Enhancing Soil Organic Carbon with Agricultural Residues

Dr. Christine Lamanna,
December 2018

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On-Farm Sources of Organic Carbon

Source	On the soil (Mulched)	Incorporated into the soil
Crop Residue	X	X
Non-crop Residues/ Green Manure	X	X
Agroforestry Residues	X	X
Animal Wastes/Manure		X

On-Farm Sources of Organic Carbon

1. Ways to return Agricultural Residues to soil
    1. Mulching
    2. Incorporation

2. Types of Agricultural Residues
    1. Crop Residue
    2. Green Manure
    3. Agroforestry Residues
    4. Animal Wastes/Manure

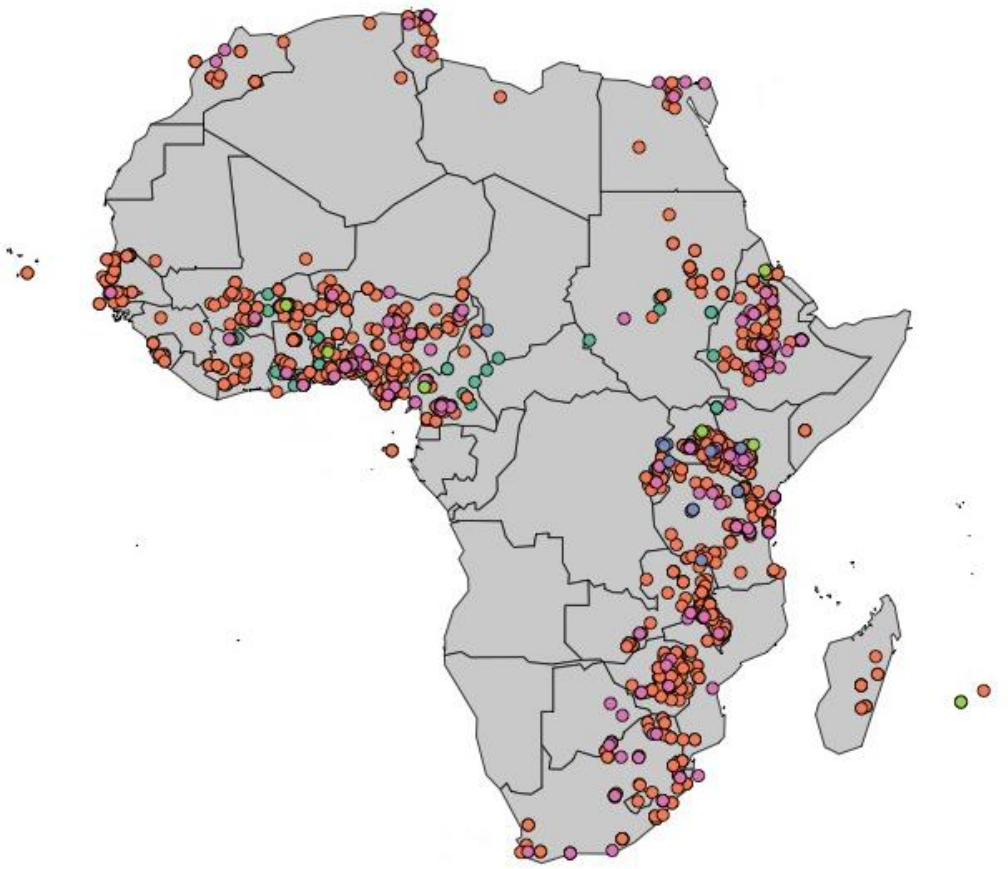
What is Mulching?

- Mulching of agricultural residues is a process of using residues to cover bare soil on the farm.

Mulch Benefits

- Returns organic material to soil, **sequestering carbon**, and enhancing soil fertility
- Increases soil moisture
- Reduces soil erosion
- Prevents growth of weeds
- Increase crop yields
- Reduce frost damage/increase soil temp

What does the data say?

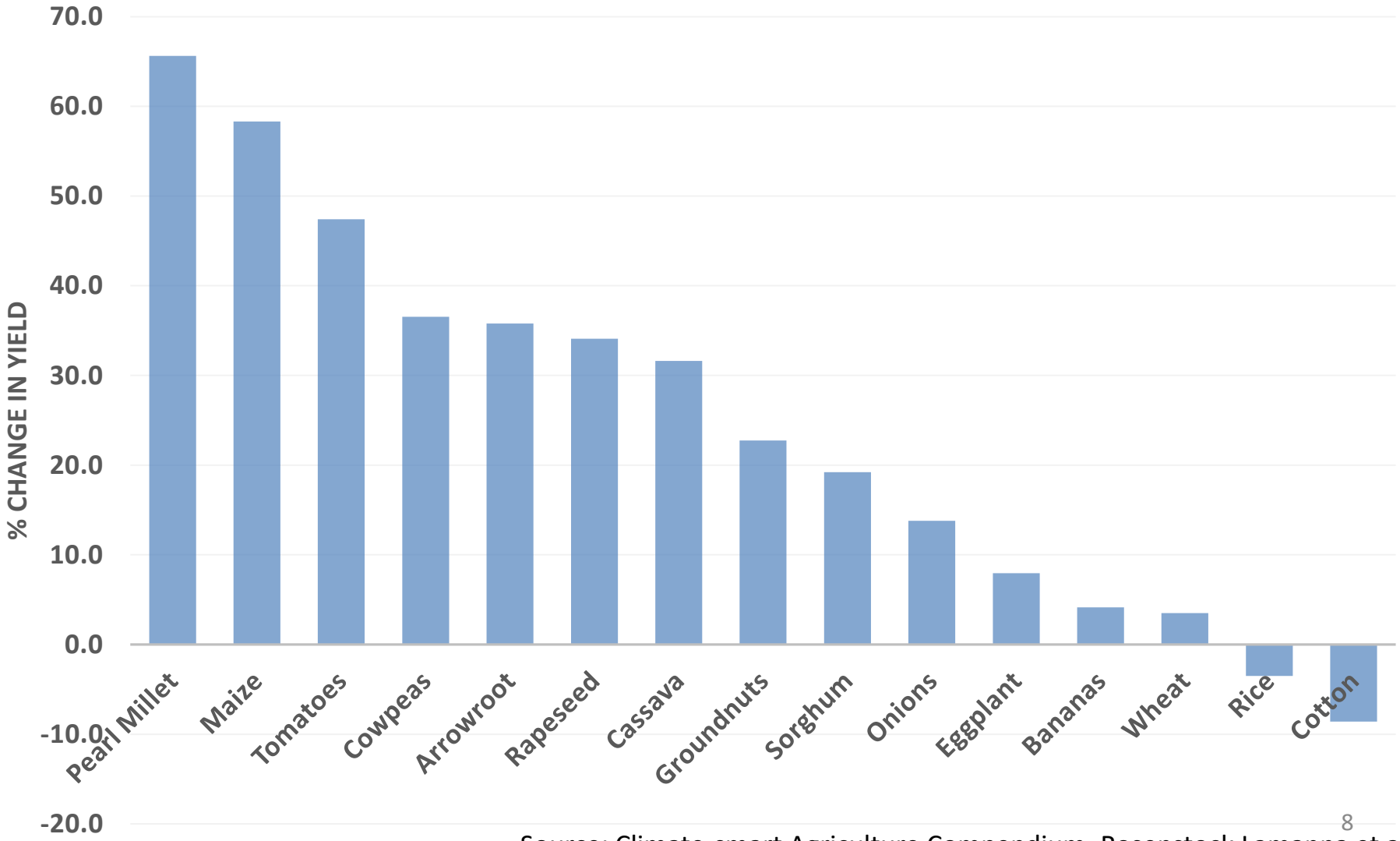


Climate-Smart Agriculture Compendium

- 1800 peer-reviewed studies
- >100 agricultural practices
- >50 indicators of outcome
  - Yield
  - Economics
  - Environmental
  - GHGs
- Launching in 2019

