Building resilience against drought and soil erosion: impact of field water conservation in the drought prone Vertisol areas of northern Ethiopia

Tesfay Araya (1,2), Wim M. Cornelis (1), Jan Nyssen (3), Bram Govaerts (4), Dirk Raes (5), K.D. Saire (4), Jozef Deckers (5)

(1) Ghent University, Dep. Soil Management, Belgium
(2) Mekelle University, Dep. Crop and Horticultural Science, Mekelle, Ethiopia
(3) Ghent University, Dep. Geography, Belgium
(4) International Maize and Wheat Improvement Centre (CIMMYT), Mexico.
(5) K.U.Leuven, Dep. Earth and Environmental Sciences, Belgium

UNIVERSITEIT GENT

MEKELLE UNIVERSITY

CIMMYT

VLIR Vlaamse Interuniversitaire Raad
UOS University Development Co-operation

1. Background – what is the problem?

- Land degradation in northern Ethiopia is due to:
  - complete removal of crop residues at harvest
  - aftermath grazing of livestock
  - frequent tillage

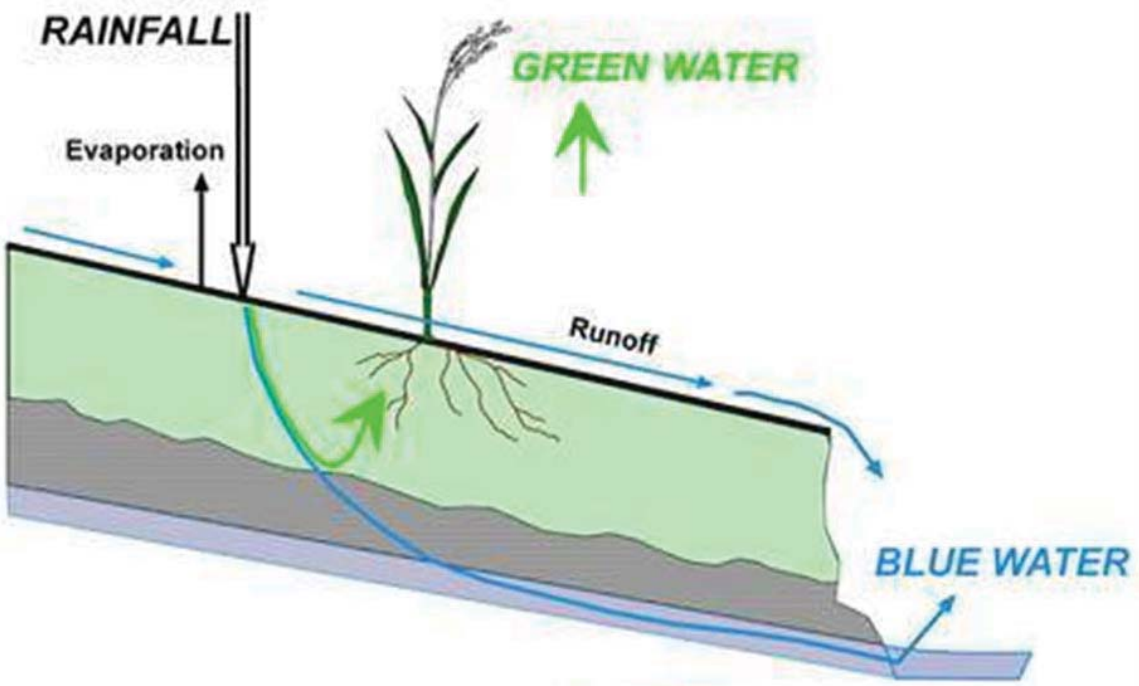
Reduce OM ⬇ increase runoff & soil loss

- The major limitations for crop production on vertisols in the Ethiopian highlands
  - periodical (agricultural) drought/dry spell
  - periodical water logging
  - soil erosion by water

1. Background – what is the problem?

- Rain fed farming agriculture is dominant in Ethiopia

- Rainfall is erratic and insufficient in northern Ethiopia.



Water, stored in the soil and used by plants, equals green water.
Runoff and deep drainage, recharging groundwater and feeding streams, equals blue water.

Rockström, 1997

imbalanced soil hydrology

↓

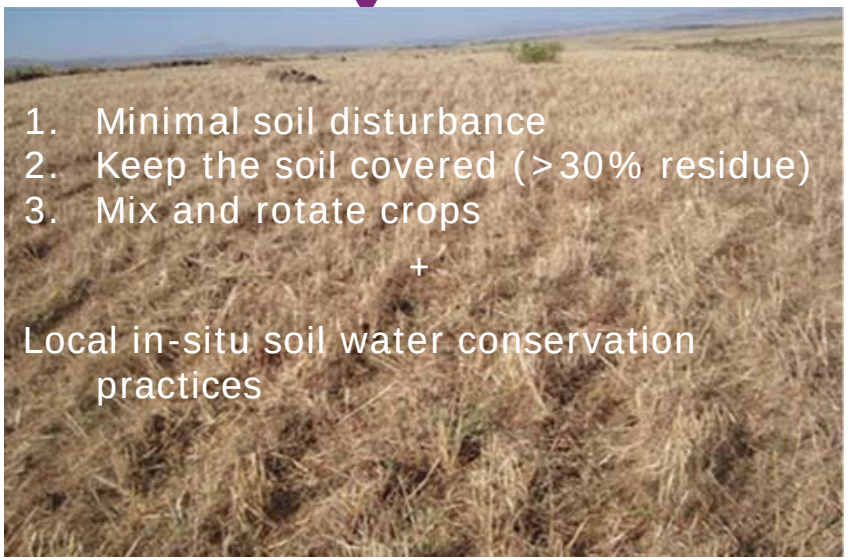
often due to

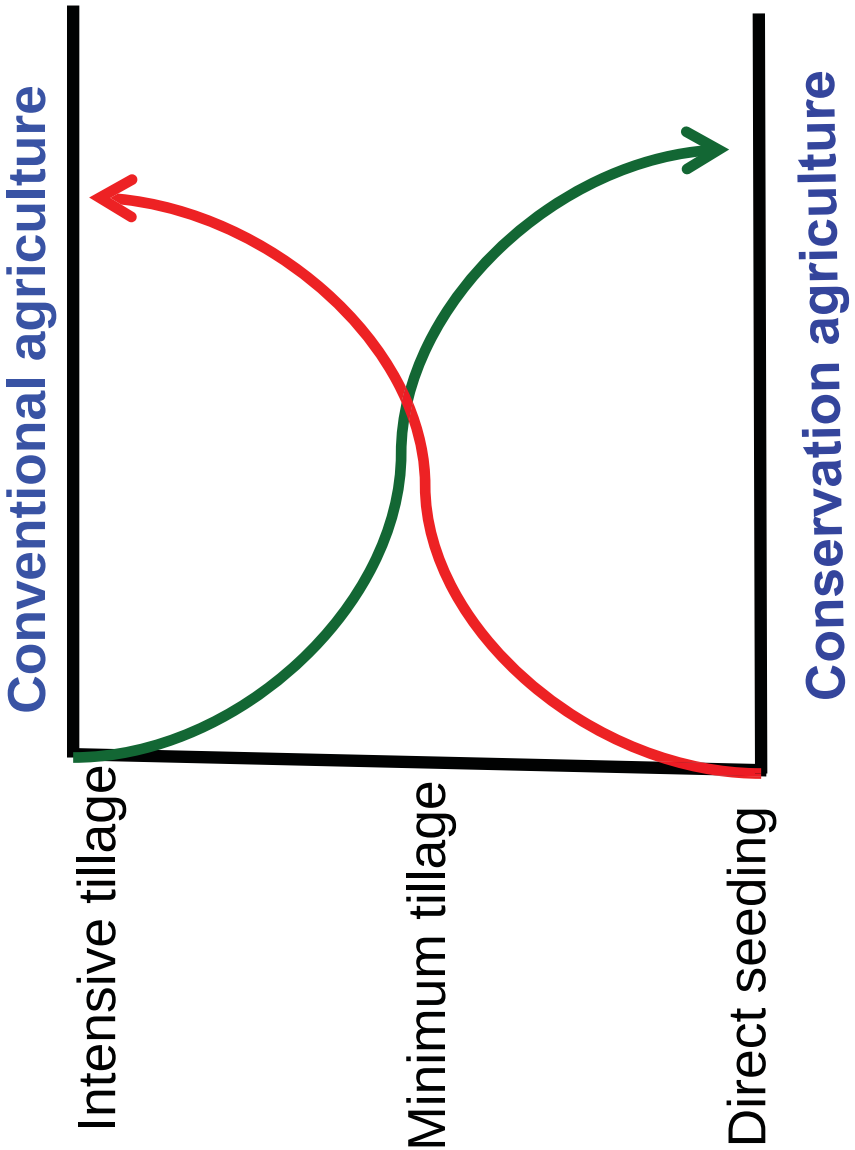
- deteriorated physical quality of soil
- absence of add. control measures

