Effects of Zero Tillage (No-Till) Conservation Agriculture on soil physical and biological properties and their contributions to sustainability

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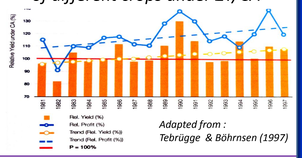
CONSERVATION AGRICULTURE = NO-TILLAGE OR MINIMUM SOIL DISTURBANCE

Economic results

Improvements in soil physical and biological conditions are mirrored by improved yields and profit. The Spanish Assoc. for CA (Living Soils - www.aeac-sv.org) showed consistent cost reductions and profit increases of ZT/CA versus IT and Min-Till (MT) in spite of slightly lower yields.

Yield is not absolute: profit is more important for sustainability

Germany : Relative yield and profit of different crops under ZT/CA

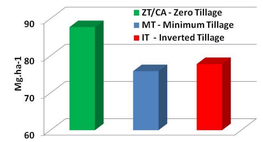


Adapted from : Tebrügge & Böhrnsen (1997)

Soil organic matter (SOM)

Tebrügge et al. (2001) have shown consistent relative gains of SOM over time under ZT/CA versus IT in Canada, Germany, Spain, Italy and Portugal; IT alone reduces SOM but ZT/CA builds it up. MT causes more SOM loss than IT.

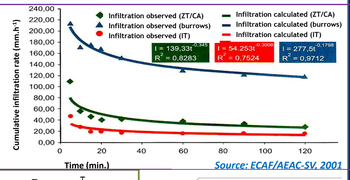
Which is more sustainable?



Soil water infiltration rate

Observed and calculated water infiltration rates ($mm.h^{-1}$) in Brazil under different management systems with and without beetle larva burrows. Earthworms have a similar effect.

Improved infiltration rates are essential to erosion control

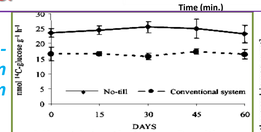


Source: ECAF/AEAC-SV, 2001

Biological Activity

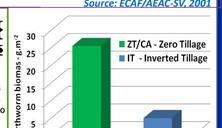
Microbial activity is considerably enhanced under ZT/CA systems. Both, in Europe and the Americas, earthworm populations increase by a factor of X10.

A living soil improves medium term nutrient availability and biological controls



Microbial activity in a Brazilian Rhodic Oxisol after 23 years

Source: Prata et al. (2005)

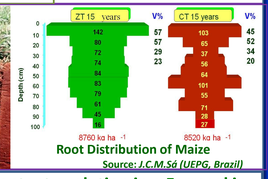


Source: Lane et al. (2006)

Rooting patterns

Rotation with pasture improves deep root distribution and SOM.

All impediments to root development must be removed before ZT/CA adoption



Root Distribution of Maize

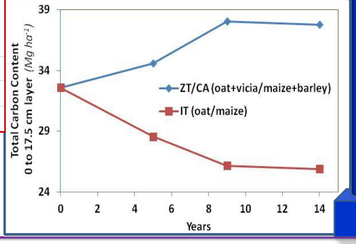
Source: J.C.M.Sá [UEPG, Brazil]

Soil Carbon Sequestration

Carbon sequestration after ZT/CA adoption (in relation to inverted tillage)	Carbon sequestration	CO_2 remotion from atmosphere for a 20 cm soil layer
	$kg\ C\ ha^{-1}\ year^{-1}$	$MgCO_2\ ha^{-1}\ year^{-1}$
Cerrado (tropical)	350	1.28
South (subtropical)	480	1.76

Sources: Bayer et al., 2000; Freitas et al., 2007

Carbon content evolution in a Ferrasol in southern Brazil *(Source: Bayer et al., 2000)*



General Numbers:

Europe: 0.4 MgC ha^{-1} yr^{-1} *(Smith et al., 1998)*

Brazil: 0.5 to 2.6 MgC ha^{-1} yr^{-1} *(Sá et al., in press)*

CONSERVATION AGRICULTURE = CROP ROTATION

Conservation Agriculture

No-tillage, crop rotation, cover cropping and permanent soil cover by residues are the pillars of Conservation Agriculture (CA), that reverses the historically accelerating degradation of soil organic matter (SOM) and soil structure, while increasing soil biological activity by a factor of 2 to 4.

Agronomic benefits of CA:

- No-tillage increases soil porosity, leaving old root holes to facilitate water drainage, averts pulverization of soil aggregates and formation of pans, reduces draft power for planting and
  gives shelter, winter food and nesting sites for fauna.
- Crop residues on the surface practically eliminate soil erosion, reduce water evaporation, and act as a reserve of organically-bound nutrients (as residues decompose to humus).
- More SOM means higher available water and nutrient retention, higher biological activity (enhancing biological controls), higher levels of water-stable aggregates and a positive carbon sink in incremental SOM.