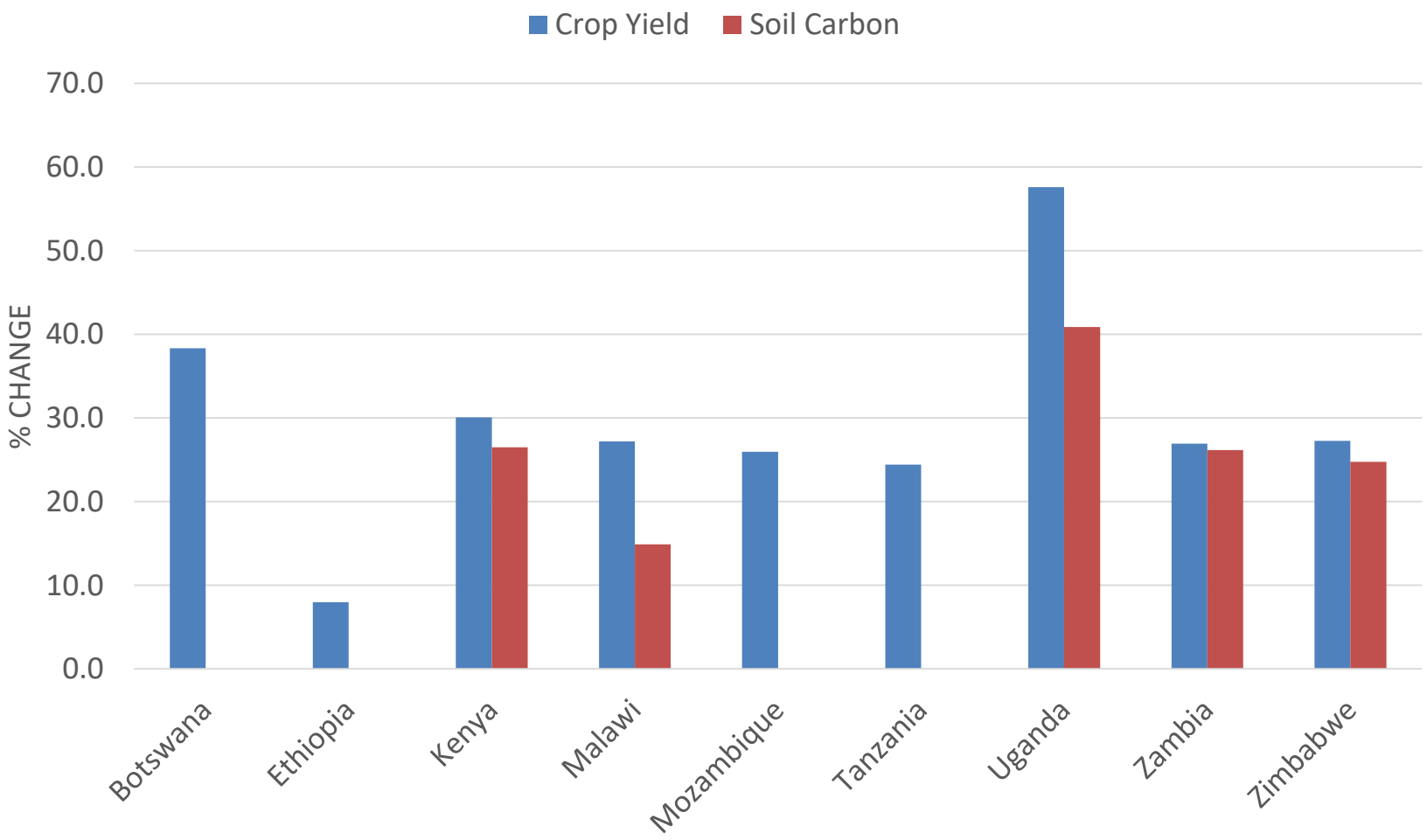
World Agroforestry Centre
CGIAR
RESEARCH PROGRAM ON Climate Change, Agriculture and Food Security
CCAFS
CIAT International Center for Tropical Agriculture Since 1967 Science to cultivate change

Mulch Benefits: Crop Yield



Source: Climate-smart Agriculture Compendium, Rosenstock,Lamanna et al.

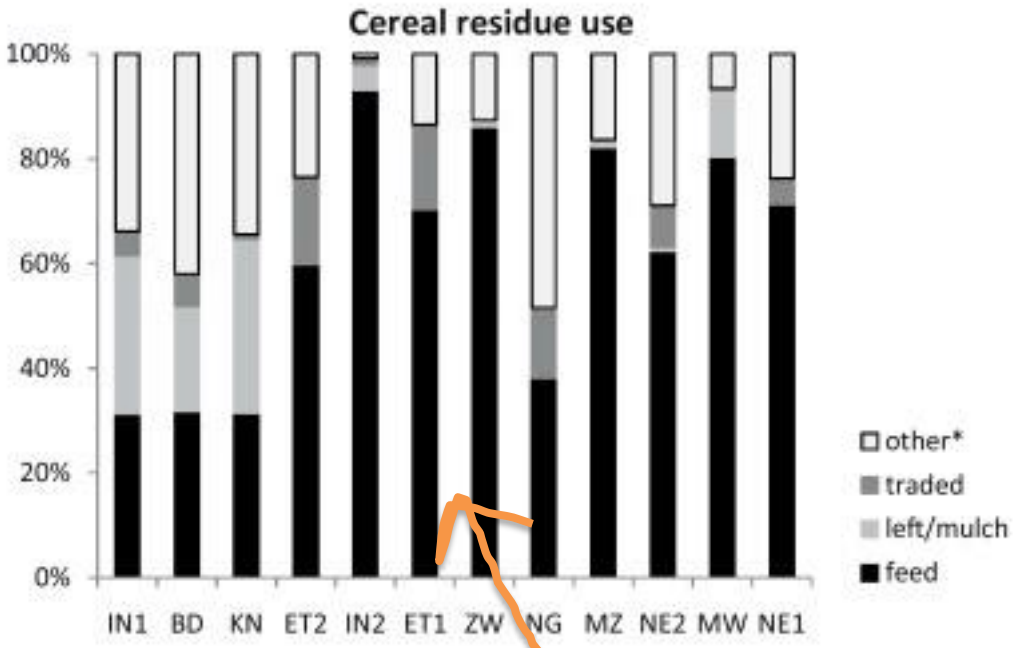
Mulch Benefits: Soil Carbon



Source: Climate-smart Agriculture Compendium, Rosenstock,Lamanna et al.

Mulch Disadvantages

- Trade-off with livestock fodder



Smallholders use 30-90% of cereal residues for animal feed

Valbuena et al. FCR 2012

Mulch Disadvantages

- Trade-off with livestock fodder
- Extra labor or cost
- Bury seedlings
- In humid areas, may increase likelihood of fungal disease or water logging
- Can produce weeds if seeds are not removed

Where Is Mulching Practiced?

- Tropics, subtropics, dry lands! Everywhere!



- Mulching is a simple, low-cost, low-tech solution for improving agricultural productivity, resilience, and sequestering carbon
- High adoption rates among smallholder farmers

Where to get Mulch?

