The No-Till Show and Conference, Groundswell, Weston Park Farms, Hitchin, Hertfordshire, UK, 30 June 2016

The No-Till Revolution: A Worldwide Phenomenon

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Global Conservation Agriculture Community of Practice (CA-CoP)
• Why the need for a worldwide No-Till revolution?

• What does No-Till revolution offer in terms of mobilizing greater crop and land potentials?

• What is the scale and geography of No-Till revolution?
Conventional land preparation
regular tillage, clean seedbed, exposed

Effects:
• Loss of organic matter
• Loss of pores, structure → soil compaction
• Destruction of biological life & processes
But underneath?
Residue retention distinguishes CA from conventional farming systems.

Soil crusts – no mulch low SOM
Stagnating Yields (yield gap)

Rising-plateau regression analysis of wheat yields throughout various European countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Year of stagnation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Denmark</td>
<td>1995 (**)</td>
</tr>
<tr>
<td>France</td>
<td>1996 (**)</td>
</tr>
<tr>
<td>Germany</td>
<td>1999</td>
</tr>
<tr>
<td>Italy</td>
<td>1994</td>
</tr>
<tr>
<td>Netherlands</td>
<td>1993 (**)</td>
</tr>
<tr>
<td>Spain</td>
<td>1989</td>
</tr>
<tr>
<td>Switzerland</td>
<td>1990 (**)</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>1996 (**)</td>
</tr>
</tbody>
</table>

But inputs and input costs going up, diminishing returns setting in,
Water infiltration, just after a thunderstorm
Runoff and soil erosion
TILLAGE AGRICULTURE -- Erosion
Degradation of soil, water and biodiversity resources

All agricultural soils show signs of degradation

World map of severity of land degradation – GLASOD (FAO 2000)
Also, the Millennium Ecosystem Assessment 2005 – 89% our ecosystems
   Degraded or severely degraded, only 11% in reasonable shape. 400-500 M ha lost
Consequences of tillage-based agriculture at any level of development

FOR THE CROP (AND SOCIETY)

• Higher production costs, lower farm productivity and profit, sub-optimal yield ceilings, poor resilience

• less use efficiency of mineral fertilizer: “The crops have become ‘addicted’ to fertilizers”

• loss of (agro)biodiversity in the ecosystem, below & above soil surface

• more pest problems (breakdown of food-webs for micro-organisms and natural pest control)

• falling input efficiency & factor productivities, declining or stagnating yields

• reduced resilience, reduced sustainability

• Poor adaptability to climate change & mitigation
Consequences of tillage-based agriculture at any level of development

FOR THE LAND (AND SOCIETY)

• Dysfunctional ecosystems, loss of biodiversity, degraded ecosystem services -- water, carbon, nutrient cycles, suboptimal water provisioning & regulatory water services etc. Low livestock and human carrying capacity.

• Loss of OM, porosity, aeration, biota (=decline in soil health -> collapse of soil structure -> compaction & surface sealing -> decrease in infiltration)

• Water loss as runoff & soil loss as sediment

• Loss of time, energy, seeds, fertilizer, pesticide (erosion, leaching)

• Less capacity to capture and slow release water & nutrients
What does No-Till revolution offer in terms of greater crop and land potentials?
Technical objectives of SPI

- Agricultural land productivity
- Natural capital and flow of ecosystems services

*Simultaneously*

- Enhanced input-use efficiency
- Build farming system resilience (biotic and abiotic), including being climate-smart
- Contribute to multiple-outcome objectives at farm, community & landscape, and national scales e.g. climate change mitigation
  
  *And*

- Capable of rehabilitating land productivity and ecosystem services in degraded and abandoned lands

These objectives can be and are being met with No-Till CA
Conservation Agriculture is an approach to managing agro-ecosystems for improved and sustained productivity, increased profits and food security while preserving and enhancing the resource base and the environment. CA is characterized by three linked principles, namely:

1. Continuous no or minimum mechanical soil disturbance.
2. Permanent soil mulch cover - crop residues, cover crops.
3. Diversification of crop species grown in sequences or associations or rotations.

