保护性耕作与清洁发展机制

J.N. Tullberg

CONTROLLED TRAFFIC FARMING
CTF solutions

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

清洁发展机制由京都议定书提出，支持研究发展经济同时降低全球变暖倾向的生产系统

本讲主要分析以下问题：

保护性耕作能否通过耕作减少温室气体排放:

1.减少气体排放?

2.增加土壤含碳量?

主要内容:

- 讨论温室气体和保护性耕作的不同
- 概况影响温室气体排放的几个重要因素，提出可能的改进方法
- 分析对土壤含碳量的影响

危险!

这个结论的得出取决于过去的一些假设

这些假设中国和澳大利亚的旱地小麦生产是成立的。

更多的细节，包括假设及计算过程，在会议论文集中。

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农业温室气体 (GHG's):

CO_2 – 来自石油燃料和土壤

CO_2 是主要的农业温室气体, 所以其他的 GHG 影响通常量化为 "CO_2 E" – 全球变暖能力与 CO_2 的量化比率

例如：

氧化氮 **N_2O – 大部分来自土壤**

1 kg= 300 kg CO_2E

甲烷 **CH_4 – 大部分来自动物和水田**

1kg= 25 kgCO_2E

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GHG 影响 – 能量

CO_2 来自拖拉机燃烧柴油，机器、农药和化肥生产厂商

拖拉机燃料：从燃料使用记录上估计.加上设备生产厂商使用的燃料，要再加上 **15%.**

农药生产商 **:**消耗燃料能量相当于 **2-10L/kg.**

(草甘膦是非常耗能的).

1升汽油产生 **2.5 kg CO_2**

GHG 影响 – 氮肥

氮肥生产是非常耗能的，每公斤N相当于要消耗**2 L. (**要产生**5.0 kg CO_2E)**

如果**1Kg**的**N**只有**2%**被**“**硝化**”**的话，那么产生的的氧化亚氮相当于**6Kg**的**CO2**量则每公斤**N**所产生的总的**CO2**量为**11Kg**。

N肥产生效应还有待进一步研究

保护性农业Conservation Agriculture (CA)

保护性农业的目的是提高产量、保持水土、减少能量投入

早期保护性农业通过采用除草剂和秸秆覆盖地表实现，免耕是保护性农业最好的方式

最近研究的保护性耕作通过压实土壤，提供良好的滑转率，采取固定道的做法以减少机具对作物生长区域的危害。

“作物最佳的生长环境是松软的土壤，机具最佳的工作环境是坚实的土壤”