High Cost

- Purchased from company
- Produced with machinery

Low Cost

- Sourced on-farm:
  - Crop residues
  - Green manures
  - Tree wastes
  - Grass
  - Compost

Residue Incorporation

- Residues may also be **incorporated** into the soil, before or after **composting**

Incorporation Benefits

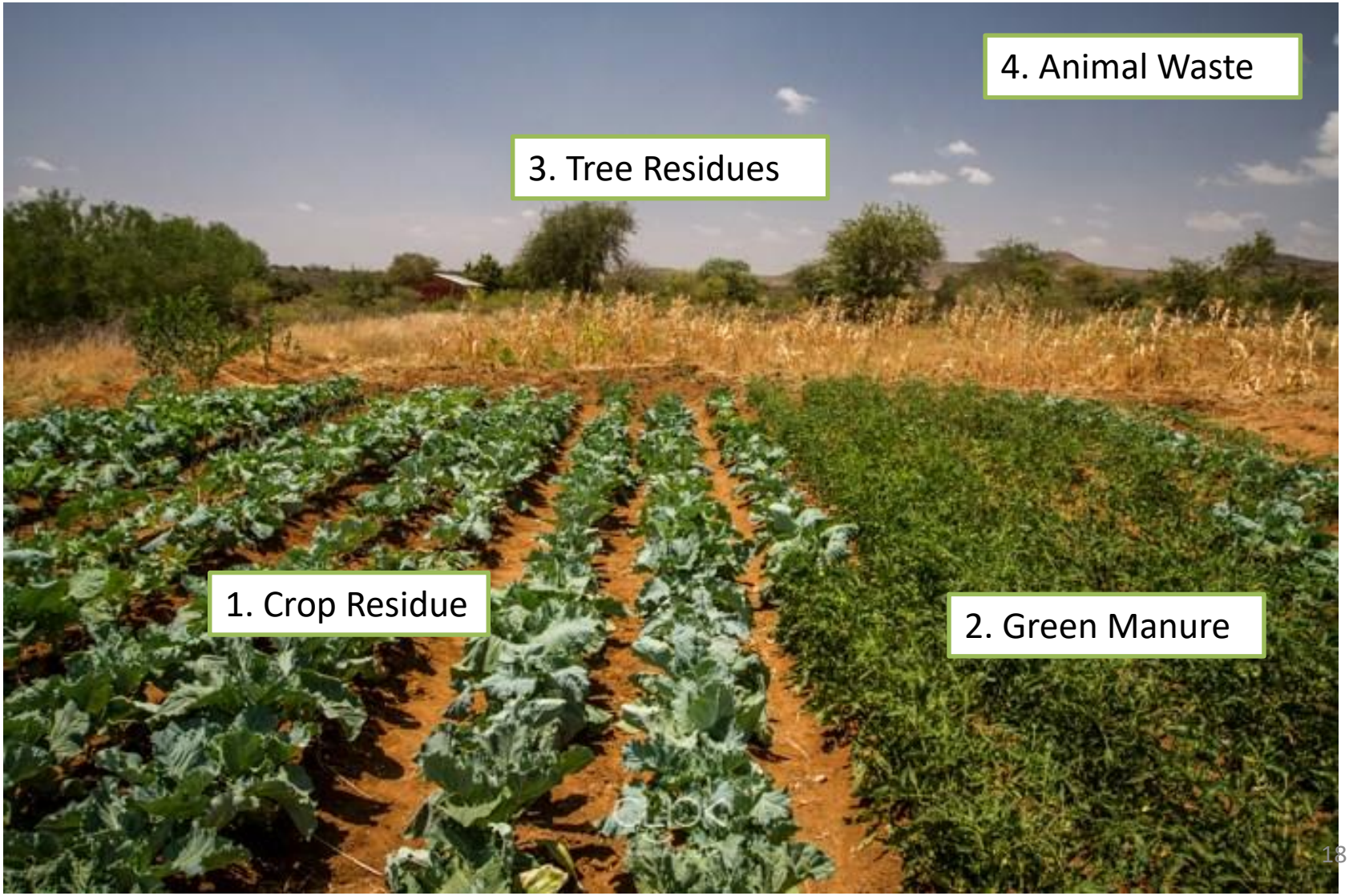
- Returns organic material to soil, **sequestering carbon**, and enhancing soil fertility
- Increases soil moisture
- Quicker release of nutrients than with mulch
- Increased yields

Incorporation Disadvantages

- Trade-off with livestock fodder
- Higher labor requirements than mulching
- Tilling soil can reduce soil carbon and increase erosion

Agricultural Residues

Agricultural Residues



1. Crop Residues

- All crops produce residue: the non-edible or non-marketable portion of the growth.

Nutrients in Crop Residue

Are all residues the same?

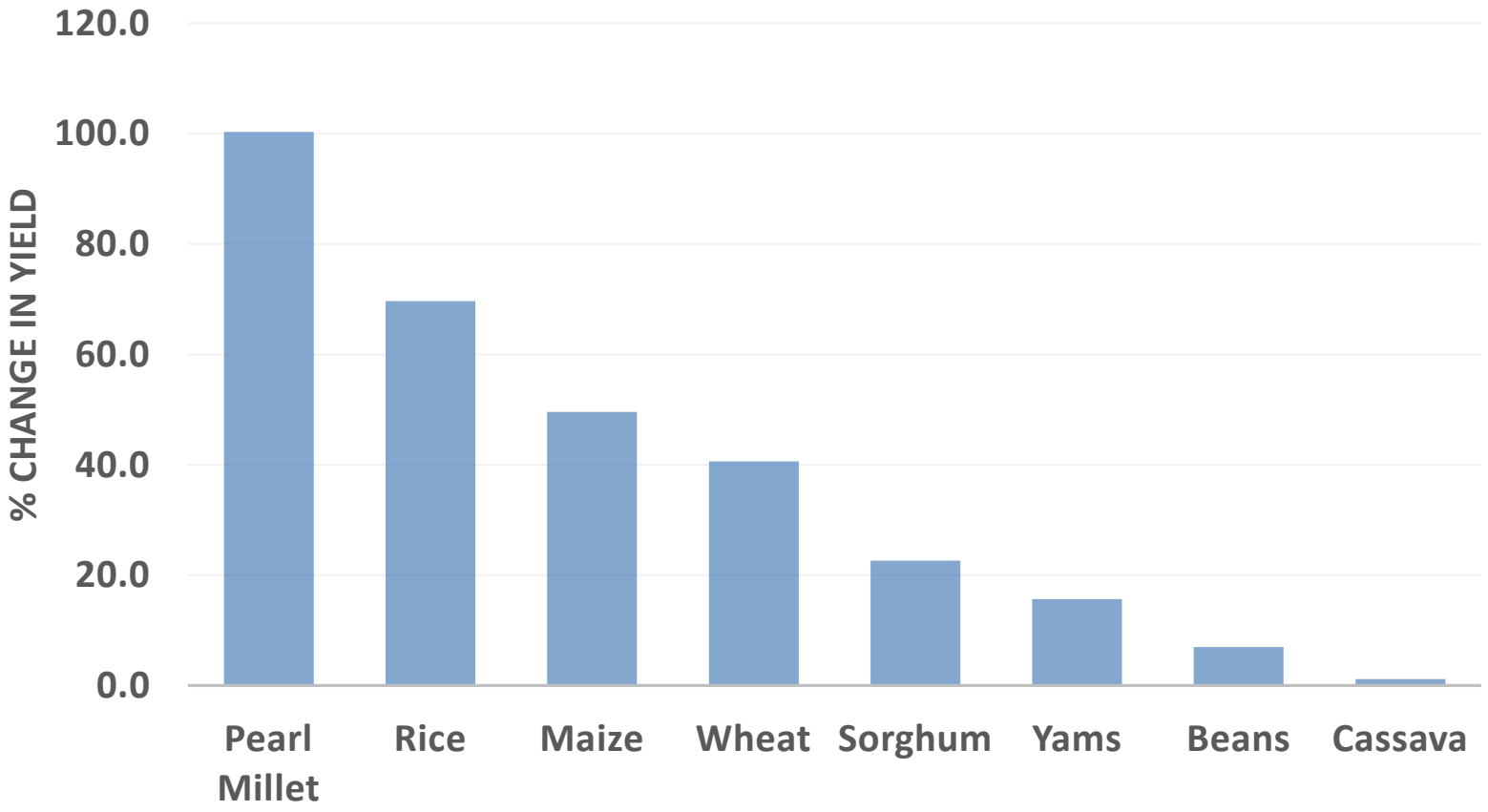
Nutrients in Crop Residue

Are all residues the same?

(kg/ha/yr)				
Crop/species	***N***	***P***	***K***	***C/N ratio***
Cowpea stem	1.07	1.14	2.54	-
Cowpea leaves	1.99	0.19	2.20	-
Rice	0.58	0.10	1.38	105.0
Maize	0.59	0.31	1.31	55.0

Leguminous crop residues contain more Nitrogen (and often Phosphorus and Potassium too) than cereals.

