Discussion and Outlook for Developing Circular Agriculture in China

Prof. Gao Wangsheng

Agronomy Dep., China Agricultural University (CAU)
Director, Circular Agriculture Research Center (CARC)
Chairman, China Farming System Research Association (CFSRA)

Email: wshgao@cau.edu.cn
Tel/Fax: 8610-62731163
Outline

1. Conceptual thinking about circular agriculture
2. Importance to develop CA in China
3. Basic modes and technology of CA in China
4. Outlook
1. How to think about circular agriculture (CA)
1.1 From Circular Economy (CE) concept to Circular Agriculture (CA)

- Since 1960’s, the reflections on conventional “fossil energy economy” mode have been going on for half a century.

- “Spaceship Economy” (K. E. Boulding, 1962)
- The Limits to Growth (Rome Club, 1972)
- Sustainable Development (WCED, 1987)
- The concept of “Circular Economy” by D. Pearce, 1990
What is Circular Economy (CE) mode?

This is such a desirable industry system, which want to accomplish multi-level and multi-gradient recycling utilization of all materials in industrial system, to attain highest resource use efficiency, and to minimize the emissions or “zero emissions” to the environment in the system.
The ‘3R’ Rules for CE

Reduce

to reduce the unnecessary material and energy inputs from the outside of the system

Reuse

to apply for rules of material multi-level and multi-gradient utilization to make use of the most mediate products

Recycle

to re-entering the material recycling process for those which have completed their function after using by some measures
1.2 What's the concept for Circular Agriculture (CA)?

Circular agriculture is such an agricultural production mode, which is based on circular economy theory and had to attain the four goals by integrated design and management of an agricultural system—

- highest natural resource use efficiency
- least purchased resource input
- highest renewable resources recycle efficiency
- least pollutant emissions

(Gao, 2007)
a) **opening system:** CA system is not a closed but an open one. so CA is not fully constructed followed by a closed industry cycle model as factory.
b) **Two channels input**: CA system always exchange information in the form of energy and matter including “two-channels type”--- natural energy (or matter) and artificial energy (or matter).

Therefore, we can’t make a mistake to understand the CA only as a natural system to circulate by itself.
c) Bio- self- circulation. CA system is required to make use of the biological interactions of mutualism, competition exclusion principles etc, to construct compound biological structure and enhance the biodiversity.

d) Multiple benefits: CA is a multi-purposes eco-economic system with the aim for productivity, economy efficiency as well as ecological, social harmony.
Conclusion: CA is one of sustainable agriculture mode with the features of ‘high economy efficiency, available technology, ecological safety, environment friendly and social approval’.
1.3 The key technology features for CA
Special ’4R’ rules for CA technology.

1. **Recycle** - for the renewable natural resource, such as climate, water etc), and for recycling matter resources. Crop-livestock-process system.
2. **Reuse** - for the reproductive resource, such as straw, excrements.
3. **Reduce** - for the purchased resource, such as fertilizer, pesticide, fuel energy.
4. **Regulating** - for the pollution emission materials, such as GHGs, NP pollution.

Technical Goals:

1. **Highest resource use efficiency**
2. **Least resource input consumption**
3. **Least pollutant emissions and waste output**
① Key techniques aimed at “reduce” rule

**Reduce fertilizer**
- High NP cycle effective utilization and fertilizer-saving techniques
  - Nitrogen cycle regulation
  - Phosphor cycle utilization
  - Biological Nitrogen Fixation
  •

**Reduce pesticide**
- Biological Control and pesticide-reducing techniques
  - Natural Enemies Utilization
  - Biological Pesticides
  - Bioremediation
  •

**Reduce energy**
- Tillage and energy-saving techniques
  - Minimum and no-tillage
  •
- New type energy-saving machines
  •
Key techniques aimed at “reuse” rule

1. Direct reuse techniques of reproductive resources in farmland
   - Straw straight return to field
   - Animal manure back land

