Conservation Agriculture

and the

Clean Development Mechanism

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CONTROLLED TRAFFIC FARMING CTF solutions

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The “Clean Development Mechanism” was specified in the Kyoto agreement to support research on production systems with a smaller global warming potential, for developing economies.

So this presentation addresses the question:

Can conservation agriculture reduce the greenhouse gas produced by cropping by:

1. ***Minimising Gas Emissions?***
2. ***Storing more Soil Carbon?***

This Presentation:

- **Discusses greenhouse gases and the difference between conservation agriculture systems.**

- **Outlines some important factors affecting greenhouse gas production from cropping, and provides an estimate of possible improvements.**

- **Considers the impact on soil carbon**

Danger!

Outcomes of this complex assessment depend on the assumptions used.

The assumptions used here are reasonable for dryland grain production in China & Australia.

Much more detail, including the assumptions and basis for calculations, is given in the full report published in the conference handbook.

Agricultural Greenhouse Gases (GHG's):

Carbon dioxide CO_2 -- from fossil fuels and soils

CO_2 is the major GHG, so other GHG effects are usually quantified as "CO_2 E" -- the quantity of CO_2 with the Equivalent Global Warming Potential.

Examples:

Nitrous oxide **N_2O -- largely from soils**

1 kg= 300 kg CO_2E

Methane **CH_4 – largely from animals and irrigated agriculture**

1 kg= 25 kgCO_2E

(not considered here)

GHG Impact – Energy

CO_2 from burning diesel fuel in tractors, and from the manufacture of machines, herbicides and fertilises

Tractor Fuel: Estimated from fuel use records. Fuel for equipment manufacture is included by adding 15%.

Herbicide manufacture : 2-10L/kg fuel energy equivalent .

(glyphosate is the most energy-intensive).

One litre of petroleum fuel produces 2.5 kg of CO_2

GHG Impact – Nitrogen Fertiliser

Nitrogen fertiliser manufacture is energy-intensive, requiring the equivalent of 2 L diesel fuel per kg N. (ie producing 5.0 kg CO_2E)

But

If only 2 % of that 1kg of N is "denitrified"

(to Nitrous Oxide with 300 x greater effect),

The nitrous oxide represents 6 kg CO_2E, ***so***

Total GHG impact is 11 kg CO_2E per kg N applied

N fertiliser effects are large and not fully understood

Conservation Agriculture (CA)

Conservation agriculture attempts to increase crop production while conserving soil, rainfall and energy.

Early conservation agriculture systems used herbicides to reduce tillage and maintain residue protection of soil surfaces. Zero tillage is best.

More recent conservation agriculture systems also use compacted, permanent traffic lanes to avoid wheel damage to soil in cropping areas, and get better trafficability on permanent traffic lanes.

"Crops grow better in soft soil, wheels work better on roads"

