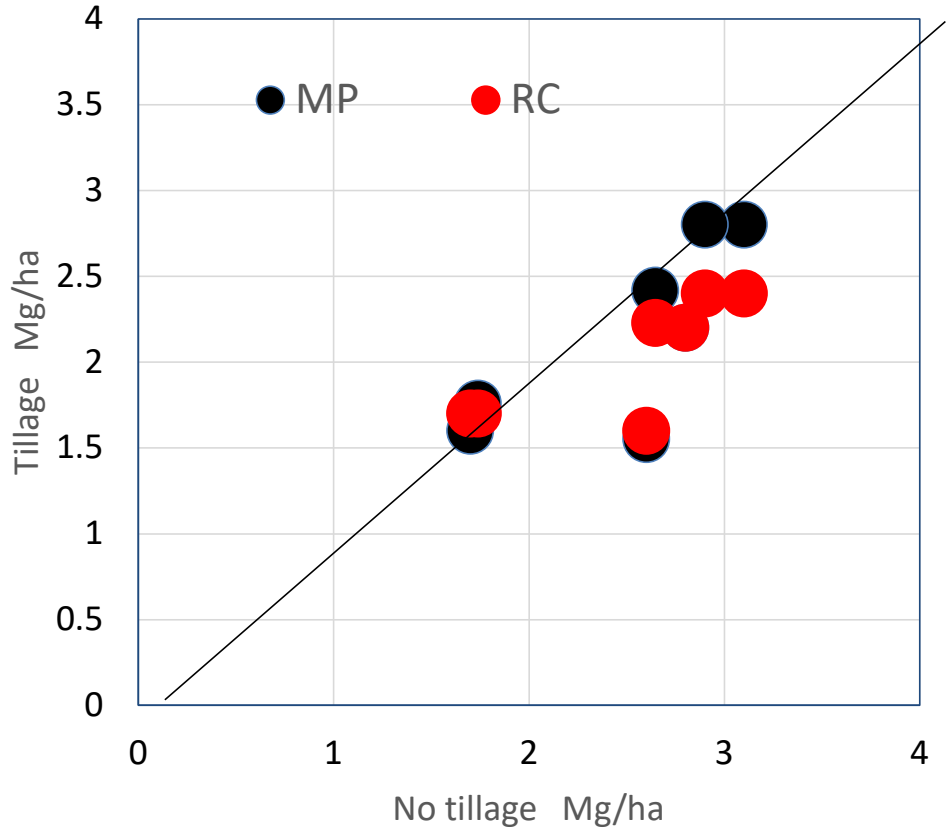
Ito （Ph.D. Tithes）

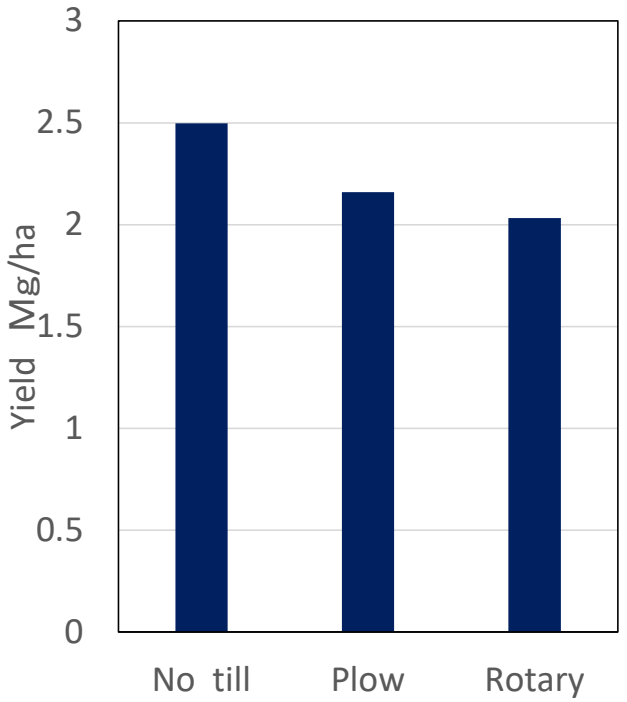
Earthworms a abundance