Crop Residue & Crop Yield



Source: Climate-smart Agriculture Compendium, Rosenstock,Lamanna et al.

2. Green Manure

- A **Green Manure** is a crop grown specifically to improve soil fertility
- They are generally herbaceous, non-edible legumes, but many species can be grown as green manure
- Similar to **cover crops**

Green Manure Crops

Crotalaria juncea

Sesbania rostrata

Cow pea

Cluster bean

Sesbania aculeata

How to Grow Green Manure

Green manures can be **rotated with other crops** and grown during fallow seasons or short seasons. Before green manure goes to seed, it is either cut and left (no till), or incorporated into the soil.

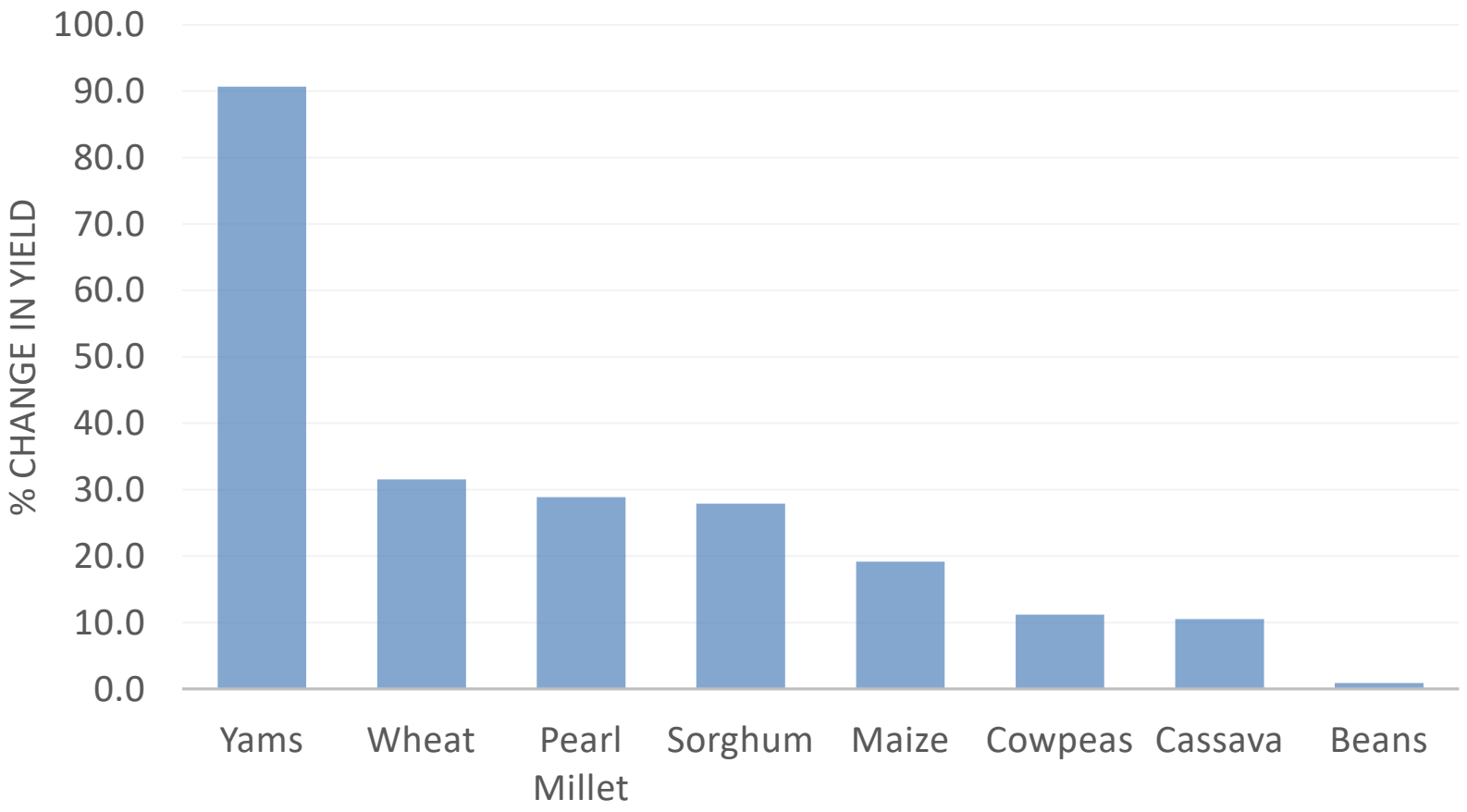
How to Grow Green Manure

Green manures can be **intercropped with other crops** during main cropping seasons. Benefits to both intercrop and next season's crops. Can be combined with crop residue retention.

Green Manure Benefits

- Prevents growth of weeds & loss of soil fertility during fallows
- Reduces/Prevents erosion
- Increases soil fertility and soil carbon
- Increases soil moisture
- Can increase farm biodiversity, including pollinators

Green Manure Benefits



Source: Climate-smart Agriculture Compendium, Rosenstock,Lamanna et al.

Green Manure Disadvantages

- Green manures may compete with crops for nutrients or water.
- Must chose appropriate green manure for soil type and nutrient needs.
- Trade-off with area for marketable crops
- Trade-off with livestock fodders

https://eap.mcgill.ca/publications/EAP51.htm

3. Agroforestry Residues

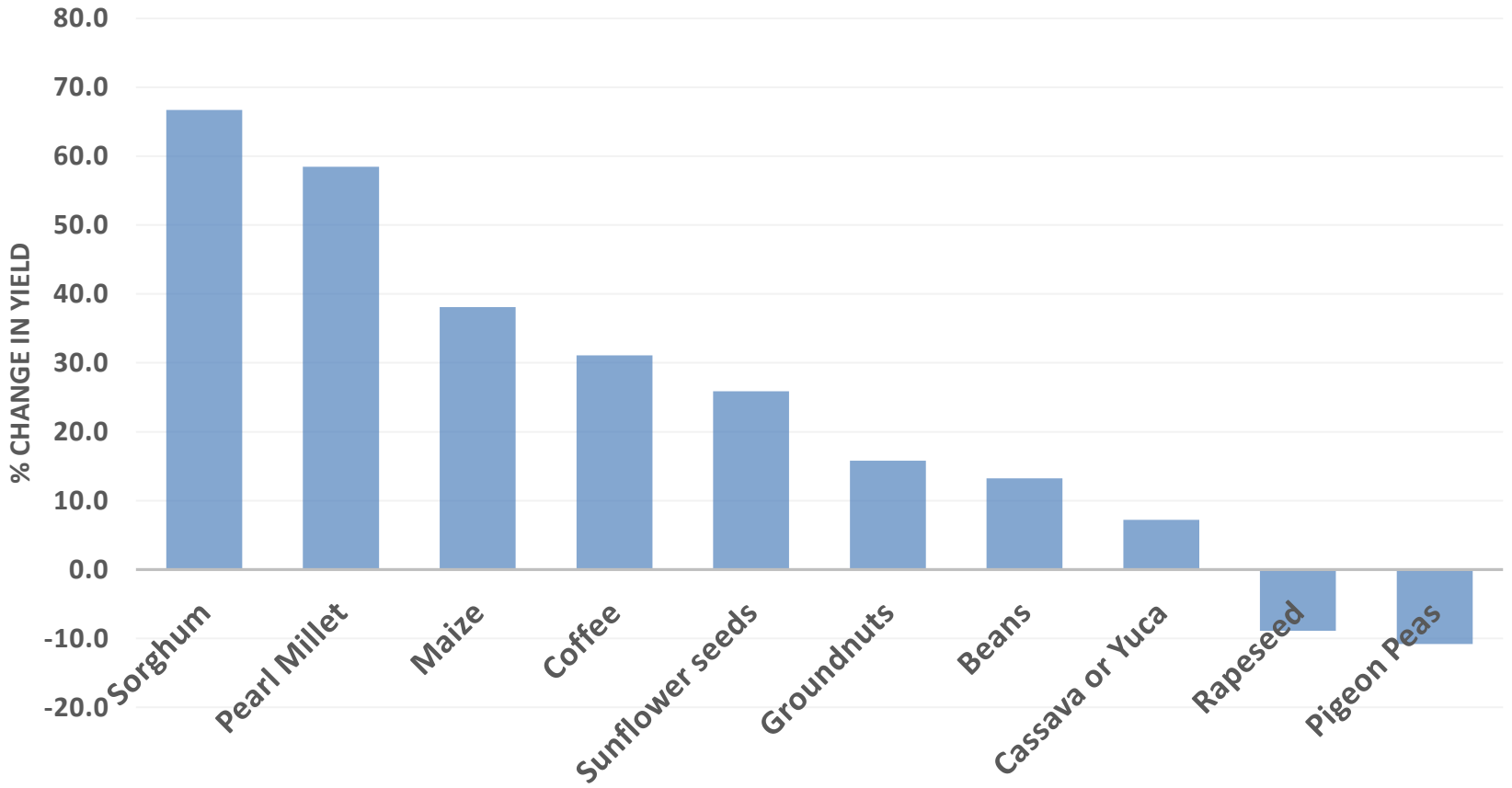
- **Tree residues**, such as leaves, can also be a rich source of carbon and nitrogen
- In **agroforestry systems,** trees are intercropped with crops. These trees are often **nitrogen fixing**.

