Soybean Industry and Research in China: Current Status, Challenges and Prospects

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Status of Soybean Production in China (2011/12)

- Soybean has been planted over 4500 years in China
- It is the 4th major crop ranking after corn, rice, and wheat
- China is the 4th producing country among ~50 countries
Soybean production ratio decreased

Total production: 251 mt

China 5%
Argentina 19%
India 4%
Other 7%
United States 33%
Canada 1%
Paraguay 3%
Brazil 28%

Argentina 19%
United States 33%
China 5%
Soybean harvested area tends to decrease

- Harvested area: 8.0 ~ 9.5 mha
- Position: 5th in the world
China is the expanding market for world soybean production

- **Consuming:** 58 mt, 60% world exporting
- **Importing:** 52.5 mt
## Feed Production in China

- The total yield of feeding industry was 169 mt, taking 24.6% of the total world production in 2011.
- 33 feeding corporations have producing ability over 0.5 mt per year, taking 43% total yield in China (2011)

<table>
<thead>
<tr>
<th>Items</th>
<th>Total</th>
<th>Compound</th>
<th>Concentrate</th>
<th>Premix</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>148,132</td>
<td>115,350</td>
<td>26,863</td>
<td>5,925</td>
</tr>
<tr>
<td>2010</td>
<td>162,000</td>
<td>130,000</td>
<td>26,480</td>
<td>5,790</td>
</tr>
<tr>
<td>2011</td>
<td>169,000</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Growth in 2010</td>
<td>9.36%</td>
<td>12.7%</td>
<td>-1.4%</td>
<td>-2.2%</td>
</tr>
<tr>
<td>Growth in 2011</td>
<td>4%</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Source: China Feed Industry Office; N/A = not available
# Domestic Consumption of meal and oil in China

- 70% protein feed of livestock and poultry came from soybean and its processing products

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td><strong>Meal</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>49.56</td>
<td>56.43</td>
<td>62.88</td>
<td>67.74</td>
<td>70.68</td>
</tr>
<tr>
<td>Soy meal</td>
<td>31.67</td>
<td>37.55</td>
<td>43.38</td>
<td>47.44</td>
<td>51.00</td>
</tr>
<tr>
<td>%</td>
<td>63.90</td>
<td>66.54</td>
<td>68.99</td>
<td>70.03</td>
<td>72.16</td>
</tr>
<tr>
<td><strong>Oil</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>24.74</td>
<td>26.91</td>
<td>27.69</td>
<td>29.24</td>
<td>30.67</td>
</tr>
<tr>
<td>Soy oil</td>
<td>0.95</td>
<td>1.04</td>
<td>1.11</td>
<td>1.19</td>
<td>1.29</td>
</tr>
<tr>
<td>%</td>
<td>3.84</td>
<td>3.86</td>
<td>4.01</td>
<td>4.07</td>
<td>4.21</td>
</tr>
<tr>
<td>Import soy oil</td>
<td>0.25</td>
<td>0.15</td>
<td>0.13</td>
<td>0.15</td>
<td>0.15</td>
</tr>
</tbody>
</table>
At present, the output value of soybean foods accounted for about 7% of the total output value of China's food industry.

>10 mt soybeans, accounting more than 70% of the total domestic production directly used for food processing.
Soybean Processing Industry in China

A: Traditional soybean processing

- Plants: > 1800 with large and medium scale
- Processing: > 8 mt/yr soybeans in the factories (except those in rural small works)
- Products: 2 series, >100 varieties
  - Socking food: soymilk, tofu and derivatives
  - Fermented food: douchi, paste, sauce, furu

Modern technology is replacing traditional processing procedure.
B: Soybean protein industry

- SPI: protein isolates having 30 processing lines
- SPC: protein concentrates are quite less, will be increased due to the high recovery and low cost
- SPT: textured protein
  In studying for its technology, equipment and used in meat or wheat dough based utilization in fast-frozen foods and meat analogs
- Additives: low-denatured defatted soyflour, deodorized full fat soyflour