Cropping System Definitions

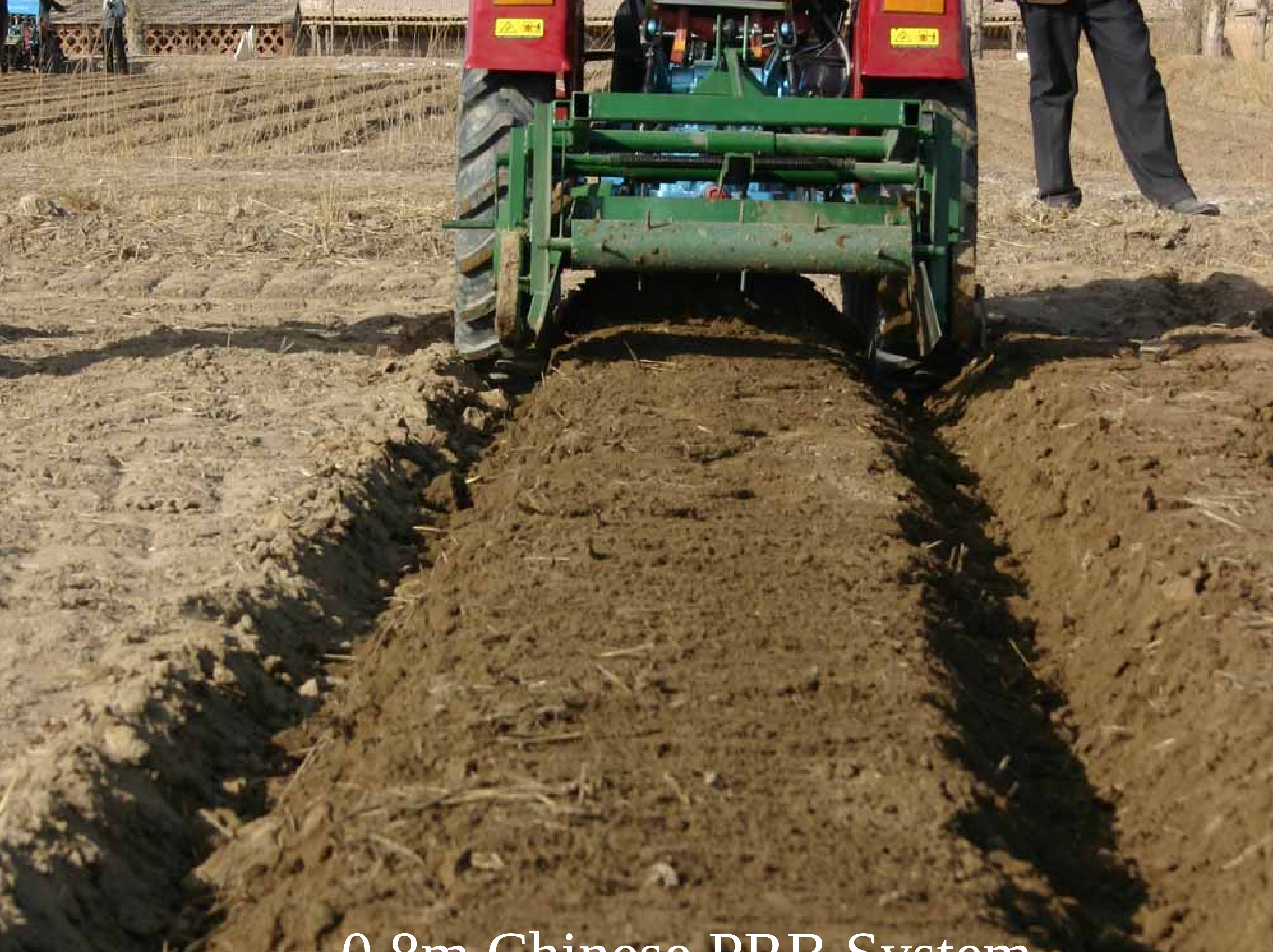
Traditional Tillage (TT): multiple tillage operations/crop to bury residue, control weeds, prepare seedbed. Random traffic.

Zero Tillage (ZT): less than one tillage operation/crop to level surfaces or break up compaction. Herbicide weed control and advanced planter to place seed in hard soil through crop residue. Random traffic.

Controlled Traffic or Permanent Raised Bed (CTF or PRB): maximum of one non-inverting tillage or bed-forming operation. Herbicide weed control. Controlled traffic

3m Australian CTF System

Photo: Rob Taylor


0.8m Chinese PRB System

GHG Comparisons: Operations

	TT
Heavy Tillage	1
Medium till	2
Light till	1
Herbicide	
Planting	1
Harvesting	1
Residue Chop	

GHG Comparisons TT:ZT

TT– GHG effects from tractor fuel and fertiliser.

ZT– Less tractor fuel than TT, but more herbicide. Residue chopping required and occasional tillage to deal with soil compaction.

Sometimes more fertiliser.

