No-tillage as technology to prevent desertification

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Agenda

- Desertification: extent, cause and consequence
- No-tillage: extent and importance
- No-tillage and erosion
- No-tillage and soil organic matter
- No-tillage and soil health/quality
- No-tillage and production
- Conclusion

Objectives

- This presentation aggregated research on several aspects to show how no-tillage affect soils and crops to prevent desertification.
- It is difficult to arrest the process of desertification.
- The paper just illustrates the importance of no-tillage systems as technologies for preventing desertification.
- The paper is aiming to implement the UNCCD in its goal to combat desertification and drought with the no-tillage system.

Desertification: Définitions

- Overall environmental (natural resources) and socio-economic degradation.
- Evolution from viable to desertlike lands
- UNCCD restricted desertification to drylands receiving from less than 150mm to 800 mm per year.
- Desertification can howver occur in most climates.
- Socio-economical driven phenomena ratter than climatically driven environmental change
- Desertification reduces the land's resilience to climate variability.

Desertification: definitions

- A set of biological, chemical and physical processes which converge to create desertlike conditions (Rozanov)
- A social problem involving people at all stages (Spooner)
- Lands become irreversibly sterile in human time terms and within reasonable economic limitations (Mainguet)
- A diminution or a loss of the potential for sustainable use (Warren & Agnew)
- Difficulty of seed germination is the fundamental criterion for desertification (Dregne)

Driving forces and consequences

- The causes and impacts are complex.
- Desertification is a global issue linking degradation to food production and availability.
- About 900 million people in more than 100 countries are at risk from desertification.

Driving forces and consequences

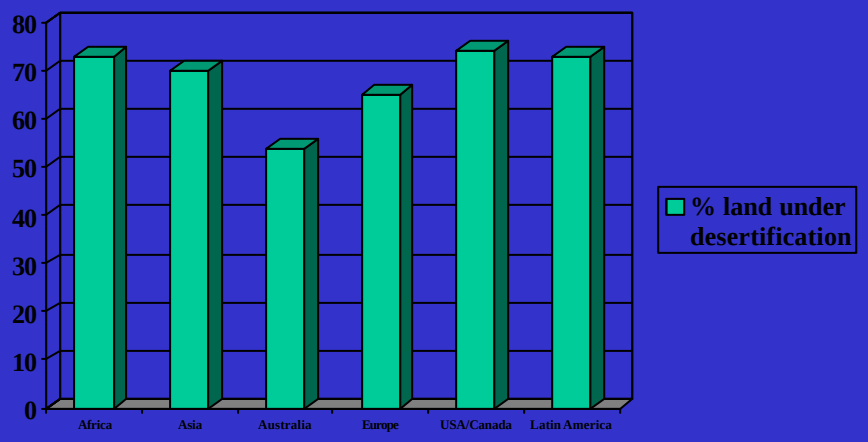
- **The dominant role is played by slight (41%) and moderate (45%), while strong (13%) and extreme (1%) degrees of desertification are not very significant.**
- **Major causative factors responsible for desertification are overgrazing (34%), deforestation (29%) and mise-management of soils (28%).**

Desertification: context

This is not desertification but desert-like 'paysage'

In the agricultural sense, desertification leads to a loss of sustainable production through its alteration in one or all of a soil's physical, biological and chemical properties and processes.
The most widely desertification processes in agricultural lands are soil erosion, compaction and organic matter and nutrient loss.

Desertification : Importance



Problems in modern farming: numbers!

- World-wide soil degradation mechanisms for all land-use types:
  - Water erosion: 56%
  - Wind erosion: 28%
  - Chemical degradation: 12%
  - Physical degradation: 4%
  - Biological degradation: ?
- Erosion causes the world's topsoil to be lost at an estimated 0.7% per year.

Is there enough land for all?