耕作方式分类Cropping System Definitions

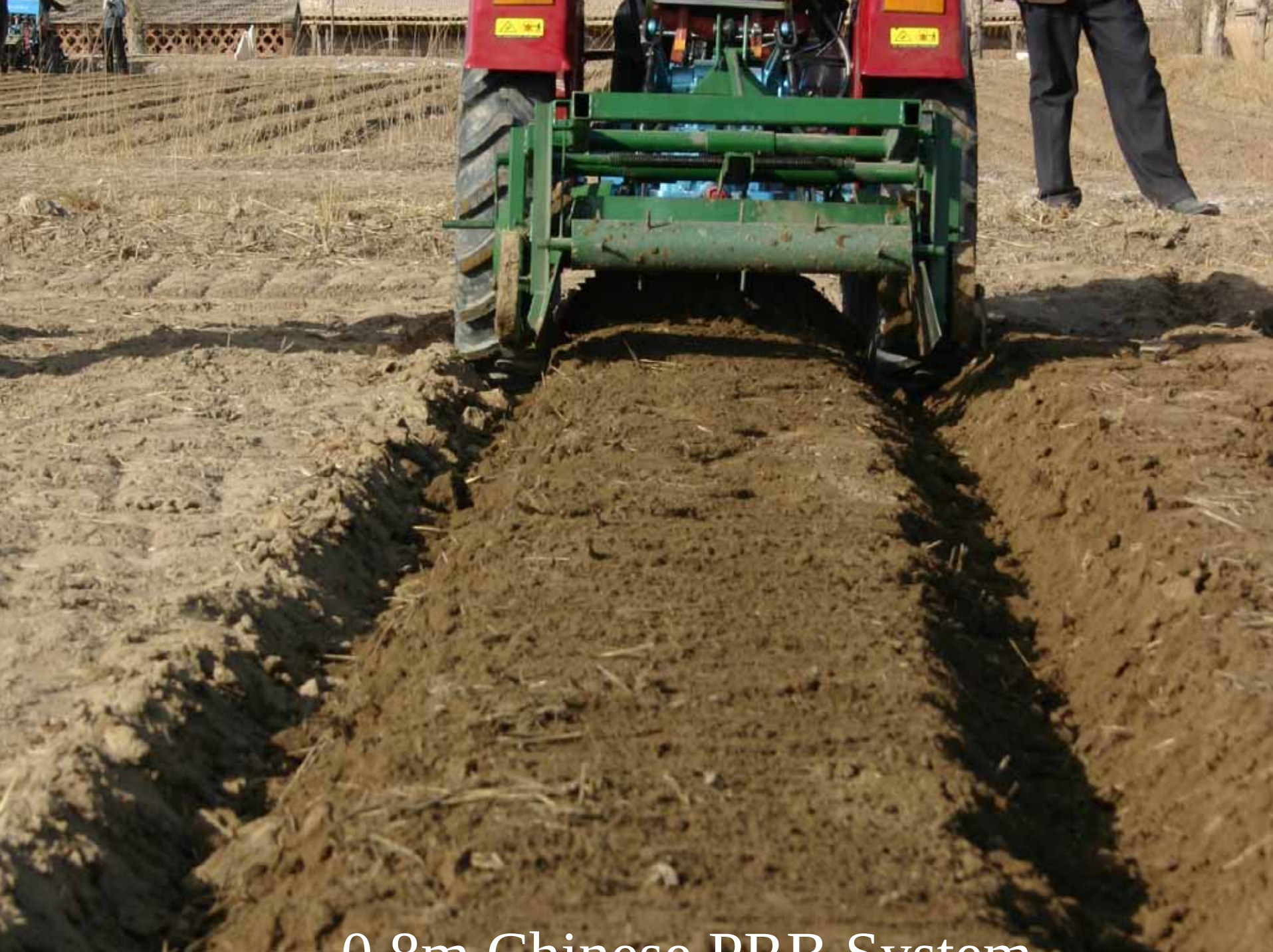
传统耕作：多种多样，秸秆焚烧，杂草控制，种床准备，机轮进地不固定**Traditional Tillage (TT): multiple tillage operations/crop to bury residue, control weeds, prepare seedbed. Random traffic.**

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



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.

