Conservation Agriculture Policy – Perspective & Scope

By

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Introduction

- Mid sixties – high yielding varieties – Green Revolution
- Production 50 mt (1950-51) to 203 m.t. (1998-99)
- Required
  - higher doses of fertilizer
  - more irrigation water
  - increase use of plant protection chemicals
  - increase use of diesel and electricity
- Resulted in widespread problems of resource degradation and environmental problems & GHGs
Introduction

- Fuel crisis in 1970 and uncertainty in
  - supply of hydrocarbons
  - growing concern of environmental pollution
  - by Inefficient use of energy led to emphasis on
  - energy efficiency
  - energy conservation

- Increase demand on energy from Agricultural Sources
  - large scale deforestation
  - soil erosion
  - loss of fertility
  - manifold increase in commercial energy
Introduction

- High mechanized system of USA uses 16.5% of total national energy (80% of which is provided by petroleum products)
- Rice-wheat system (R-W) – main cropping system of IGP.
- 30% of rice and 42% of wheat grown in IGP
- IGP – R-W – 13.5 m ha.
  - India – 10.5 m ha.
  - Pakistan 1.6 m ha.
  - Bangladesh – 0.8 m ha.
  - Nepal – 0.6 m ha.
  - China – 10 m ha.
- Rice-wheat in India – contributes 52% of India’s total food production (220 m t.)
Introduction

The rice-wheat areas of the Indo-Gangetic Plains and the five agro-ecological transects
Interactive threats to productivity and sustainability in rice-wheat cropping systems the Indo-Gangetic Plains

Production inability to keep pace with the continued expansion in the demand for foodgrains driven by population and income growth

Area: Less land available for rice and wheat production

Yield: Unacceptably slow rate of future yield increase for rice and wheat

Shift to lower-yielding but higher-value varieties

Stagnating rice and wheat yields in the recent past

Exhaustion of most sources of future productivity growth for rice and wheat

Productivity improving rice and wheat technology not available or not used

Degradation of land and waster resources devoted to the production of rice and wheat. Nutrient Mining
Interrelated Sustainability concerns in rice-wheat cropping systems of the Indo-Gangetic Plains

- Late onset of monsoon
- Available groundwater not used in eastern IGP
- Labor shortage, seasonality
- Excessive tillage and puddling
- Lack of water for break of GM crops in Summers
- Pre-germinated weeds force tillage
- Late seedling in nursery
- Efficient nutrient, water management practices

Delayed rice transplanting

Late planting of winter crops

- Short turn-around time
- Excessive preparatory tillage
- Long duration rice varieties
- Fields don’t come to condition eastern GP
- Ruts of combines spoils field leveling
- Pre-germinated weeds
- Efficient nutrient, water management practices
- Intercrops- agronomic and crop management practices
- Climate change

- Yield stagnation
- Yields below potential
- Declining factor productivity
- Receding water table
- Nutrient mining & K deficiency
- Low input use efficiency
- Decline in SOM, Biodiversity/ diversification
- Surface cover/burning
- Competition for residues
- Environmental pollution
- Rice fallows
- Salinity buildup and
- Ground water quality
Interrelated Sustainability concerns in rice-wheat cropping systems of the Indo-Gangetic Plains

- Rice-Wheat system
  - fatigued – natural resources and declining factor productivity
  - reduced organic matter levels
  - pesticide – health hazard
  - sodicity and salinity problems
  - depletion of ground water levels
  - lowering of water quality and groundwater pollution
  - tillage costs and overall cost rising
  - increase emission of GHGs due to burning of paddy straw
Interrelated Sustainability concerns in rice-wheat cropping systems of the Indo-Gangetic Plains

- Sustainability of the system is in question
- Consortium of South Asian NARS to address R-W system
- (R-W Consortium)
  - Bangladesh, India, Nepal, Pakistan
  - International Centres (CIMMYT, CIP, ICRISAT, IRRI & IWMI)
  - ARIs
  - NGOs
  - Private entrepreneurs and farmers
  - IGP
  - Bangladesh, India, Nepal and Pakistan – most productive agriculture region
- 24 m.ha.
- 30% rice and 42% wheat
Interrelated Sustainability concerns in rice-wheat cropping systems of the Indo-Gangetic Plains

- Tillage – Intensive farm operations – maximum energy
- Fuel crises 70’s – forced scientists to reduce energy requirement
- Reduced tillage – minimum tillage
- Conservation Tillage (CT)
  - development of zero-till drills
  - rota till drills
  - one pass equipment
- Zero-till drills resulted in saving in
  - fuel
  - time
  - labour
  - cost of operation
  - reduced energy requirement
Interrelated Sustainability concerns in rice-wheat cropping systems of the Indo-Gangetic Plains

