Recent eco-agronomic technologies and potential for economic returns in small holder farms

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India 641003
Indian Farming

Contributes 14% of GDP

Provides food to 1.3 billion people

Sustains 65% population who depends mainly on farming

Provides raw materials to Industries

1/6th of Export earning from farming Sector
One Country with 15 Climatic Zones

Agro-climatic zones of India

Rich in Biodiversity

Geographical area = 328 mha
Net Area Sown = 142 mha
Major Crop area in India

Rice, Wheat, Oil Seeds, Cotton, Jute and Tea
Farmers Classification in India

- **Marginal**: < 1 ha
- **Small**: 1-2 ha
- **Medium**: 2-4 ha
- **Large**: >4 ha
Farmers Classification in India

- Small: 60%
- Medium: 19%
- Large: 7%
- Marginal: 14%

ICAR, 2018
Fragmentation of land holding .... A major concern

In India, farm holding is getting reduced each year

- Small and Marginal: 38.9
- Big farmers: 47.4

2000-01

- Small and Marginal: 47.4
- Big farmers: 20.0

In 2019, large farmers just 7 %
small and marginal farmers about 74 %

ICAR, 2018
Cotton growing Zones in India

Area = 12 mha
Production = 36.1 m bales
Small is BIG

India: 6 m ton, 6.5m farmers

World: 25 m ton
Recent eco-agronomic technologies and potential for economic returns in small holder farms

1. Polyethylene mulch technology
2. i) Drip Irrigation
   ii) Drip + Poly mulching
3. Biodegradable polyethylene mulching
4. Crop residue mulching
5. Herbigation
6. Structured water irrigation
7. Perennial legume with cotton
8. Use of PPFM as bio inoculants
9. Structured water irrigation
10. High density planting system

i) SSBT + leguminous cover crops
Poly ethylene mulching
Poly ethylene mulch technology

40 micron thickness, Silver colour top layer with black bottom the most ideal
coloured mulching for cotton .....  

40 micron, Silver colour top layer with black bottom layer most ideal
Cotton crop intercropped with green gram
Influence of poly mulching on rhizosphere and phyllosphere microorganisms

<table>
<thead>
<tr>
<th>Microorganisms</th>
<th>Poly mulch</th>
<th>No mulch</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Rhizosphere</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Diazotrophs $x 10^4$</td>
<td>164.2</td>
<td>63.7</td>
</tr>
<tr>
<td>2. PPFM s $x 10^4$</td>
<td>109.2</td>
<td>26.4</td>
</tr>
<tr>
<td>3. Azospirillum $x 10^4$</td>
<td>19.2</td>
<td>0.67</td>
</tr>
<tr>
<td>4. PSB $x 10^3$</td>
<td>90.57</td>
<td>42.9</td>
</tr>
<tr>
<td><strong>B. Phyllosphere</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Diazotrophes $x 10^4$</td>
<td>75.6</td>
<td>14.7</td>
</tr>
<tr>
<td>2. PPFM s $x 10^4$</td>
<td>134.6</td>
<td>39.3</td>
</tr>
</tbody>
</table>
Soil temperature due to poly mulching

- **Control**:
  - Forenoon: 24.4°C
  - Afternoon: 28.4°C
  - Mean: 26.4°C
  - PM: 30.4°C

- **PM**:
  - Forenoon: 28.4°C
  - Afternoon: 32.3°C
  - Mean: 30.4°C

<table>
<thead>
<tr>
<th>Time</th>
<th>Control (°C)</th>
<th>PM (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forenoon</td>
<td>24.4</td>
<td>28.4</td>
</tr>
<tr>
<td>Afternoon</td>
<td>28.4</td>
<td>32.3</td>
</tr>
<tr>
<td>Mean</td>
<td>26.4</td>
<td>30.4</td>
</tr>
</tbody>
</table>
Available soil moisture

Poly mulch: 24.9
Control: 19.8
Water Use Efficiency (kg seed cotton/ha cm)