Millions hectares	Land area	Arable land	Irrigated land	Potentially cultivable
Developed	**5,773**	**677**	**59**	**877**
Developing	**7,619**	**784**	**152**	**2,154**

<12% of the earth's total land surface is currently cultivated and little arable land is available

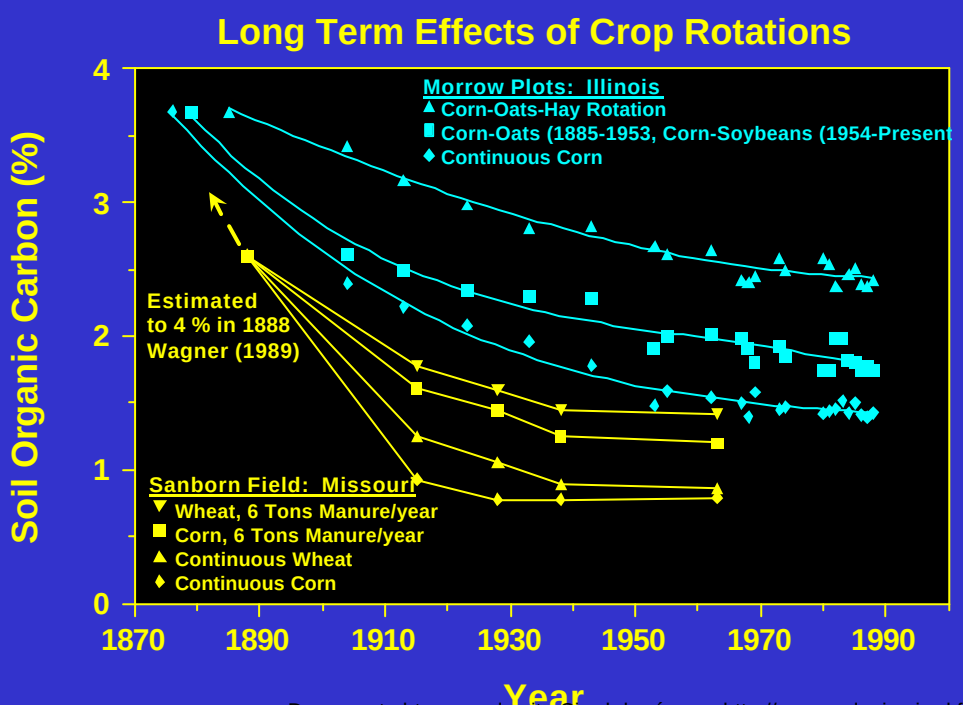
The results of desertification is not just lands are gone out of production but that less degraded lands need investments and inputs to be productive.

Mechanical Tillage: A serious cause of desertification

- Mechanization of agricultural systems has been accompanied by damaging effects and pressure on the environment.
- These negative effects on the environment created an increasing awareness of the need for an economically and environmentally sustainable agriculture and consequently a review of much of the soil management practices.
- The need for tillage has been questioned, in the last 5 decades, partly because of the excessive erosion from farmlands.

Mechanical Tillage: A serious cause of desertification

- In developing world, Intensive land cultivation methods using tractors and plow are a major cause of severe soil loss and land degradation.
- In industrialized world, exaggerated mechanized tillage using powerful heavy machines has caused compaction and soil damage.
- Especially in warmer areas, where the topsoil layer is thin, conventional tillage contributes to soil loss.








Erosion of agricultural soils: various forms

Photos: Séguy et al.

Tillage
Translocation or
Erosion =

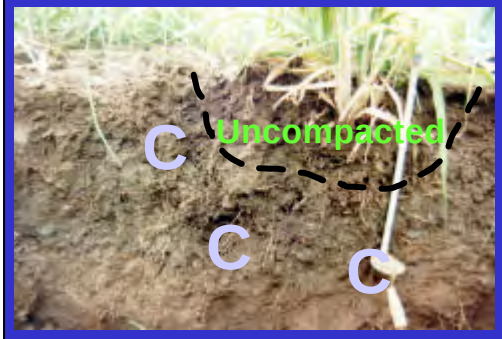
Desertification

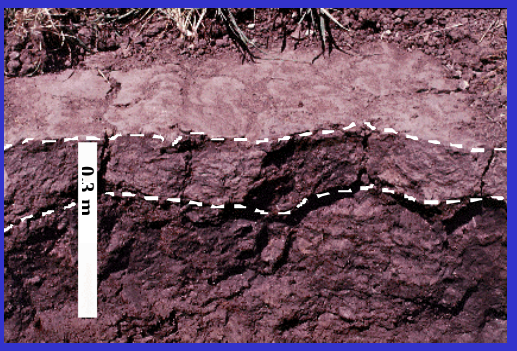



Water but also the best of soils is lost: organic matter, nutrients and clay particles

A selective process with the most fertile soil particles taken away
It is also carrying applied fertilizers.