Soybean Processing Industry in China

protein flour 1.6 mt/yr
Soybean Processing Industry in China

C: Functional uses of soybeans

- Phospholipids
  - Concentrates 50000 t/yr
  - Powder 900-1000 t/yr
  - Soft gel 7 billion capsules/yr
- Vitamin E
  - > 10 processing lines with capacity of 800 t/yr
- Isoflavones
  - > 6 processing lines with capacity of 100 t/yr
- Oligosaccharidies, hull fiber etc.
Soybean Germplasm in China

- Collection: >30,000 accessions (local>90%, PI<10%)
- Catalogue: passport data, agronomic traits, 60% characteristics
- Evaluation: multiples locations field tests for yield and extensive genotyping with molecular markers

G. soja: >7,000
G. max: >23,000
**Artificial Selection: Alleles Distribution of GmTfl1/Dt1 related to the cultivation habitat**

Establishing a series of core collections for extensive phenotyping and genotyping in order to increase usage of soybean germplasm

(Tian et al., PNAS, 2010)
Released Soybean Varieties

- **High yielding**: Zhonghuang 35, Nannong 88-31
- **Good quality**: Suinong 14, Zhongdou 36
- **Disease resistance**: Kangxian 6, Wandou 16
- **Stress tolerance**: Jindou 21, Nandou 12
- **Special type**: Jinlinxialidou 3
The genetic gain of soybean yield is 1.07%
• Recently released varieties had higher mean seed yield
Zhong huang 13: High-yield and wide-adaptability
The 1st prize of scientific and technologic progress
Hybrid Soybean: Heterosis exploitation
2nd prize of national science and technology invention

CMS lines: higher outcrossing rate
Pollinators: alfalfa leaf cutting bee, bee, natural insects
Producing seed: >1003kg/ha, 1M:2F
Planting regions of soybean in China

I1

(Sp)

Single Cropping

I2

(Sp, Su)

Double Cropping

III

(Sp, Su, Au, Wi)

Multiple Cropping

IIASA-LUC GIS Database, 2001
Multiple Cultivation Systems

Inter-row mulching on the ridges

Intercropping and relay model
- Maize/Soybean
- Cotton/soybean
- Tea/Soybean
- Wheat/Maize/Soybean

Dense within wide row model

Ridge 3 Cultivation model
Machinery
Soil nutrition and management

Control  Inoculation

Soil Database

Inoculating Rhizobia (Bradyrhizobium)
Management of Post-wheat Soybean

2.6 M ha straw handling
No-tillage and Straw Mulching Precise Sowing Technique

- Technical points
  A. Side deep fertilizing
  B. Precise sowing
  C. Pre-emergence herbicide use
  D. Straw mulching

- Technical advantages
  A. Cost saving: cut the operation step
  B. Benefit increase: boost soybean production
  C. Improve soil fertility: returning all straw to the field
  D. Environment friendly: avoid straw burning

Yield increase: 225-300 kg/ha

Yield: 4135.5 kg/ha
Biotechnology

- Established Pan-genome 7 accessions (G. soja)
- Sequenced 1 landrace (G. max)
Discovery favorite gene or alleles in soybean

- Construct high density molecular map by lower coverage sequencing populations
- Mapping >248 QTLs controlled important traits by genetic segregation population
- More than 59 loci having either contribution rate ≥10% or genetic distance between markers ≤2 cM within 10 years
- Identified elite accession with phenotypic effect and carriers of marker (QTL) alleles at loci significantly associated with yield
- Cloning more than 74 genes and less than 20 have been tested in either model plants (arabdopsis or lotus) or soybean
- Developing functional molecular markers for MAS breeding
Resequencing of soybean genomes identifies patterns of genetic diversity and selection

- Lower level of genetic diversity in cultivated soybeans
- Selection processes acting on cultivated soybeans different from wild soybeans
- High LD in soybean genome

(Lam et al., Nature Genetics, 2010)
Mapping eQTLs of rubisco activase genes in soybean

- Expression of RCA genes modulate photosynthesis, and potentially, seed yield
- Both GmRCAα and GmRCAβ are controlled by two trans-eQTLs

Yin et al, 2010, Plant Physiology
Characterization of *GmCRYs* and *GmFTs* in photoperiodic flowering of *G. max*