T1 - 100 micron
T2 - 75 micron
T3 - 50 micron
T4 - 30 micron
T5 - Control

Water Use Efficiency due to polymulching
Seed cotton yield as influenced by polymulching

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Yield kg/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1 - 100 micron</td>
<td>2200</td>
</tr>
<tr>
<td>T2 - 75 micron</td>
<td>2200</td>
</tr>
<tr>
<td>T3 - 50 micron</td>
<td>2200</td>
</tr>
<tr>
<td>T4 - 30 micron</td>
<td>2200</td>
</tr>
<tr>
<td>T5 - Control</td>
<td>1000</td>
</tr>
</tbody>
</table>
Intactness of sheets after cotton harvest
Polymulched maize roots

Nomulch maize roots
Drip and flood irrigation comparison

Drip Irrigation resulted in 20 ha cm water saving, 25% fertilizer saving and 34% enhanced seed cotton yield
Drip + Poly mulching
Drip + poly ethylene mulching
Drip + poly ethylene mulching

Seed cotton yield (kg/ha)

- Drip + Polymulch: 7040 kg/ha
- Drip: 4820 kg/ha
- Conventional: 3775 kg/ha

Water requirement:
- Conventional: 80 ha cm
- Drip + Polymulch: 46.4 ha cm
- Drip: 63.0 ha cm
<table>
<thead>
<tr>
<th>Fertilizer Treatments</th>
<th>Drip</th>
<th>Drip + Polymulching</th>
<th>Convention</th>
<th>MEAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1 - 100% NPK</td>
<td>3740</td>
<td>5920</td>
<td>3290</td>
<td>4316</td>
</tr>
<tr>
<td>T2 - T1 + Zn SO₄</td>
<td>4460</td>
<td>6480</td>
<td>3720</td>
<td>4886</td>
</tr>
<tr>
<td>T3 - T1 + Mg SO₄</td>
<td>5320</td>
<td>6970</td>
<td>3820</td>
<td>5370</td>
</tr>
<tr>
<td>T4 – T1 + Boron</td>
<td>5200</td>
<td>7370</td>
<td>3910</td>
<td>5493</td>
</tr>
<tr>
<td>T5 – T1+ Zn SO₄+ Mg SO₄+ Boron</td>
<td>5760</td>
<td><strong>7820</strong></td>
<td>4110</td>
<td>5896</td>
</tr>
<tr>
<td>T6 – 75% T5</td>
<td>4430</td>
<td>7660</td>
<td>3920</td>
<td>5336</td>
</tr>
<tr>
<td>MEAN</td>
<td>4820</td>
<td>7040</td>
<td>3775</td>
<td></td>
</tr>
</tbody>
</table>

CD (P=0.05) for W: 416
CD (P=0.05) for F: 599
Biodegradable polyethylene

• The polyethylene mulch film could be made biodegradable by adding prodegradant additive (d2w), a patented product from UK at 4% concentration at the time of manufacturing the poly film.
Herbigation
Herbigation

Pre emergence pendimethalin 1.0 kg ai/ha on third day followed by one HW 30 DAS and application of metolachlor 1.0 kg ai through drip 35 DAS
Structured water Irrigation
Structured water Irrigation

Water Molecules from bore-well → Water passes through ‘Crystal Blue’ water structuring unit → Structured Water
Structured water unit

Specially tuned geometry creates an energy environment for water to structure itself. This gives water a lower surface tension and better hydrating properties.
Available moisture holding capacity (%)

Structured water: 27.1%
Bore well water: 25.6%
Seed cotton yield (kgs/ha)

- Suvin: 695 (Structured), 556 (Bore well)
- Suraj: 1448 (Structured), 1138 (Bore well)
- Mallika Bt: 2222 (Structured), 1743 (Bore well)
- Bunny Bt: 2028 (Structured), 1239 (Bore well)
- Surabhi: 1545 (Structured), 1264 (Bore well)
- MCU 5 Vt: 1039 (Structured), 614 (Bore well)
- Anjali: 1092 (Structured), 800 (Bore well)
water Use efficiency (Kg of seed cotton/ ha cm of water)