1. Background – is there a solution?

- In order to increase crop productivity, in-situ soil and water management practices need improvement.
- Conservation agriculture (CA) in combination with other in situ conservation practices can improve the soil hydrology
- Until recently, no such practice of implementing CA in northern Ethiopia

1. Background – is there a solution?





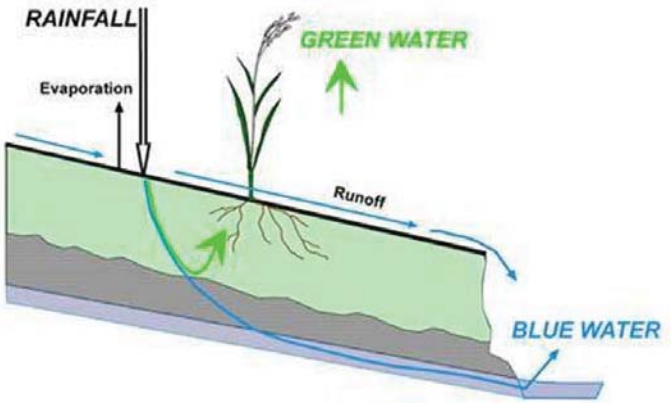
1. Background – why research on CA?

- Impact of CA vs. conventional agriculture practices based on experiments in different parts of the world has not been consistent across:
  - socioeconomic setups
  - soil types
  - climate
  - crops
  - ploughing implements

→ small-scale farming systems, vertisols, semi-arid, ox-drawn *marasha* ard plough and local crop rotations (incl. teff) in the northern Ethiopian highlands

1. Background – objectives?

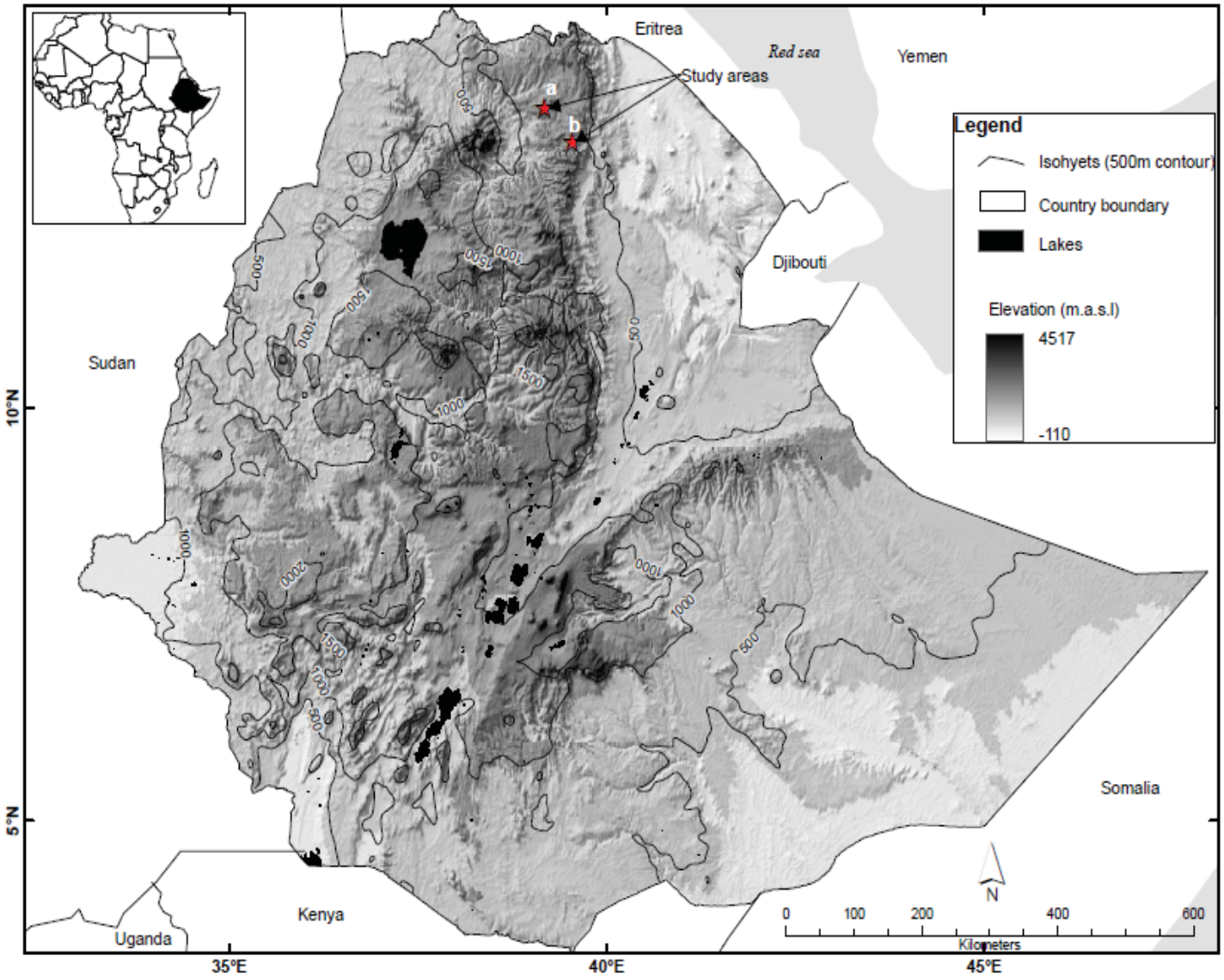
- Study the effect of two conservation tillage practices vs conventional tillage practices under local conditions in terms of
  - runoff and soil loss
  - in situ water conservation
  - grain and straw yield



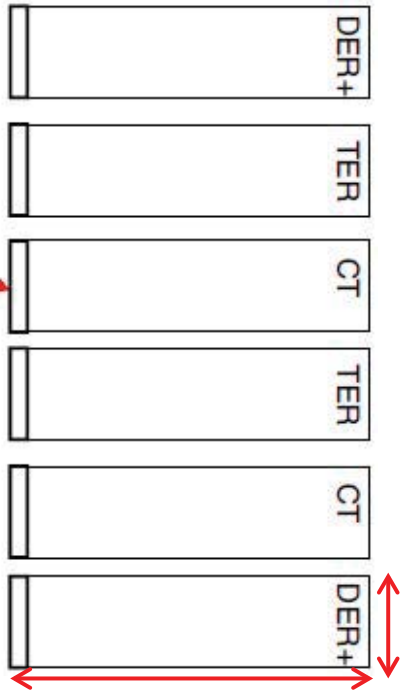
indigenous
conservation practices + tillage tools (*marasha* ard plough)

