Sustainable Utilization of Organic Waste in Arable Land of China

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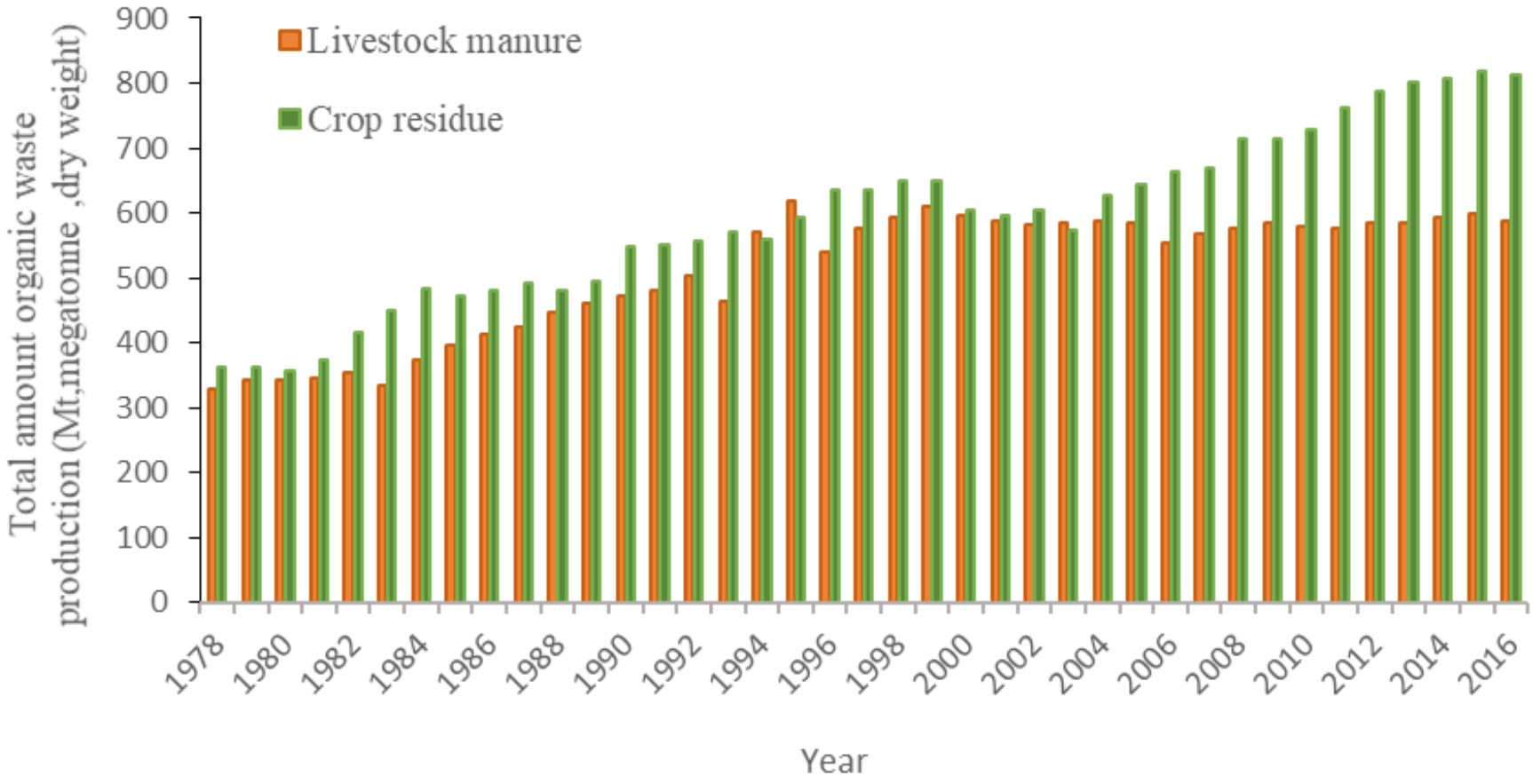
Content

- Challenges to recycle main organic waste in Chinese agriculture
- Principles to comply with agricultural and environmental requirements
- Strengthening the recycling of organic waste through fertilizer market
- Perspectives