- SW Drip 1.0 ETc: 64.1
- SW Drip 0.8 ETc: 68.4
- SW Drip 0.6 ETc: 72.9
- SW Drip 0.4 ETc: 76.9
- SW control: 32.8
- BW Drip 1.0 ETc: 59.2
- BW Drip 0.8 ETc: 61.7
- BW Drip 0.6 ETc: 68
- BW Drip 0.4 ETc: 70.9
- BW control: 29.6
Bio mulching
Crop residue mulching for rain fed crop
Healthy cotton crop under gunny sheet mulching
Monsoon rainfall levels in India are falling

2012: -7%
2013: +6%
2014: -12%
2015: -14%
2016: -3%
2017: -5%
2018: -9%

Source: India Meteorological Department
Graphic: Jason Kwok, CNN
21 Indian cities are expected to run out of groundwater by 2020.
Countries that will be water scarce by 2040

- Low <10%
- Low to medium 10-20%
- Medium to high 20-40%
- High 40-80%
- Extremely high >80%

Source: World Resources Institute
Graphic: Gabrielle Smith, CNN
Pesticides consumption - global

- Insecticides, 33%
- Fungicides, 22%
- Herbicides, 45%
## Losses due to pests in India

<table>
<thead>
<tr>
<th>Pests</th>
<th>Per cent Loss</th>
<th>Annual Loss in cores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weeds</td>
<td>33</td>
<td>1980</td>
</tr>
<tr>
<td>Insects</td>
<td>26</td>
<td>1300</td>
</tr>
<tr>
<td>Diseases</td>
<td>20</td>
<td>1000</td>
</tr>
<tr>
<td>Rodents</td>
<td>6</td>
<td>300</td>
</tr>
<tr>
<td>Other pests</td>
<td>6-8</td>
<td>300</td>
</tr>
</tbody>
</table>
Cotton associated weeds

- Weeds of cotton fields vary widely in their floral composition as well as density depending on the ecological situation and crop management.

- About 100 weed species were reported as associated with cotton, only a dozen of them are responsible for significant yield losses.
Herbicidal weed management

- Pendimethalin, metolachlor, fluometuron etc., as pre-emergence spray.

- For post emergence application, fluazifop butyl, quizalofopbutyl (grasses)

- Pyrithiobac sodium for broad leaved weeds
Exhausting weed seed bank under Stale seed bed technique
SSBT  *Vigna unguiculata* as cover crop

Weeds were converted into organics by SSBT
Comparing SSBT with cover crops against pre-emergence pendimethalin

SSBT and cover crop

Pendimethalin treated (no SSBT and no cover crop)
Crotalaria juncea as cover crops
Weed count on 30 DAS as influenced by SSBT and Cover crops

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Weed count/ m² on 30 DAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. SSBT followed by <em>Mimosa invisa</em> + HW</td>
<td>67.25</td>
</tr>
<tr>
<td>2. SSBT followed by <em>Crotalaria juncea</em> + HW</td>
<td>63</td>
</tr>
<tr>
<td>3. SSBT followed by <em>Sesbania aculeata</em> + HW</td>
<td>46.75</td>
</tr>
<tr>
<td>4. SSBT followed by <em>Vigna unguiculata</em> + HW</td>
<td>49.75</td>
</tr>
<tr>
<td>5. SSBT followed by <em>Desmanthus virgatus</em> + HW</td>
<td>74</td>
</tr>
<tr>
<td>6. pendimethalin 1.0 kg as pre emergence + HW (Twice)</td>
<td><strong>198.7</strong></td>
</tr>
<tr>
<td>SED</td>
<td>17.51</td>
</tr>
<tr>
<td>CD (p=0.05%)</td>
<td><strong>37.33</strong></td>
</tr>
<tr>
<td>Treatments</td>
<td>Bolls/plant</td>
</tr>
<tr>
<td>---------------------------------------------------------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>1. SSBT followed by <em>Mimosa invisa</em> + HW</td>
<td>28</td>
</tr>
<tr>
<td>2. SSBT followed by <em>Crotalaria juncea</em> + HW</td>
<td>33.4</td>
</tr>
<tr>
<td>3. SSBT followed by <em>Sesbania aculeata</em> + HW</td>
<td>24.8</td>
</tr>
<tr>
<td>4. SSBT followed by <em>Vigna unguiculata</em> + HW</td>
<td>34</td>
</tr>
<tr>
<td>5. SSBT followed by <em>Desmanthus virgatus</em> + HW</td>
<td>28.2</td>
</tr>
<tr>
<td>6. pendimethalin 1.0 kg pre emergence + HW (Twice)</td>
<td>24.9</td>
</tr>
<tr>
<td>SED</td>
<td>1.635</td>
</tr>
<tr>
<td>CD (p=0.05%)</td>
<td>3.49</td>
</tr>
</tbody>
</table>
To avoid herbicide resistance development ...