Agroforestry Residues

- Agroforestry trees often need to be **pruned** to avoid shading or competition with crops.

- **Prunings** can be returned to the soil to enhance soil fertility.

Agroforestry Residues



Application of agroforestry residues to crops tends to increase yields.

Source: Climate-smart Agriculture Compendium, Rosenstock,Lamanna et al.

4. Animal Waste & Manure

- **Manure** is a rich source of organic carbon, nitrogen, potassium and other nutrients, and is readily available for many farmers

Manure Methods

Manure can be applied to the soil, or incorporated into the soil, after it has been **composted.**

Manure can also be used to create **liquid fertilizer** by mixing with urine, water, or plant materials.

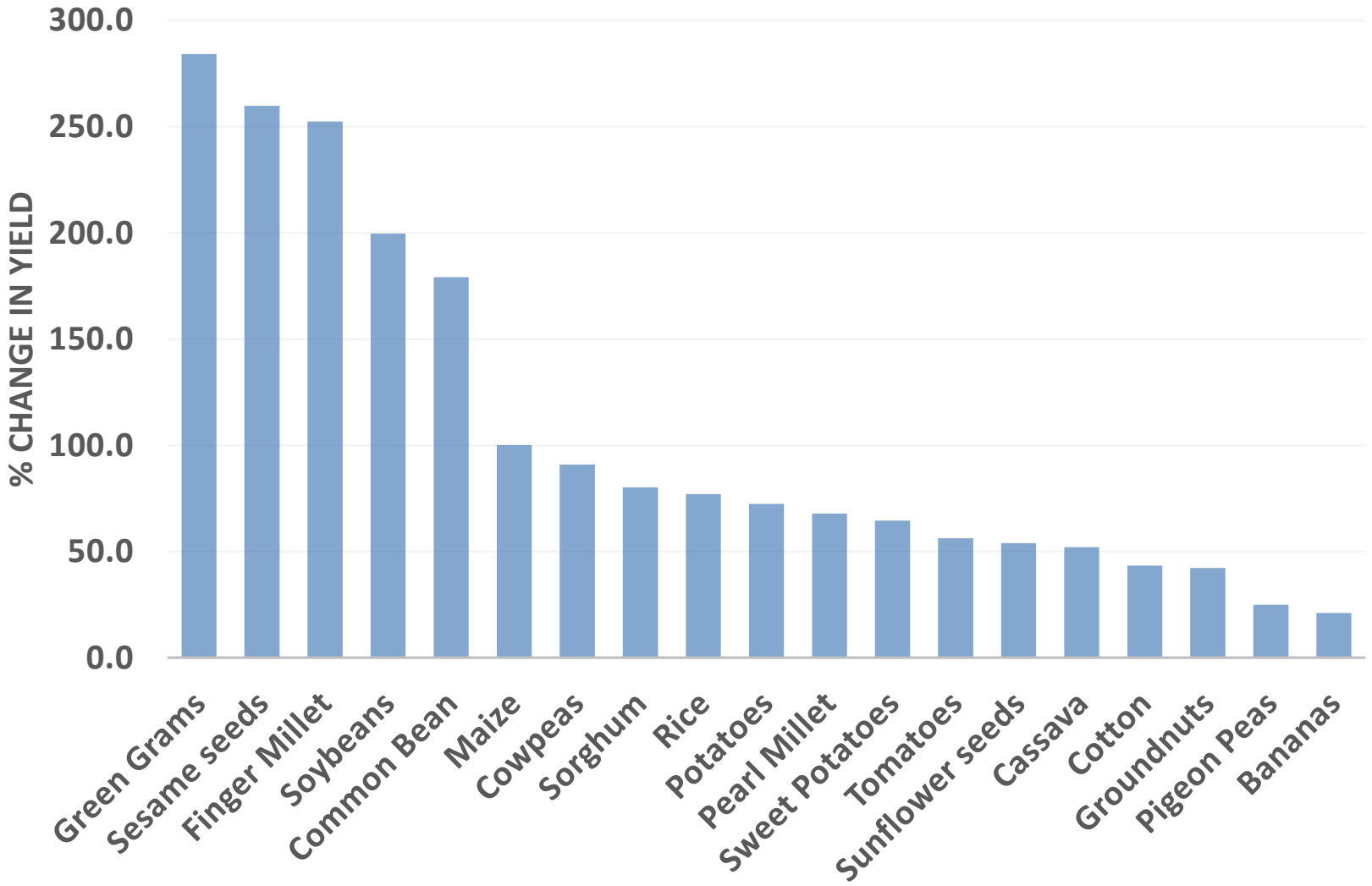
Manure Methods

In **kraaling**, animals are kept on fallow fields to directly deposit manure. The kraal is then prepared for planting and the animals moved to a new fallow field.

Manure Benefits

- Returns organic material to soil, **sequestering carbon**, and enhancing soil fertility
- Increases soil moisture
- Reduces soil erosion
- Increase crop yields
- Reduces GHG emissions from manure