Along with other GAPs → SPI & CSA
No-Till CA works because it pays attention to:

- the ecological foundation of production system
- Soil health and biology
- Biodiversity
- Ecosystem services
CA does not solve **ALL** problems (NO panacea) but complemented with other good practices CA base allows for high production intensity and sustainable agriculture in all land-based production systems (rainfed & irrigated, annual, perennial, plantation, orchards, agroforestry, crop-livestock, rice systems).
Soil productive capacity (vs. fertility) is derived from several components which interact dynamically in space and time:

- **Physical**: architecture - pore structure, space & aeration
- **Hydrological**: moisture storage - infiltration
- **Chemical**: nutrients, CEC, dynamics
- **Biological**: soil life & non living fractions
- **Thermal**: rates of biochemical processes
- **Gravity**: retention & flows of liquids
- **Cropping system**: rotation/association/sequence

A productive soil is a living system and its health & productivity depends on managing it as a ‘complex’ biological system, not as a geological entity.
Pays attention to biodiversity

Soil food webs...

Co-evolved plant-microbiome interactions

Above ground food webs & habitats for natural enemies of pests

Pest-predator dynamics

Ground-nesting birds, animals and insects
Pays attention to eco-agriculture landscapes: harmonizing multiple objectives at farm, community, landscape scales

Monteverde Cloudforest Reserve provides important source of water in landscape and downstream

Path to waterfall on private property brings income to locals in the form of ecotourism

Windbreaks provide habitat and corridors for wildlife, control erosion and protect livestock from wind

Shaded coffee extends wildlife habitat from reserve and reduces erosion

Coffee, corn, sugar cane and other products are sold at a local cooperative

All fences are live rows of trees
Pays attention to harnessing ecosystem services from Land

Source: The Millennium Ecosystem Assessment (2005)
Sustainable Land Preparation - smallholders

Planting holes, ripping or mulching, direct drill
No-till in Europe

(W. Sturny)
Scale and Geography of No-Till Revolution

With evidence of superior performance of crop and land productivity in the tropics, subtropics and temperate regions
History and Adoption of CA (2013). Since 2008/09 increasing at 10 M ha annually.
### Area of cropland under CA by continent - 2013

(source: FAO AquaStat: [www.fao/ag/ca/6c.html](http://www.fao/ag/ca/6c.html))

<table>
<thead>
<tr>
<th>Continent</th>
<th>Area (Mill. ha)</th>
<th>Per cent of global total</th>
<th>Per cent of arable land of reporting countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>South America</td>
<td>66.0 (49.6)*</td>
<td>41.3 (34)#</td>
<td>60.0</td>
</tr>
<tr>
<td>North America</td>
<td>54.0 (40.0)</td>
<td>34.8 (40)</td>
<td>24.0</td>
</tr>
<tr>
<td>Australia &amp; NZ</td>
<td>17.9 (12.2)</td>
<td>11.5 (47)</td>
<td>35.9+</td>
</tr>
<tr>
<td>Asia</td>
<td>10.3 (2.6)</td>
<td>6.6 (291)</td>
<td>3.0</td>
</tr>
<tr>
<td>Russia &amp; Ukraine</td>
<td>5.2 (0.1)</td>
<td>3.4(5000)</td>
<td>3.3</td>
</tr>
<tr>
<td>Europe</td>
<td>2.1 (1.6)</td>
<td>1.4 (31)</td>
<td>2.8</td>
</tr>
<tr>
<td>Africa</td>
<td>1.2 (0.5)</td>
<td>0.8 (140)</td>
<td>0.9</td>
</tr>
<tr>
<td><strong>Global total</strong></td>
<td><strong>157 (106)</strong>*</td>
<td><strong>100 (48)#</strong></td>
<td><strong>10.9 (7.4)*% global cropland + includes non-cropland</strong></td>
</tr>
</tbody>
</table>