- Herbicide rotation
- Mixing herbicides with different mode of action
- Combining nonchemical methods like mulching
- Stale seed bed method
- Mechanical removal
- Growing compatible intercrops
- Combination of all the above wherever possible
Integrated Weed Management

- Crop rotation
- Time of emergence
- Time of control
- Crop variety
- Row spacing
- Herbicides
- Seeding density
- Resource management
Alley Cropping of Perennial legume with Cotton for Sustainability
Soil Organic Carbon Map of INDIA

67% of Indian Soil is having lower organic Carbon

Source: Coromandel’s Internal Finding
OC test done - 3.4 lac samples
Alley cropping of perennial legumes with cotton for sustainability
Alley cropping of perennial legumes with cotton for sustainability

Cotton + Desmanthus at 100 % RDN

Sole cotton at 100 % RDN
Seed cotton yield as influenced by Alley cropping of Desmanthus and graded levels of N

- Desmanthus + 75% RDN: 2265
- Desmanthus + 100% RDN: 2796
- Desmanthus + 125% RDN: 2575
- Sole Cotton + 75% RDN: 1788
- Sole Cotton + 100% RDN: 1935
- Sole Cotton + 125% RDN: 2037
Chlorophyll content (mg/g) as influenced by Alley cropping of Desmanthus and graded levels of N

- Desmanthus + 75 % RDN: Chlorophyll a = 1.54, Chlorophyll b = 1.03, Total chlorophyll = 2.57
- Desmanthus + 100 % RDN: Chlorophyll a = 1.68, Chlorophyll b = 1.12, Total chlorophyll = 2.80
- Desmanthus + 125 % RDN: Chlorophyll a = 1.81, Chlorophyll b = 1.21, Total chlorophyll = 3.02
- Sole cotton + 75 % RDN: Chlorophyll a = 1.97, Chlorophyll b = 1.26, Total chlorophyll = 3.23
- Sole cotton + 100 % RDN: Chlorophyll a = 2.04, Chlorophyll b = 1.33, Total chlorophyll = 3.37
- Sole cotton + 125 % RDN: Chlorophyll a = 2.12, Chlorophyll b = 1.40, Total chlorophyll = 3.52
Desmanthus virgatus – the most suitable perennial legume identified

In 38 months, we have added 22 t of biomass translating to 700 kgs N/ha
Use of Pink Pigmented Facultative Methylo trophs
Pink Pigmented Facultative Methylotrophs (PPFM) as potential bio inoculant for Cotton

The upper and lower surface leaf imprints of fresh leaf samples were made on the solidified media separately and incubated at 28±2°C for 5 days.