wide international body of knowledge on CA

2. Field experiments – where?



2. Field experiments – design?



2005-2007:
3 T × 2 R

2008-now:
3 T × 3 R

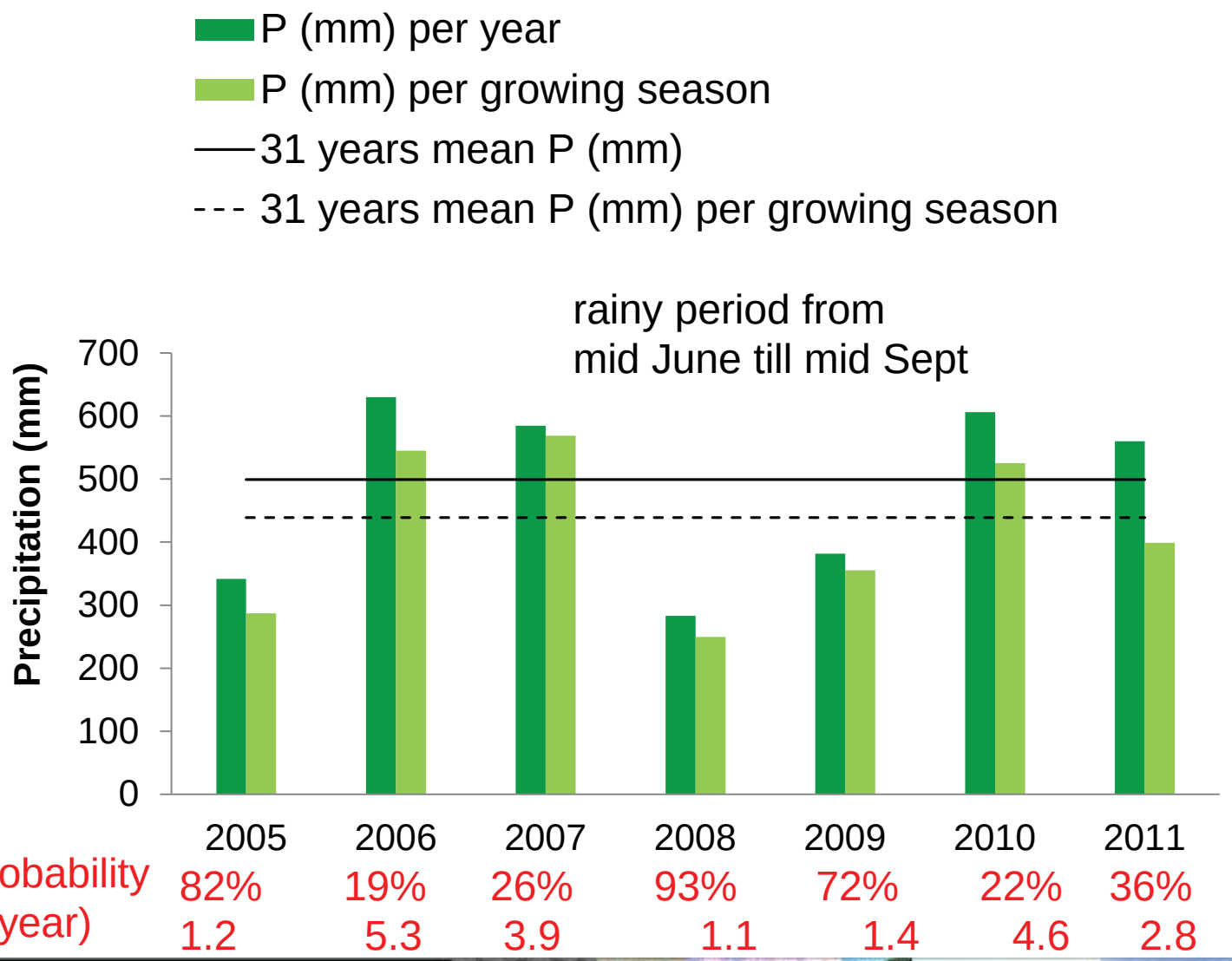
2. Field experiments – tillage practices?

a. conventional tillage (CT)

b. *terwah*+ (TER+)

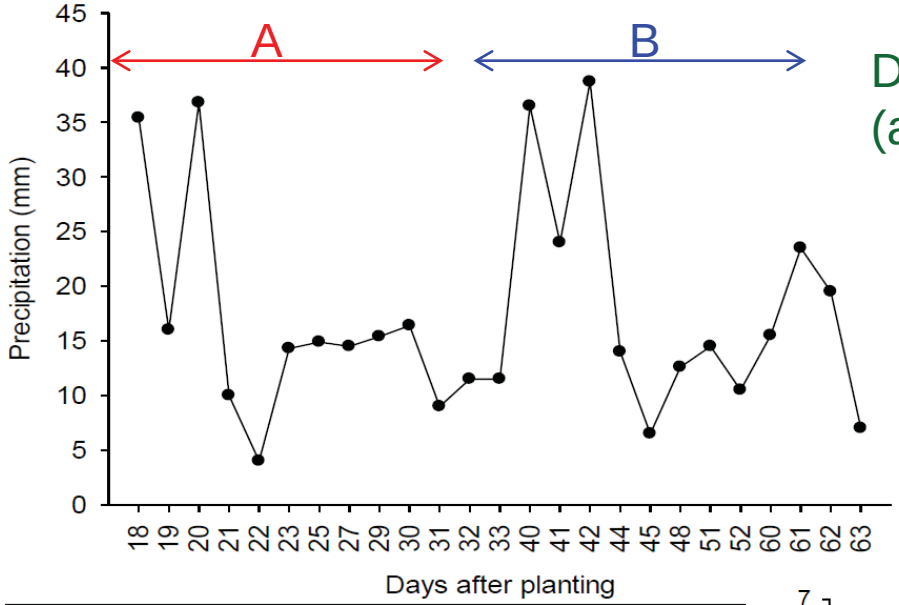
c. *derdero*+ (DER+)

3. Results – rainfall during study period?

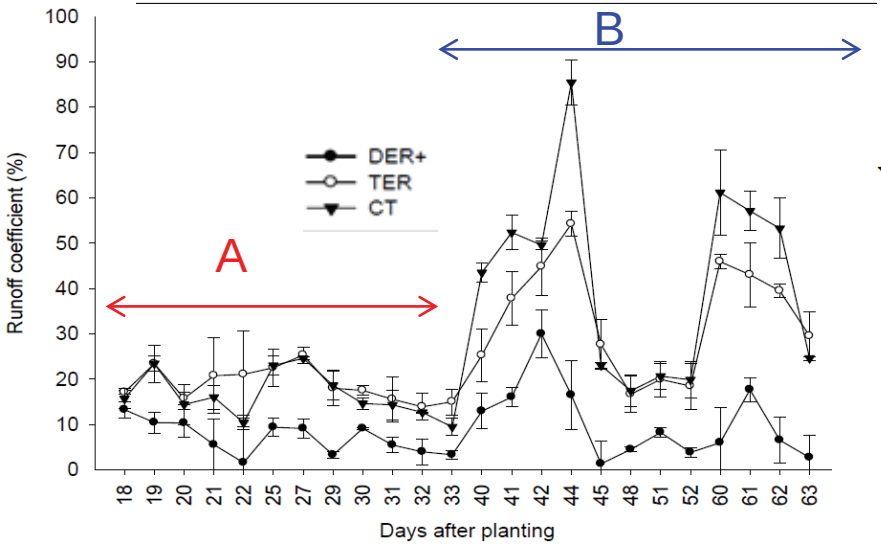


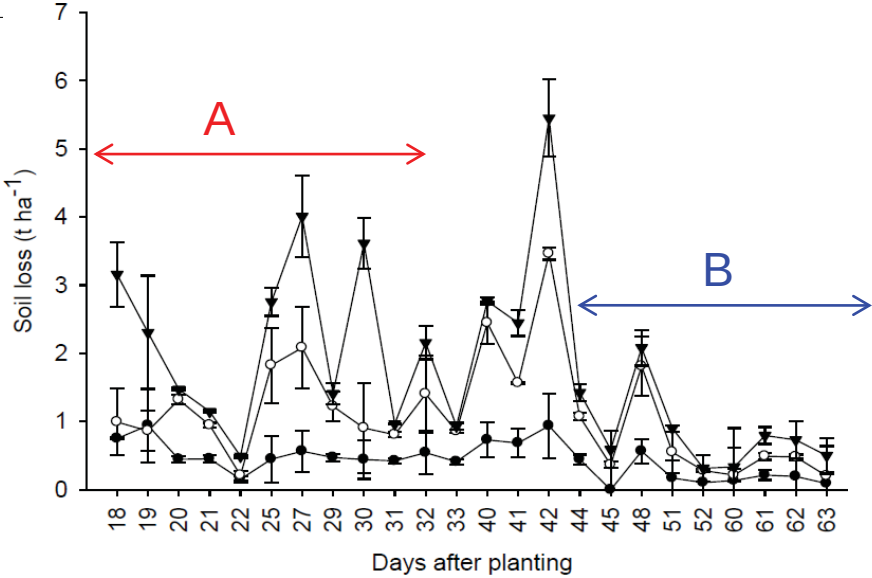
	2005	2006	2007	2008	2009	2010	2011
Exceedence probability	82%	19%	26%	93%	72%	22%	36%
Return period (year)	1.2	5.3	3.9	1.1	1.4	4.6	2.8

