Conservation Agriculture (CA) Machines

He Jin, Professor

China Institute of Conservation Tillage, China Agricultural University
Conservation Tillage Research Centre, MOA

Email: hejin@cau.edu.cn
China Conservation Tillage Network
http://www.cn-ct.net

新疆博乐市保护性耕作工作推进会顺利召开

2019年10月13日，由博乐市人民政府组织的保护性耕作工作推进会在博乐市以西粮食主产区顺利召开。推进会向博尔塔拉蒙古自治州粮食主产区农业、农机、粮农展示了玉米免耕精量播种与水肥管理的最新技术。
Tasks

- Machine Development
- Conservation Agriculture
- Yields
- Economic benefit
- Wind erosion
- Water erosion
- Soil Moisture
- Weeds Control
- GHG Emission
- Others
Main Principles of CA

1. Minimum tillage and soil disturbance

2. Permanent soil cover with crop residues and live mulches

3. Crop rotation and intercropping

CA globally 180 Million ha (2015/16)
(12.5% of annual cropland)

Source: FAO
Distribution of CA area

Source: FAO
<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total area of crop land</td>
<td>149 Mha</td>
</tr>
<tr>
<td>Conservation agriculture (CA)</td>
<td>7.6 Mha</td>
</tr>
<tr>
<td>Percentage of CA</td>
<td>5.1%</td>
</tr>
</tbody>
</table>
Current Status of CA

INTERNATIONAL JOURNAL OF ENVIRONMENTAL STUDIES
https://doi.org/10.1080/00207233.2018.1494927

ARTICLE

Global spread of Conservation Agriculture

A. Kassam\textsuperscript{a}, T. Friedrich\textsuperscript{b} and R. Derpsch\textsuperscript{c}

\textsuperscript{a}School of Agriculture, Policy and Development, University of Reading, UK; \textsuperscript{b}Food and Agriculture Organization (FAO) of the United Nations, La Paz, Bolivia; \textsuperscript{c}International Consultant for Conservation Agriculture/No-till, Asunción, Paraguay

ABSTRACT

Conservation Agriculture (CA) comprises the practical application of three interlinked principles, namely: no or minimum mechanical soil disturbance, biomass mulch soil cover and crop species diversification, in conjunction with other complementary good agricultural practices of integrated crop and production management. In 2015/16, CA was practised globally on about 180 M ha of cropland, corresponding to about 12.5\% of the total global cropland. In 2008/09, the spread of CA was reported to be about 106 M ha. This change constitutes an increase of some 69\% globally since 2008/09. In 2015/16, CA adoption was reported by 78 countries, an increase in adoption by 42 more countries since 2008/09, respectively. The average annual rate of global expansion of CA cropland area since 2008/2009 has been some 10.5 M ha. The largest extents of adoption are in South and North America, followed by Australia and New Zealand, Asia, Russia and Ukraine, Europe and Africa.

KEYWORDS

No-till; mulch; crop diversification; sustainability; adoption; policy
• Benefits

➢ Increase crop yields
➢ Decrease production cost
➢ Improve soil property
➢ Reduce soil erosion (water/wind)

Avoid straw burning  Improve soil property  Dust and run-off reduction
Machine is the key for large area adoption of CA
CA machines

◆ Straw chopping machine
◆ Reduced tillage machine
◆ No/minimum-tillage seeder
## 1.1 The chopping blade

<table>
<thead>
<tr>
<th>Type</th>
<th>Figure</th>
<th>Description</th>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hammer</td>
<td><img src="image1" alt="Hammer" /></td>
<td>Suit for hard crop straw (maize, cotton); usually made of high strength and wear-resistant cast steel</td>
<td>Good chopping quality; long operating life</td>
<td>High fuel consumption</td>
</tr>
<tr>
<td>Straight</td>
<td><img src="image2" alt="Straight" /></td>
<td>Suit for soft crop straw (wheat, rice); usually work with stationary blade; sharp cutting edge</td>
<td>Good chopping quality; low fuel consumption</td>
<td>Poor pick up ability</td>
</tr>
<tr>
<td>Bent</td>
<td><img src="image3" alt="Bent" /></td>
<td>Suit for hard crop straw (maize, sorghum); blade shape is usually L or Y type;</td>
<td>Good pick up ability; low fuel consumption</td>
<td>Low blade strength</td>
</tr>
<tr>
<td>V-L</td>
<td><img src="image4" alt="V-L" /></td>
<td>Suit for maize; a V-bending section is added on L shaped blade; barycenter locates in the same plane with blade handle</td>
<td>Good chopping quality; high work efficiency</td>
<td>Complex shape; high machining requirements</td>
</tr>
</tbody>
</table>
### 1.1 The chopping blade