- CT – Conservation Agriculture (CA)
  - reduce input use – seed, chemicals, fertilizer, water and excessive tillage
- CA - refers to a system of raising crops without tilling the soil while retaining the crop residues
- Aim – Conserve, improve and make efficient use of natural resources
  - Soil
  - Water
  - fossil fuels through integrated management
- Good number of equipment and technology developed to address to
- CA and these will be discussed.
Conservation Agriculture

- Over exploitation of natural resources
  - water table gone down
  - in some places water logging - leaching of salts
  - excessive use of chemicals – polluted ground water
  - burning of crop residues – GHGs
- C.A. – many definitions
- C.A. refers to the system of raising crops without tilling the soil while retaining the crop residues on the soil surface.
- CA aims to achieve sustainable and profitable agriculture and subsequently aims to improve livelihoods of farmers through the three CA principles
  - minimal soil disturbance
  - permanent soil cover
  - crop rotation
Conservation Agriculture

- CA aims to conserve, improve and make more efficient use of natural resources through integrated management of available water and biological resources through integrated management of available soil, water and biological resources combined with external inputs – referred as resource efficient/ resource effective agriculture.

- CA – range of soil management practices that minimize affects on composition structure and natural biodiversity and reduce erosion and degradation.

Challenge

- Strategies : address twin concerns of
  - maintaining and enhancing the integrity of natural resources
  - improved productivity

- CA – different agro – ecological regions

- CA – 80 m.ha. Globally – US, Brazil, Mexico, Newzeland, Australia, Argentina, Canada, South Asia, China, etc.
Conservation Agriculture

- CA – India – IGP

- Need to evolve a scientifically land use system, a sound CA Policy and mission orient programme.

- CA defer from soil type, rainfall, climate and socio-economic condition.

- Call for developing new strategies and promotion of new technologies to enhance crop production, productivity and formulation of long term perspective.
## Advantages and Disadvantages of CA

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduces labour, time and fuel costs</td>
<td>Formation of hard pan below soil surface due to zero tillage and requires use of sub-soiler to break hard pan after 5-7 years</td>
</tr>
<tr>
<td>Reduces overall cost of operation</td>
<td>Need to control weeds by using herbicides thus increasing cost</td>
</tr>
<tr>
<td>Reduce use of fossil fuel leads to less environmental pollution</td>
<td>Not suitable to all crop rotations</td>
</tr>
<tr>
<td>Reduces soil compaction due to less trafficability</td>
<td>May result in soil borne pests and pathogens in transition stage</td>
</tr>
<tr>
<td>More yields in dry years</td>
<td>High cost of machinery such as, laser land leveler, zero-till drill, strip till drill, raised bed planter, straw cutter cum incorporator, straw combine, straw baler, biomass digesters</td>
</tr>
<tr>
<td>Saving in water</td>
<td></td>
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<tr>
<td>Less soil erosion less flooding</td>
<td></td>
</tr>
<tr>
<td>Less environmental pollution, Carbon sequestration (green house effect)</td>
<td></td>
</tr>
<tr>
<td>Less leaching of chemicals &amp; solid nutrients into ground water</td>
<td></td>
</tr>
<tr>
<td>Less pollution of water</td>
<td></td>
</tr>
<tr>
<td>Increased crop intensity</td>
<td></td>
</tr>
<tr>
<td>Recharge of aquifers due to better infiltration</td>
<td>It may also result in low yields</td>
</tr>
</tbody>
</table>
## Concern leading to interest in CA

<table>
<thead>
<tr>
<th>Water regime</th>
<th>Concerns</th>
<th>Possible approaches</th>
</tr>
</thead>
<tbody>
<tr>
<td>High rainfall</td>
<td>- Rapid erosion and degradation</td>
<td>- Residue cover</td>
</tr>
<tr>
<td></td>
<td>- Nutrient lose</td>
<td>- Sensible crop rotations</td>
</tr>
<tr>
<td>Low rainfall</td>
<td>- Late sowing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Drought stress</td>
<td>- Direct drilling</td>
</tr>
<tr>
<td></td>
<td>- Low soil fertility</td>
<td>- Residue cover</td>
</tr>
<tr>
<td></td>
<td>- High weeds</td>
<td>- Residue+crop rotation+ mech., chopper+ Pesticides</td>
</tr>
<tr>
<td>Dryland</td>
<td>- Drought stress</td>
<td>- Straw cover</td>
</tr>
<tr>
<td></td>
<td>- Soil erosion</td>
<td>- Sub-soiling for in-situ moisture conservation</td>
</tr>
<tr>
<td>Irrigated</td>
<td>- Ground water depletion</td>
<td>- Water management</td>
</tr>
<tr>
<td></td>
<td>- High cost of pumping</td>
<td>- Efficient use of input resources</td>
</tr>
<tr>
<td></td>
<td>- High cost of production</td>
<td>- Profitable crop rotations</td>
</tr>
<tr>
<td></td>
<td>- Scarcity of labour</td>
<td>- Controlled traffic cultivation</td>
</tr>
<tr>
<td></td>
<td>- Compaction</td>
<td>- Permanent bed system</td>
</tr>
</tbody>
</table>
CAM : Requirements