3. Results – does CA affect daily runoff and soil loss?

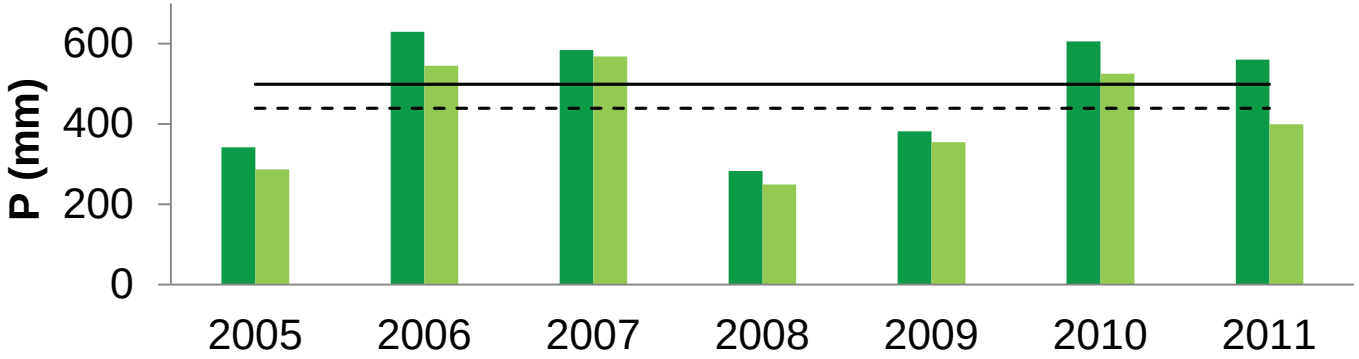


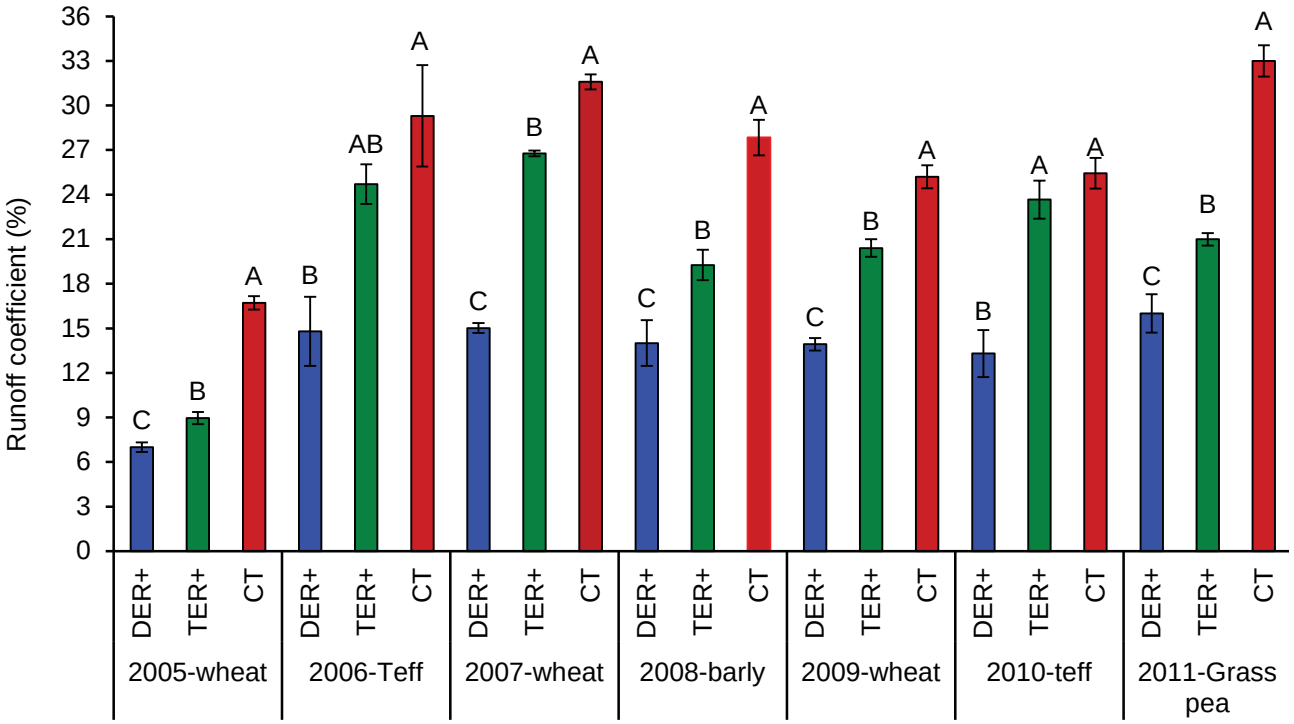
Daily runoff and soil loss in 2007 (after 3 years)





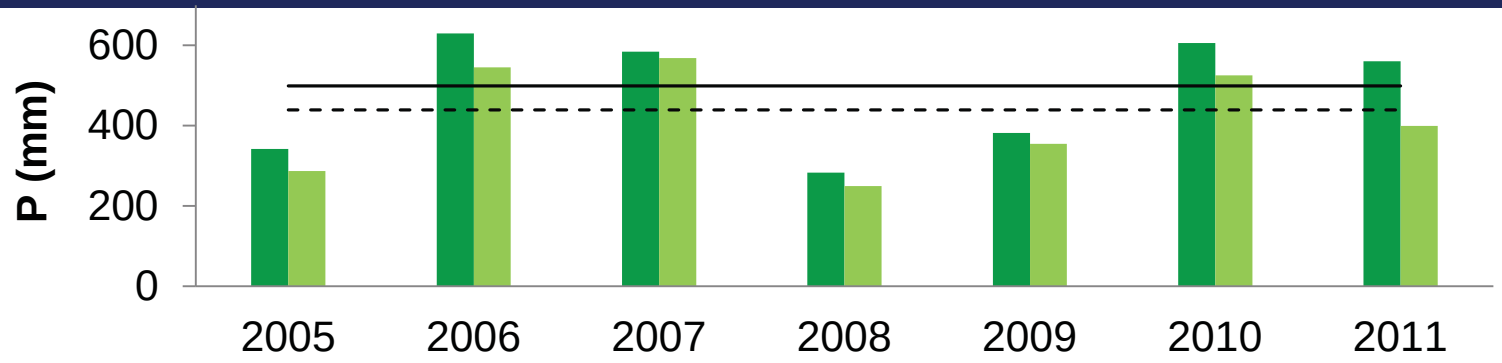
3. Results – does CA affect runoff coefficient?

