Climate Change Mitigation and Adaptation Potential of Conservation Agriculture: Effects on Runoff, Rainwater Use Efficiency, Soil Moisture, Soil Organic Carbon and Energy Use

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22-25 June, 2014
Outlines:

CA benefits
Experimental details, baseline information & field lay out
Effects of CA on-
    Runoff
    RWUE
    Soil moisture
    SOC
    Energy use & CO₂ emission
Major challenges we faced
Conclusions
Benefits of CA:

Conservation Agriculture

- **Residue retention/Cover crops**
  - Improves water infiltration
  - Improves water holding capacity of soil
  - Reduces evaporative losses of stored soil water
  - Protects soil against raindrop hammering, lesser detachment of soil particle
  - Reduces runoff volume, lesser loss of fertile soil
  - Protects soil from wind erosion

- **Zero tillage**
  - Improves nutrient recycling
  - Improves soil quality
  - Cover crops fix atmospheric N through BNF
  - Reduces nutrient losses through water and wind erosion
  - Improves biological activities in soil
  - Improves nutrient availability
  - Helps in timely sowing
  - Saves energy, time and labour

- **Crop rotations**
  - Legumes in rotation enriches soil through BNF
  - Promotes C sequestration in deeper layers
  - Improves nutrient recycling
  - Creates near-natural conditions for soil life
  - Crop rotations help in insect-pest and disease management
  - Lesser use of pesticides

**Benefits of CA in summary**

- Soil conservation
- Improved soil quality
- Input saving
- More water available to plants/soil biota
- Carbon sequestration
- Reduced GHGs emission
- High biodiversity

**Higher productivity**

- Higher income
- Sufficient biomass for fodder and recycling in soil
- Climate change mitigation and adaptation
- Sustainable crop intensification
- Food security

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Experimental detail:

Treatments:
- **Two tillage practices**: Minimum tillage and Normal tillage
- **Two residue management practices**: Residue retained and residue removed
- **Two cropping systems**: Maize-chickpea sequence and maize/pigeonpea intercropping system

**Experimental design**: split-split

**Replications**: four

**Total experimental area**: \( \approx 2.4 \) hectares

**Experimental site**: ICRISAT, Patancheru, India.
17° 50’ latitude, 78° 26’ longitude
Baseline information of experimental site

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>Coarse sand (2.0-0.2)</th>
<th>Fine sand (0.2-0.02)</th>
<th>Silt (0.02-0.002)</th>
<th>Clay (&lt;0.002)</th>
<th>pH</th>
<th>EC (dS/m)</th>
<th>SOC (%)</th>
<th>Total N (kg ha⁻¹)</th>
<th>Av. P (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-15</td>
<td>12.6</td>
<td>14.7</td>
<td>22.9</td>
<td>49.9</td>
<td>7.9</td>
<td>0.22</td>
<td>0.41</td>
<td>797.6</td>
<td>4.72</td>
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<tr>
<td>15-30</td>
<td>11.9</td>
<td>13.5</td>
<td>20.9</td>
<td>53.7</td>
<td>7.9</td>
<td>0.19</td>
<td>0.23</td>
<td>451.9</td>
<td>1.50</td>
</tr>
<tr>
<td>30-60</td>
<td>10.8</td>
<td>12.9</td>
<td>20.5</td>
<td>55.8</td>
<td>8.0</td>
<td>0.29</td>
<td>0.21</td>
<td>399.9</td>
<td>1.52</td>
</tr>
<tr>
<td>60-90</td>
<td>10.0</td>
<td>12.2</td>
<td>20.4</td>
<td>58.3</td>
<td>8.0</td>
<td>0.22</td>
<td>0.18</td>
<td>346.8</td>
<td>1.12</td>
</tr>
<tr>
<td>90-120</td>
<td>8.6</td>
<td>12.6</td>
<td>20.0</td>
<td>58.8</td>
<td>8.0</td>
<td>0.24</td>
<td>0.16</td>
<td>312.3</td>
<td>1.15</td>
</tr>
</tbody>
</table>
Field lay out

Numbers in the figure represent plot numbers. Filled rectangular boxes represents plots with soil moisture monitoring setups, filled circles represents plots with runoff recorders, and black dotted arrows represents direction of runoff flow.
Location of Runoff recorders (IDRSMU)
Conservation Agriculture lowered runoff losses of rainwater: important for *in-situ* water storage and crop resilience against droughts.