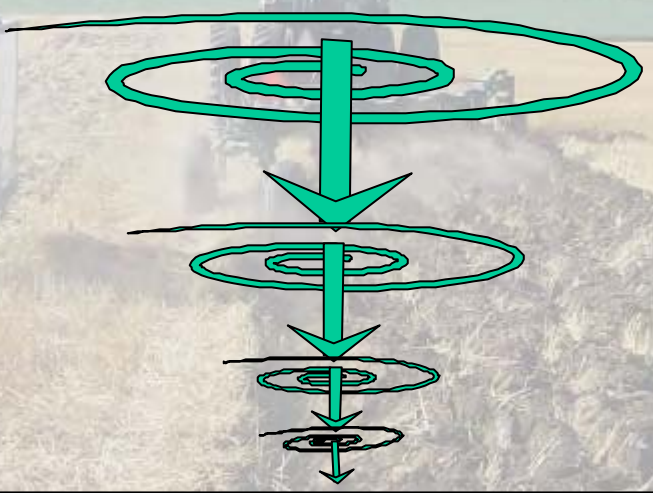
Already to difficult and expensive to manage





Compaction: severely restricted root growth and erosion of topsoil (Photos by McGarry)

Intensive tillage causes an accelerated downward spiral of soil degradation.



Degraded soil + water loss

Desertification: cause of no-tillage development

What is No-tillage system?

A production system where soils are not manipulated with tillage tools and are protected by mulch cover

The four principles of no-tillage system are:

1. **Maintaining soil cover with plant residues or/and Cover crop**
2. **Elimination of mechanical soil tillage**
3. **Weed control**
4. **Direct seeding with special instruments**

Known Benefits of No-tillage Agriculture

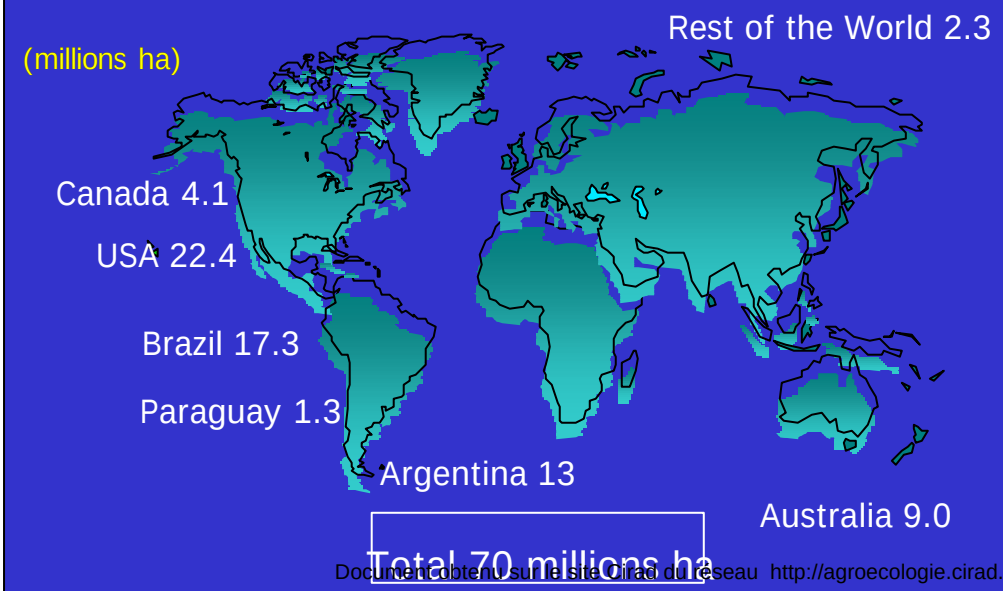
- **Reduced labor requirements**
- **Time and Fuel savings**
- **Reduced machinery wear**
- **Improved long- term productivity**
- **Improved surface water quality**
- **Reduced soil erosion and Improved water infiltration**
- **Greater soil moisture retention**
- **Improved soil tilth and Decreased soil compaction**
- **More wildlife**
- **Reduced release of carbon gases**
- **Reduced air pollution Reduced air pollution**