* Includes non-cropland

~50% in developing regions, ~50 % in industrialized regions
Conservation Agriculture globally 157 Million ha (2013) (~11% of annual cropland)
Documented benefits of CA for food security, environment, sustainability, rehabilitation

**Small scale** -- Paraguay, Tanzania, India, China, Lesotho, Zimbabwe, Zambia, Mozambique ......

**Large scale** – Canada, USA, Brazil, Australia, Argentina, Kazakhstan ......

*publications*
Drivers for adoption of CA

• **Erosion:** North America, Brazil, China
• **Drought:** China, Australia, Kazakhstan, Zambia
• **Cost of production:** global
• **Soil degradation:** global
• **Ecosystem services:** global
• **Climate change A&M:** global
• **Sustainable intensification:** global
• **Pro-poor:** developing regions

**Spread is farmer-led** but needs policy & institutional support, specially for smallholders
Challenges/issues/considerations of transformation and transition

- Weeds/herbicides
- Labour
- Larger farms
- Livestock
- Community engagement
- Temperate areas

- Farmers working together
- Equipment and machinery
- Knowledge and technical capacity
- Risk involved in transforming to no-till systems
- Approaches to adoption and scaling
- Policy and institutional support – private, public, civil society
Patterns of benefits and evidence of superior performance with Conservation Agriculture
Impact pattern with CA – small or big farms

CROP

• Increased & stable yields, productivity, profit (depending on level and degradation)
• Less fertilizer use (-50%) no fertilizer less pesticides (-20->50%) no pesticides
• Less machinery, energy & labour cost (50-70%)
• water needs (-30-40%)

LAND

• Greater livestock and human carrying capacity
• Lower impact of climate (drought, floods, heat, cold) & climate change adaptation & mitigation
• Lower environmental cost (water, infrastructure)
• Rehabilitation of degraded lands & ecosystem services
Empirical evidence: The Frank Dijkstra farm in Ponta Grossa, Brazil - Sub-humid tropics

Source: Dijkstra, 1998
Wheat yield response to nitrogen fertilization (--- according to the model) - Dry sub-tropics WR

Carvalho et al., 2012
Longer term maize grain yields on farmers fields in Malawi – Lemu – Semi-arid tropics

Harvest year
2007 2008 2009 2010 2011 2012
Maize biomass yield (kg ha\(^{-1}\))

- Conventional control, maize (CPM)
- CA, maize (CAM)
- CA, maize/legume intercropping (CAML)

![Bar chart showing maize biomass yield across different years and treatments.](chart.png)
Longer term maize grain yields on farmers' fields in Malawi - Zidyana

CIMMYT– Thierfelder et al.
Economic viability-Malawi

<table>
<thead>
<tr>
<th></th>
<th>Lemu</th>
<th>Zidyana</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CP</td>
<td>CA</td>
</tr>
<tr>
<td>Gross Receipts</td>
<td>528.6</td>
<td>881.5</td>
</tr>
<tr>
<td>Variable costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inputs</td>
<td>238.5</td>
<td>341.0</td>
</tr>
<tr>
<td>Labour days (6 hr days)</td>
<td>61.7</td>
<td>39.9</td>
</tr>
<tr>
<td>Labour costs</td>
<td>159.5</td>
<td>103.2</td>
</tr>
<tr>
<td>Sprayer costs</td>
<td>1.7</td>
<td>1.2</td>
</tr>
<tr>
<td>Total variable costs</td>
<td>398.1</td>
<td>445.9</td>
</tr>
<tr>
<td><strong>Net returns (US$/ha)</strong></td>
<td><strong>130.5</strong></td>
<td><strong>435.5</strong></td>
</tr>
<tr>
<td>Returns to labour (US$/day)</td>
<td>1.8</td>
<td>5.2</td>
</tr>
</tbody>
</table>