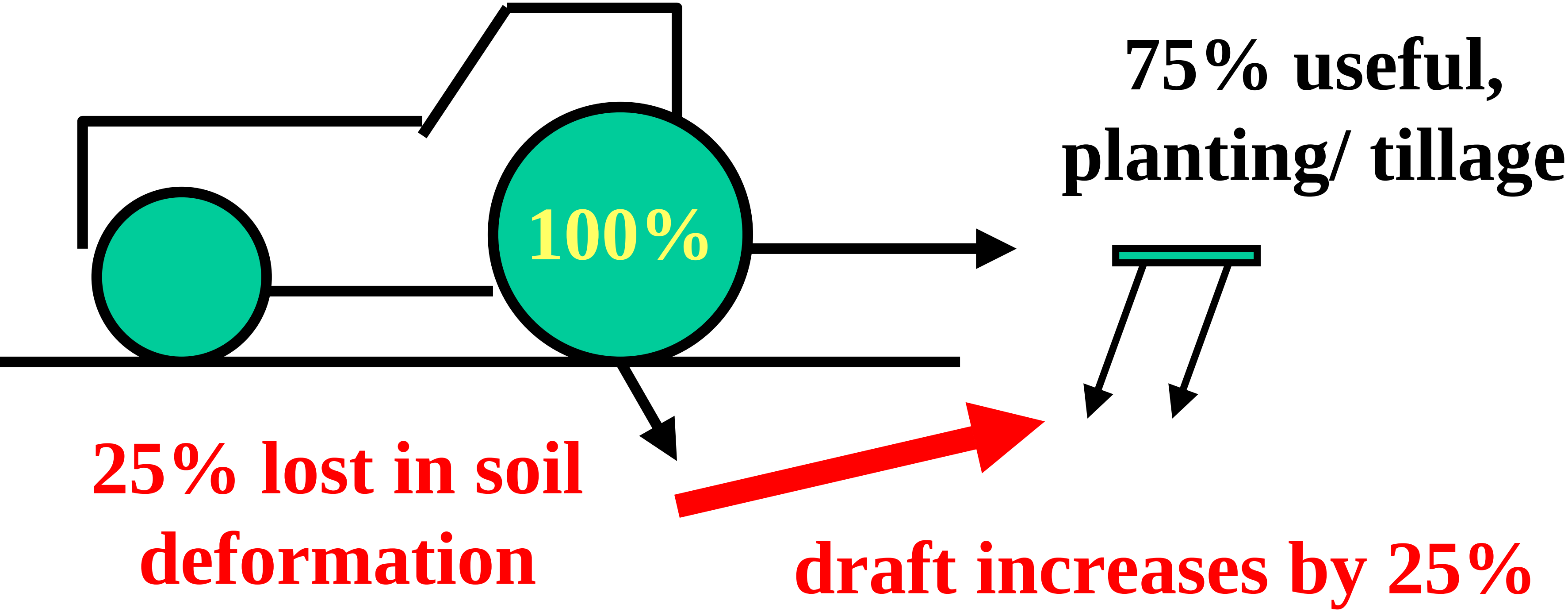
GHG Comparisons ZT: CTF/PRB

ZT– Less tractor fuel than TT, but more herbicide. Residue chopping required and occasional tillage to deal with soil compaction. Sometimes more fertiliser.

CTF/PRB – less tractor fuel than ZT, no disturbance of compacted soil, all jobs carried out from hard, permanent traffic lanes.

WHY?