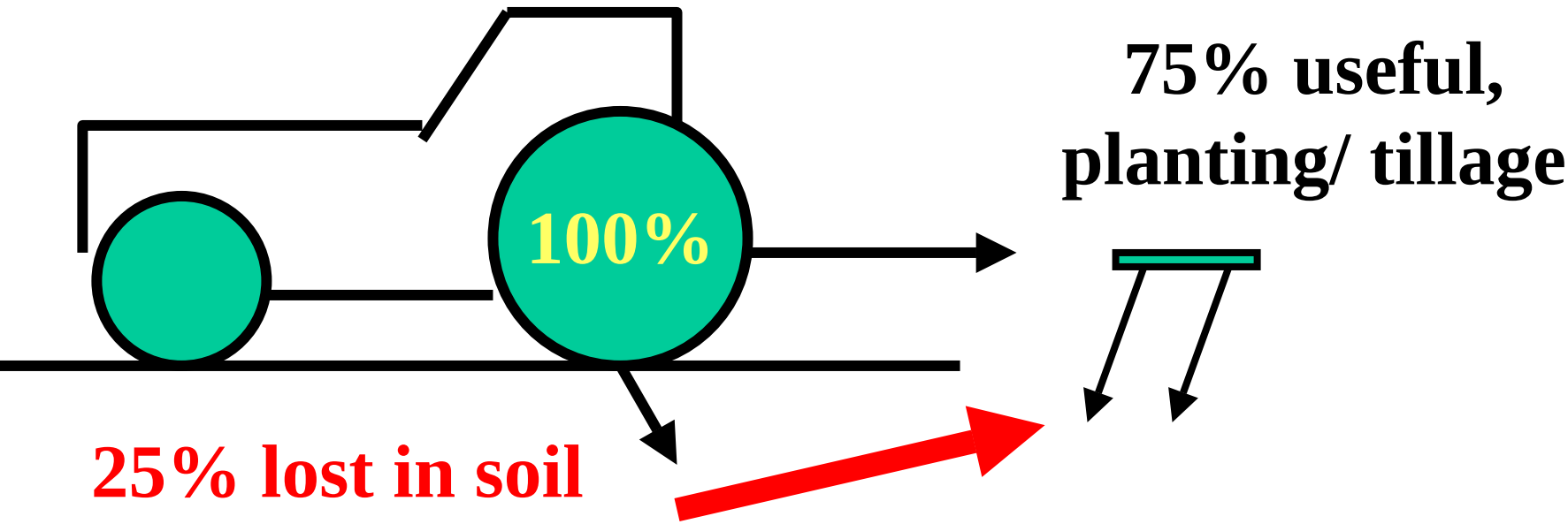
GHG Comparisons ZT: CTF/PRB

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

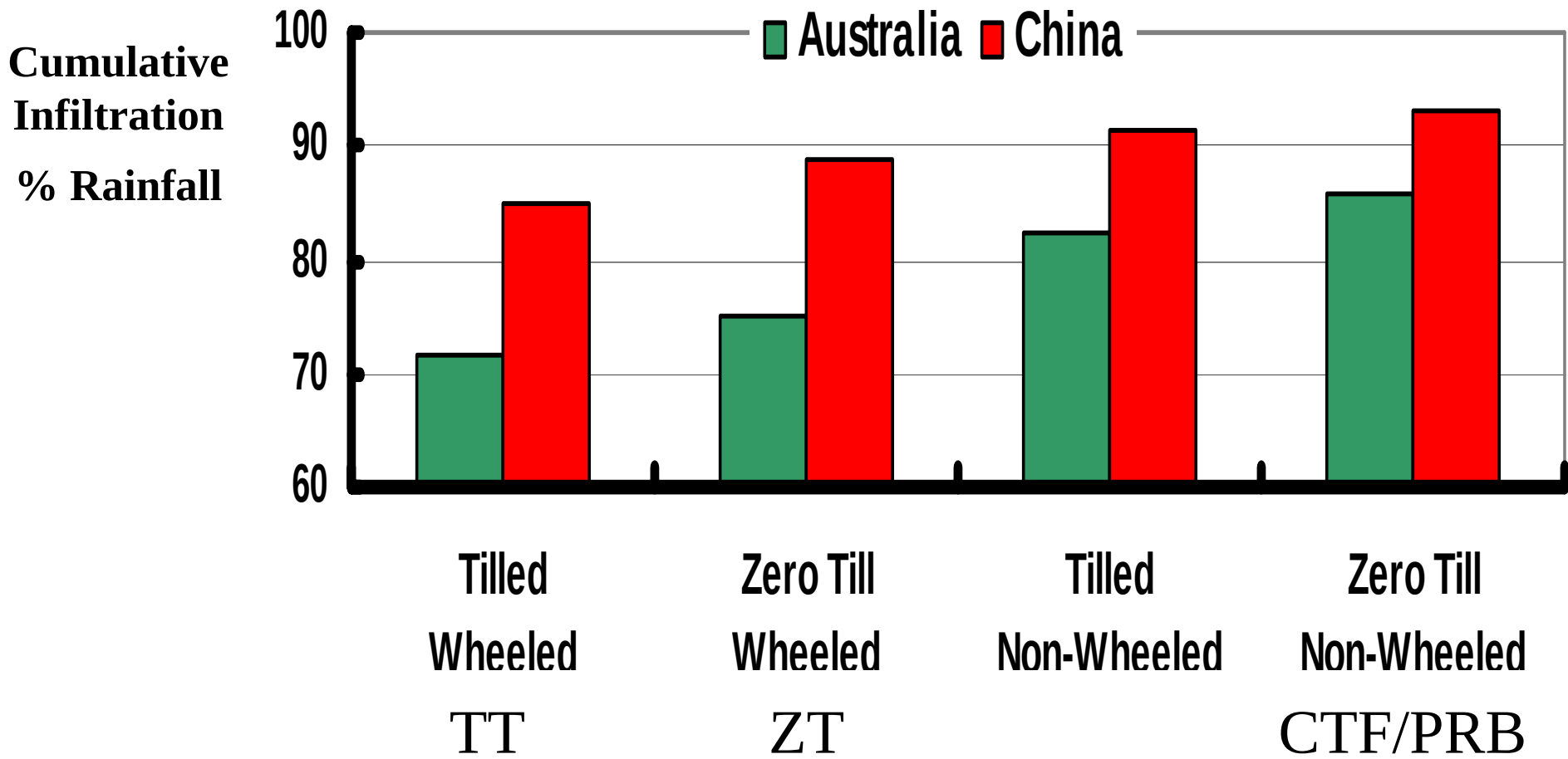
CTF/PRB – less tractor fuel than ZT, no disturbance of compacted soil, and all jobs carried out from hard, permanent traffic lanes, *and*