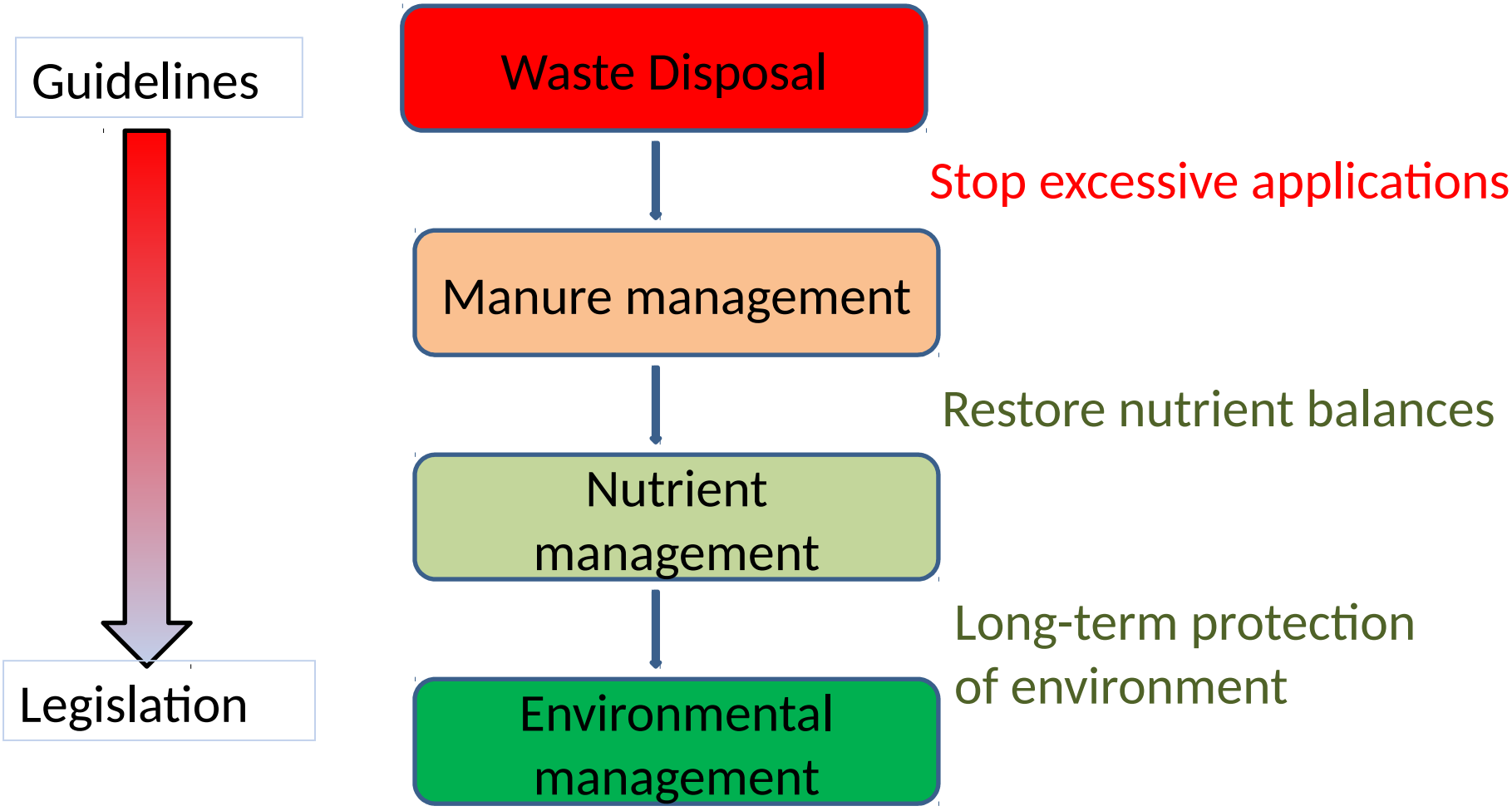
The change of main organic waste i.e. manure and crop residue in agriculture of China from 1978 to 2016

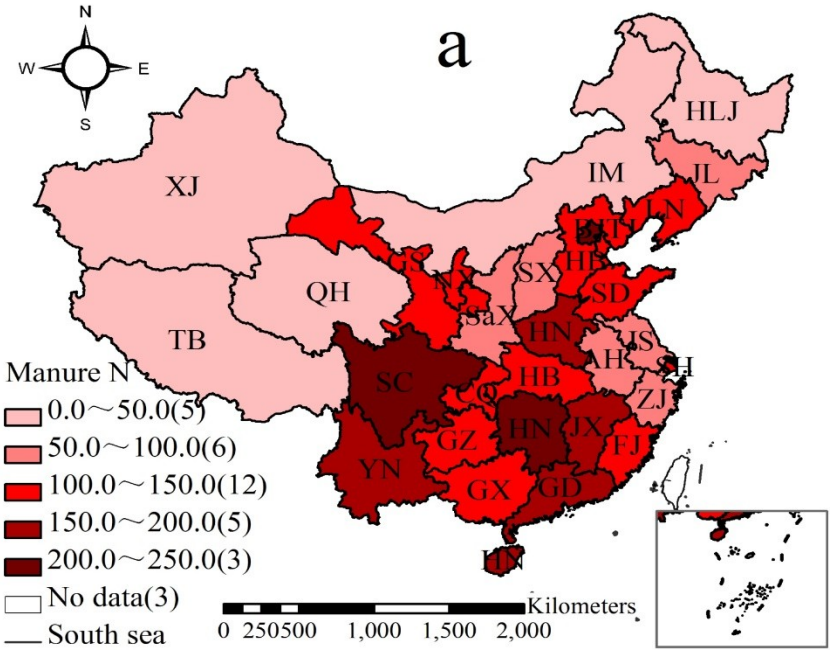


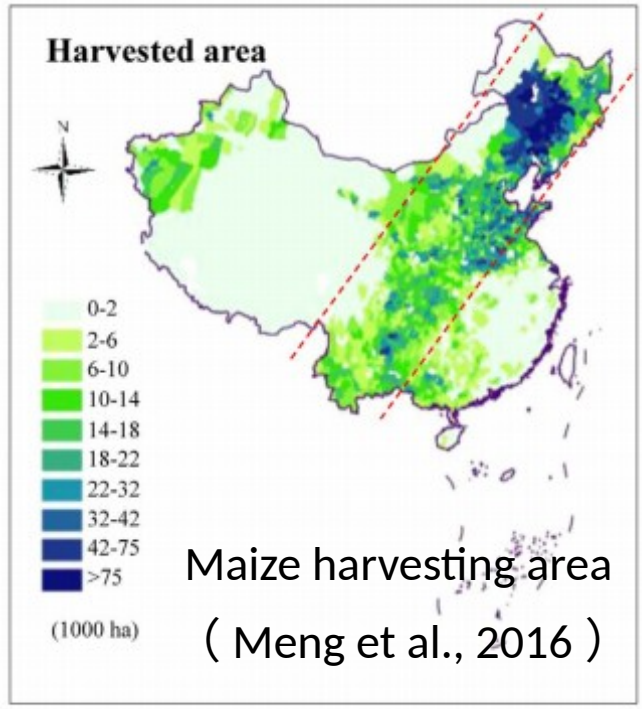
Data were estimated based on Chinese Statistical Books and Jia et al., 2018

These organic wastes contain: 17.3 mt N, 4.0 mt P, 12.7 mt K in manure; 8 mt N, 1.2 mt P and 6.6 mt K in crop residue

Manure: a disposal problem or a nutrient resource?