- Alleviate soil compaction
- Soil loosening only in crop rows
- Surface soil loosening with or without straw mulch
- Soil working condition
- Residue cover
# Studies on Conventional and Minimum Tillage

<table>
<thead>
<tr>
<th>Comparison made</th>
<th>No. of Comparisons</th>
<th>Harvest population per acre</th>
<th>Yield, bushel per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Conventional Tillage</td>
<td>Minimum Tillage</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>RESEARCH RESULTS ON AGRICULTURAL ENGINEERING FIELD</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total comparisons</td>
<td>70</td>
<td>14,500</td>
<td>14,000</td>
</tr>
<tr>
<td>Comparisons in which minimum tillage gave higher yields than conventional tillage</td>
<td>12</td>
<td>13,800</td>
<td>14,800</td>
</tr>
<tr>
<td>Comparisons in which conventional tillage gave higher yields than minimum tillage</td>
<td>13</td>
<td>13,900</td>
<td>12,300</td>
</tr>
<tr>
<td><strong>RESULTS OF DEMONSTRATION FIELDS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total comparisons</td>
<td>16</td>
<td>11,800</td>
<td>11,200</td>
</tr>
</tbody>
</table>
Studies on Conservation Agriculture

Conservation Tillage

- Tillage – mechanical manipulation of soil to provide conditions favourable for crop growth.
- Primary and secondary tillage (m.b. plough, disc plough, rotavator, cultivator, harrow, tractor)
- Tillage consumes
  - 1600 MJ/ha – wheat
  - 2200-2600 MJ/ha – rice
- Baleman & Bowers (1962) – Illinois – Conventional tillage and minimum tillage
### Comparison of Conventional Tillage, Reduce Tillage & Zero Tillage in wheat in U.K.

<table>
<thead>
<tr>
<th>Hectares sown in 40 hr week</th>
<th>Treatments</th>
<th>Fuel consumed (litres)</th>
<th>Cost/ha (£/ha)</th>
<th>Man hr requirement per hectare</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.7</td>
<td>Conventional tillage (1 ploughing +3 discking)</td>
<td>6.66</td>
<td>46.50</td>
<td>5.2</td>
</tr>
<tr>
<td>10.8</td>
<td>Reduced cultivation (2 chisel plough + 2 disc harrowing)</td>
<td>3.88</td>
<td>37.50</td>
<td>3.7</td>
</tr>
<tr>
<td>40.0</td>
<td>Direct drilling (zero tillage + gramaxone)</td>
<td>1.15</td>
<td>25.00</td>
<td>1.0</td>
</tr>
</tbody>
</table>
1971 – AICRP on ERAS

- to assess energy use in various farm operations for different production sectors of agriculture.
- to locate critical components of use and technique to improve
- system efficiency by reducing wasteful uses
- make assessment of future energy demand

Results have provided a benchmark of spatial and temporal variations in the energy use pattern in Indian agriculture

In 1980’s – zero tillage concept introduced by ICI to promote “gramaxone”

- Tractor drawn zero-till drill developed in Punjab by Shukla, Tandon & Verma for sowing wheat after paddy without land preparation
  - Reversible shovel
  - Clod formation
## Comparative performance of No-Tillage and conventional Tillage Systems for Growing wheat after paddy

<table>
<thead>
<tr>
<th>Field No.</th>
<th>Plot No.</th>
<th>Treatment</th>
<th>Moisture Content of soil in percentage</th>
<th>Average germination count/m</th>
<th>Wheat Yield (Quintal/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>1.</td>
<td>No-till</td>
<td>12.00</td>
<td>41.50</td>
<td>31.61</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1 discking + 2 cultivator + 1 planking</td>
<td>12.50</td>
<td>39.00</td>
<td>30.12</td>
</tr>
<tr>
<td>II</td>
<td>3</td>
<td>No-till</td>
<td>14.00</td>
<td>43.10</td>
<td>34.58</td>
</tr>
<tr>
<td></td>
<td>4.</td>
<td>1 discking + 2 cultivator + 1 planking</td>
<td>14.00</td>
<td>41.30</td>
<td>34.58</td>
</tr>
</tbody>
</table>
## Comparisons of zero tillage and reduced tillage for sowing wheat after paddy and in fallow field