More production in water-limited systems, using.

less fertiliser and herbicide/unit production.

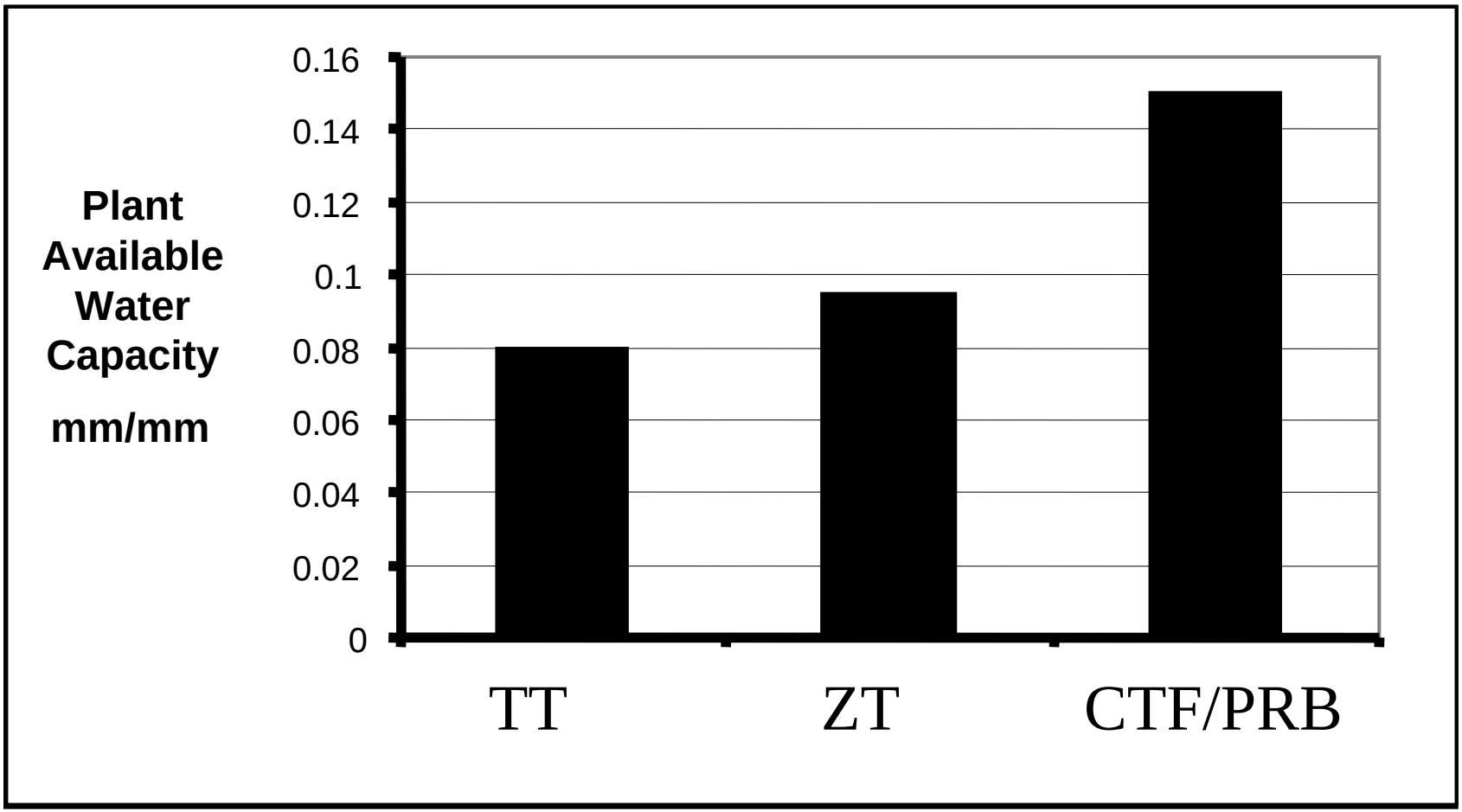
Why?