Why? Greater Energy Efficiency



System Efficiency ~50%

CTF/PRB = 50% less tractor and fuel

GHG Comparisons ZT: CTF/PRB

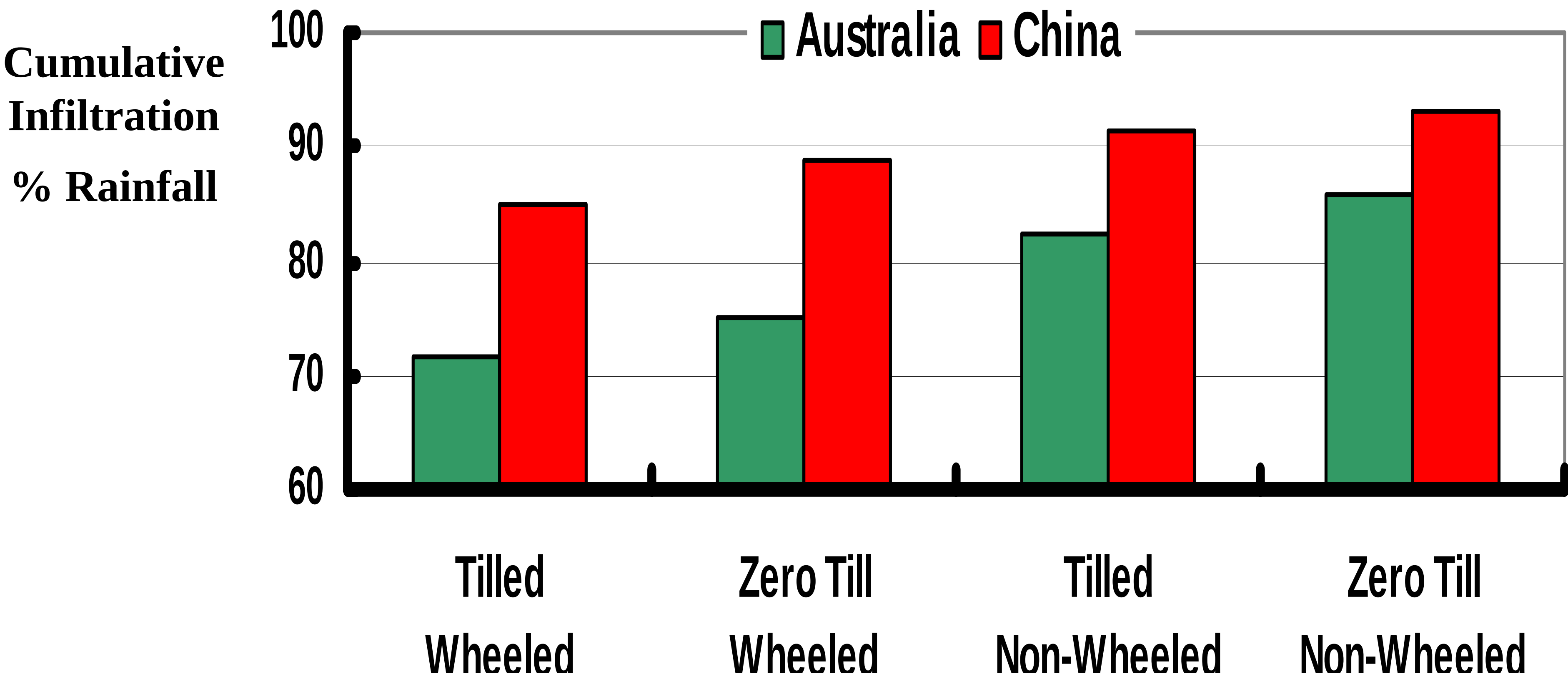
CTF/PRB – less tractor fuel than ZT, no disturbance of compacted soil, and all jobs carried out from hard, permanent traffic lanes, ***and***

More production in water-limited systems, using.

less fertiliser and herbicide/unit production.

Why?