2. High value techniques of reproductive resources in farmland
   - Straw ensiling technique
   - Fodder with crops atraws processing
   - Organic fertilizer crops straws processing
   - Producing edible fungus with straws

3. Bioenergy techniques for reproductive resources
   - Biofuel
   - Biomass products
③ Key techniques aimed at “recycle” rule

1. Key techniques of climate resources recycle round the year
   - Multiple cropping, vertical cropping in farmland

2. Key techniques of recycling production based on the industry correlation
   - Conjunction of farmland and animal husbandry
   - Conjunction of farmland and edible fungi industry
④ Key techniques aimed at “regulating” rule

1. NP pollutant control technique in farmland
   Biological control technique
   Engineering control technique
   Catchment control technique

2. GHGs release control technique
   Methane (CH₄) control technique
   Nitric oxide control technique
   Carbon sequestration increasing technique in farmland
2. The importance of developing circular agriculture in China
2.1、The first crucial demand is how to *reduce high energy consumption and resources inputs* in farming system so as to decreasing the cost of economy and ecology.
China feed 22% population in the world by using of the world.

-- 20% of the rural labors
-- 30% of the fertilizers
-- 25% of the pesticides
-- 25% of the irrigation water
Industrial material inputs increasing of agriculture 1980-2005

- Plastic film
- Pesticide
- Chemical fertilizer

- Fertilizer: 4766 million tons
- pesticide: 146 million tons
- Film: 176 million tons

Data source: "China Agriculture Statistics Yearbook"
The chemical fertilizer amount and total grain since 1975, China.
2.2  The second demand is how to reuse the natural (climate, water, land, etc) resources efficiently as to alleviating the pressure on agricultural natural resources for China.
Climate reuse potential: Average light energy use efficiency in farmland is lower than 1% in China, but it can reach 5% theoretically. Cropping Index Potential in whole China can be up to about 170%, but it is 156% now.

Water reuse potential: average farmland water using ratio is less than 40% in China but more than 70% in the world; more than 10 billion m³ renewable water resources to farming.

Land reuse potential: more than 50 million ha lower yield cropland, and many marginal land can be use for sustainable farming or forestry and bio-fuel production.
2.3 The third demand is *how to regulate and reduce pollutants* in agricultural production so as to protecting the environment.
Average rates of N and P fertilizer in Chinese farmland are in relatively high level in the world, more than 350 kg/ha per year.
The pesticides output in China is 1.5 million ton, up to the second largest in the world, in which include 70% of the insecticides.
The average residual rate of the mulching plastic to the soil is over 20%, residual plastic in farm more than 0.5 million ton every year.
Total polluted farmland is over 15 million ha in China.
About over 40% river water polluted in different level.
2. 4  The forth demand is *how to return-use or recycle-use more renewable medium residues material* such as crop straw, so as to extending the energy, matter, economy chains of agriculture system.
About 0.7 billion tons of the straw resources per year, more than 50% of which was not used, Most of which were directly firing in the farmland and wasted or polluted the regional environment.

The results from our investigation on straw utilization in 200 villages in China (2006): 44.2% for fuel, and for 30.9% fodder, and 25.2% straight return to field.
3、 The main patterns of CA in China
The circular patterns of multiple cropping

The circular patterns of combination farming with animal husbandry

The patterns of processing and using agricultural wastes

The patterns of circular agriculture related to eco-enterprises
3.1. The patterns of mixed cropping system

- Intercropping
- Relay cropping
- Multiple cropping
- Agro-forestry

This pattern has a long history with rich forms in China. The planting areas of all kinds of this pattern are about 33 million ha now.
3.2. The patterns of crop straw returning to field directly

- Returning the wheat stubble to land
- Maize stalks crushed to the field
- Rice no-till cultivation with straw mulching in south of China
Northeast corn mulch return in winter
Centre plain area corn straw total return to field
Rice straw crashed return to field---planting wheat
South area, rice straw cover field ---planting cash crops
3.3. The patterns of combine crop with livestock production