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Av germination count per meter length/ No. of tillers/plant</th>
<th>Average grain to straw ratio</th>
<th>Yield, q/ha</th>
<th>Type of weeds</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. No tillage (paddy-wheat)</td>
<td>43.00/3.144</td>
<td>1:1.35</td>
<td>34.90</td>
<td>Lamb’s quarter/Chenopodium album, Mexican prickly poppy (Argemone mexicane)</td>
</tr>
<tr>
<td>2. One discking (Paddy-wheat)</td>
<td>57.00/2.34</td>
<td>1:1.95</td>
<td>41.16</td>
<td>Lamb’s quarter/Chenopodium album, Cynodondactylon</td>
</tr>
<tr>
<td>3. No-tillage (Fallow-wheat)</td>
<td>54.00/2.56</td>
<td>1:0.77</td>
<td>21.32</td>
<td>Canabis sativa, Chanopodium album</td>
</tr>
</tbody>
</table>
In 1996 :-

- Pantnagar (GBPUAT) – zero-till drill with “Inverted T-type” furrow openers.
- 100 drills sanctioned under FLD.
- NATP – 30 centres – zero-till drills.
- RWC formed for address problems of R-W growing countries of IGP.
- In India – 3 m.ha. – zero-tillage – Punjab, Haryana, Bihar, U.P.
Advantages of use of zero tillage

- Saves INR 2000-3000/ ha
- Higher yields (1-2 q/ ha)
- Less lodging
- No crop yellowing after first irrigation
- Controls *Phalaris minor* (30-50%) - weed
- Less tractor use/ wear of parts
- Better germination in salt affected area
- Less need of herbicide
- Improved residue management
- Saving in time (30-40%)
- Saving in labour and fuel (60 lt/ ha)
- Less incidence of stem borer
Reasons for adoption of zero-tillage for wheat by the farmers

Adopters
All categories of farmers

_____ for Adoption

- Reduction in cost of cultivation
- Reduction in fuel consumption
- Timely sowing of wheat
- Reduction in philaris minor population
Other direct benefits

- High crop yield
- Soil fertility increases due to residue management
- Irrigation water - saves 1st
- irrigation – quicker spread of water, reduces pumping time

Major adoption facility factors

- Refinement of no-till drill
- Promotion of manufacturers - by private manufacturers
- Steady government support and subsidies
- Integration of research efforts and large scale demonstration at farmers fields
## Conservation drills

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Zero till drill</th>
<th>Strip till drill</th>
<th>Roto dill drill</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source of power</td>
<td>45 hp tractor</td>
<td>45 hp tractor</td>
<td>45 hp tractor</td>
</tr>
<tr>
<td>Type/no. of furrow openers</td>
<td>Inverted ‘T’ type/09-11</td>
<td>Shoe type/09</td>
<td>Shoe type/11</td>
</tr>
<tr>
<td>Row spacings, mm</td>
<td>180 (Adjustable)</td>
<td>200 (Fixed)</td>
<td>160 (Adjustable)</td>
</tr>
<tr>
<td>Working width, mm</td>
<td>1600-2000</td>
<td>1800</td>
<td>1750</td>
</tr>
<tr>
<td>Drive wheel</td>
<td>Angle lug – front mounted</td>
<td>Angle lug – side mounted</td>
<td>Star lug – rear hinged</td>
</tr>
<tr>
<td>Weight, kg</td>
<td>210</td>
<td>250</td>
<td>280</td>
</tr>
<tr>
<td>Unit price, Rs</td>
<td>15000</td>
<td>45000</td>
<td>60000</td>
</tr>
</tbody>
</table>
# Field Performance

<table>
<thead>
<tr>
<th>Particular(s)</th>
<th>Zero tillage seeding</th>
<th>Strip tillage seeding</th>
<th>Roto tillage seeding</th>
<th>Conv. tillage (3 passes) – sowing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time, h/ha</td>
<td>3.23 (70.15)</td>
<td>4.17 (61.46)</td>
<td>3.45 (68.11)</td>
<td>10.82</td>
</tr>
<tr>
<td>Fuel used, l/ha</td>
<td>11.30 (67.36)</td>
<td>17.50 (49.45)</td>
<td>13.80 (60.14)</td>
<td>34.62</td>
</tr>
<tr>
<td>Operational energy, MJ/ha</td>
<td>648.96 (67.16)</td>
<td>1001.76 (49.31)</td>
<td>783.60 (60.35)</td>
<td>1976.11</td>
</tr>
<tr>
<td>Cost of operation, Rs/ha</td>
<td>639.54 (66.39)</td>
<td>979.95 (48.51)</td>
<td>807.30 (57.58)</td>
<td>1903.04</td>
</tr>
</tbody>
</table>
## Production–economics: Conservation drilling