<table>
<thead>
<tr>
<th>Type</th>
<th>Figure</th>
<th>Description</th>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Y</strong></td>
<td><img src="image" alt="Y type blade" /></td>
<td>Suit for hard crop straw (maize, sorghum); Similar to Y type blade; barycenter locates on symmetric line of blade</td>
<td>Good symmetry of the shape; big inertia moment</td>
<td>Short edge line; large mass</td>
</tr>
<tr>
<td><strong>T</strong></td>
<td><img src="image" alt="T type blade" /></td>
<td>Suit for maize; chopping straw and shredding stubble simultaneously; three parts of blade fixed together</td>
<td>More cutting edge; big inertia moment</td>
<td>Complex structure; inconvenient installation</td>
</tr>
<tr>
<td>Three-section linked</td>
<td><img src="image" alt="Linked blade" /></td>
<td>Suit for maize and wheat; Chopping straw and shredding stubble simultaneously; three parts of blade hinged together</td>
<td>Good chopping quality; high work efficiency</td>
<td>High working resistance; short operating life</td>
</tr>
</tbody>
</table>
1.2 The chopping machine

Features:
- High speed rotation of knife: 2000r/min;
- Straw was cut, teared and rubbed to segments or fibers
- The chopped straw is spread to the field by the airflow and centrifugal force
- ……
CA machines

◆ Straw chopping machine
◆ Reduced tillage machine
◆ No/minimum-tillage seeder
2. Reduced tillage machine

2.1 Subsoiler

2.2 Shallow tillage machine

2.3 Strip tillage machine
2.1 Subsoiler

Classification:

1. Chisel subsoiler
2. Omni-directional subsoiler
3. Vibrating subsoiler
1. Chisel subsoiler

Features:
- Shank compressed, lifted and cut soil
- Subsoiling depth: 30~50cm
- Shank spacing: 40~80cm
- Simple
- …..
1. Chisel subsoiler

**Features:**
- Increase loosening range
- Higher loosening soil coefficient
- ……

**Disadvantages:**
- Increase power consumption

*Chisel with wing subsoiler*
2. Omni-directional subsoiler

V-type

Side bended type
2. Omni-directional subsoiler

**Features:**
- Soil loosening coefficient: $\geq 0.77$
- Wider loosening range
- Flat soil surface after subsoiling (with roller)
- ……

**Disadvantages:**
- Higher power consumption
- Poor passibility when straw mulching and much weed in the soil
- Unsuitable in intertillage stage
3. Vibrating subsoiler

Classification
- Self-excited vibrating subsoiler
- Forced-excited vibrating subsoiler

Chisel subsoiler + excitation source = vibrating subsoiling

Omni-directional subsoiler

Reduce traction resistance by 6.9-17%
3.1 Self-excited vibrating subsoiler

Excitation source of spring

Excitation source of hydraumatic
3.2 Forced-excited vibrating subsoiler

**Features:**
- Significantly reduce traction resistance
- Power excitation source form tractor

**Main Composition:**
Eccentric shaft, eccentric bearing, cross connector, connecting plate and supporting rotating shaft

**Disadvantages:**
- Higher power consumption
- Effect the life of subsoiler
- Partly compressed broken soil by vibration
2.2 Shallow Tillage machine

**Function:**
- Loosens and flat surface soil to obtain a better seedbed and reduce ditch resistance
- Adjustment of surface straw coverage
- Better weeding function

**Main Structure:**
- Multi-beam structure, chisel/shovel spring tooth harrow or shallow tillage shovel

**Working depth:** 5-10 cm
2.3 Strip Tillage machine

➢ Only tillage in seed row
➢ 20-50% soil was distributed
➢ Tillage width: 15-25 cm;
➢ Tillage depth: 10-20 cm;
➢ No-till in row space and straw mulching
➢ Fertilization in seed row
Classification of strip tillage machine

- Chisel shovel type
- Disc type
Chisel shovel type

1. Residue cutting disc
2. Cleaning disc
3. Chisel shovel
4. Depth adjustment
5. Floating closing disc
6. Broken soil disc
Disc type

- Hanger
- Strip cleaning disc
- Depth wheel
- Disc
- Closing disc
- Frame
- Broken soil disc
CA machines

◆ Straw chopping machine
◆ Reduced tillage machine
◆ No/minimum-tillage seeder
No-till seeding condition

No-till, heavy residues cover, uneven. Great challenge!!
Key technology for no-till seeder

Residue Handling
Three main principles of residue handling for no-till seeder

1. Residue *slips* from Tine Opener
2. Residue *cut* by Disc whose line speed equals to tractor
3. Residues are moved, picked up, chopped by highly moving components which are *driven* by PTO
Type 1
Residue slips from Tine Opener

- High
- Wide
- Simple

...
High-clearance

Traditional Seeder

No-Till Seeder
Wider row space
Wider row space
Wider row space
Simpler ground components
Additional components to push away residues
Avoiding residues rows
---by Guiding System

By experience

Chinese Beidou Navigation System
Some words to these seeders

• It is easy for Tine Opener to open furrow;

• Also easy for Tine Opener to become stubble collector, then blocked.