Manure Benefits



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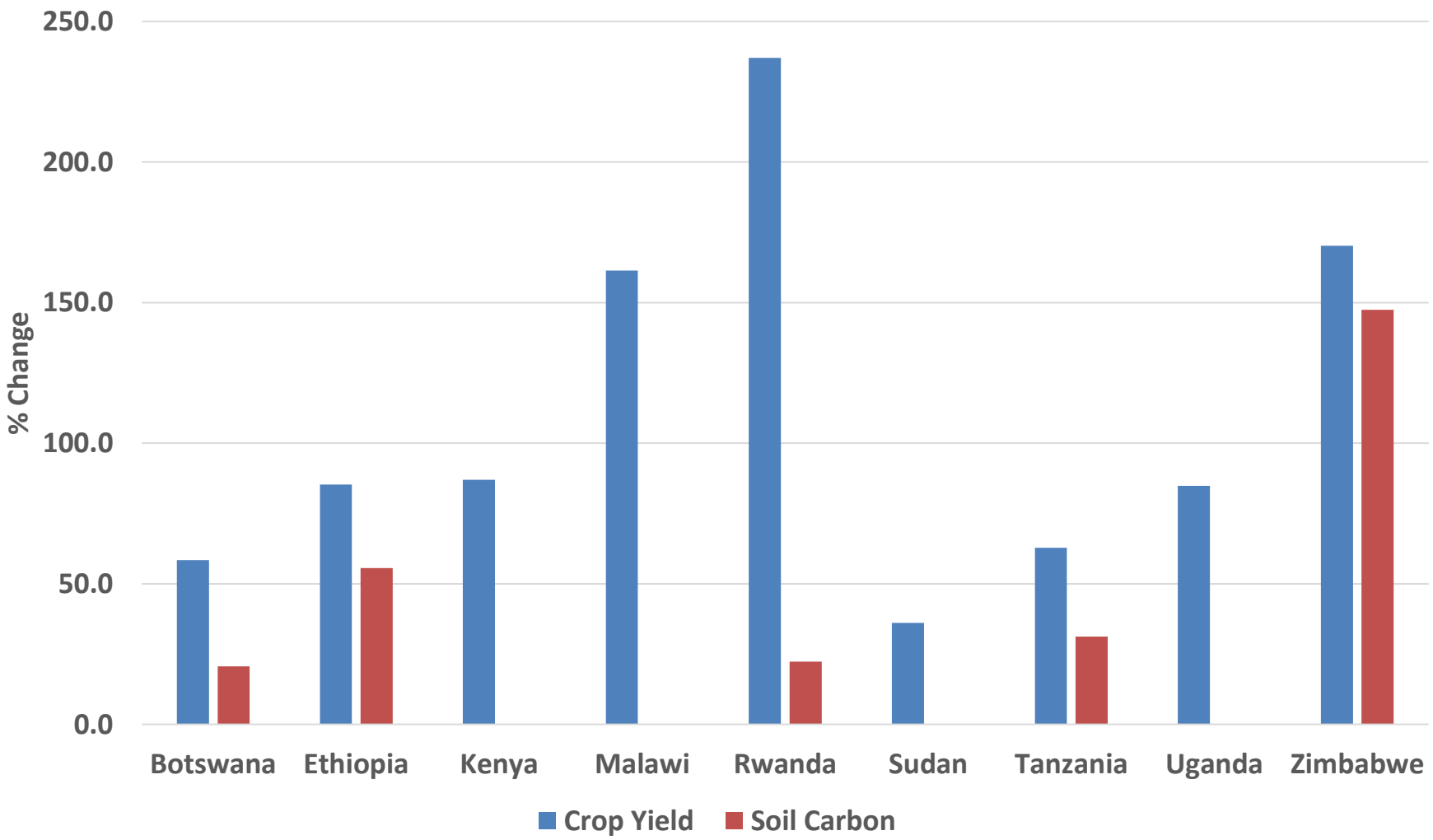
Manure Benefits



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Manure Considerations

- If not managed properly, can pollute soil and water
- May increase exposure to zooinotic diseases
- Management can be labor intensive

On-Farm Sources of Organic Carbon

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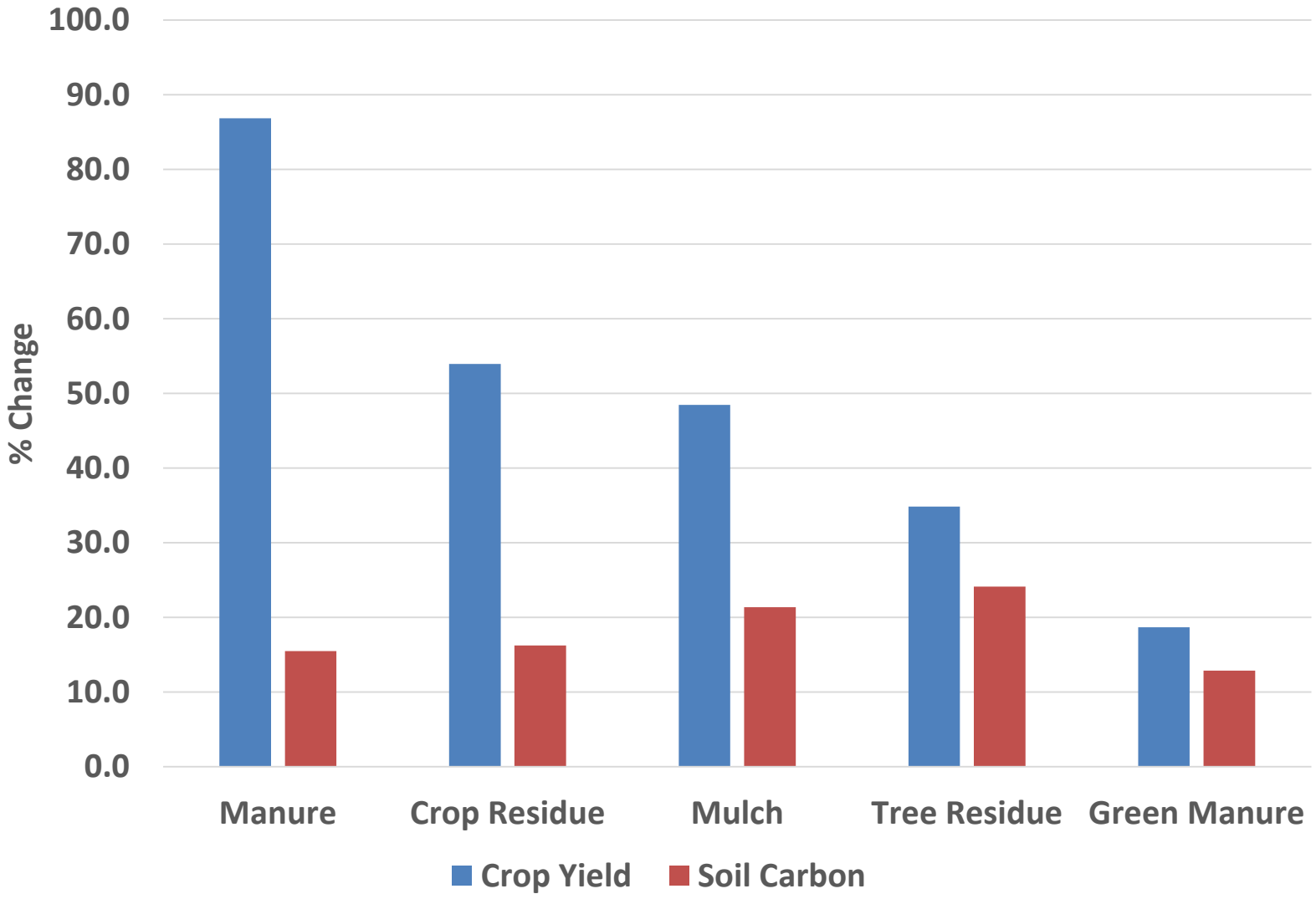
On-Farm Sources of Organic Carbon