- GmCRY1 plays the predominant role in determining flowering time
- Strong correlation of the circadian rhythmic expression of GmCRY1a with photoperiodic flowering and latitudinal distribution of soybean cultivars
- Two FT orthologs have florigen-like functions and coordinately control flowering

(Zhang et al., PNAS, 2008; Kong et al., Plant Physiol, 2010)
Phosphate transporter GmPT5 and miR482, miR1512, and miR1515 regulate nodulation in soybean

- Overexpression or knockdown of GmPT5 in soybean altered nodulation and plant growth performance
- GmPT5 controls Pi entry from roots to nodules and subsequently regulates soybean nodulation and growth performance
- Transgenic expression of miR482, miR1512, and miR1515 led to significant increases of nodule numbers

(Qin et al., Plant Physiol, 2012; Li et al., Plant Physiol, 2010)
Two Soybean NAC transcription factors promote abiotic stress tolerance in transgenic plants

- Overexpression of *GmNAC20* enhances salt and freezing tolerance in transgenic Arabidopsis plants
- *GmNAC11* over-expression only improves salt tolerance

(Hao et al., *Plant J*, 2011)
Pathogen: Transcriptional Programming and Functional Interactions within the Phytophthora sojae RXLR Effector Repertoire

- First using omics and high throughput method to analyze Phytophthora sojae
- Systematically analysis of 169 P. sojae RXLR effector toxic secretory protein
- Clarify P. sojae infecting plant by different RXLR effectors interaction

rhizobia: Extensive recruitment of lineage-specific genes in adaptations of rhizobia nodulating soybean

- Pan-genome of 26 representative strains nodulating soybean — extensive investigation of microsymbionts from soybean
- Phyletic distribution of symbiosis genes reflects the species phylogeny of soybean microsymbionts and other rhizobia.
- Recombination including lateral gene transfer in rhizobial long-term evolution.
Challenging

• Can the biotechnology (Such as GM soybean) be the opportunity?
• How can we break through the natural pressure such as climate change?
• What is best balance among integrated technique for high yield?
Diseases and Insects

- Soybean rust
- *Cercosporidium sofinum* (Soybean frogeye leaf spot)
- Soybean mosaic virus / Seed coat mottling
- Phytophthora sojae
- Northeast Giant Black Chafer
- white mold
- Aphid
- Bean borer
- Soybean cyst nematode
- Lepidoptera
  - Soybean leaf-feeding insects
Can we close the yield gap?

- Average yield of the soybean production in China: 1650~1850 kg/ha
  - 27% lower than the world average (2250 ~ 2350 kg/ha)
  - 39% lower than US
  - 44% lower than Brazil
  - 36% lower than the national farms in China

- Shortening the gap between producing yield and the potential of yield
Chinese soybean production will continually meet the food needs in the future.

- **Cultivar Development**
  - High and stable yield

- **Breeding for Resistances and Tolerances**
  - 4 diseases & 2 insects

- **Breeding for Quality Traits**
  - Protein, Oil, and S-containing amino acids

- **Ideo Type Definition and Germplasm Creation of Major Breeding Target Traits**

- **Environment**

- **Variety**

- **Management**
Prospects:

Production Goals of Modern Agricultural Development Plan in China (2010-2015)

<table>
<thead>
<tr>
<th>Items</th>
<th>2010</th>
<th>2015</th>
<th>Annual Growth Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain Production Capacity (mmt)</td>
<td>&gt;500</td>
<td>&gt;540</td>
<td></td>
</tr>
<tr>
<td>Grain Acreage (mha)</td>
<td>110</td>
<td>&gt;106.7</td>
<td></td>
</tr>
<tr>
<td>Meat Production (1,000 tons)</td>
<td>79,260</td>
<td>85,000</td>
<td>1.41</td>
</tr>
<tr>
<td>Egg Production (1,000 tons)</td>
<td>27,630</td>
<td>29,000</td>
<td>0.97</td>
</tr>
<tr>
<td>Dairy Production (1,000 tons)</td>
<td>37,480</td>
<td>50,000</td>
<td>5.93</td>
</tr>
</tbody>
</table>
Thank you!