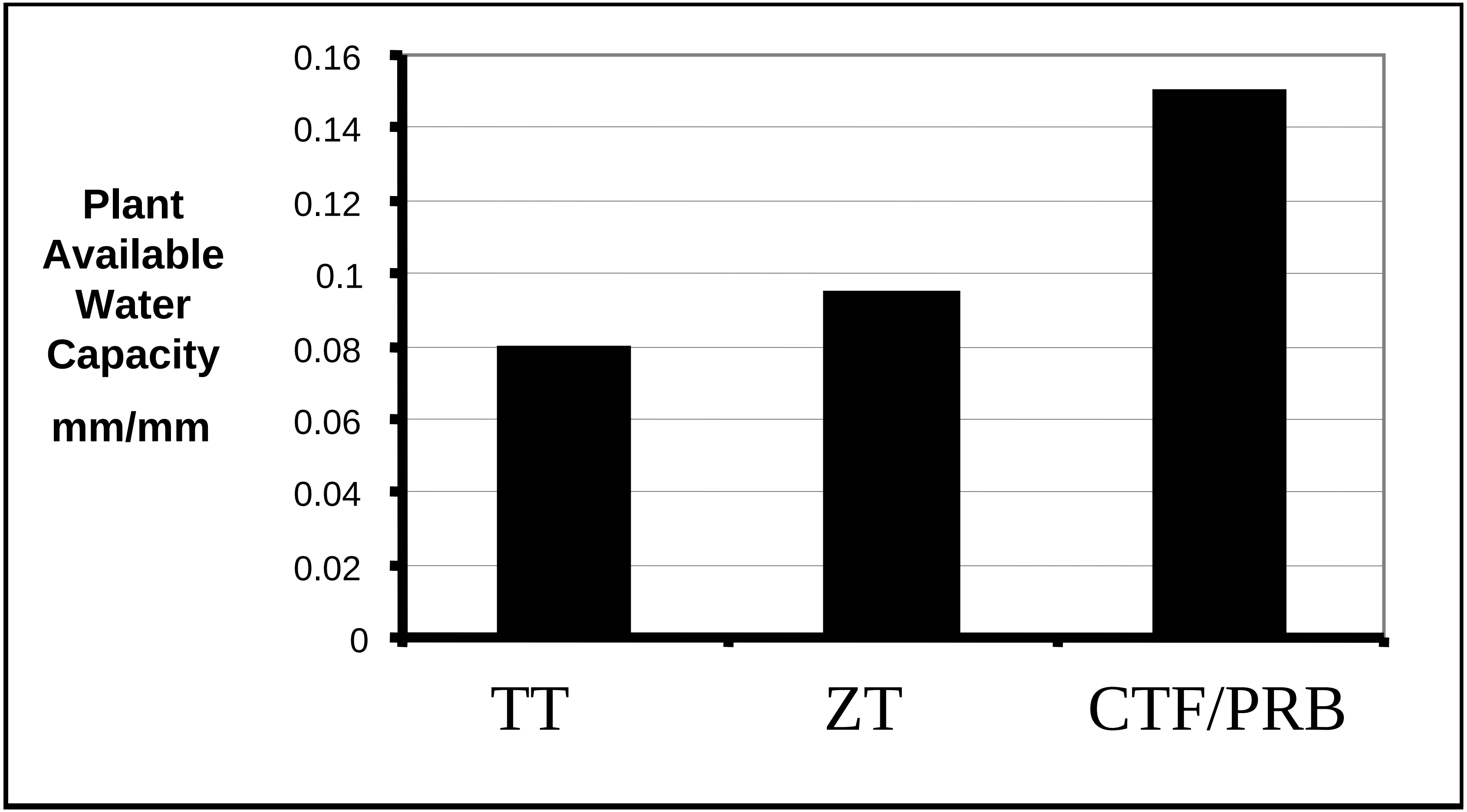
Why? More Rainfall Infiltration



TT ZT CTF/PRB

Australia-6 Seasons Data *China -4 Seasons Data*

And More Plant Available Water Capacity



CTF/PRB:ZT

- **Better field efficiency and reduced delays after rain = better herbicide efficiency.**

- **Access to growing crops allowing *split fertiliser application* = greater efficiency**

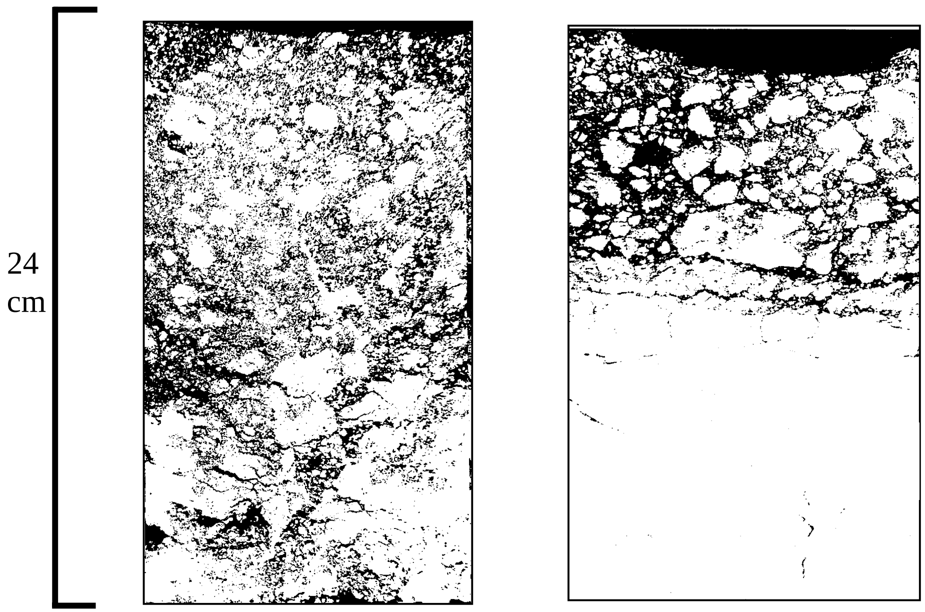
  (= less Nitrogen loss, less GHG's)