Evolution of no-till in the world

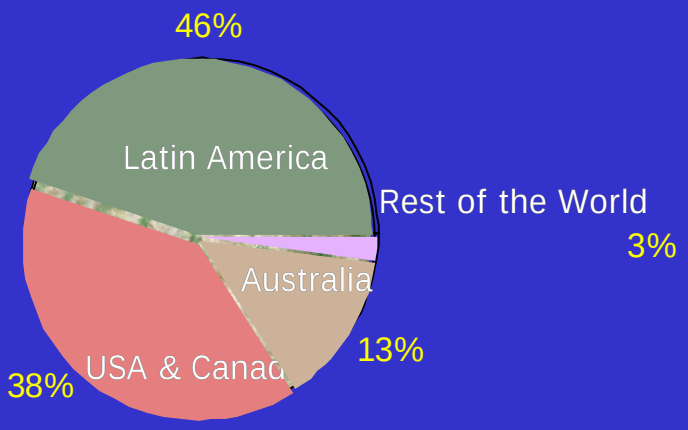
Countries	Area cropped in million hectares			
	1973-74	1988-89	1996-97	1999-2000
USA	2.2	6.5	19.4	21.12
Australia	0.1	0.4	1.0	8.64
Brazil	0.01	1.9	6.5	14.33[2]
Canada		1.9	6.7	4.08
Argentina[1]		1.1	4.4	10.50
Mexico			0.5	0.65
Paraguay			0.5	1.10
Spain			-	1.00[3]
Others			0.8	1.00

Derpsch, 2001

Worldwide Adoption of No-tillage Systems 2002

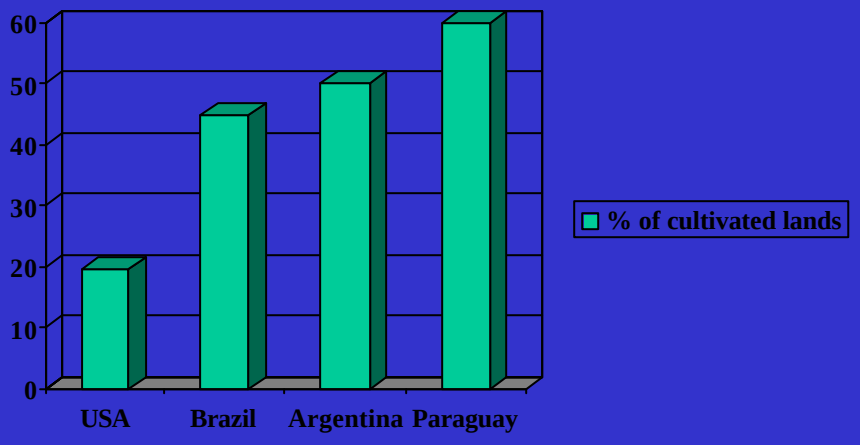


No-tillage adoption in the World

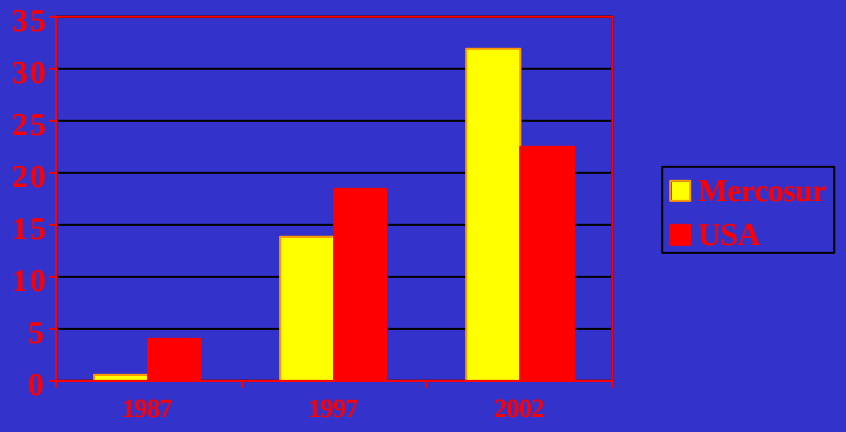


84% of No-tillage systems is practised in America

No-tillage importance in selected countries



No-tillage expansion in Millions of Hectares



NT Reality

- **World cropland ~1500 M ha**
- **World No-Till cropland ~70 M ha**

Only 4% of the world's cultivated land is under no-tillage systems

We have a long way to go to get no-tillage systems implemented around the world.