• A little bit more soil disturbance as compared to Disc Opener
Problems?
Blockage
Type 2
Residue cut by Disc Opener

High Speed, Cut residues by machine weight
Speed and Force
China Made No-Till Seeders
Some words to these seeders

• Soil disturbance is lowest, it is even difficult to find the furrow after sowing
• Need heavy weight to give enough pressure to disc;
• Need big tractor to draw the seeder to run faster to make disc rotate quickly;
• Not easy to make the disc
Problem?

Seeds planted on residues
Type 3
Residues handled by powered components
(1) Strip-till seeding
Rice transplanting after strip-till
(2) Strip-chop seeding
(3) Driven oblique disc

a. Middle  b. Side  c. None
(4) Driven straight disc–embedded in tine opener
(5) Driven residue-throwing finger
(6) Driven chain with tooth
(7) Residue picked, chopped and thrown back of seeder, Happy seeder
(8) Residue Strip-chopped
(9) Residue picked, chopped and thrown aside of seeder
No/minimum-till seeders powered by 2 wheels tractor
Some words to these seeders

• Can be used in all condition, especially heavy stubble;

• Need more power to drive the powered components;

• A little bit more soil disturbance
Manual and animal-traction no-till seeder

Pushed or pulled
Jab Planter
Hand Hoe Seeder/Li Seeder
Vietnam

Premier Tanzania

East Timor
Development of small/medium size no-till and minimum-till seeders in Asia: A review

He Jin, Zhang Zhiqiang, Li Hongwen*, Wang Qingjie

(College of Engineering, China Agricultural University, Beijing 100083, China)

Abstract: The benefits of conservation agriculture (CA), have been widely recognized and CA has been widely adopted in many parts of the world. However, there are some factors that limit the widespread adoption of CA in Asia. The most prominent factor appears to be the lack of suitable CA seeders for small to medium sized land-holding (SLH) farmers. This paper summarizes the small to medium no-till and minimum-till seeders currently available in Asia, and classifies these seeders into four types: manually operated units, animal traction seeders, two-wheel tractor and four-wheel tractor driven seeders. Detailed characteristics have been provided for some typical CA seeders and comparisons were made as to their suitability under particular working conditions. Typically manual and animal traction seeders are confined to small farms and hilly areas, while the larger CA seeders suited to four-wheel tractors are used on larger acreages. To ensure seeding performance on most four-wheel tractor CA seeders, two types of anti-blocking mechanisms (passive and active anti-blocking) have been fitted. Finally, the paper proposes a future direction and development of CA seeders for small/medium size farms in Asia, and also suggests changes in policy support, improvement of anti-blocking mechanisms, suitability for various crops, geographical zones and the contribution of development by public private partnerships to advance the adoption of CA seeders.

Keywords: conservation agriculture (CA), conservation tillage, no-till, minimum-till, seeder, tractor, anti-blockage, Asia

DOI: 10.3965/j.ijabe.20140704.001
Challenge and Outlook

Challenges

- Suitable machines
- Economic benefit due to small farmland
- Weed
- Farmers’ traditional notion
- ……
Central Document No. 1

- **2005**: Reform traditional tillage methods and develop conservation agriculture
- **2006**: Continue to implement conservation agriculture demonstration projects
- **2007**: Pilot project to promote subsidies for no-tillage cultivation technology
- **2008**: Continue to implement conservation agriculture projects
- **2009**: Vigorously carry out conservation agriculture
- **2010**: Promote conservation agriculture techniques
- **2011**: Using conservation agriculture techniques
- **2012**: Actively promote conservation agriculture techniques
- **2013**: Continue to implement soil organic matter enhancement subsidies
- **2014**: Promote mechanized straw retention technology
- **2015**: Carry out straw resource utilization
- **2017**: Encourage local government to increase integrated straw management and improve the subsidy mechanism for straw diversification
- **2018**: Promote integrated straw management

Accelerating the sustainable agriculture development
Policy priorities for CA in China

• National policy and financial support
• Locally applicable scientific research
• Better extension and training for farmers
• International cooperation and communication
• ……
A special book on CA ----by World Bank Institute

Exchanging Experience with Conservation Agriculture
Towards Climate Resilience

Authors:
LI Hongwen, XIE Mei, HE Jin
Assisted by:
HUAN Yu

Art drawing:
JIANG Heping
Conservation Agriculture --- A story from China

Welcome south-south knowledge sharing delegation

My name is Li Long. Welcome to my farm.

Thank you for inviting us!

It is our pleasure to meet you, Mr. Li.

I hear that you are having a bad drought. But I see that your crops are doing very well. What is your trick?

Well, my “trick” is conservation agriculture.
China Institute of Conservation Tillage, China Agricultural University
Conservation Tillage Research Centre, MOA

Thanks!