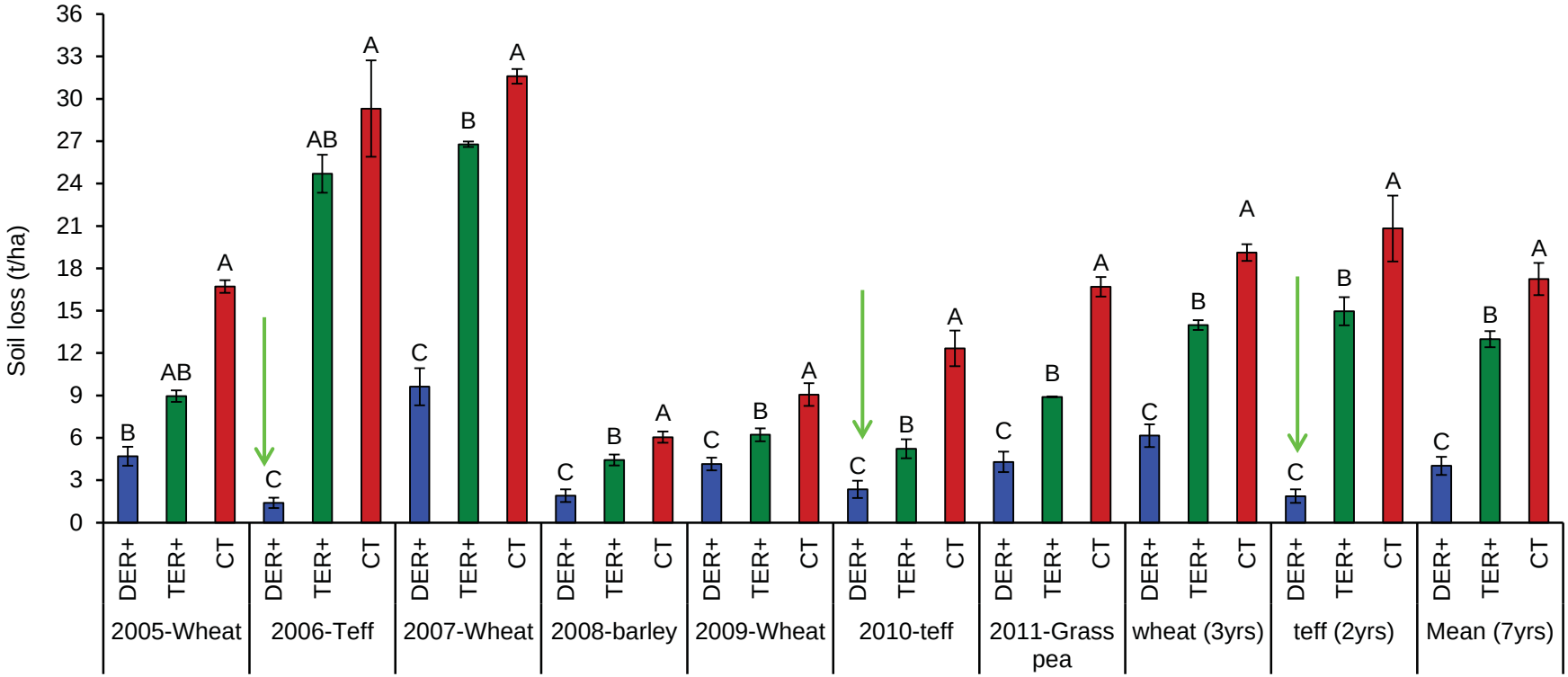




✓ The 7-yrs mean runoff coefficient: 13 % in DER+, 20 % in TER+ and 27 % in CT

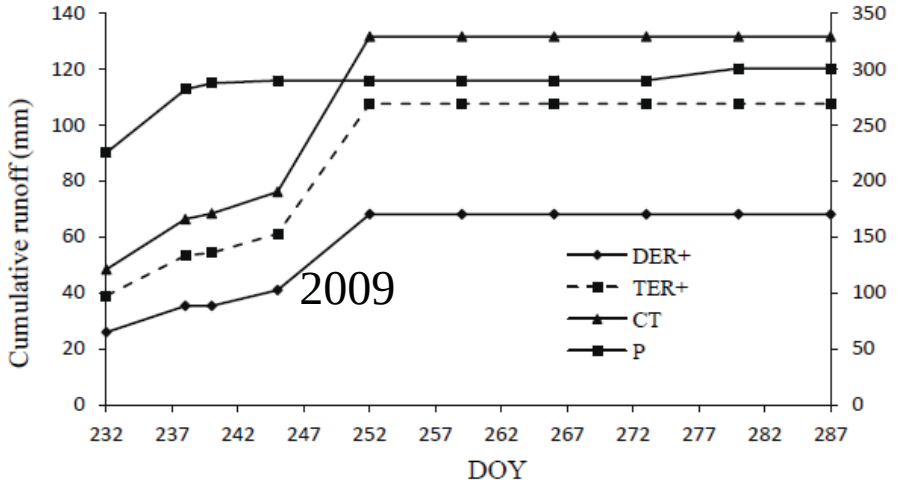
3. Results – soil loss?

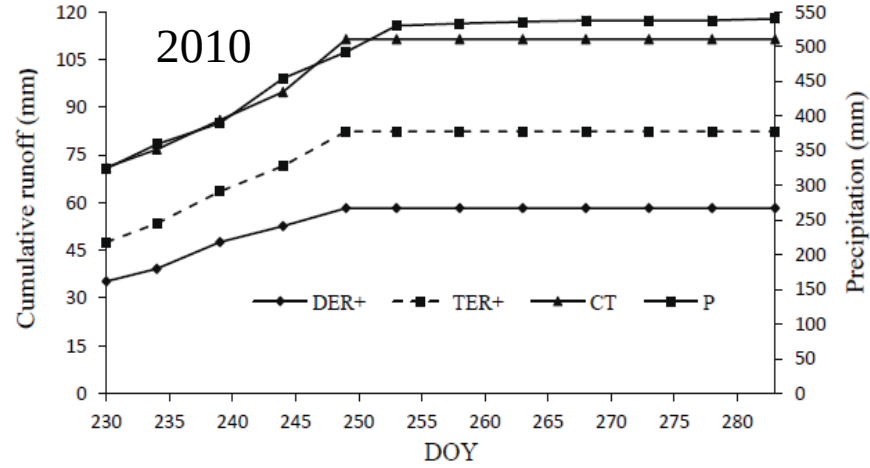


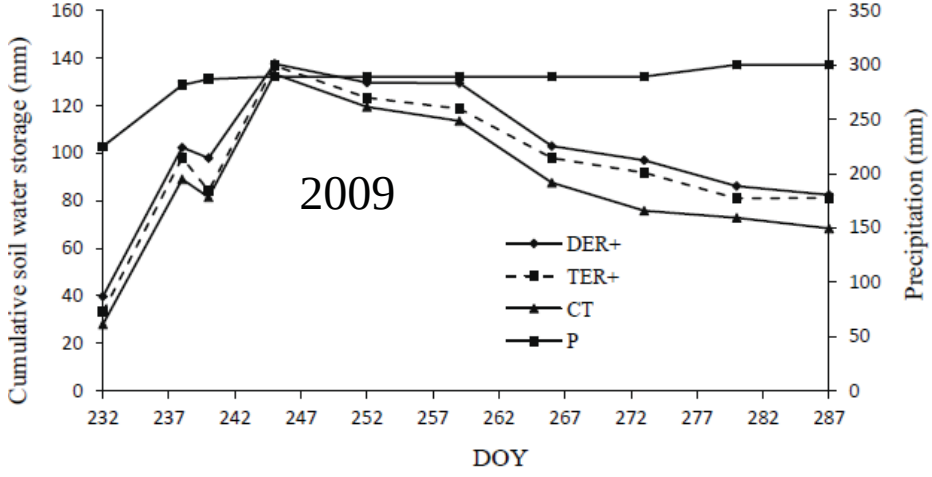


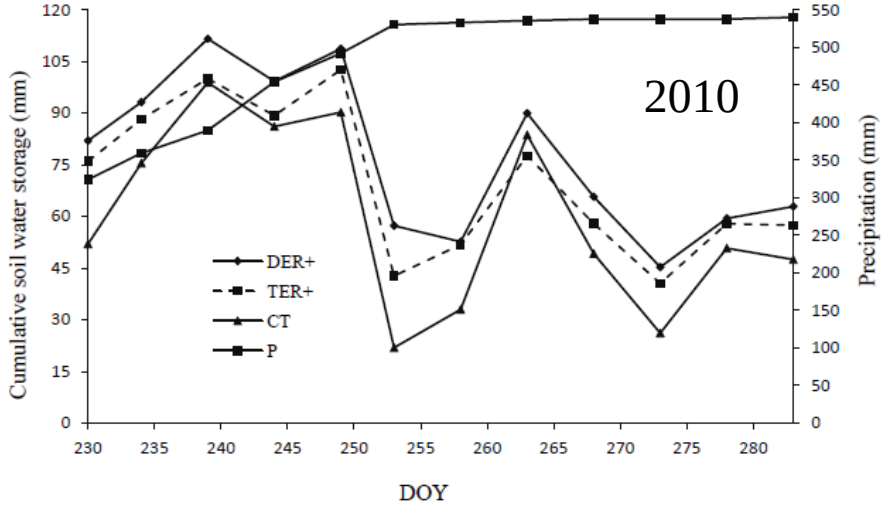
➢ 7-yrs mean soil loss: 4.4 in DER+, 12.5 in TER+ and 18 t/ha in CT