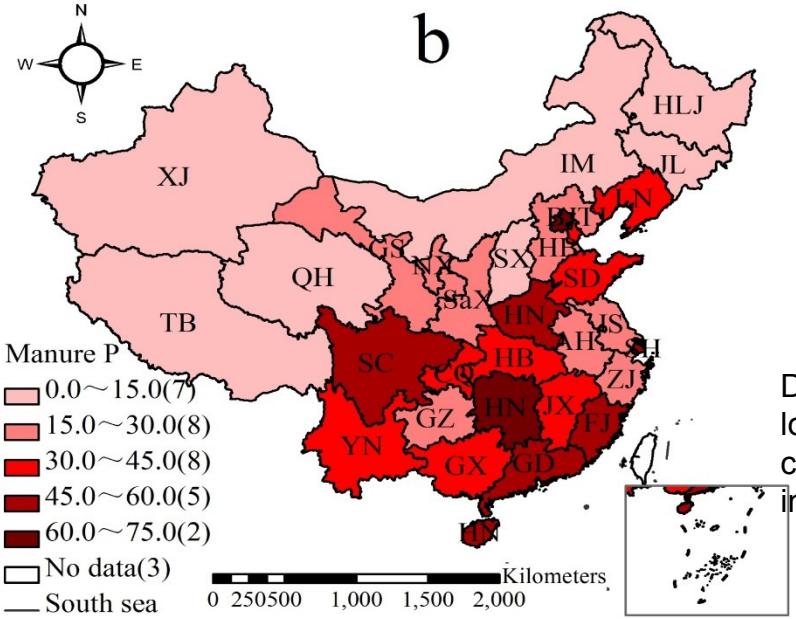






Maize harvesting area

（Meng et al., 2016）



Spatial distribution inconsistency between feeds (maize etc) and manure considering nutrient (N and P etc) recycling

Distribution of manure and manure N and P at the provincial level, with loading rates in (a) kilograms of N and (b) kilograms of P per hectare of cropland and (c) megagrams (Mg) of manure. Values in parentheses indicate the number of provinces in the given category (Jia et al., 2018)