<table>
<thead>
<tr>
<th>Tillage and residue management practices</th>
<th>Runoff (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MT-RT, 2010</td>
<td>MT-RR, 2010</td>
</tr>
<tr>
<td>2010 Seasonal rainfall 1071 mm</td>
<td></td>
</tr>
<tr>
<td>MT-RT</td>
<td>188</td>
</tr>
<tr>
<td>MT-RR</td>
<td>253</td>
</tr>
<tr>
<td>NT-RT</td>
<td>203</td>
</tr>
<tr>
<td>NT-RR</td>
<td>263</td>
</tr>
</tbody>
</table>

MT= Minimum tillage, NT= Normal tillage, RT= Residue retained, RR= Residue removed

MT-RT, 2010 Seasonal rainfall 409 mm

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<thead>
<tr>
<th>Tillage and residue management practices</th>
<th>Runoff (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MT-RT</td>
<td>5.2</td>
</tr>
<tr>
<td>MT-RR</td>
<td>21.0</td>
</tr>
<tr>
<td>NT-RT</td>
<td>7.2</td>
</tr>
<tr>
<td>NT-RR</td>
<td>26.3</td>
</tr>
</tbody>
</table>

High erosion in NT-RR indicates high runoff volume.
CA lowered peak runoff rate: important to decrease soil erosion

2010

<table>
<thead>
<tr>
<th>Tillage and residue management practices</th>
<th>2010 Peak runoff rate (cum/s/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MT-RT</td>
<td>0.137</td>
</tr>
<tr>
<td>MT-RR</td>
<td>0.126</td>
</tr>
<tr>
<td>NT-RT</td>
<td>0.130</td>
</tr>
<tr>
<td>NT-RR</td>
<td>0.183</td>
</tr>
</tbody>
</table>

2011

<table>
<thead>
<tr>
<th>Tillage and residue management practices</th>
<th>2011 Peak runoff rate (cum/s/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MT-RT</td>
<td>0.003</td>
</tr>
<tr>
<td>MT-RR</td>
<td>0.005</td>
</tr>
<tr>
<td>NT-RT</td>
<td>0.004</td>
</tr>
<tr>
<td>NT-RR</td>
<td>0.011</td>
</tr>
</tbody>
</table>
Conservation Agriculture and Rain WUE

2010-11

- Maize- chickpea system
- Maize- pigeonpea system

Tillage and residue management practices

2011-12

- Maize- chickpea system
- Maize- pigeonpea system

Tillage and residue management practices

Sole maize

Intercropped maize
Conservation Agriculture improved average soil moisture content: important for drought resilience.
Conservation Agriculture enhanced C sequestration

**Tillage and residue management practices**

- Maize-chickpea cropping sequence
- Maize/pigeonpea intercropping system

**0-15 cm**

- SOC %

**15-30 cm**

- SOC %
Conservation Agriculture lowered fuel use and CO₂ emission

**Saving of diesel**

<table>
<thead>
<tr>
<th>Tillage practices</th>
<th>Minimum tillage</th>
<th>Normal tillage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel consumption (litre/ha)</td>
<td>85%</td>
<td>100%</td>
</tr>
</tbody>
</table>

**Reduction in CO₂ emission due to less fuel use**

<table>
<thead>
<tr>
<th>Tillage practices</th>
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<th>Normal tillage</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂ emission (kg/ha)</td>
<td>18.71</td>
<td>129.3</td>
</tr>
</tbody>
</table>

Major Challenges that need to be resolved

- **Ensuring effective weed control**- must to prevent yield losses in the absence of tillage and, improve RWUE; need to supply post emergence herbicides for popular cereals- legume intercropping systems of SAT at cheaper rates.

- **Refinement in machinery** for optimum plant stand and residue management; supply at subsidized rates to smallholders.

- **Pest management**- especially rats and termites that prosper in surface retained residues.
Conclusions

- CA reduced runoff and peak runoff rate
- CA may favourably influence Rain water use efficiency and soil moisture content
- CA sequestered more carbon in soil
- CA reduced energy consumption and emitted less CO₂

Therefore:

CA could be one potential technology for climate change mitigation and adaptation in SAT regions
Thank you!

ICRISAT is a member of the CGIAR Consortium

International Crops Research Institute for the Semi-Arid Tropics