3. Results – Rootzone Water balance (2009 & 2010)?





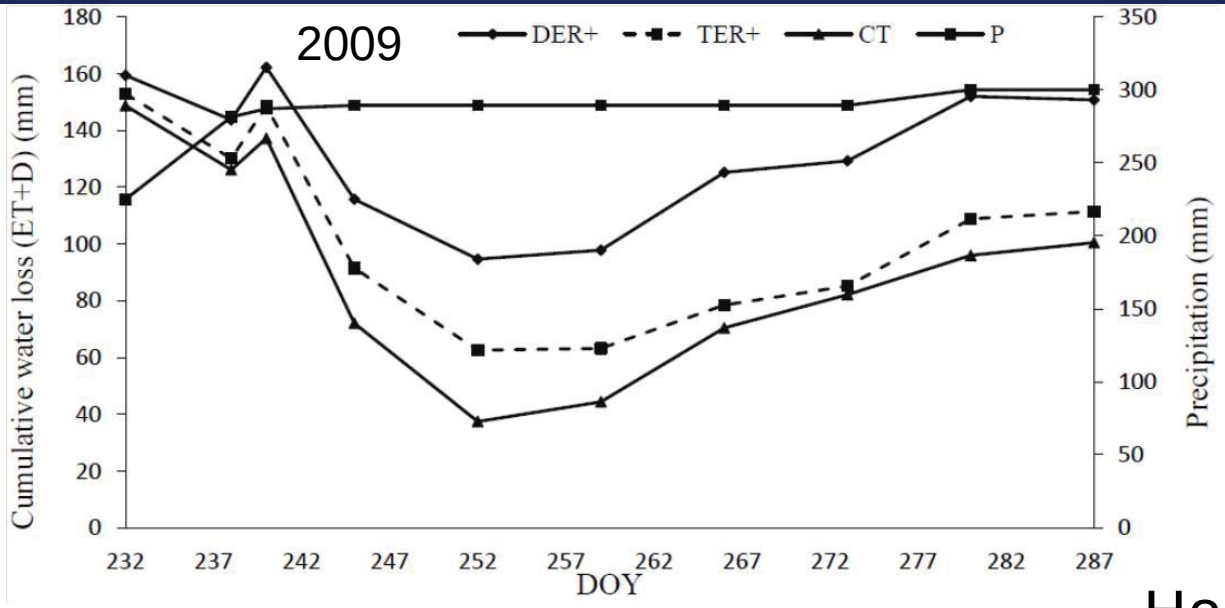


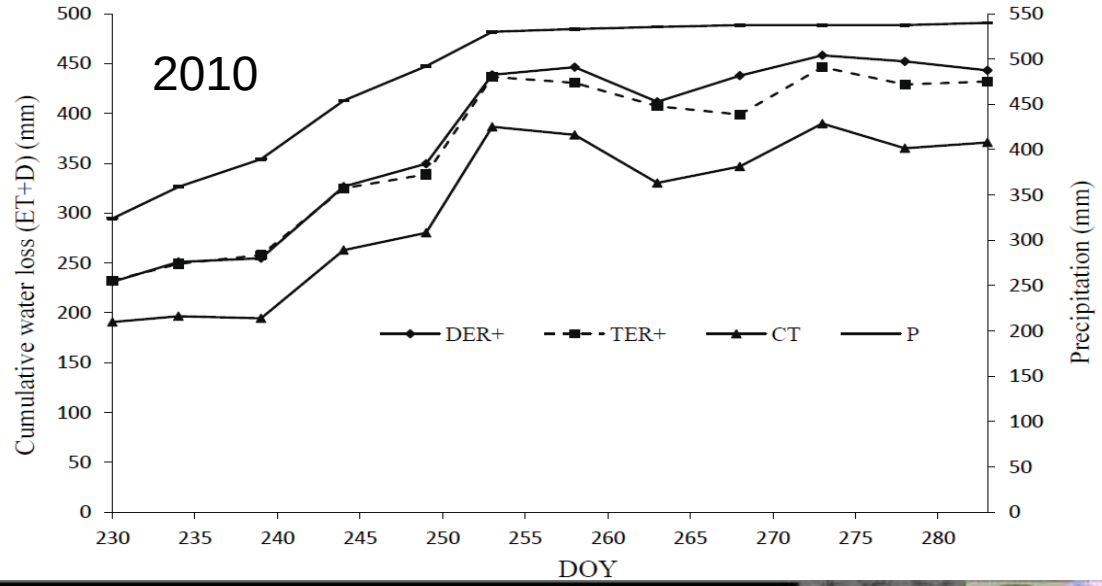


Runoff: DER+ < TER+ < CT

Soil water storage: DER+ > TER+ > CT

3. Results – Rootzone water balance (2009 & 2010)?



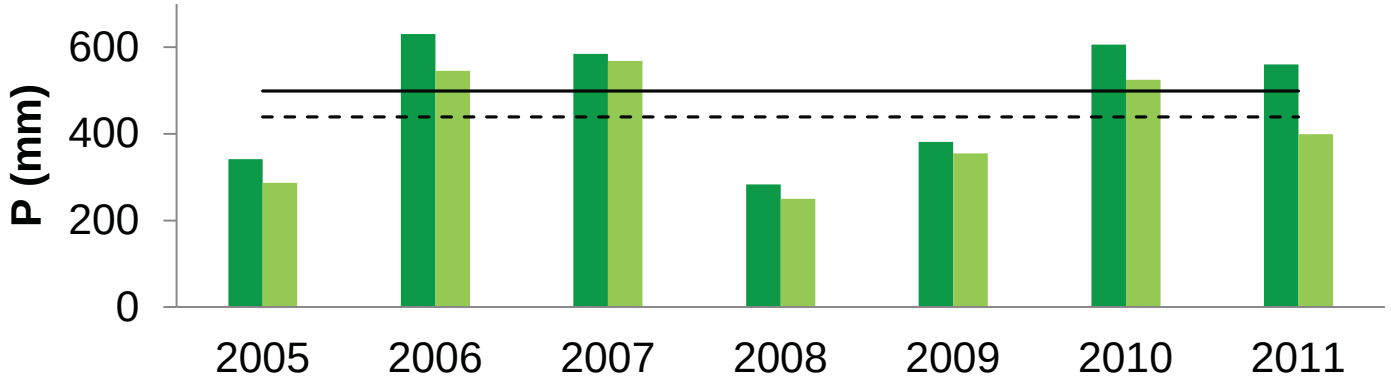


However, water loss (ET+D): DER+ > TER+ > CT

3. Results – soil water storage ?

Photographs of CT and DER+ plots taken 15 min after a 38.7 mm rainfall event on August 22, 2007

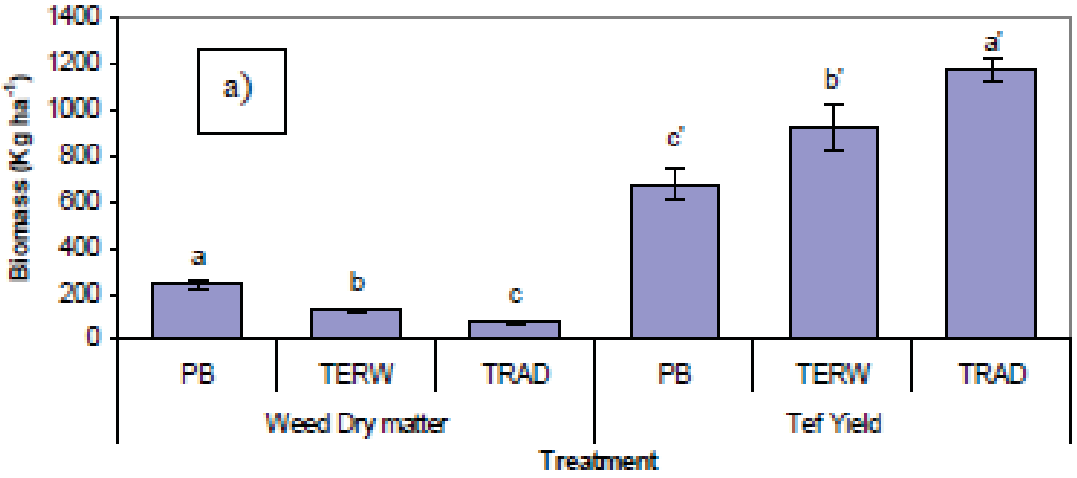
3. Results – does yield increases under CA?