Enhancing Soil Organic Carbon with Cross-Slope Barriers

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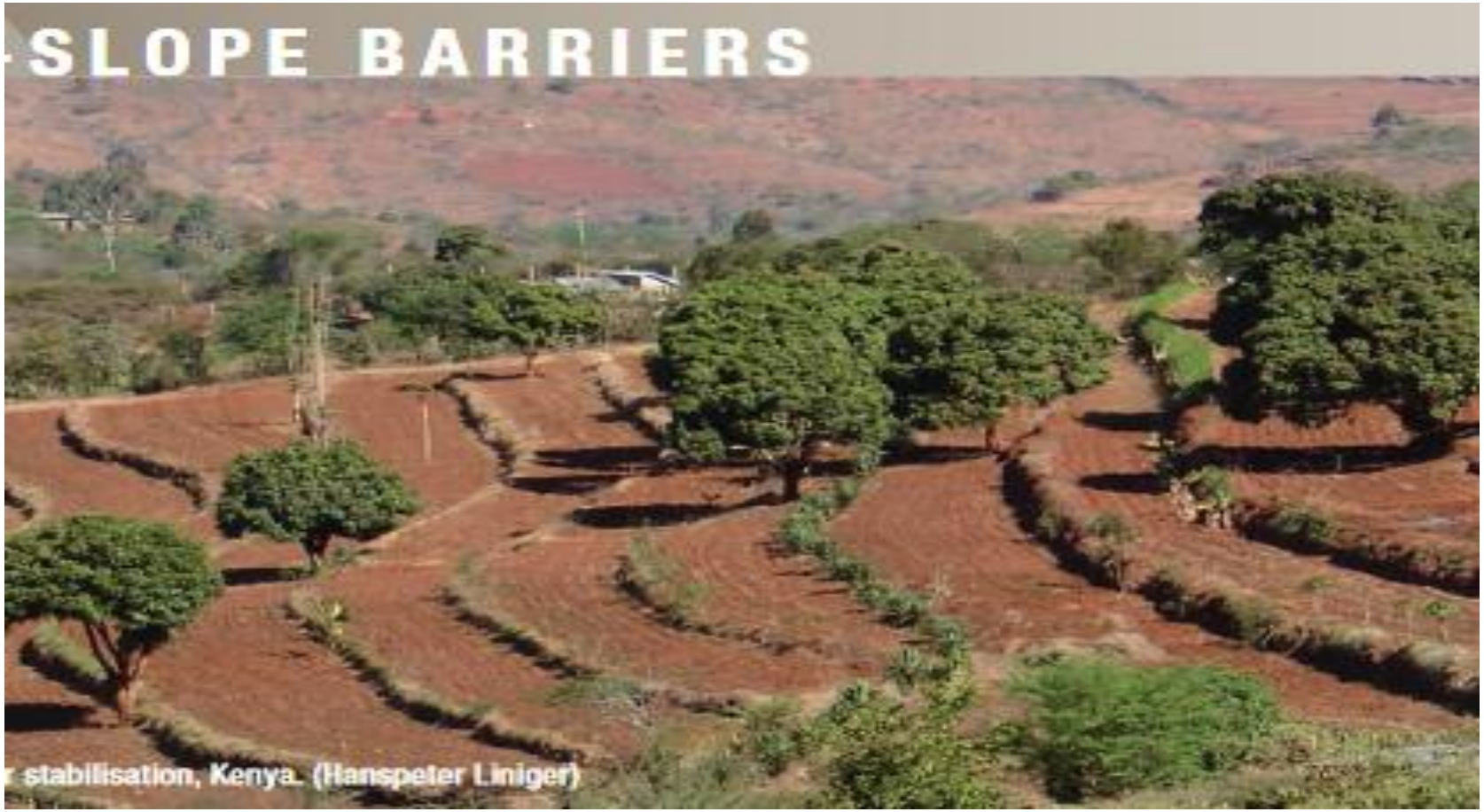


What Are Cross-Slope Barriers?

Cross-slope barriers are measures on sloping lands that **reducing runoff velocity** and soil loss, thereby contributing to soil, water and nutrient conservation. This is achieved by reducing steepness and / or length of slope.

FAO 2011

Cross-Slope Barriers

Type	Where Common	Slopes
Terracing	Steep areas	Moderate to Very Steep
Stone Lines	West Africa, stony areas	Gentle to Steep Slope
Earth Bunds/Ridges	Semi-arid areas	Gentle to Moderate Slope
Fanya Juu/Fanya Chini	East Africa	Moderate to Steep Slope
Vegetative Strips	Humid areas	Gentle to Steep Slope

Terracing Systems in Steep Areas throughout Africa

Konso Terraces in Ethiopia.

Rima Mekdaschi Studer, FAO 2011

Stone Lines on Low Slopes Mainly West Africa (Burkina Faso, Mali, Niger)

Stone lines catching run-off water and fertile soil sediments, Niger

Hanspeter Liniger, FAO 2011

Vegetative Strips throughout Africa Especially in the More Humid Zones

Vegetative strips along contour line for reducing surface runoff and erosion, Kenya

Christoph Studer, FAO 2011

Fanya juu mainly in East Africa (Tanzania, Kenya, Uganda, Ethiopia)

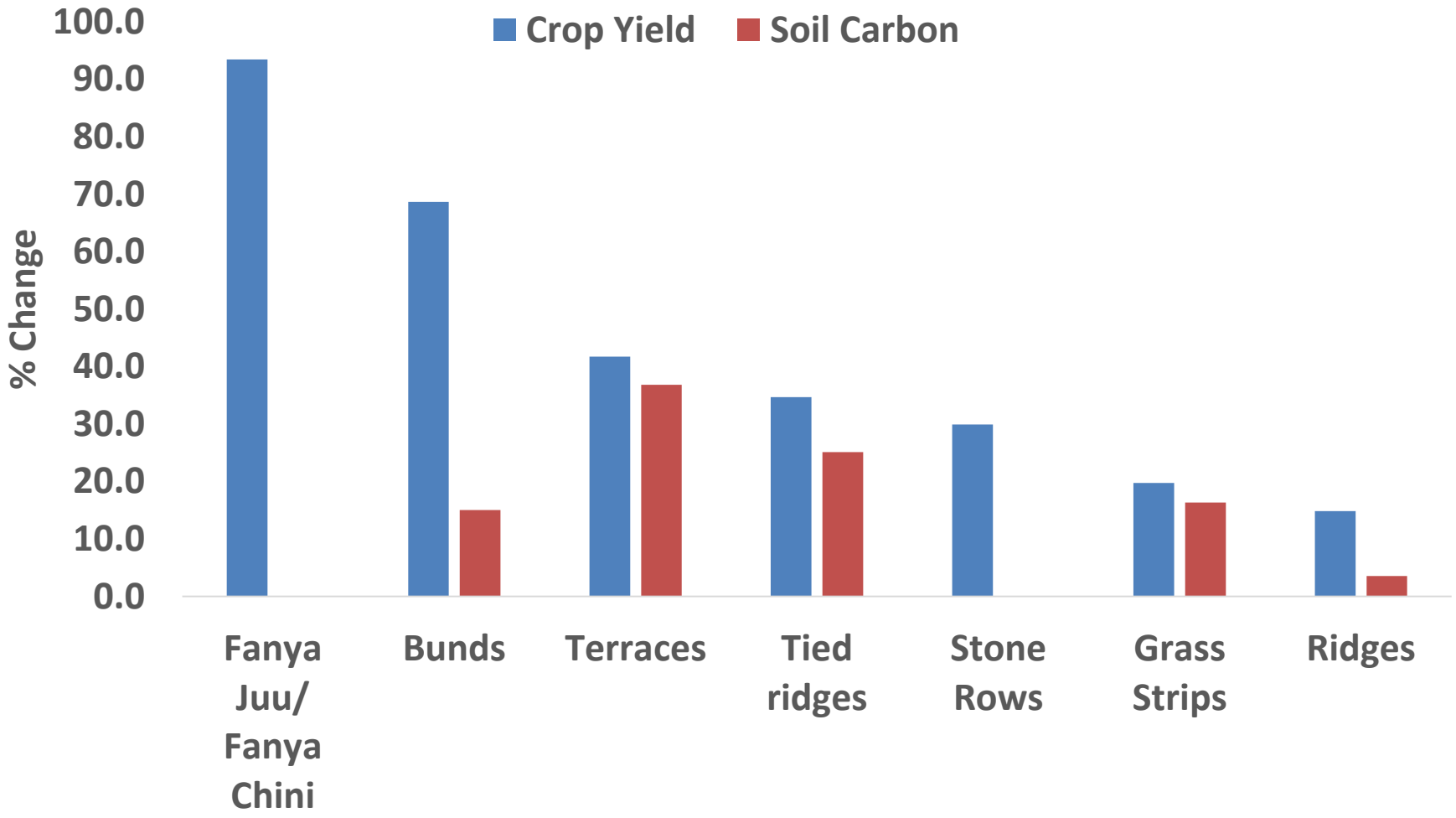
Fanya juu terrace with napier grass, Kenya

Hanspeter Liniger, FAO 2011

Cross-Slope Barriers Benefits

- Reduces soil erosion & runoff
- Increases soil moisture
- Improved watershed health
- Makes more land available for farming
- Increased crop yields
- Increased farm diversity
- Increased soil carbon
- Resilience to extreme rainfall events

Cross-Slope Barriers Benefits



Source: Climate-smart Agriculture Compendium, Rosenstock,Lamanna et al.