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Zero till drilled</th>
<th>Strip till drilled</th>
<th>Roto till drilled</th>
<th>Conventionally sown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain yield, t/ha</td>
<td>4.84</td>
<td>4.62</td>
<td>4.78</td>
<td>4.60</td>
</tr>
<tr>
<td>Cost of production, Rs/ha</td>
<td>8635</td>
<td>9114</td>
<td>9315</td>
<td>10710</td>
</tr>
<tr>
<td>Benefit-cost ratio</td>
<td>3.64</td>
<td>3.29</td>
<td>3.34</td>
<td>2.79</td>
</tr>
<tr>
<td>Operational energy, MJ/ha</td>
<td>8114</td>
<td>8712</td>
<td>8444</td>
<td>9516</td>
</tr>
<tr>
<td>Sl. No.</td>
<td>Name of the country</td>
<td>Area under Zero tillage</td>
<td></td>
<td></td>
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<tr>
<td>--------</td>
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<td>-------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>USA</td>
<td>19,347,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Brazil</td>
<td>11,200,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Argentina</td>
<td>7,270,000</td>
<td></td>
<td></td>
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<tr>
<td>4</td>
<td>Canada</td>
<td>4,080,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Australia</td>
<td>1,000,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Paraguay</td>
<td>790,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>India</td>
<td>3,000,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Mexico</td>
<td>500,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Bolina</td>
<td>200,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Chile</td>
<td>96,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Uruguay</td>
<td>50,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Others</td>
<td>1,000,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>46,533,000</strong></td>
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<td></td>
</tr>
</tbody>
</table>
Conservation Practices in Paddy

- Paddy raised in nursery
- Transplanted
  - Laborious
  - drudgerous operation
  - requires frequent irrigation
  - 2000-3000 lit of water-1 kg of rice
- Pre-germinated paddy seeder
- Mat type transplanter
- Direct drilling on raised bed
  - Sesbania sisbon (brown manuring)
Experience of Bangladesh & Nepal

Participants discussing effect of single transplants, date of transplanting and suitability of rice cultivars (sudha and Parbhat) in cropping system perspective
Direct Seeded Rice – A promising Resource Conserving Technology (RCT)

Sesbania crop planted with rice
Traveling seminar participants visit a DSR field
Comparative input cost in puddled transplanted rice and saving in DSR

<table>
<thead>
<tr>
<th></th>
<th>Puddled Transplanted</th>
<th>DSR</th>
<th>∆ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Cost US$</td>
<td>518 ± 48</td>
<td>275 ± 47</td>
<td>73</td>
</tr>
</tbody>
</table>

Input cost in Puddled transplanting

Saving in DSR

Input cost breakdown for Puddled Transplanting:
- Transplanting: 5%
- Seed: 2%
- Fertilizers: 14%
- Irrigation: 22%
- Weedicide/Insecticide: 7%
- Harvest: 7%
- Land Preparation: 37%

Saving in DSR:
- Irrigation Water: 15%
- Land Preparation: 77%
Furrow Irrigated Raised Bed System (FIRBS)

- Wheat raised in small and broad beds
- 50% saving in seed
- 30-40% saving in water
- Higher yields
- Reduction in drudgery
- Facilitates mechanical weeding by tractor
- Offers opportunity for last irrigation at grain filling stage
- Avoids temporary water logging problems
- Allows subsurface basal and top dressing of fertilizer
- Reduces N losses & promotes rain-water conservation
Paddy sown or raised bed
Reducing unproductive evaporation losses of water by

- Residue management
- Seedling age at transplanting
- Seeding time
- Cultivar choice
- Laser land leveling
# Raised bed planting

<table>
<thead>
<tr>
<th>Particular</th>
<th>Planting on fresh preparatory tillage</th>
<th>Planting on permanent beds</th>
<th>Flat sowing zero tillage</th>
<th>Conv. Flat sowing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time required, h/ha</td>
<td>13.04</td>
<td>4.80 (55.6) [63.2]</td>
<td>3.23</td>
<td>10.82</td>
</tr>
<tr>
<td>Operational energy, MJ/ha</td>
<td>2605.36</td>
<td>1154.03 (41.6) [55.7]</td>
<td>648.96</td>
<td>1976.11</td>
</tr>
<tr>
<td>Cost of operation, Rs/ha</td>
<td>2479.84</td>
<td>1060.80 (44.3) [57.2]</td>
<td>639.54</td>
<td>1903.04</td>
</tr>
</tbody>
</table>