The straw yield trend was similar to the grain yield .

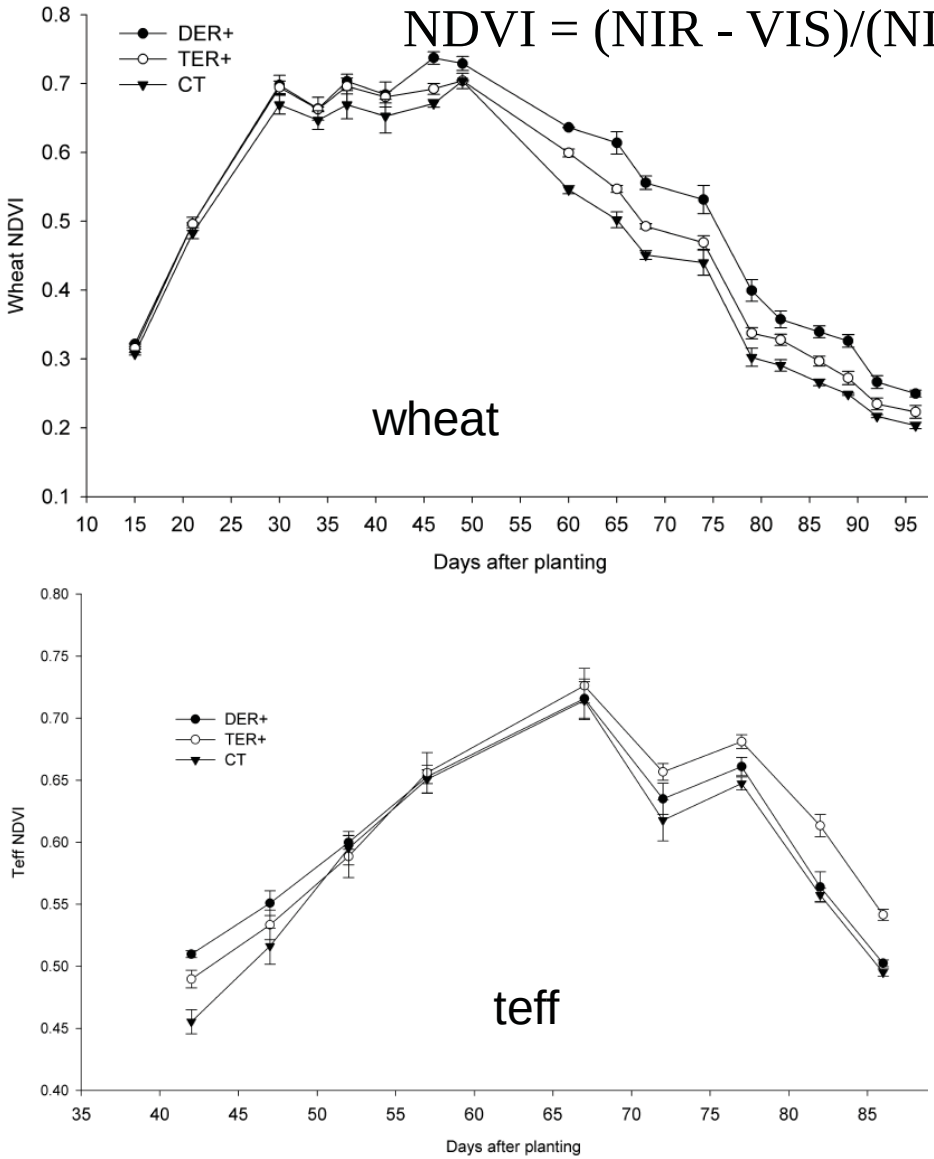
3. Results – why lower teff yields in DER+?

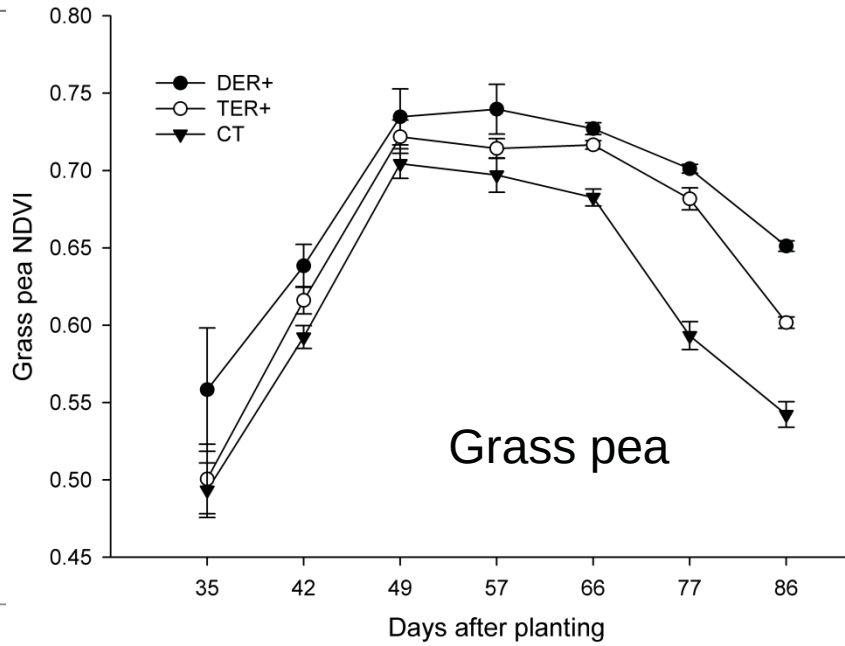
- lower teff yield in 2006 in DER+:
  - water logging in furrows: seeds are washed into furrows → teff grows in furrows
  - weed infestation



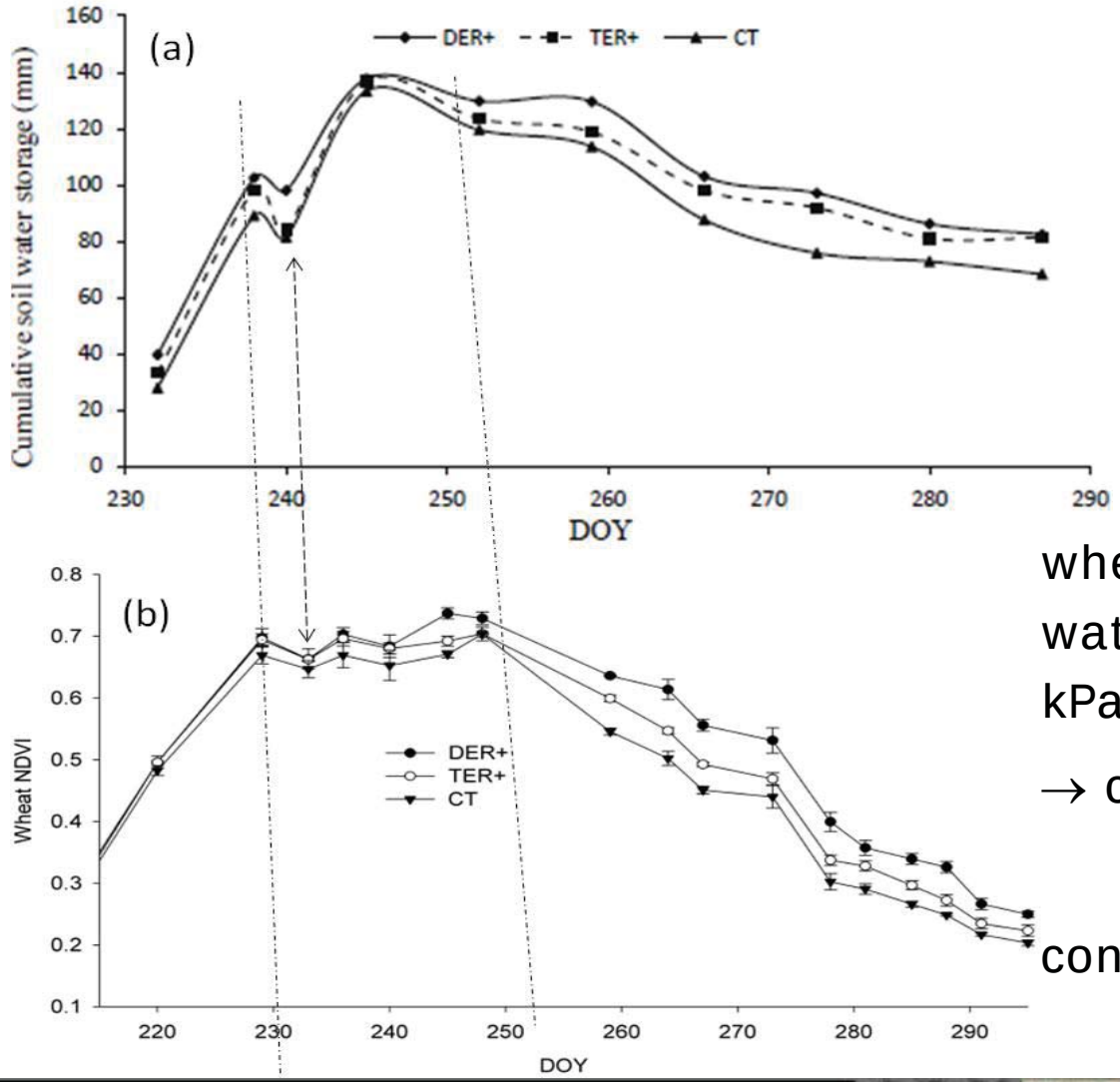
3. Results – does yield increases under CA?