Why? More Rainfall Infiltration



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**

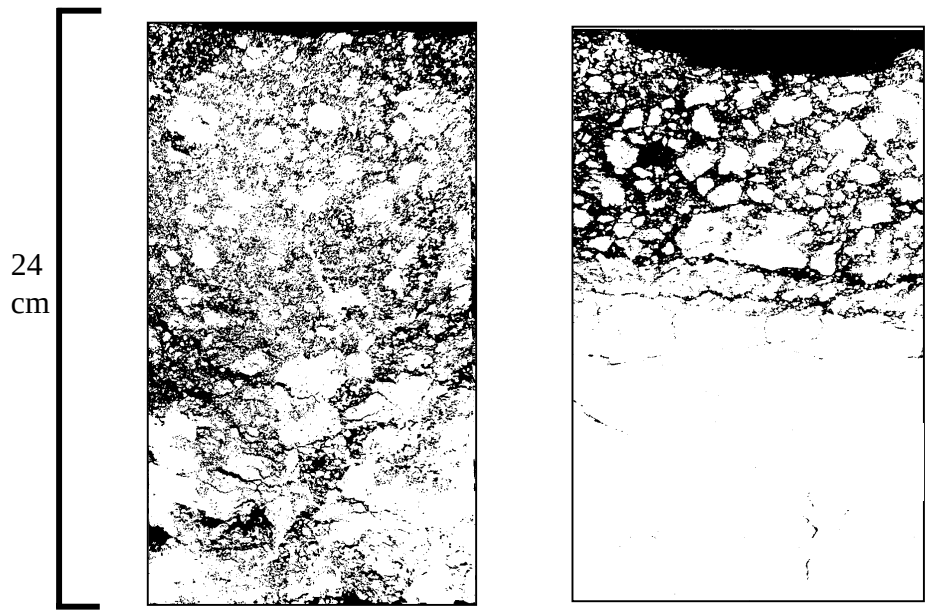
  (= less Nitrogen loss, less GHG's)