Positive impacts for society:

- positive carbon sink in SOM and possible reductions in N_2O emissions
- reduced fossil fuel use and cultivation costs
- cleaner air through effective elimination of dust as a product of cultivation
- less water pollution and greater aquifer recharge from reduced rainfall runoff
- reduced demand for (tropical) de-forestation, by permitting crop expansion on steeper lands
- reduced flood and drought-induced famine risks
- increased wildlife populations (skylarks, plovers, partridge and peccaries)
- improved conservation mind-set in farmers.

It is notable that, in spite of successful practitioners in all European Countries, mainstream adoption is still to come: Europe´s CA area is 1.35 Mha, while the world area is some 125 Mha and growing at a rate of 7 Mha per year. More scientific evaluation of the benefits of this system is required, both to assist adoption and to trigger policy measures.

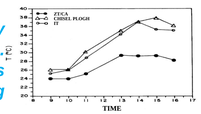
In the UE, CAP reform (greening) needs to consider making environmental services payments for these social benefits, since a reduction in single farm payments is ineluctable and carbon footprint reduction is of the essence, in the face of constantly-rising fuel prices and the need to cut GHG emissions.

As the principal farm tool which offers an effective and immediate solution towards positive changes in soil quality, productivity and sustainability, ZT/CA adoption needs financial incentives, which have high economic and environmental returns to society.

CONSERVATION AGRICULTURE = COVER CROPPING

Soil temperature

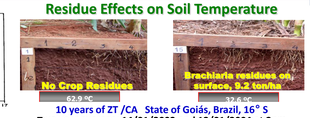
In Europe, crop residues may delay soil warming in spring. But higher albedo of residues could reduce global warming by 0.2ºC



Soil temperature at 5 cm depth in an oat/ corn sequence *Source: De Castro et al., 1987*

Lobell et al. (2006)

Residue Effects on Soil Temperature



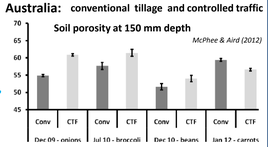
10 years of ZT /CA State of Goiás, Brazil, 16° S
Two year average: 14/01/2003 and 13/01/2004 at 2pm
Source : Embrapa CNPAF, Brazil

Subsoil compaction & B. Soil capping

A. Tracks (% covered ha^{-1}) + 54.5% higher in IT vs ZT/CA
Soil Density ($Mg\ m^{-3}$) in ZT/CA vs IT:
0-25 cm depth + 20%; at 25-35 cm depth – 7%.

B. Capping: ZT - Slight, IT- High (Hauert & Liniger, 2003)
Sealing index in crop = 62.5% higher in IT vs ZT/CA (Tebrügge 2001)

Australia: conventional tillage and controlled traffic



SOLUTION: A combination of Controlled Traffic Farming (CTF) and ZT/CA eliminates both problems.

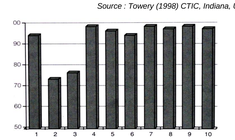
Erosion

Erosion is the most important cause of loss of productive land worldwide. Above about 70% of crop residue cover, erosion risk is minimal (graph at right).

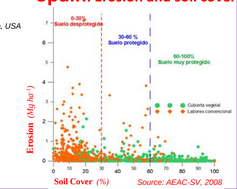
That´s why ZT/CA is SUSTAINABLE.

USA: Efficacy (%) of CA vs. IT in erosion control

Source : Towery (1998) CTIC, Indiana, USA



Spain: Erosion and soil cover



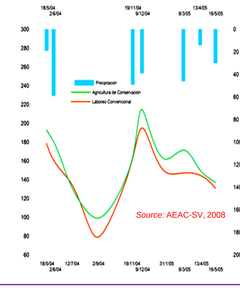
Source: AEAC-SV, 2008

Soil Moisture

The mulch effect of crop residues on the soil surface conserves soil moisture

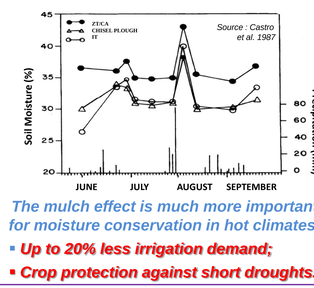
Crop residues as mulch also have multiple other functions for soil health.

Spain



Source: AEAC-SV, 2008

Brazil



The mulch effect is much more important for moisture conservation in hot climates:

- ***Up to 20% less irrigation demand;***
- ***Crop protection against short droughts.***

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The principles of Zero Tillage and Conservation Agriculture are universal, the solutions are local

CONSERVATION AGRICULTURE = PERMANENT SOIL COVER BY RESIDUES