Environmental pressure from organic waste in livestockfarm

Faeces and uraine

N loss 27%

- Ammonia emission
- GHG emission
- Odor emission

Composting

N loss 30.7%

Storage

N loss 37.8%

- Ammonia emission
- GHG emission
- Odor emission

Biogas N loss 9%

- Ammonia emission
- GHG emission

Crop uptake

N loss 31.1% of applied

N and P runoff

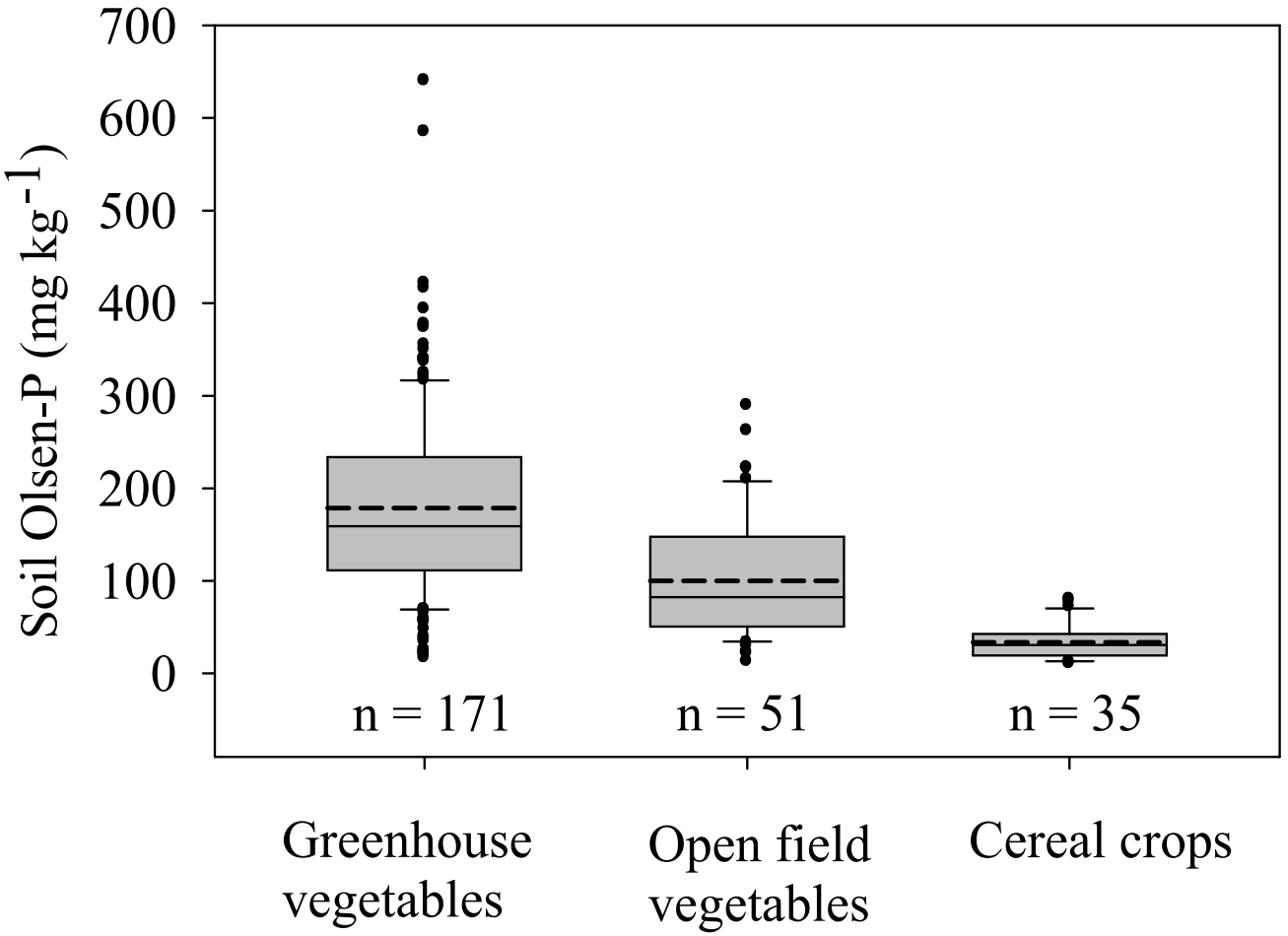
Heavy metals & P accumulation

Nitrate & P leaching

Euthrophication

Based on some literatures

Focusing on high P accumulation in vegetable fields which revealed dominant manure discharged from livestock farms



The P-imbalance in vegetable field

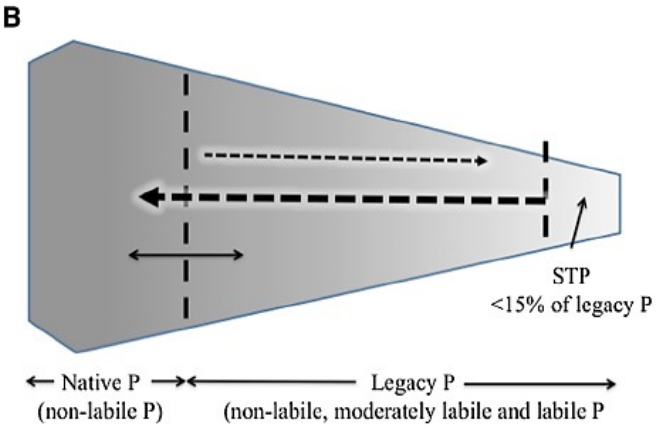
P application exceeded P removal by 13.0-fold in greenhouse and 4.7-fold in open field; Over 50%of applied P derived from manure

(Yan et al., 2013)

95% of protected-field existed the high risk of P mobility

- Agronomic threshold: 46-57 mg P kg^{-1} in open field; ~90 mg P kg^{-1} in protected field
- Environmental threshold: 50-60 mg P kg^{-1} (Jiang et al., 2008; Qin et al., 2010; Zhang et al., 2012; Wang et al., 2006)

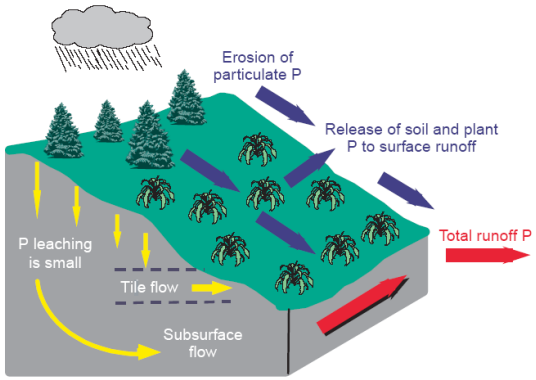
How to avoid the environmental risk caused by high legacy phosphorus ?



(Wither et al., 2014)

Soil P fertility

Eutrophication



The levels and forms of soil legacy P indicated the availability to crop or the mobility to environment

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The Swedish Experience:

- Livestock density: according to P contents of manure (23-25 kg P/ha)
- Manure storage: storage capacity, covering of urine and slurry pits, filling beneath the cover
- Application of manure: ban, new requirements, incorporation, spreading techniques when spreading in a growing crops
- Application of fertilisers: nitrogen application according to the crops requirements, ban on winter spreading
- Winter-green land: 60 resp. 50%
- Permits for farms with more than 200 livestock units

Christine Jakobsson, 2003

The Livestock Manure N Farm Limit in UK

- *The amount of livestock manure applied to land each year, including by the animals themselves, shall not exceed 170 kg N/ha.' (Derogation to 250 kg N/ha)*
- Calculate the farm manure N capacity and manure N loading (area of farm, standard N production figures, manure imports/exports)
- Calculations must be shown

Stocking rate limit: 170 kg N/ha = 1.7 cows/ha. 250 kg N/ha = 2.5 cows/ha

Grassland	
Sandy or shallow soils	**All other soils**
1 Sept – 31 Dec (4 months)	**15 Oct – 15 Jan (3 months)**

Tillage land	
Sandy or shallow soils	**All other soils**
1 Aug – 31 Dec* (5 months)	**1 Oct – 15 Jan (3.5 months)**

*On sandy or shallow soils, application is permitted between 1 August and 15 September provided a crop is sown on or before 15 September

Index of regional land carrying capacity in China

It easy to select N other than P

Only for livestock farms

N discharge from livestock farm × Collection coefficient

$$N = \frac{\sum\left(N_i \times M_i \times D_i \times 10^{-6} \times \left(\sum P_{s,j} S_{i,j}\right) \times \prod\left(\sum P_{c,j} C_{i,j}\right)\right)}{P \times \sum\left(A_i \times S_i \times 10^{-2}\right)}$$

N > 1 , Excessive

N < 1 , Inadequate

Crop N demand derived from organic fertilizer in the region

Controlling factors:

- Animal species and feeding density
- Feed formula
- Collecting methods of organic waste in livestock farm
- Processing methods of collected waste
- Planting crop species
- Application method…

There ars no specific and legislative regulations to limit the application of manure or/and chemical fertilizers to arable land in China so far

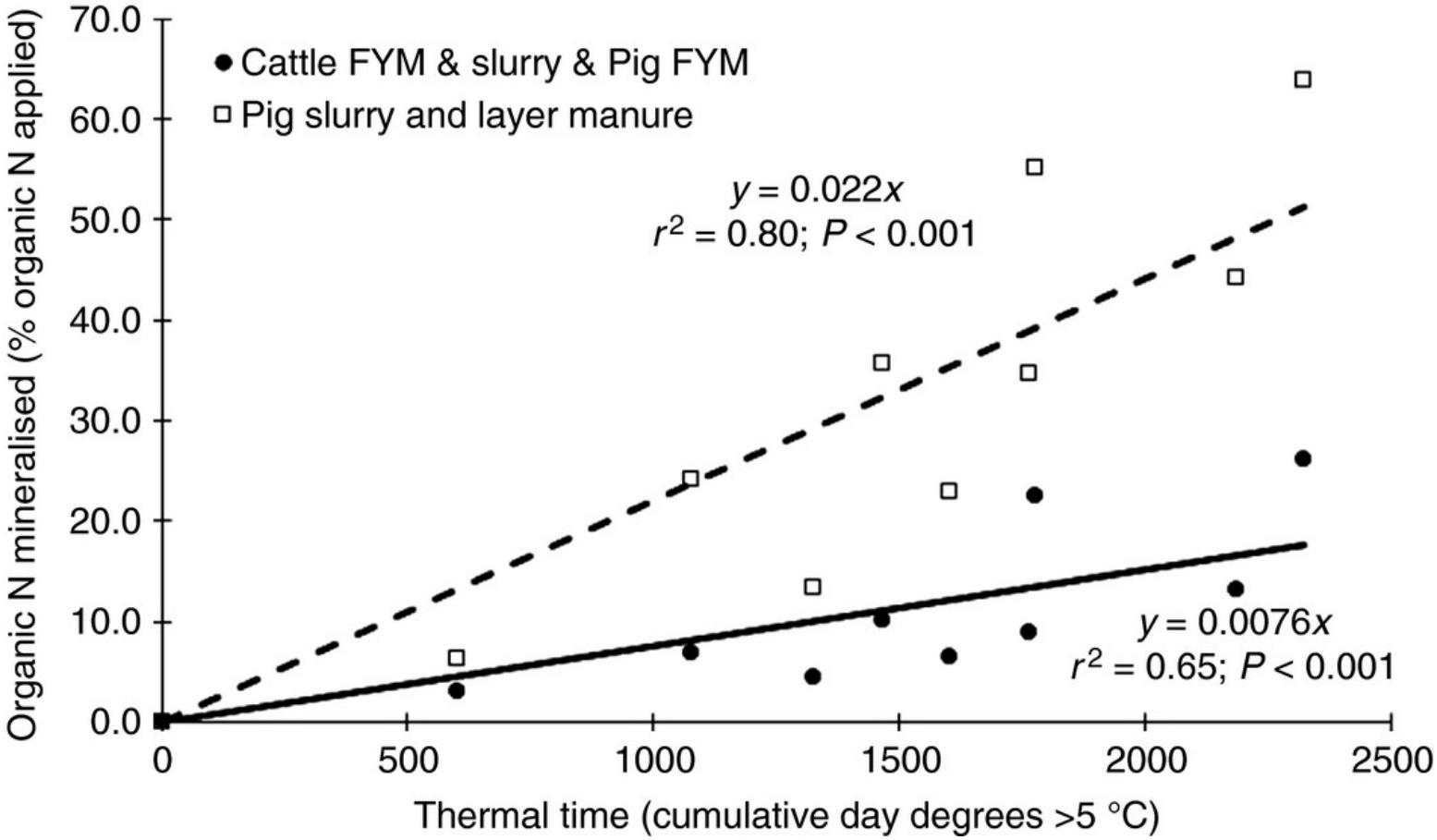
Only some available recommendations

- Use recommendation systems to assess crop nutrient r equirement
- Take soil samples
- Account for manure nutrients
  - Nutrient content
  - Application rate
  - Minimize losses
- Use nutrient management plans to target appropriate bagged fertilizer use

Typical fertilizer value of organic manure applications

Manure type	Application rate (m^3 or t/ ha)	Crop available nitrogen* (kg/ha)	Total phosphate (kg/ha)	Total potash (kg/ha)
Cattle slurry	30	27	36	81
Pig FYM	35	25	210	280
Poultry manure	8	67	136	168
Food based digestate	25	66	28	60
Biosolids cake	20	33	220	12
Green compost	30	0	90	204

Mineralization of organic nitrogen from farm manure applications



- Organic mineralisation related to C:N ratio
- Greater mineralisation from poultry manure and pig slurry

Bhogal et al. (2016)

If we selected P index to limit manure application in arable land

- More strictly, and high limits to let more livestock closed (Vegetable field, low P demand…)
- The index needs soil labile P levels before and after manure application
- Accumulative P effects needs more time,

How to do…

·P-based application rates to reduce the rate of P applied to soil
·Soil test based application
·Soil amendments(gypsum,lime) to enhance P sorption in soil
·Increase time between manure

·Avoid application to wet/frozen soils and at low temperature
·Manure incorporation/injection