Source: Ngwira et al., 2012
### SUMMARY OF ANNUAL EXPENSES

<table>
<thead>
<tr>
<th></th>
<th>CONVENTIONAL TILLAGE (Year 2000)</th>
<th>DIRECT DRILLING (Year 2003)</th>
<th>REDUCTION (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintenance and repair of tractors</td>
<td>10 450.47 €</td>
<td>1 507.15 €</td>
<td>85</td>
</tr>
<tr>
<td>Maintenance and repair of tillage/drilling implements</td>
<td>8 158.41 €</td>
<td>1 840.40 €</td>
<td>77.5</td>
</tr>
<tr>
<td>Fuel</td>
<td>17 460 €</td>
<td>7 110 €</td>
<td>60</td>
</tr>
<tr>
<td>Labour</td>
<td>25 000 €</td>
<td>15 000 €</td>
<td>40</td>
</tr>
<tr>
<td><strong>TOTAL ANNUAL</strong></td>
<td><strong>61 068.88 €</strong></td>
<td><strong>18 347.55 €</strong></td>
<td><strong>70</strong></td>
</tr>
</tbody>
</table>

Farm power – 4 tractors with 384 HP under tillage & 2 tractors with 143 HP under no-till
Farm near Evora, South Portugal
Example 1-- Canada: Carbon offset scheme in Alberta

Sequestering soil Carbon with CA and trading offsets with regulated companies to offset their emissions by purchasing verified tonnes (from ag and non-ag sectors)

Source: Tom Goddard et al.
Water resources are threatened by conventional tillage agricultural practices. Conservation Agriculture is an alternative to reduce impacts on river’s quality and to maintain a higher level of productivity and sustainability.

Cultivating Good Water Programme

Itaipu reservoir dam today (source: Itaipu Binacional)
• CA can sustainably mobilize greater crop and land potentials with increased efficiency and resilience.

• CA offers greater output and profit to smallholders and large farmers, with less resources and minimum land degradation.

• CA is increasingly seen as a real alternative for SPI and ES, and it is spreading at an annual rate of 10 M ha.
And, the messages, once understood, even make people dance!

More information: amirkassam786@googlemail.com
http://www.fao.org/ag/ca
Join CA-CoP
The Supply Side – what does it look like?

Latest FAO projections for 2050 – 50-70% increase globally = 0.9% increase annually

<table>
<thead>
<tr>
<th>Year</th>
<th>Population (billion)</th>
<th>Cereal output (mil. t)</th>
<th>Net Production Area (mil. Ha)</th>
<th>Yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>7.2</td>
<td>2,532 (352 kg pc)</td>
<td>715</td>
<td>3.54</td>
</tr>
<tr>
<td>2050</td>
<td>9.2</td>
<td>3,280 (356 kg pc)</td>
<td>763</td>
<td>4.30 (3.44)#</td>
</tr>
<tr>
<td>Plateau</td>
<td>10.0~</td>
<td>5,000* (500 kg pc)</td>
<td>763^</td>
<td>6.55 (5.24)#</td>
</tr>
<tr>
<td>(2100+)</td>
<td></td>
<td>or 1000^</td>
<td></td>
<td>5.00 (4.00)#</td>
</tr>
</tbody>
</table>

* at 500 kg/capita which is the current Western European level of cereal use (including wastage)

# with 50% cut in food waste

^ Cereal: non-cereal ratio is ~50:50; so total arable land requirement would be 2,000 M ha assuming some expansion in cropland or could be 1,470 M ha assuming no expansion beyond 2050. In addition, we need land for permanent crops which could mean another 500 M ha. So the total land required to meet future demand would be somewhere between 2000 and 2,500 M ha.

Potential suitable land is 4,495 M ha, currently used is 1,559 M ha. Marginal land is 2,738 M ha, which includes some 400-500 M ha of abandoned land due to degradation (Gibbs and Salmon, 2015).

If we decide to eat less meat in the future, then the required area and yields can be lower. There is also the biofuel question which will push the area up.
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