- **= 10% more yield in Australia and China**

Soil Differences

- **ZT soil has more soil life (worms etc.) than TT,**
- **CTF/PRB is better aerated than ZT,**
  so even more soil life.
- **Greater soil health = greater fertiliser efficiency**
  = reduced soil disease

Impact of Wheels
(a*nd Power Wasted by Tractors*)



CTF/PRB ZT

Soil Profile Section:

Black is Soil Porosity

White is Soil Solids

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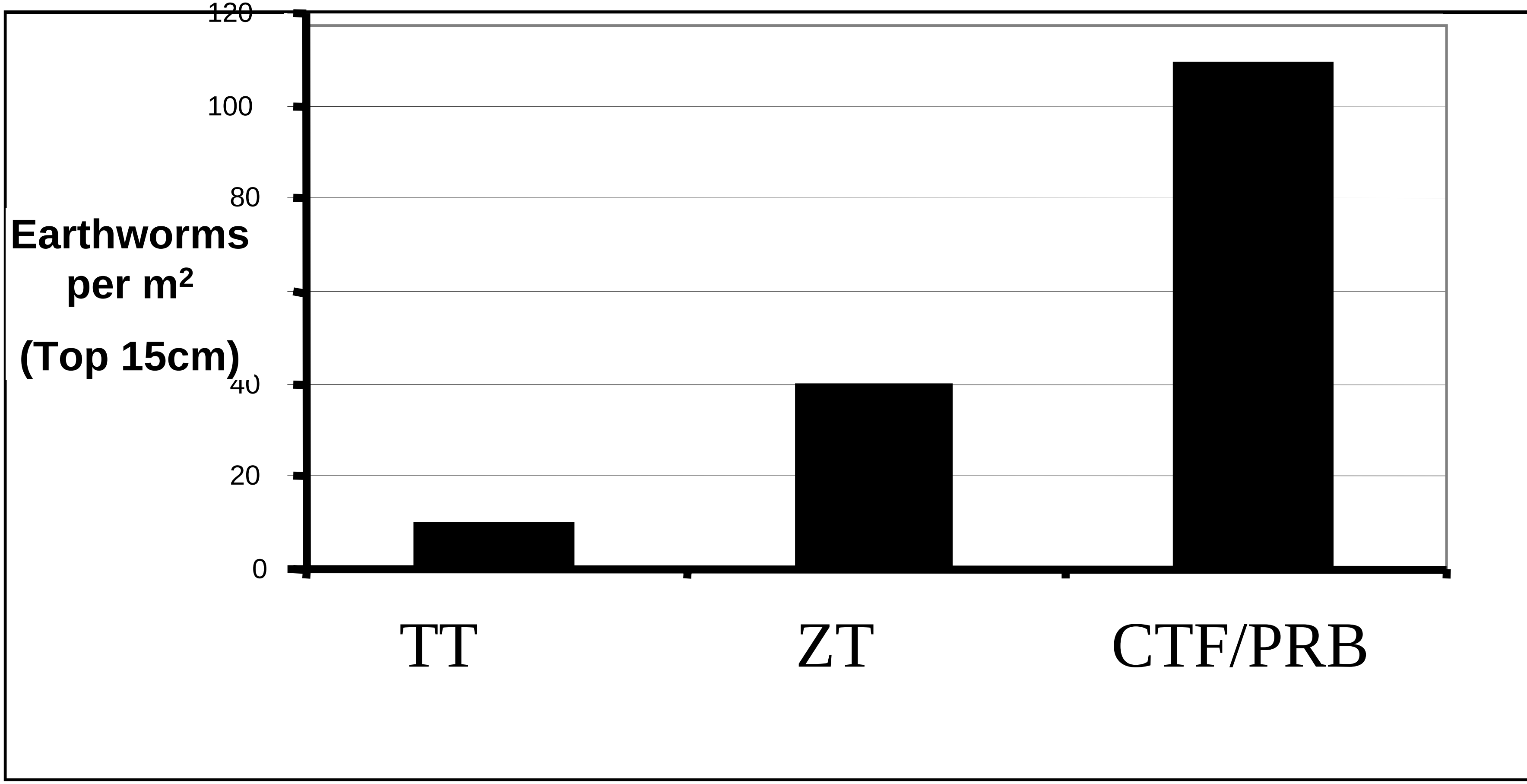
Soil Health Effects -- TT: ZT: CTF/PRB