We need more guides on manure / slurry / biodigestate application

- Directly apply manure nutrients to match crop demand
  - Right rate of application
  - Right time of application
  - N mineralization and nutrient transformation
  - Chemical fertilizer replacement
- Spreading machine selection
  - Need to know quantity spread and the area
- Slurries
  - Tanker volume/rate
  - Injector
  - Ammonia emission
- Solid manures
  - Weigh trailer full & empty
  - Use estimated densities

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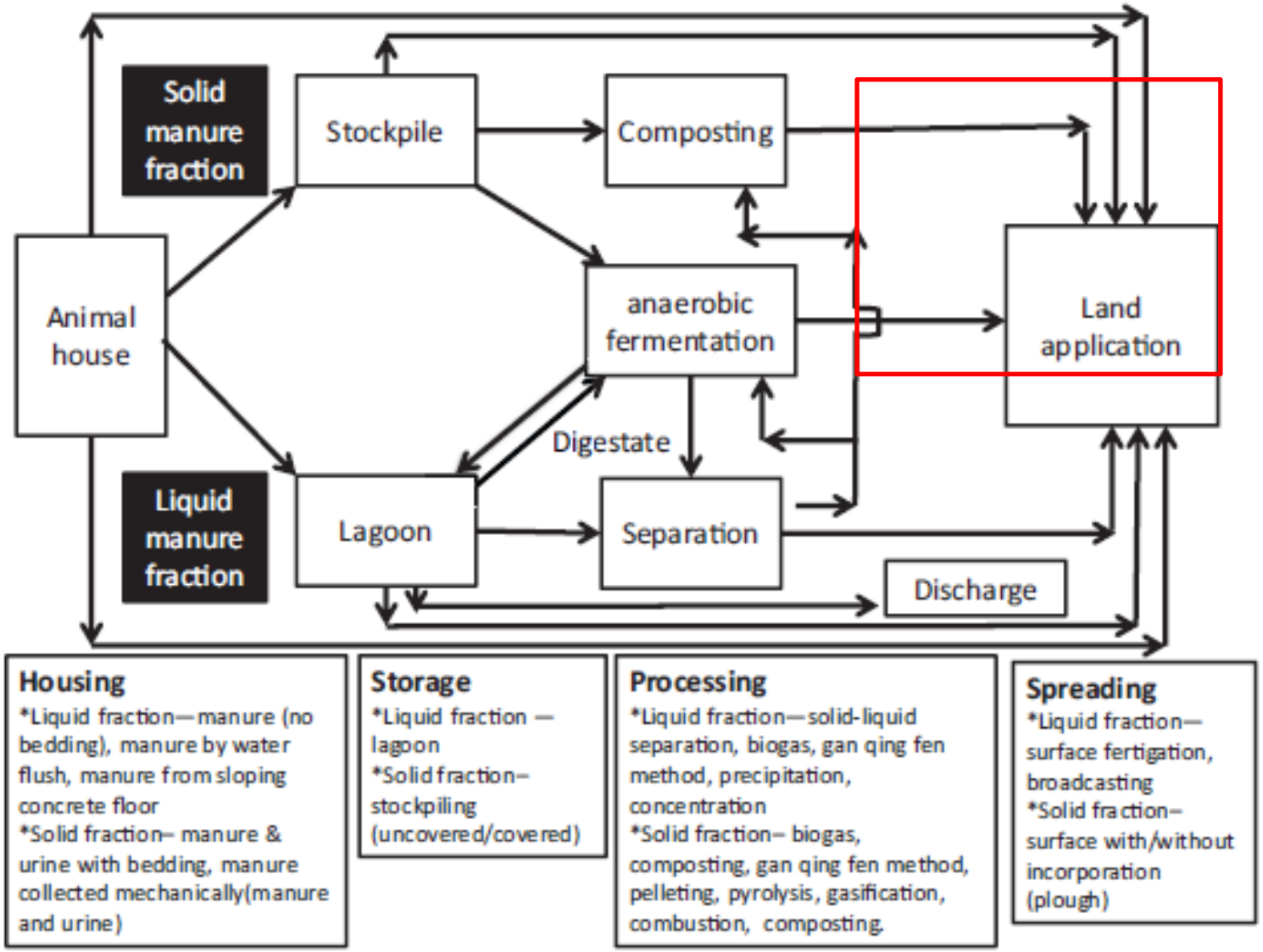
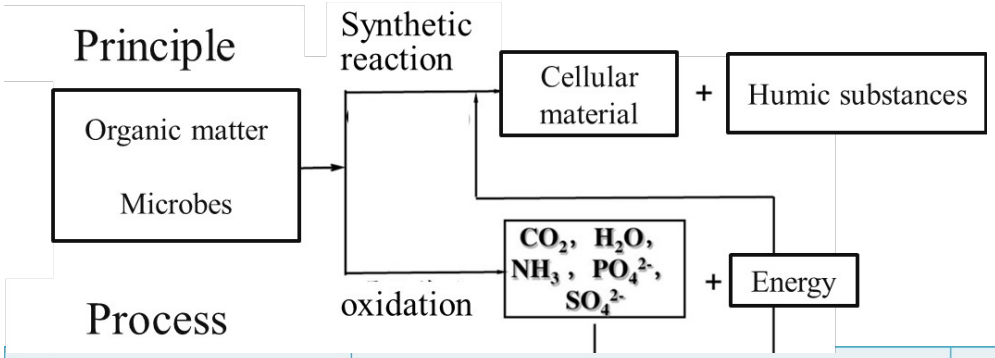
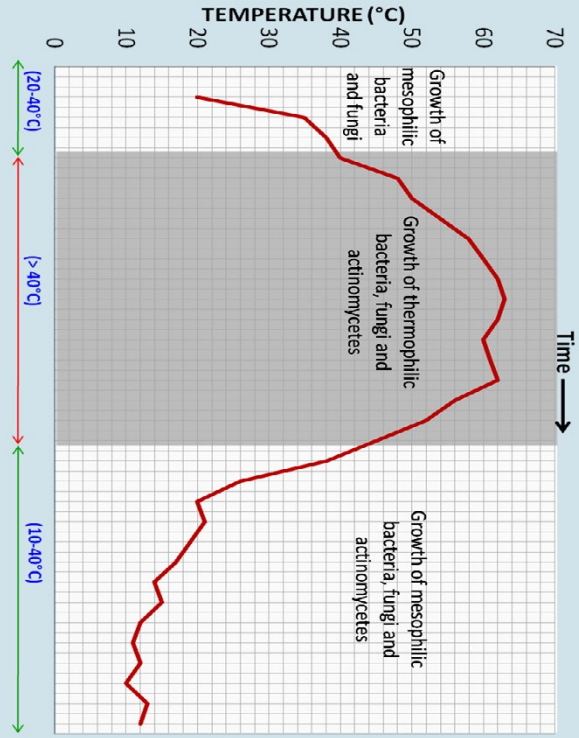
Composting and added-value fertilizers are important pathway to recycle organic waste