No-tillage system vs. soil erosion

Where crusting is occurring no-tillage is the solution

The impact of raindrops on bare soil surface

It is equivalent, in one year, to 50 ton/ha of dynamite on a fragile bare soil

Soil cover reduces the negative effect on soil porosity of raindrop impacts. The consequence is greater infiltration of rainwater into the soil.

In No-tillage the soil is never tilled

Retention of crop residues or cover-crop distinguish NT to other conventional production systems characterized by maintaining the soil surface bare and exposed to rain, heat and wind.

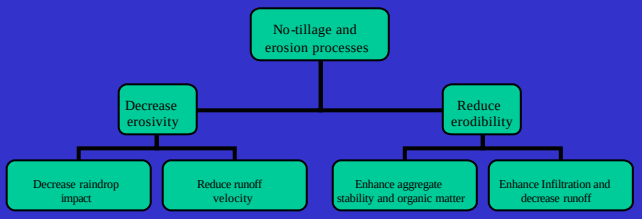
Soil erosion and water infiltration

Many farmers, researchers and extension agents still believe that loosening the soil with tillage implements increase rainwater infiltration

Soil cover is a key factor to reduce soil erosion by runoff and increase water infiltration into the soil

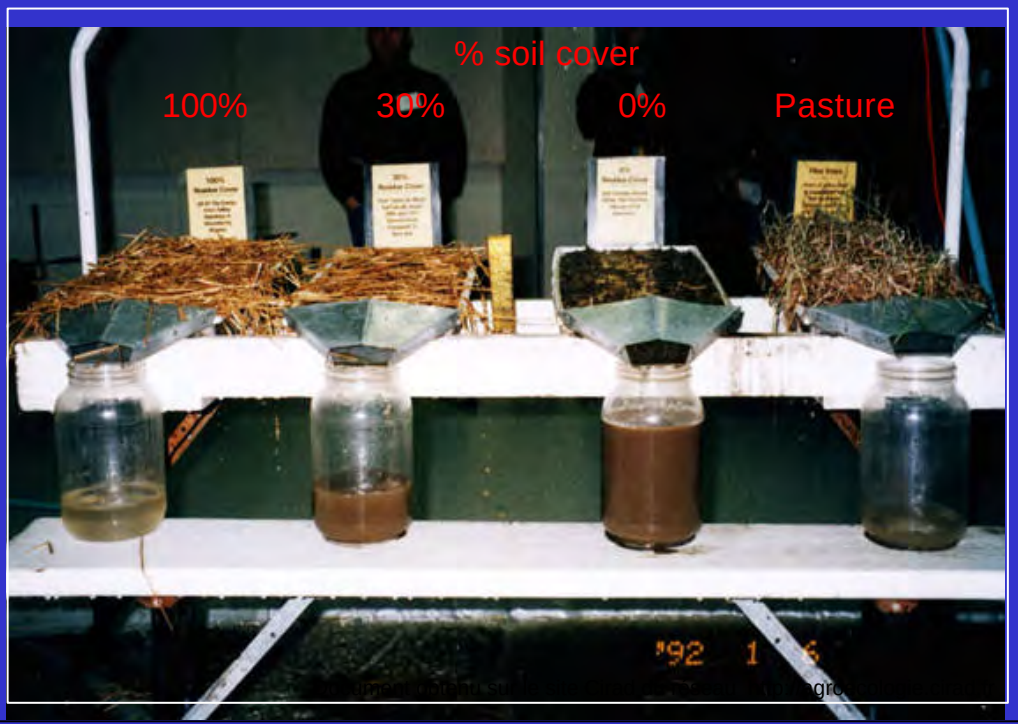
Erosion can be reduced by 90% under NT full cover
Even a modest amount of soil cover (30%) give substantial improvements in water conservation, soil quality and, especially, erosion control