Un published

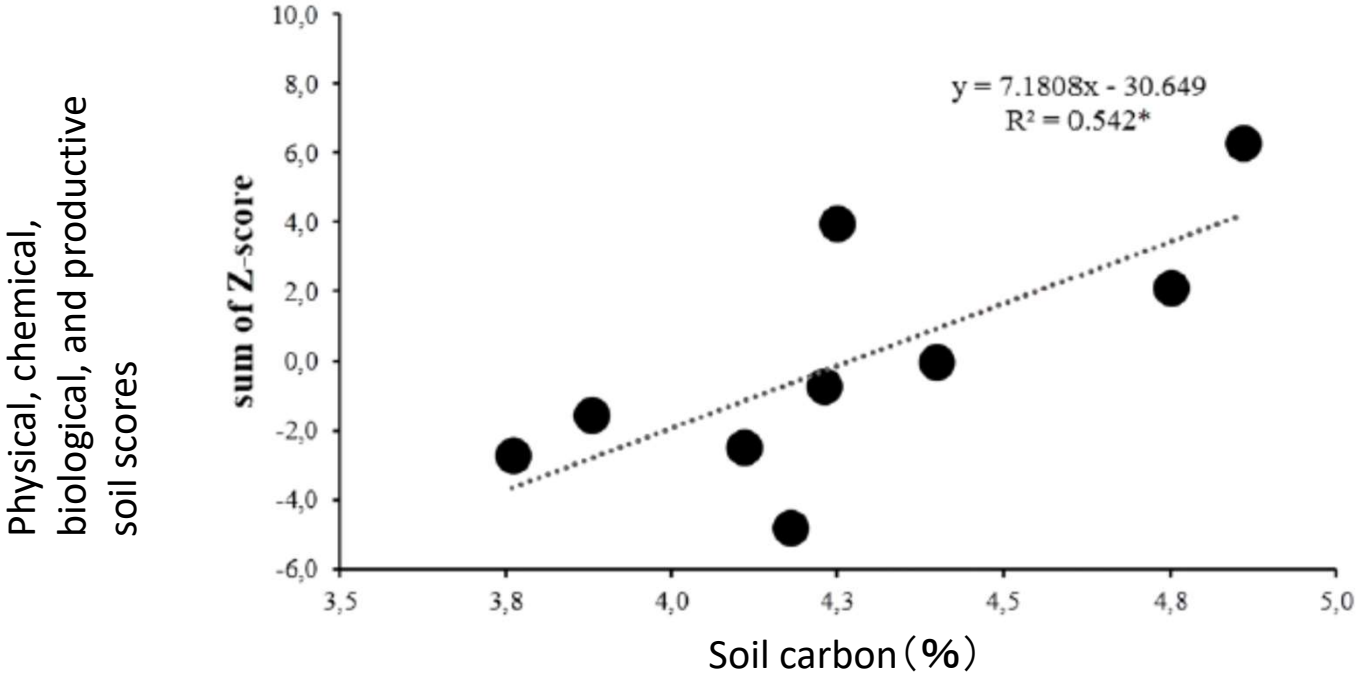
The effect of tillage method on soybean yield (2010-2015)