Energy Impact Summary

Operations	TT
Heavy Tillage	**1**
Medium till	**2**
Light till	**1**
Herbicide	
Planting	**1**
Harvesting	**1**
Residue Chop	
Total Energy MJ/ha	**1941**
Total GHGs kg CO_2E/ha	**108**

Nitrogen Fertiliser – we know:

- Nitrogen fertiliser efficiency is usually < 65%
- Some unused N will be released as nitrous oxide.
- Nitrous oxide production is greater in waterlogged, compacted soil, particularly with low biological activity.
- Nitrous oxide production is greater if all N is applied at planting, rather than as the crop requires it.
- Nitrous oxide production is greater during fallow.

Nitrogen Fertiliser -- Summary

If only 1% of 100kg/ha N becomes nitrous oxide, the total GHG impact is 550 kg CO_2E, so Fertiliser effect is much larger than the energy effect.

Nitrous oxide emissions can be greater in zero tillage

Nitrous Oxide emissions increase:

- **At high levels of water-filled porosity.**
- **In compacted soils, near waterlogging.**
- **When nitrate remains unused in soil.**
- **During fallow.**

Nitrogen Fertiliser -- Summary

CTF/PRB

- **Restricts compaction to non-fertilised soil.**
- **Improves drainage in seed and fertilizer zone.**
- **Precise, split fertiliser application is easier.**

= Greater fertiliser efficiency and less GHG

More research needed!

Soil Carbon

Soil carbon level is determined by the balance between *gains* and *losses*.

So carbon storage is maximised by:

- **Maximising carbon harvested by plants**
- **Maximising conversion of plant carbon to carbon in soil organic matter (SOM).**
- **Minimising the rate of soil organic matter loss**

Carbon Harvesting and Conversion to Soil Organic Matter

Maximised by:

- Continuous cropping to maximise water use efficiency, with cover crops to use water that cannot be used for direct production.
- Vigorous growth by minimising nutrient & physical constraints on production.
- Returning maximum biomass to the soil using crop residues, manures, cover crops etc., and promoting soil biological activity.

Soil Organic Matter Loss

SOM loss - a continuous, natural process, *but*

***But* accelerated by:**

breakdown of soil aggregates

high soil temperatures.

***And* generally associated with:**

- **Tillage and wheel traffic**
- **Residue burning, bare soil and fallow.**

Soil Carbon-- Summary

To increase soil carbon we must maximise water use efficiency and production, using systems which minimise tillage and traffic.

Again, CTF and PRB

Soil disturbance by wheels involves a similar energy input to the soil as that for tillage

Both should be seen destructive.

SUMMARY

There are still many unknowns about the extent to which climate change can be mitigated by changes to agricultural production systems,

but

We can be sure that greenhouse gas production will be reduced and soil carbon storage increased (v. traditional tillage systems) by using conservation agriculture techniques that minimise both tillage and traffic while maximising crop production.

THANK YOU!


(Courtesy of Leopold van Huysteen, CSIRO Soils, Adelaide)

There are a few places where traffic has always been controlled