( ) % savings over conventional practice

[ ] % savings over fresh bed planting
## Production economics of rice after wheat: straw covered and straw incorporated

<table>
<thead>
<tr>
<th>Particular</th>
<th>Straw incorporated roto tillage rice</th>
<th>Non-straw roto tillage rice</th>
<th>Straw covered zero tillage rice</th>
<th>Non-straw zero tillage rice</th>
<th>Conv. Tillage rice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain yield, t/ha</td>
<td>3.31</td>
<td>3.24</td>
<td>3.36</td>
<td>3.30</td>
<td>2.94</td>
</tr>
<tr>
<td>Cost of production, Rs/ha</td>
<td>8801</td>
<td>9740</td>
<td>8640</td>
<td>9115</td>
<td>10610</td>
</tr>
<tr>
<td>Benefit cost ratio</td>
<td>1.88</td>
<td>1.66</td>
<td>1.94</td>
<td>1.81</td>
<td>1.39</td>
</tr>
<tr>
<td>Operational energy, MJ/ha</td>
<td>5579</td>
<td>6605</td>
<td>5512</td>
<td>5594</td>
<td>9642</td>
</tr>
<tr>
<td>Sp. Cost of production, Rs/kg</td>
<td>2.66</td>
<td>3.00</td>
<td>2.57</td>
<td>2.76</td>
<td>3.61</td>
</tr>
</tbody>
</table>
## Production economics

<table>
<thead>
<tr>
<th>Particular</th>
<th>Raised bed wheat</th>
<th>Zero tillage wheat sown</th>
<th>Conventional Flat sown wheat</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fresh bed</td>
<td>Permanent bed</td>
<td></td>
</tr>
<tr>
<td>Grain yield, t/ha</td>
<td>5.03</td>
<td>5.08</td>
<td>4.84</td>
</tr>
<tr>
<td>Cost of production, Rs/ha</td>
<td>10030</td>
<td>8540</td>
<td>8635</td>
</tr>
<tr>
<td>Benefit-cost ratio</td>
<td>3.26</td>
<td>3.87</td>
<td>3.64</td>
</tr>
<tr>
<td>Operational energy, MJ/ha</td>
<td>8750</td>
<td>7684</td>
<td>8444</td>
</tr>
<tr>
<td>Special operational energy, MJ/kg</td>
<td>1.74</td>
<td>1.51</td>
<td>1.74</td>
</tr>
<tr>
<td>Special cost of production, Rs/kg</td>
<td>1.99</td>
<td>1.68</td>
<td>1.78</td>
</tr>
</tbody>
</table>

### Saving in water

- Fresh bed = 30%
- Permanent beds = 40%
Cracking pattern in DSR and puddled rice fields
Leaf color chart
Surface Seeding of Rice in Water Logged Area

- Wheat seeds broadcasted in standing paddy field or after paddy harvest
- Avoids fallow fields
- Helps in taking one more crop
- Additional yield 3-4 t/ ha
- Low lying areas of IGP of India, Bangladesh and Nepal
- Popular in Yangtze River in China
- Saves labour, fuel and tillage costs
R.C. through use of laser land leveling

- Leveling by
  - animal drawn leveler
  - tractor drawn leveler
  - laser land leveler (both direction)
- Poor crop stand
- Laser land leveler
- Over irrigation and uneven distribution due to unevenness
  - increase water application efficiency up to 50%
  - cropping intensity by 40%
  - labour requirement by 35%
  - crop yield by 15 to 66%
Uneven distribution of irrigation water under traditional land leveling

Waterlogging in a wheat field

Laser leveled field prepared for rice transplanting

Non-uniform crop stand in an undulated field
Direct seeded rice in a laser-leveled field

- Save irrigation water
- Increase cultivable area by 3 to 5% approximately
- Improve crop establishment
Total water use (m$^3$ ha$^{-1}$) in wheat under precision and traditional land leveling
Residue Management and Reduction in Environmental Pollution

- Paddy straw burnt
  - Pollution
  - GHGs
  - soil degradation (loss of organic matter)
- mulch and promote ground water recharge
- reduces soil erosion
- solve liming problem in acidic soils
- About 1000 kg of biomass can give 10 litres of ethanol
Roto till drill

RDD seeding in full residue

Turbo seeder seeding in full residue

Happy combo seeder
Straw incorporated tillage seeding
Rotavator (in-chopped straw) shallow working-higher work rate than MB plough based cultivation system