Isolation of PPFM from Cotton leaf (Corpe, 1985)
Compatibility of Methylobacterium with major bioinoculants

1. Methylobacterium
2. Azospirillum lipoferum (Az 204)
3. Bacillus megatherium (PSB TNAU 1)
Plant growth promotion

PPFM Treated

Control
Cotton seedlings treated with bio inoculants

Control

Treated
## Yield attributes and seed cotton yield of Cotton due to individual and combined inoculation

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Bolls/plant</th>
<th>Boll wt (g/boll)</th>
<th>Seed Cotton Yield (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1 – 75 % RDF</td>
<td>19.8</td>
<td>3.75</td>
<td>2340</td>
</tr>
<tr>
<td>T1 + Azospirillum</td>
<td>23.0</td>
<td>4.07</td>
<td>2847</td>
</tr>
<tr>
<td>T1 + PSB</td>
<td>23.7</td>
<td>3.93</td>
<td>2647</td>
</tr>
<tr>
<td>T1 + PPFM</td>
<td>23.5</td>
<td>3.75</td>
<td>2638</td>
</tr>
<tr>
<td>T1 + Azos + PSB</td>
<td>22.7</td>
<td>4.03</td>
<td>2609</td>
</tr>
<tr>
<td>T1 + Azos + PPFM</td>
<td>23.9</td>
<td>3.87</td>
<td>2645</td>
</tr>
<tr>
<td>T1 + PSB + PPFM</td>
<td>22.3</td>
<td>3.82</td>
<td>2703</td>
</tr>
<tr>
<td><strong>T1 + AZOS + PSB + PPFM</strong></td>
<td><strong>24.3</strong></td>
<td><strong>3.88</strong></td>
<td><strong>2982</strong></td>
</tr>
<tr>
<td>100 % RDF</td>
<td>20.3</td>
<td>4.05</td>
<td>2486</td>
</tr>
<tr>
<td>CD (p = 0.05)</td>
<td>2.05</td>
<td>0.39</td>
<td>365.6</td>
</tr>
</tbody>
</table>
# Seed cotton yield (q/ha) and Economics (₹/ha) of HDPS cotton

<table>
<thead>
<tr>
<th></th>
<th>Irrigated</th>
<th>Rainfed</th>
<th>Mean</th>
<th>Gross Return(₹/ha)</th>
<th>Rainfed</th>
<th>Mean</th>
<th>Net Return(₹/ha)</th>
<th>Rainfed</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>HDPS (60X 10 cm)</strong></td>
<td></td>
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</tr>
<tr>
<td>Anjali</td>
<td>33.1</td>
<td>29.9</td>
<td>31.5</td>
<td>107341</td>
<td>90680</td>
<td>99011</td>
<td>48831</td>
<td>37137</td>
<td>42984</td>
</tr>
<tr>
<td>Suraj</td>
<td>31.6</td>
<td>28</td>
<td>29.8</td>
<td>115182</td>
<td>108921</td>
<td>112052</td>
<td>58158</td>
<td>57078</td>
<td>57618</td>
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<tr>
<td><strong>Mean</strong></td>
<td>32.4</td>
<td>29</td>
<td>30.7</td>
<td>111262</td>
<td>99891</td>
<td><strong>105577</strong></td>
<td>53495</td>
<td>47108</td>
<td><strong>50302</strong></td>
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<tr>
<td><strong>Conventional planting (75 X 45 cm)</strong></td>
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<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Anjali</td>
<td>18.8</td>
<td>16.3</td>
<td>17.55</td>
<td>60815</td>
<td>52682</td>
<td>56749</td>
<td>19245</td>
<td>15622</td>
<td>17434</td>
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<tr>
<td>Suraj</td>
<td>21.6</td>
<td>18.9</td>
<td>20.25</td>
<td>78515</td>
<td>96014</td>
<td>87265</td>
<td>34145</td>
<td>29254</td>
<td>31700</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td>20.2</td>
<td>17.6</td>
<td><strong>18.9</strong></td>
<td>69665</td>
<td>60848</td>
<td><strong>65257</strong></td>
<td>26695</td>
<td>22438</td>
<td><strong>24567</strong></td>
</tr>
</tbody>
</table>
Conclusion
“Everything else can wait but not agriculture”
- Pandit Jawaharlal Nehru

Let us gear up to meet the challenges of climate change in Agriculture to enhance the yield, profitability and prosperity of our farmers. For the whole mankind to prosper.
“The Crown always finds its way to the Right Head”
Its Time for Acknowledging ....

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