NDVI = (NIR - VIS)/(NIR + VIS)





3. Results – Soil water storage and NDVI trends?



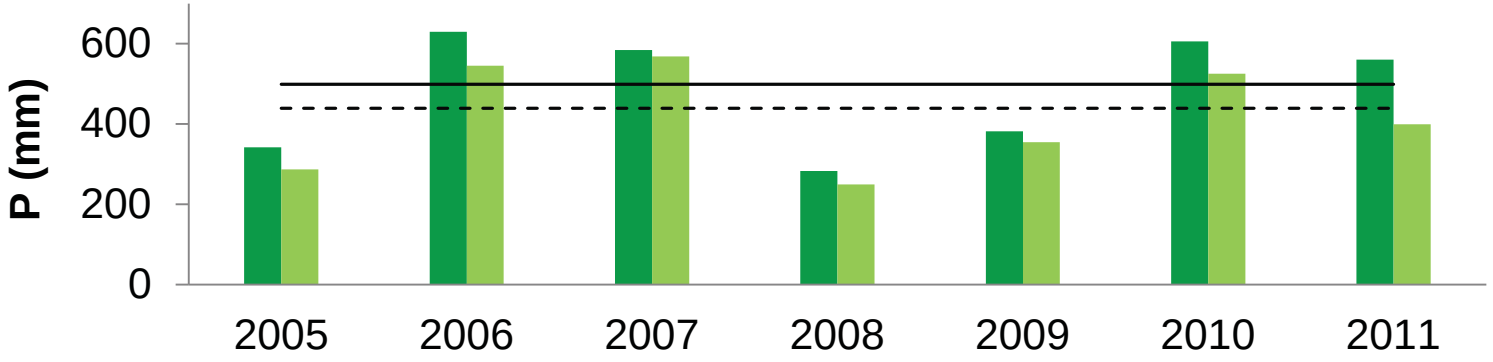
wheat:

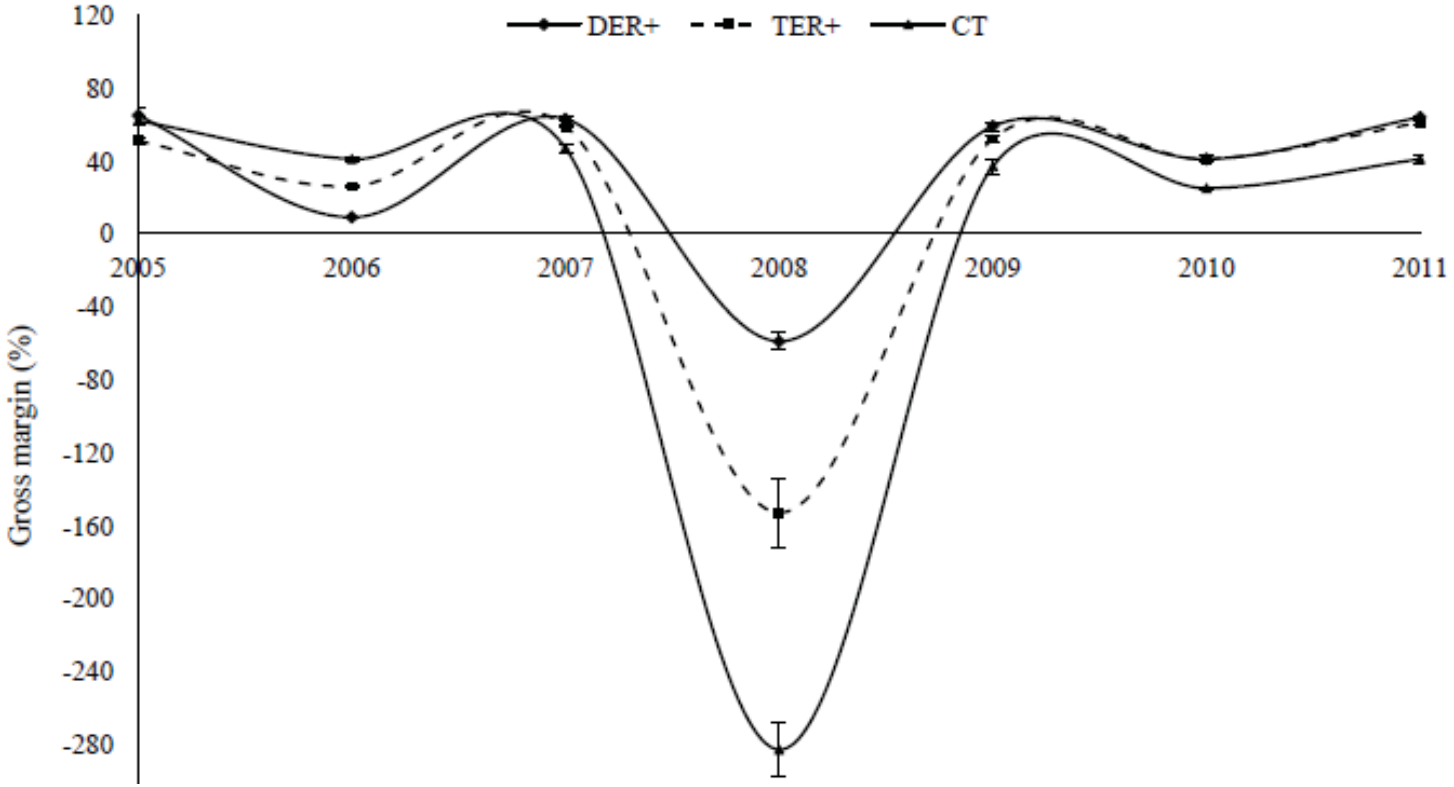
water stress from -50 to -90 kPa (Wesseling, 1991)

→ ca. 0.45 m^3 m^{-3}

continuous water stress

3. Results – does CA increase economic benefit?





4. Conclusions

- Soil loss and runoff: DER+ < TER+ < CT
- Soil water storage: DER+ > TER+ > CT
- Water loss (ET+D): DER+ > TER+ > CT
- beds avoid temporal water logging (except for teff)
- grain & straw yield of wheat/barley/grass pea: DER+ > TER+ > CT but not for teff in 2006
- The higher yield in CA plots might be due to improvements in soil hydrology: blue water as runoff was reduced and hence more green water
- We recommend DER + and TER+ planting sytems that employ CA principles for large scale dissemination and implementation on Vertisols.

Thank you for your attention!