<table>
<thead>
<tr>
<th>Type of straw field</th>
<th>Implement used</th>
<th>Time required, h/ha</th>
<th>Direct energy used, MJ/ha</th>
<th>Cost of operation, Rs/ha</th>
<th>Amount of straw incorporated, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combine harvested rice and wheat straw field (T1)</td>
<td>Stubble shaver (1)</td>
<td>2.75</td>
<td>508.06</td>
<td>511.99</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>MB plough (1)</td>
<td>5.13</td>
<td>1151.46</td>
<td>1041.84</td>
<td>76.70</td>
</tr>
<tr>
<td></td>
<td>Rotavator(1)</td>
<td>3.00</td>
<td>644.58</td>
<td>617.84</td>
<td>13.00</td>
</tr>
<tr>
<td></td>
<td>Seed-Fertilizer drill(1)</td>
<td>3.71</td>
<td>696.63</td>
<td>678.93</td>
<td>-</td>
</tr>
<tr>
<td>Combine harvested rice and wheat (T2)</td>
<td>Stubbler shaver(1)</td>
<td>2.75</td>
<td>508.06</td>
<td>511.99</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Rotavator(1)</td>
<td>3.58</td>
<td>721.30</td>
<td>768.71</td>
<td>60.43</td>
</tr>
<tr>
<td>Straw fields</td>
<td>Seed fertilizer drill(1)</td>
<td>4.88</td>
<td>916.39</td>
<td>893.04</td>
<td>-</td>
</tr>
<tr>
<td>Non-straw rice and wheat fields (T3)</td>
<td>Duck foot sweeps(3)</td>
<td>7.71</td>
<td>1446.87</td>
<td>1386.90</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Seed fertilizer drill(1)</td>
<td>2.99</td>
<td>560.53</td>
<td>546.26</td>
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</tbody>
</table>
### Production economics: straw fields

<table>
<thead>
<tr>
<th>Particular(s)</th>
<th>Wheat straw/non straw (control) -rice sown</th>
<th>Rice straw/non straw (control)-wheat sown</th>
<th>Rice-wheat straw/non straw (control)-field</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T1</td>
<td>T2</td>
<td>T3</td>
</tr>
<tr>
<td><strong>Grain yield, t/ha</strong></td>
<td>3.54</td>
<td>3.18</td>
<td>2.94</td>
</tr>
<tr>
<td><strong>Cost of production, Rs/ha</strong></td>
<td>10569</td>
<td>9805</td>
<td>10610</td>
</tr>
<tr>
<td><strong>Benefit cost ratio</strong></td>
<td>1.67</td>
<td>1.62</td>
<td>1.39</td>
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</tbody>
</table>
## Straw mulch minimum tillage rice-wheat

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Equipment used</th>
<th>Time required, h/ha</th>
<th>Operational energy, MJ/ha</th>
<th>Cost of operation, Rs/ha</th>
<th>Total time required, h/ha</th>
<th>Total operational energy, MJ/ha</th>
<th>Total cost of operation, Rs/ha</th>
<th>Amount of straw incorporation, %</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>T₁</strong></td>
<td>Stubble shaver drill</td>
<td>3.45</td>
<td>653.68</td>
<td>648.60</td>
<td>8.71</td>
<td>1859.06</td>
<td>1979.44</td>
<td>54.4</td>
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<tr>
<td></td>
<td>Roto till drill</td>
<td>5.26</td>
<td>1205.38</td>
<td>1230.84</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>T₂</strong></td>
<td>Stubbleshaver</td>
<td>3.45</td>
<td>653.68</td>
<td>648.60</td>
<td>8.21</td>
<td>1610.46</td>
<td>1591.08</td>
<td>-</td>
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<tr>
<td></td>
<td>Zero till drill</td>
<td>4.76</td>
<td>956.78</td>
<td>942.48</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>T₃</strong></td>
<td>Stubbleshaver</td>
<td>3.45</td>
<td>653.68</td>
<td>648.60</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rotavator</td>
<td>3.57</td>
<td>710.59</td>
<td>763.98</td>
<td>11.57</td>
<td>2201.98</td>
<td>2277.08</td>
<td>62.1</td>
</tr>
<tr>
<td></td>
<td>Seed cum fertilizer drill</td>
<td>4.55</td>
<td>837.71</td>
<td>864.50</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>
## Production economics of wheat after rice: straw covered and straw incorporated