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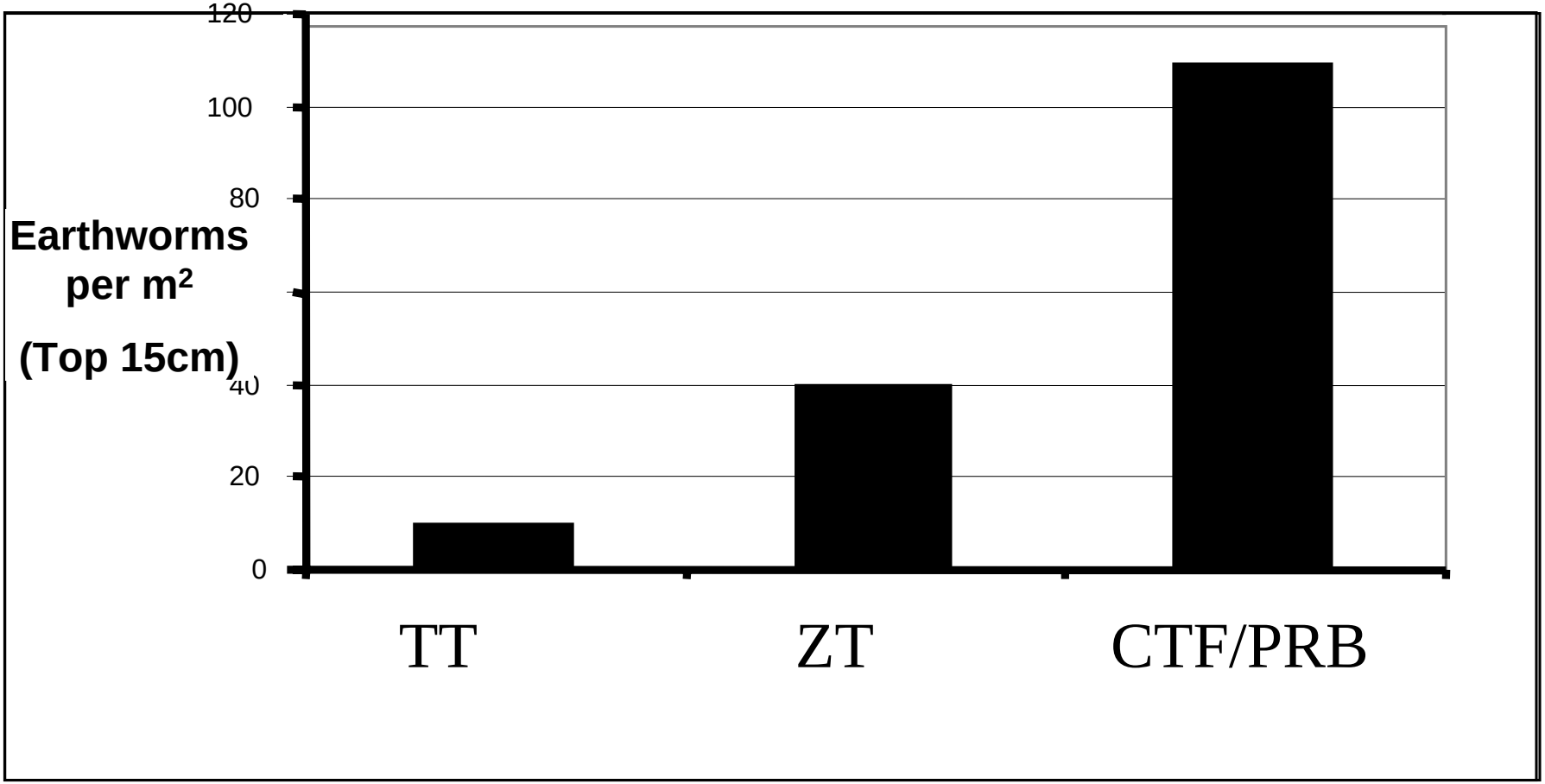
Soil Health Effects -- TT: ZT: CTF/PRB



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!

There are a few places where traffic has always been controlled