Cross-Slope Barriers Challenges

- High initial labor and materials costs
- Must be maintained annually
- Benefits largest when combined with other technologies, like mulching

Thank You!

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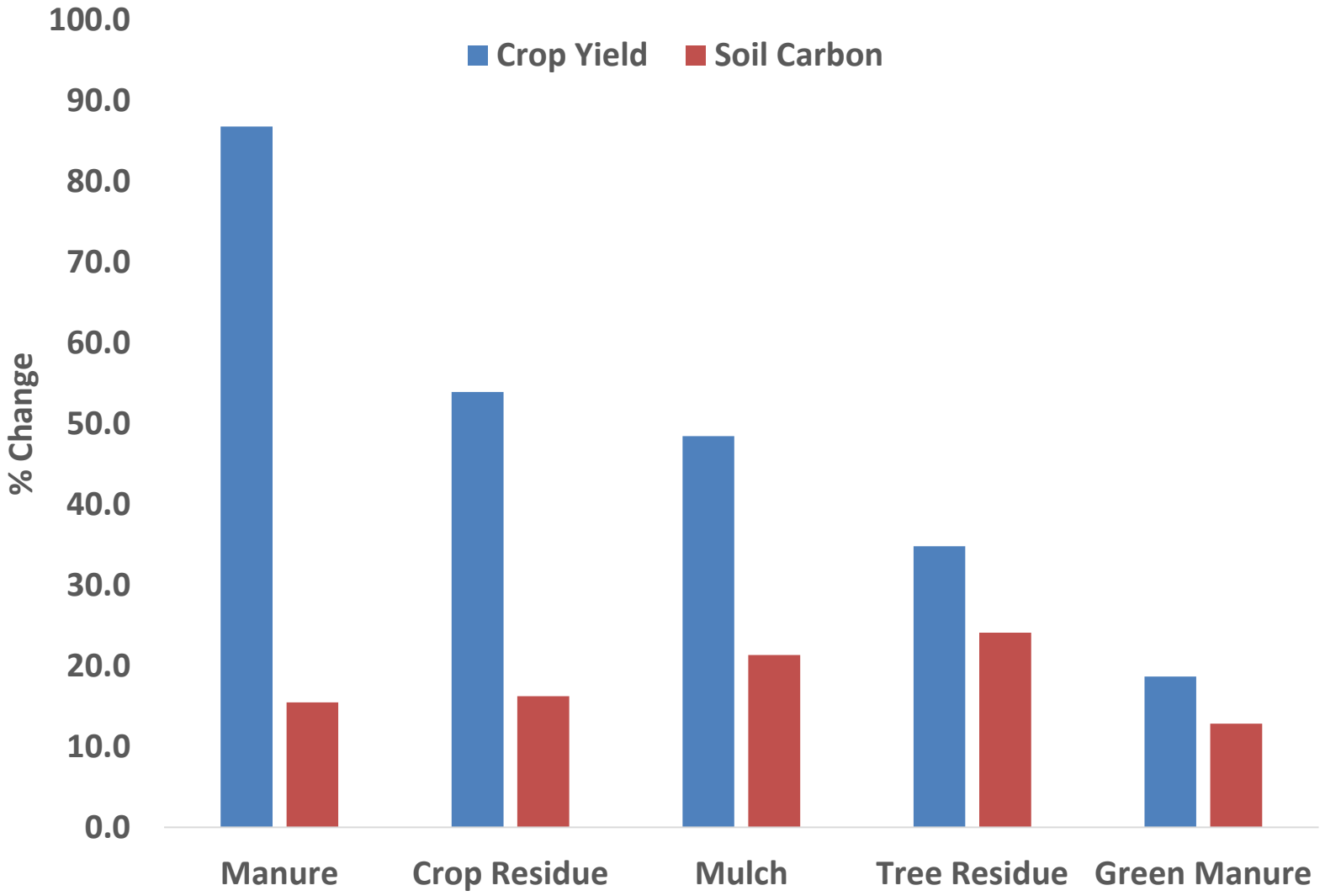
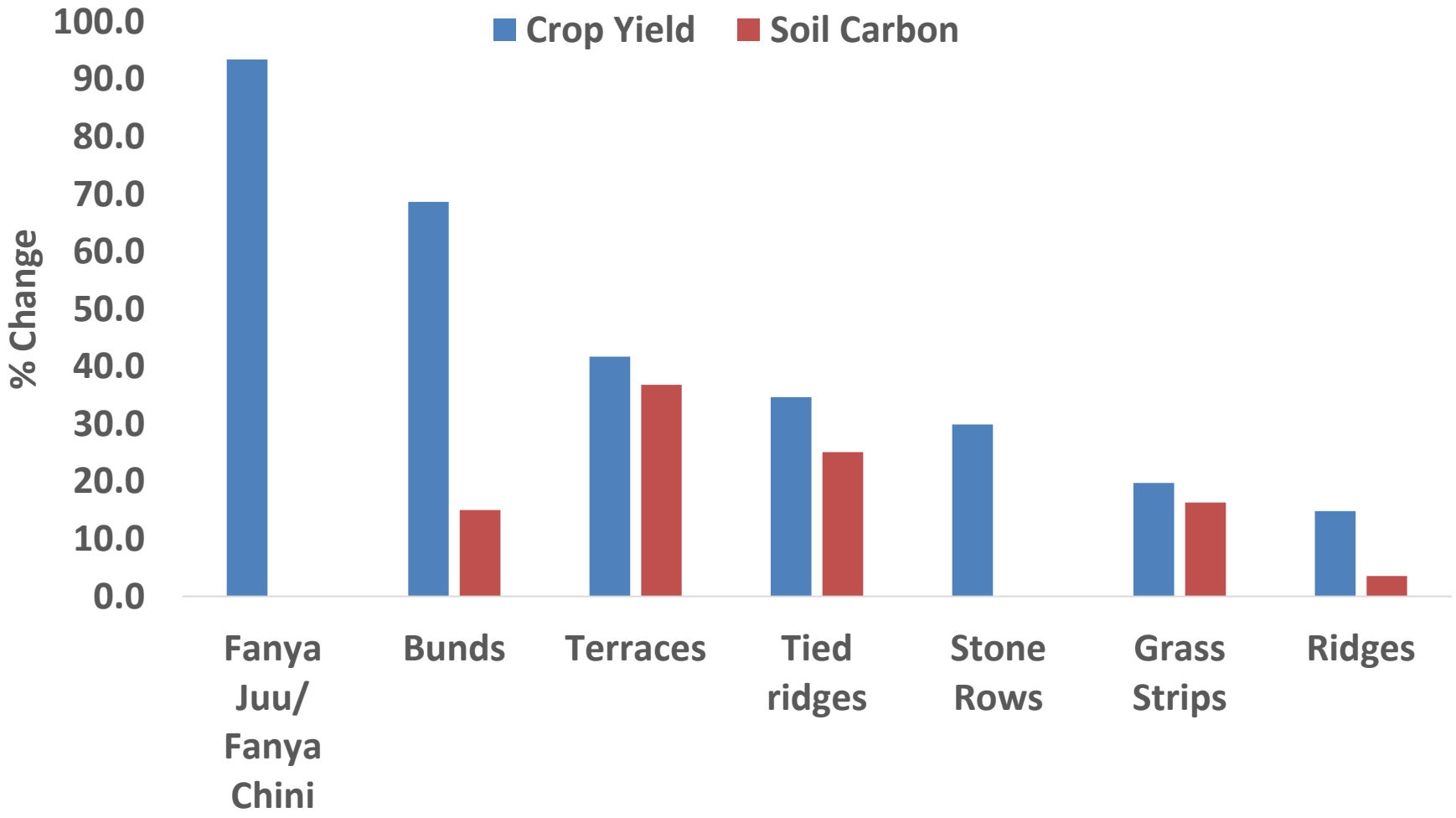
On-Farm Sources of Organic Carbon



Cross-Slope Barriers Benefits



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