Mechanisms and processes in erosion control by no-tillage systems

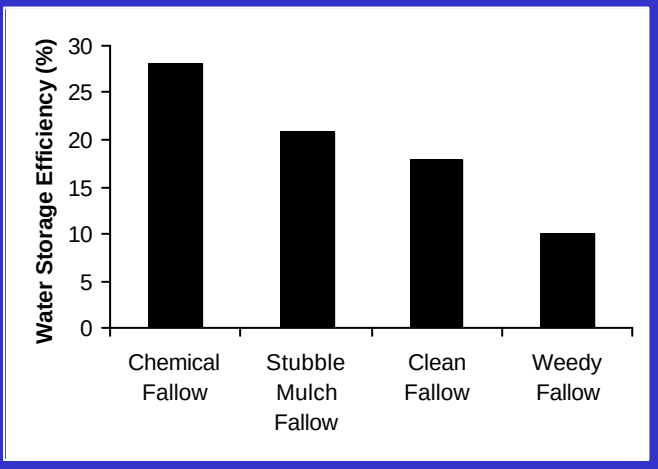


In most climates, NT reduced soil erosion (by wind and water) almost in direct proportion to the amount of mulch cover

Water infiltration and runoff: a simple evidence

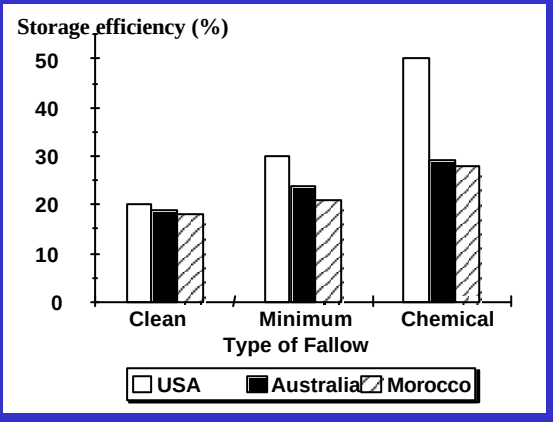


No-tillage system: Water conservation and storage



Reduced evaporation has resulted in additional water storage.
This has been expressed in improved crop yields.

No-tillage system: Water conservation and storage



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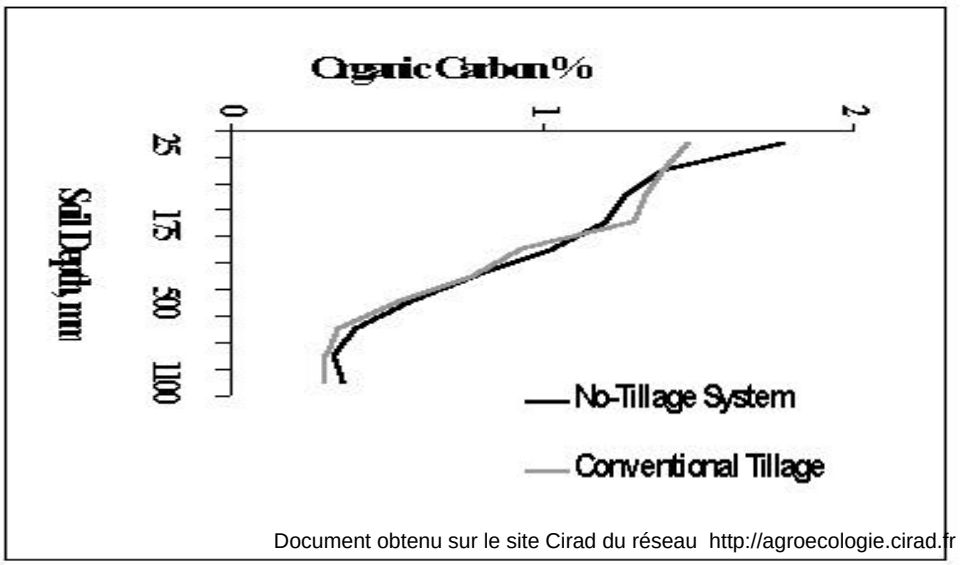
Document obtenu sur le site Cirad du réseau http://agroecologie.cirad.fr

No-tillage increases soil organic matter and nutrient availability

- No-tillage mulch builds soil organic matter
- Soil organic matter keeps soil healthy and full of nutrients
- The process is similar to composting