Chadwick et al (2015)

Composting course support more possibilities to develop innovative biofertilizer through inoculation



Composting phases	Composting phases vs. Temperature	Major microbial communities during different composting phases	References
Mesophilic Phase (Early)		**Bacteria:** Pseudomonas, *Bacillus, Flavobacterium, Clostridium, Serratia, Enterobacter* and *Klebsiella* **Fungi:** *Alternaria, Cladosporium, Mucor, Aspergillus, Humicola,* and *Penicillium*	Ghazifard et al., 2001 Chandna et al., 2013 Rawat et al., 2005
Thermophilic Phase		**Bacteria:** *Bacillus* and *Thermus* **Fungi:** *Aspergillus, Mucor, Chaetomium, Humicola, Absidia, Sporotrichum, Thermoascus* and yeast. **Actinomycetes:** *Streptomyces, Thermoactinomyces,* and *Thermomonospora*	Bella et al., 1996b Rawat et al., 2005 Makawai, 1980
Cooling/ Maturation Phase (Late Mesophilic phase)		**Bacteria:** *Bacillus, Flavobacterium, Pseudomonas* and *Cellulomonas* **Fungi:** *Alternaria, Aspergillus, Bipolaris* and *Fusarium* **Actinomycetes:** *Streptomyces* and *Thermopolyspora*	Ryckeboer et al., 2003 Ryckeboer et al., 2003 Corbaz et al., 1963

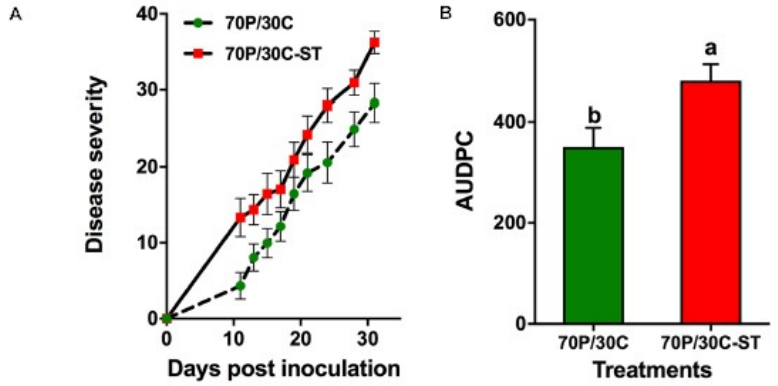
Liquid biodigestate: raw materials to produce added-value liquid organic fertilizer