For example:
The circular patterns of integration of grazing and raising: raising cattle with crop straw

The circular patterns of rice-fish ecosystem: rice-azolla-fish ecosystem

The patterns of vertical raising in paddy field: feeding ducks in paddy fields

The circular patterns of fish pond-dike system
3.4. The processing patterns reusing wastes resources

① pattern of agricultural wastes transformed into biomass energy, such as marsh gas
② pattern of agricultural residues transformed into mushroom (fungus)
③ straw stalk transformed into the paper pulp or fertilizer
The agricultural residues converted into the biogas energy

- Wastes like straw
  - Agricultural production
  - Biological energy generation or marsh gas
  - The ash or marsh liquid after burning
  - Residents’ life
  - Industrial and agricultural production
Several marsh gas pits in rural areas.
Construct mode

- Pig sty
- Washroom
- Cooking room
“home--Pig-gas--fruit ” circular mode
Benefit marsh gas in rural

Farm fuel energy

Gas $8 \text{m}^3$

80% cooking fuel

Ecologic

Gas $8 \text{m}^3$

1204 kg, firewood

3.5 mu woodland
In 2006, mash gas farmers is 21.75 million family. Annually, the total gas is about 8.5 bill. m3.

At 2010, will up to 40.00 million family, the total gas about 18.5 bill. M3

At 2020, universal using rate 70% of proper farmers in China
Recycle mode of agricultural wastes into mushrooms

Agricultural wastes → mushroom without soil → Mushroom dregs → Soil mushroom → Mushroom dregs

Field Planting

Organic fertilizer
rice straw gathering
straw composing
Mushroom production
In 2006, the mushroom production was about 14 million tons, 70% of total in the world.

The value of mushroom industry is about 60 billion RMB, as the first rank in the world.

“straw—mushroom-fertilizer-field” mode has been developed rapidly in such as Fujian, Shandong province.
(3) Recycle mode of straw converted into paper pulp or fertilizer

Agriculture production

Agricultural product

Chemical industry technology

Straw

Raw material for paper making

Paper pulp

paper

Organic fertilizer

Black liquid waste

www.umi.com
3.5. Ecological enterprise company mode

Beijing “Crab Island” mode: an urban sight-seeing agriculture company based on circular industry system
Beijing “Crab Island” mode landscape
4. Outlook for CA in China
From now to 2020, to develop CA will be concerned with follow big challenges:

---to get more grain yield and productivity for food security under the less land and more people pressure

--to reduce the input cost for farmers income increase over 1 times than now

--to protect rural environment with the integration of city-rural development
• Income increasing rate bt. city & rural

- Rural rate (%)
- GNP rate (%)
- City rate (%)

Huaxi village, Jiangsu

Rich rural

Sustainable?
Water in Lake pollution
To protect the environment, to save all resources, and to develop sustainable, environment-friendly economy have been confirmed as the basic national policy since this century in China.

In 2002, the central government of China has brought up the strategy to develop circular economy, and to build resources-save society.

In 2008, the <Circular Economy Law> Carried out.

In this LAW, it was identified the rights and obligations for different interest group (government, enterprises, community, individual, etc.) through legislation. This Law will improve CA development in the future.

Since 2002, it was emphasized and studied such the Green accounting policy, Ecological compensation policy.
More than 100 organizations and enterprises participated in the CA research network organized by MOST Since 2004

More than 10 CA practice demonstration region on farm were built by MOA Since 2004

More than 10 national research projects on the CA technology innovation started by government with some company

International co-operation on CA also strengthened further.
Summery

- CA is a new concept and one new way to design and manage the modern sustainable agriculture system.
- CA mode mainly concern with energy, matter high utilization and cycling use way, not all issues of agriculture.
- CA mode have special “4R” technical rules of which differs as typical factory system
- CA development need new technology innovation, and new policies
China pay more attention to develop CA since 2002

China will put more efforts to research on CA technology, CA regional mode, CA polices innovation, etc in the future.
Thanks for Your Attention!