<table>
<thead>
<tr>
<th>Parameter(s)</th>
<th>Rice straw condition</th>
<th>Non-straw conv. practice</th>
<th>Non-straw conv. Practice</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Roto till drilled wheat</td>
<td>Zero till drilled wheat</td>
<td>Rotavator+ drill combination wheat</td>
</tr>
<tr>
<td>Grain yield, t/ha</td>
<td>4.92</td>
<td>5.10</td>
<td>4.80</td>
</tr>
<tr>
<td>Cost of production, Rs/ha</td>
<td>9728</td>
<td>8885</td>
<td>10503</td>
</tr>
<tr>
<td>Benefit cost ratio</td>
<td>3.29</td>
<td>3.73</td>
<td>2.97</td>
</tr>
<tr>
<td>Operational energy, MJ/ha</td>
<td>8746</td>
<td>8345</td>
<td>8946</td>
</tr>
</tbody>
</table>
Straw Combine

Straw Baler
Conservation Development situations in the World and Member Countries and Policy Implication of C.A.

- CA adopted in America, Australia, U.K., Brazil, Canada
- Latin America and South Asian countries
- CA promoted
  - easy credit
  - extension programmes
  - pasture conversion by providing free seedlings
  - enforced land retirement due to excessive soil erosion and taxes due to soil erosion
- In France, Europe, Spain – CA – 1 m. ha.
- European Agriculture Federation (EAFs)
- United National Associations in France, Germany, UK, Spain, Portugal and Italy founded to promote CA.
CA has been adopted in Japan, Malaysia, Indonesia, Nepal and Bangladesh

Community led initiative strongly supported by R&D organizations and farmers and industry participation – widespread adoption.

Targeted Policy Approach and Motivate Farmers

Punjab – Water table going down-grow other crops than rice

Pride and Peer pressure- Canada, Ontario’s Environmental Farm Plan(EFO) Programme- innovative approach to Envirn. Conservation & voluntary participation of farmers to assess the Envir. Risks & raise environmental awareness

Farmers driven process supported by Govt. through funds & technical advise.

Appropriate Incentives- short & long term impact, diversification & Infrastructure
Conservation Policies & Programmes

CA Programmes/Studies launched
- African Conservation Tillage network (ACT)
- French Agriculture research Centre for International development (CIRAD), Swedish
- SIDA funded Regional land Mgt. Unit
- FAO

Study throws light on
- Challenges farmers face in keeping soil covered
- Gaining access to adequate equipment
- Controlling weeds
- Challenges faced to implement true PA
Farm Conservation Bill of US
Lays emphasis on- Cons. of resources, clean water, improvement in Grassland habitat & biofuel

- CSP - maintain & enhance quality of water, air, soil & habitat-$45,000/year
- CRP - reduce soil erosion - plant grasses - rental payments & 50% cost sharing
- WRP - restore & protect wetlands - 100% funding
- GRP - help to protect & restore grasslands, pasture, range and other lands (90% restoration cost funded)

- FRPP – protect Ag. land from urban sprawl & other development - one time payment
- EQUIP - to reduce air and pollution use, energy use and wildlife impacts (70% cost sharing)
- CWLCP - ensure no overall net loss & achieve net gain in performance of wetland acreage
Conservation Policy in India

- No Policy as such
- Govt- Watershed Development Programme- to conserve water & reduce soil erosion
- Promotion of RCT-zero-till drill, laser land leveling, straw baler, straw combine etc.
- R-W Consortium- ICAR- CIMMYT
- Alternate crops –Diversification

Following recommended

- Minimum support price, subsidy, Institutional financing, no free electricity, PPP, Land consolidation, Encourage Cooperatives, voluntary participation of farmers, NGOs, etc.
Conservation Ag. Strategies in India

Conservation of water through
- paddy sown in unpuddled soils
- paddy sown on ridges
- Less frequency of irrigation
- laser land leveling- 25 % saving in water

Conservation Tillage Studies
- Development & demonstration of zero-till drill, strip till drill, roto-till drill, till planting, raised bed planter etc.
Conservation Ag. Strategies in India

Farm Residue Management through
- stubble shaver,
- straw chopper cum incorporator
- straw combine
- straw baler

Environmental Pollution
- Exhaust gas emission norms for tractors/engines
- Fuel standards
- CNG
- Biofuel Mission
Conclusions

Benefits accrued of CAT

- Reduction in cultivation cost (1500-2000 Rs/ha)
- Savings in water and nutrients (25-30%)
- Reduced occurrence of weeds and savings in pesticides (20-25%)
- Increased yield (05%)
- Protection of environment by elimination of burning of straw (Cattle feed)
- Facilitating recycling of residue and plant nutrients (Back to soil)
- Opportunities for sensible/profitable crop rotations.
WE to Conserve for US

THANK YOU