Higashi et al. (2014)Soil & Tillage Research

Soil Carbon and Chemical, Biological, Physical, Productivity

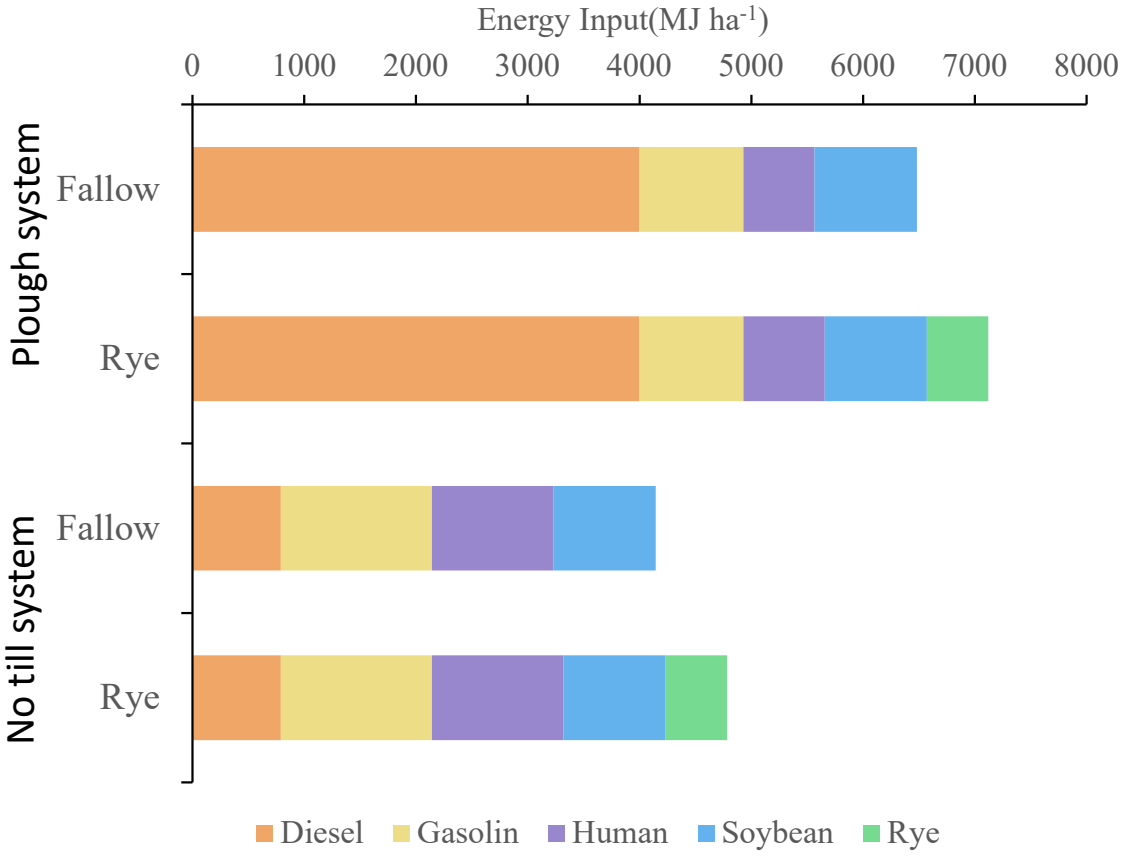


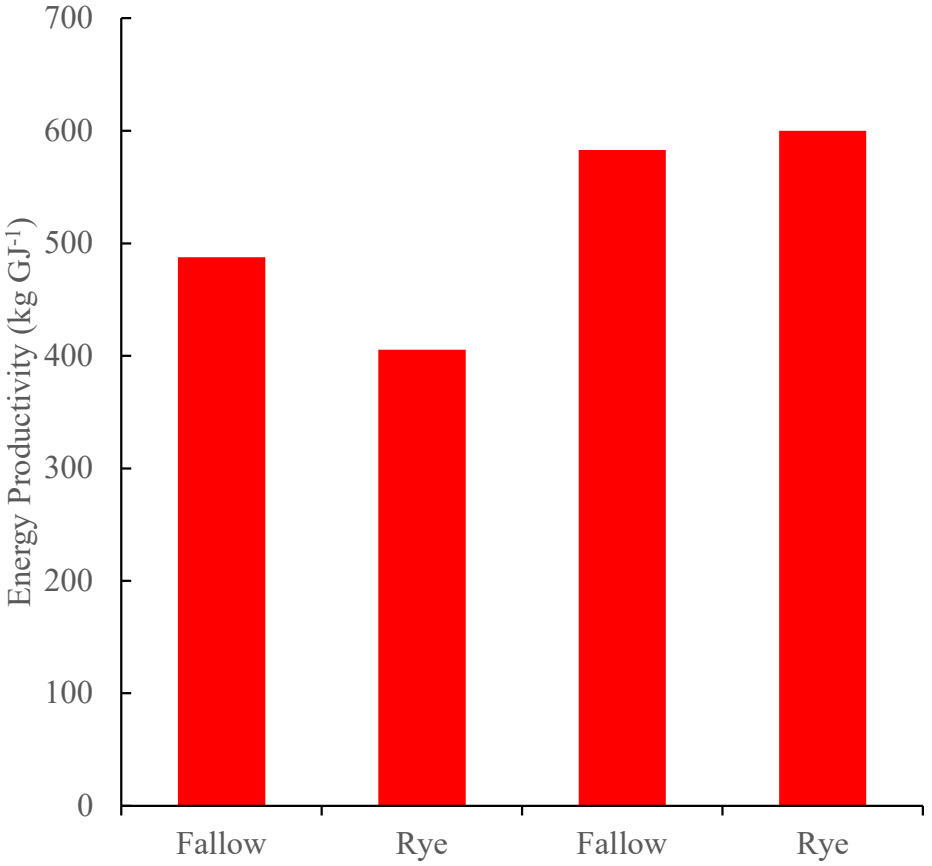
Results of the analysis of the relationship between the amount of soil carbon and the standardized score values of soil physical, chemical, biological, and yield. It was found that the accumulation of soil carbon increases soil health.