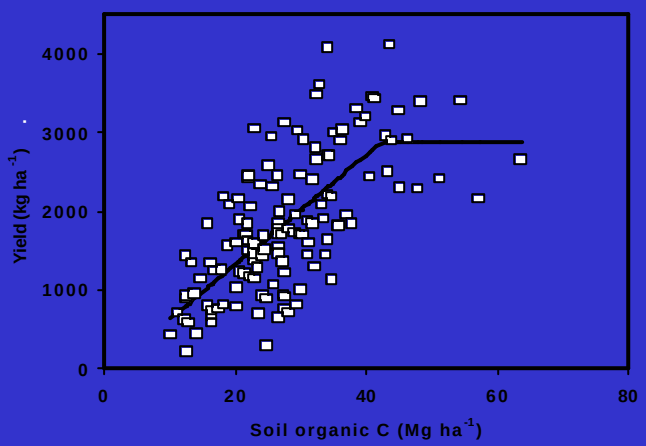
No-Tillage: Organic Carbon Profile Distribution



Tillage effect on soil organic matter (g kg^{-1}) in different Mediterranean countries

Country	Soil	Horizon (mm)	Texture	Conventional Tillage	No-Tillage
France	Alfisol	0-50	Loam	17.3	21.5
Italy	Entisol	0-100	Clay	14.3	20.1
Morocco	Mollisol	0-25	Clay	26.6	38.2
Portugal	Vertisol	0-100	Clay	19.1	25.3
Spain	Alfisol	0-50	Loam	12.0	18.9
	Alfisol	0-75	Loam	13.8	24.1
	Vertisol	0-50	Clay	14.3	26.9
Syria	Inceptisol	0-100	Clay	11.0	17.5

Wheat grain yield and soil organic C in 134 farmer fields of the inland western Pampas region, Argentina



Renewed recognition of the importance of soil organic matter.

If TOC < 42.0 Mg ha-1, Yield = -74.4 + 70.0 x TOC and if
TOC > 42.0 Mg ha-1, Yield = 2938.6 (r^2 = 0.477, $p < 0.01$)

Díaz-Zorita et al., 1999

Photos by Benites

Soil Health or Biological Tillage

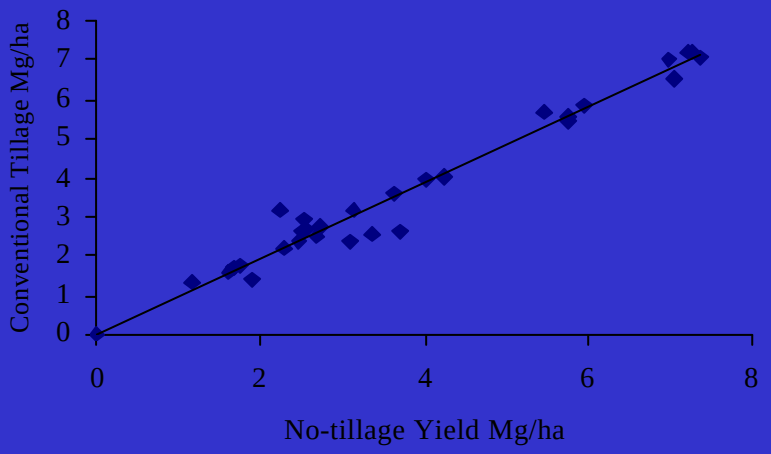
NT promotes biological activity in the soil and the development of a biologically-based soil structure.

No-tillage: Soil Quality against erosion

- Good Quality soil
  - Increased beneficial organisms
- Improved movement of air, water and nutrients
- Higher nutrient availability (improved budget in soil)
  - Better root growth & development

Dual goals of reducing off-site negative environmental impacts and enhancing on-site soil quality and productivity

Wheat yield & no-tillage and conventional tillage worldwide



No-till planter: to penetrate and interact with covered and intact soils

No-tillage system has been adopted for grain crops and pulses, for sugar cane, vegetables, potatoes, beets, cassava and fruits.

Cucumber

Sweet pepper

Onions

Tomato

Squash

Cassava

Strong visible evidence of of rainfall

Conventional tillage – is "an old style" system

No-tillage system is much "beneficial"

We need to stop exhausting soils and learn respecting them

tillage is NOT a panacea for increased productivity !

no-tillage is an ultimate system to simultaneously Increase productivity and improve soils