Biological gas compression and filling syste

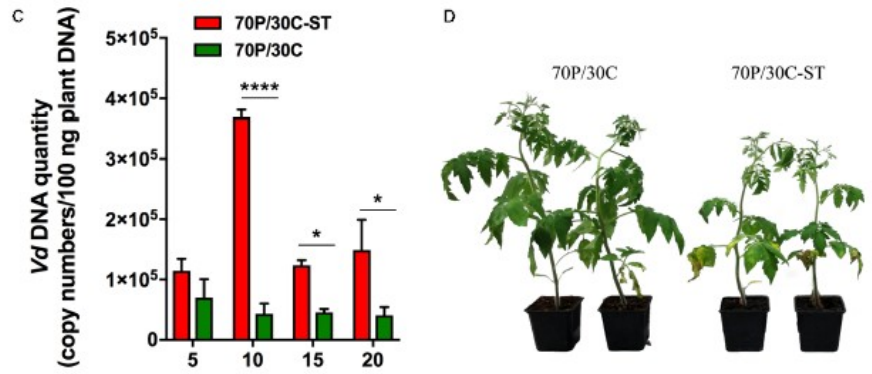
Methane fermentation system

Film purification system

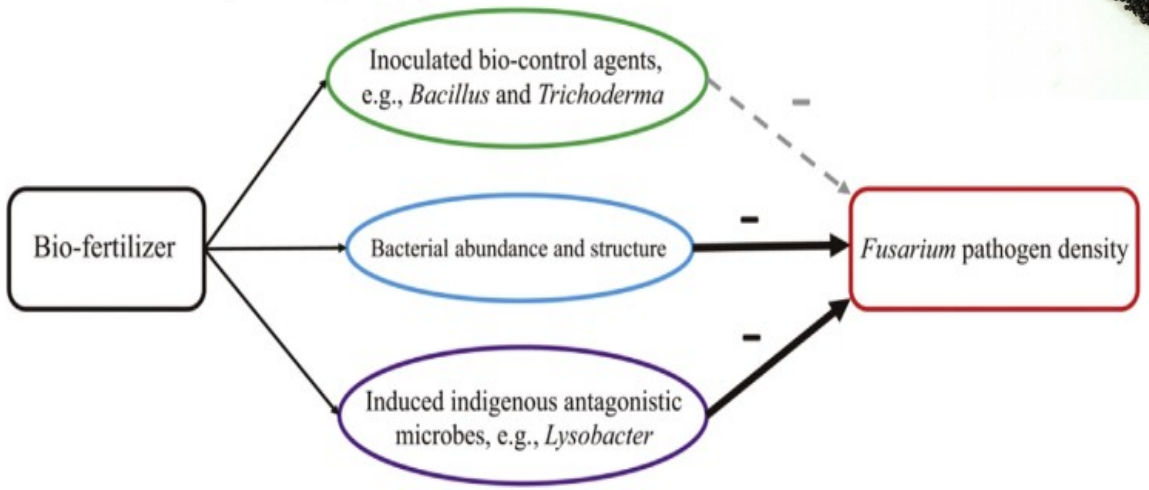
Value-added fertilizer made from compost extraction



Extraction method:
Compost: water = 1: 10 (w:v)



1) To suppress the soil-borne pathogens
2) To reduce the potential pollution
3) To increase nutrient cycling through valu-added fertilizer production



Content

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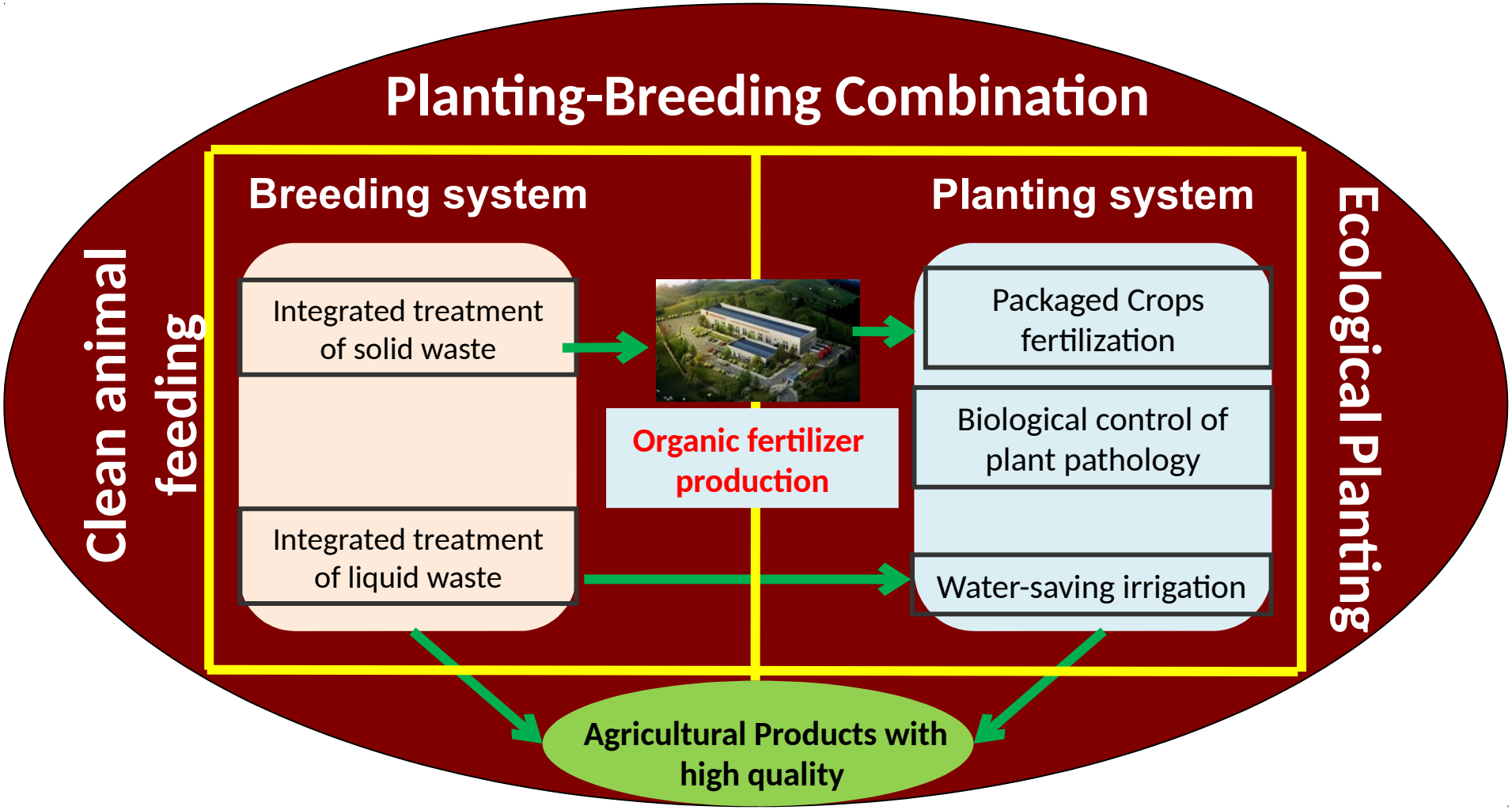
Planting-Breeding Combination
Breeding system
Planting system
Clean animal feeding
Ecological Planting
Integrated treatment of solid waste
Integrated treatment of liquid waste
Organic fertilizer production
Packaged Crops fertilization
Biological control of plant pathology
Water-saving irrigation
Agricultural Products with high quality

- The National Key R&D Program of China (2016YFD0801006)
- China Agriculture Research System (CARS-23-B16)

Thanks for your attention

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