Potential for environmental regeneration through agricultural technolo

Wulanningtyas et al. 2021. Soil & Tillage Research

Input energy analysis between tillage systems

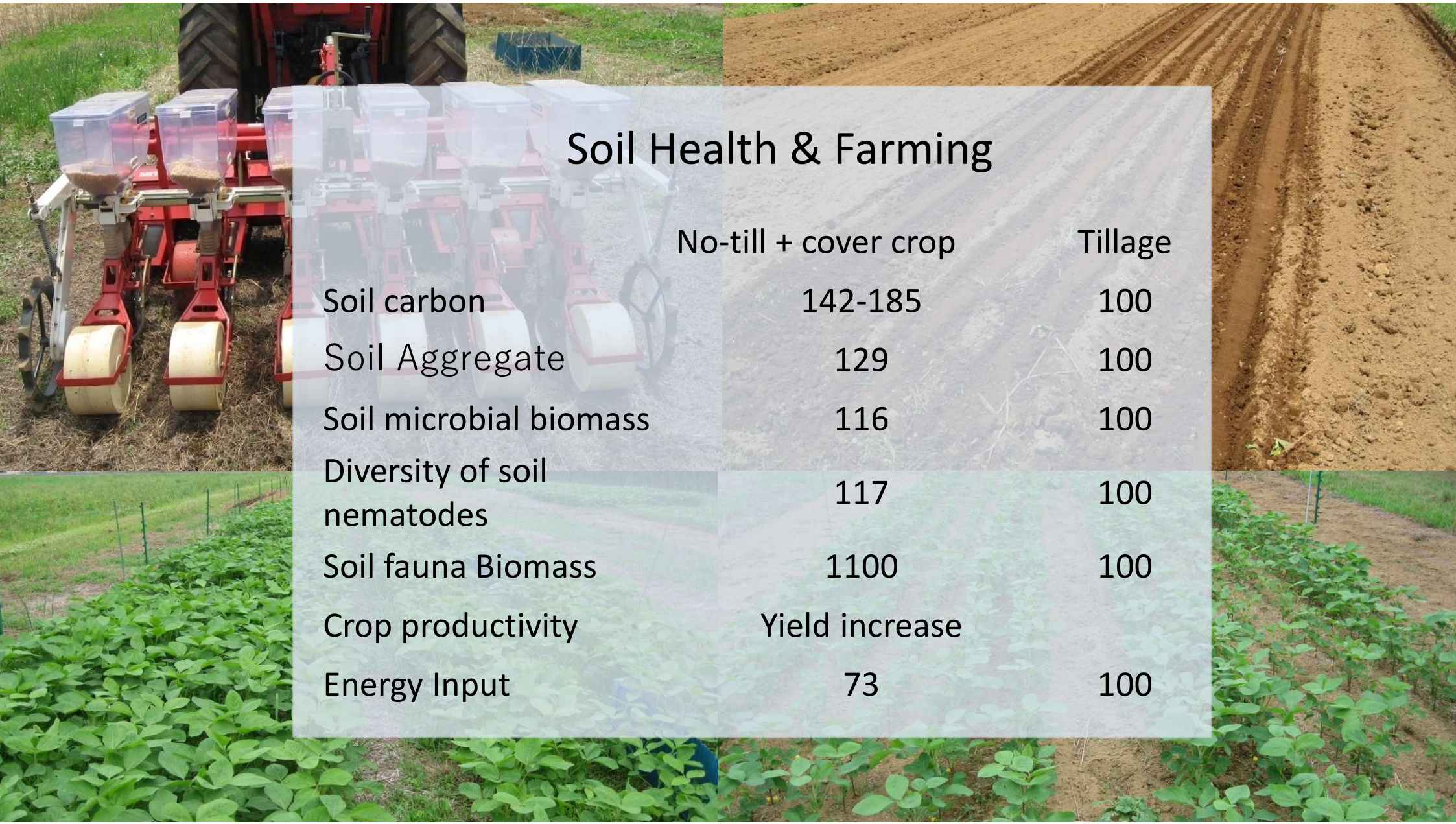




Huang al. 2023 *Journal of Cleaner Production*

Plough system

No till system



Soil Health & Farming

	No-till + cover crop	Tillage
Soil carbon	142-185	100
Soil Aggregate	129	100
Soil microbial biomass	116	100
Diversity of soil nematodes	117	100
Soil fauna Biomass	1100	100
Crop productivity	Yield increase	
Energy Input	73	100

Summary

- Soil health improves the regenerative function of the soil and provides a foundation for stable crop yields.
- In Asia, the reduction of soil disturbances, such as no-till farming, leads to carbon sequestration.
- Soil health can be improved by minimizing disturbances such as covering the field surface with cover crops and no-till cultivation.
- In order to improve soil through farming methods, it is important to take a step-by-step approach, not a zero-one discussion.