

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

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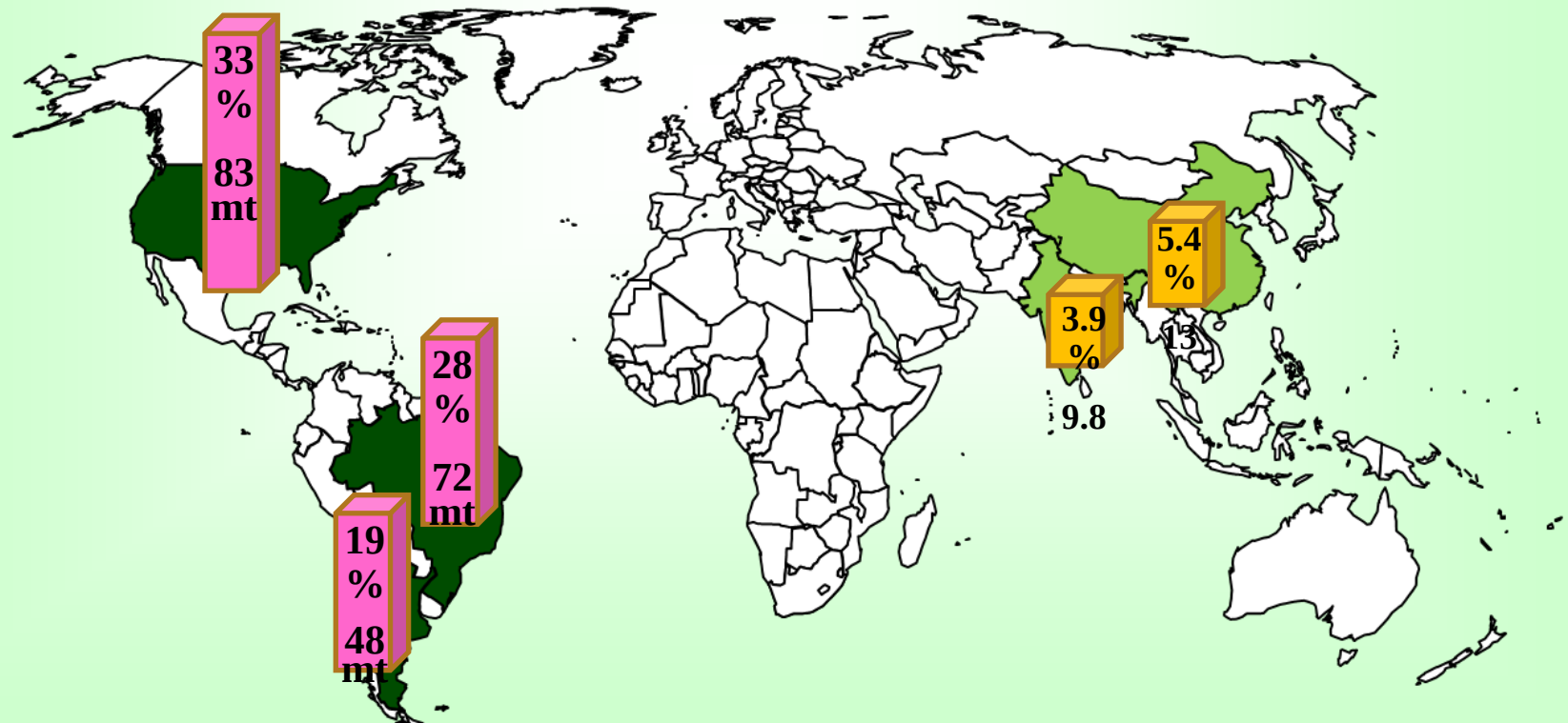
NAU

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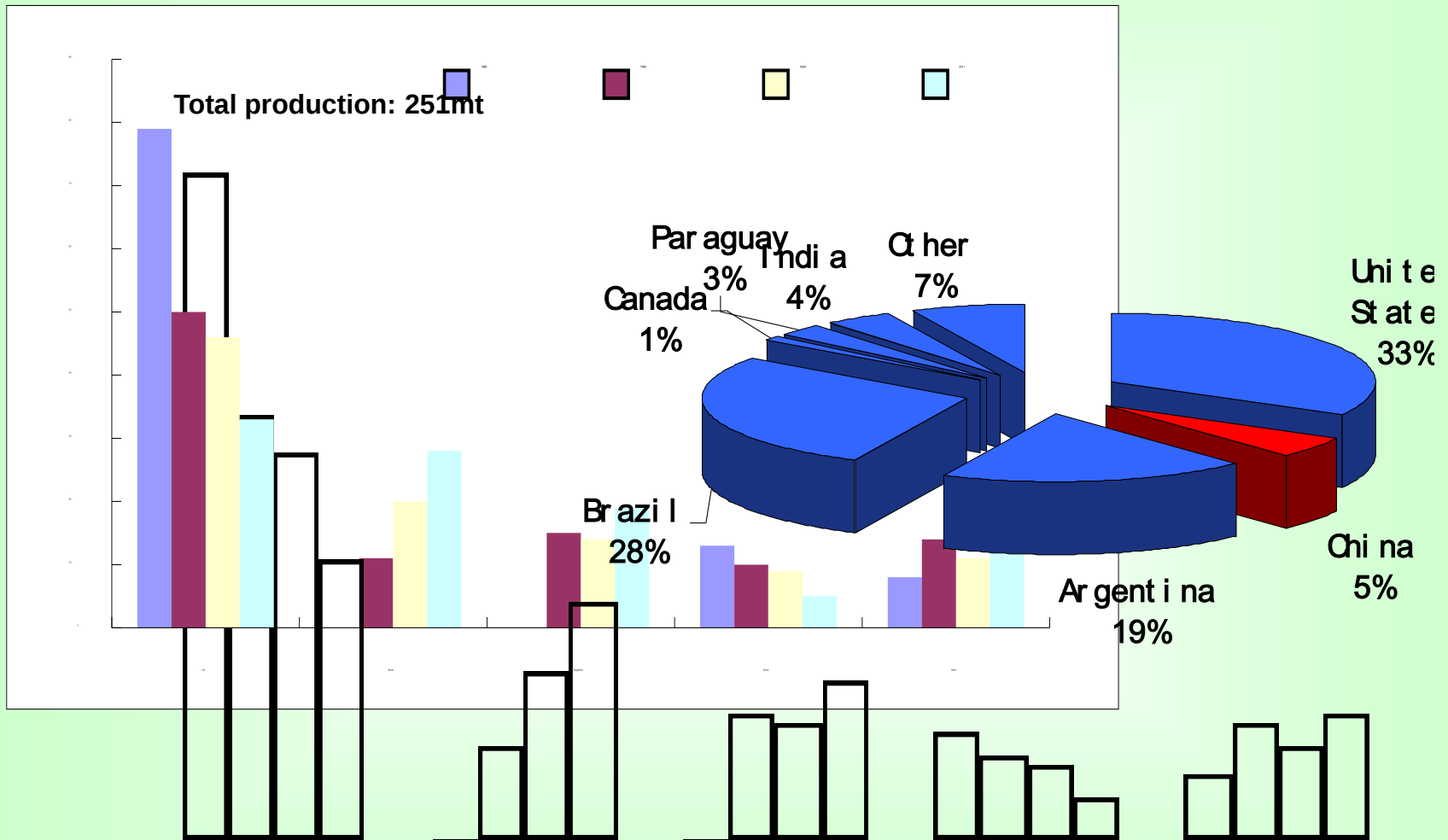


Status of Soybean Production in China (2011/12)

- 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

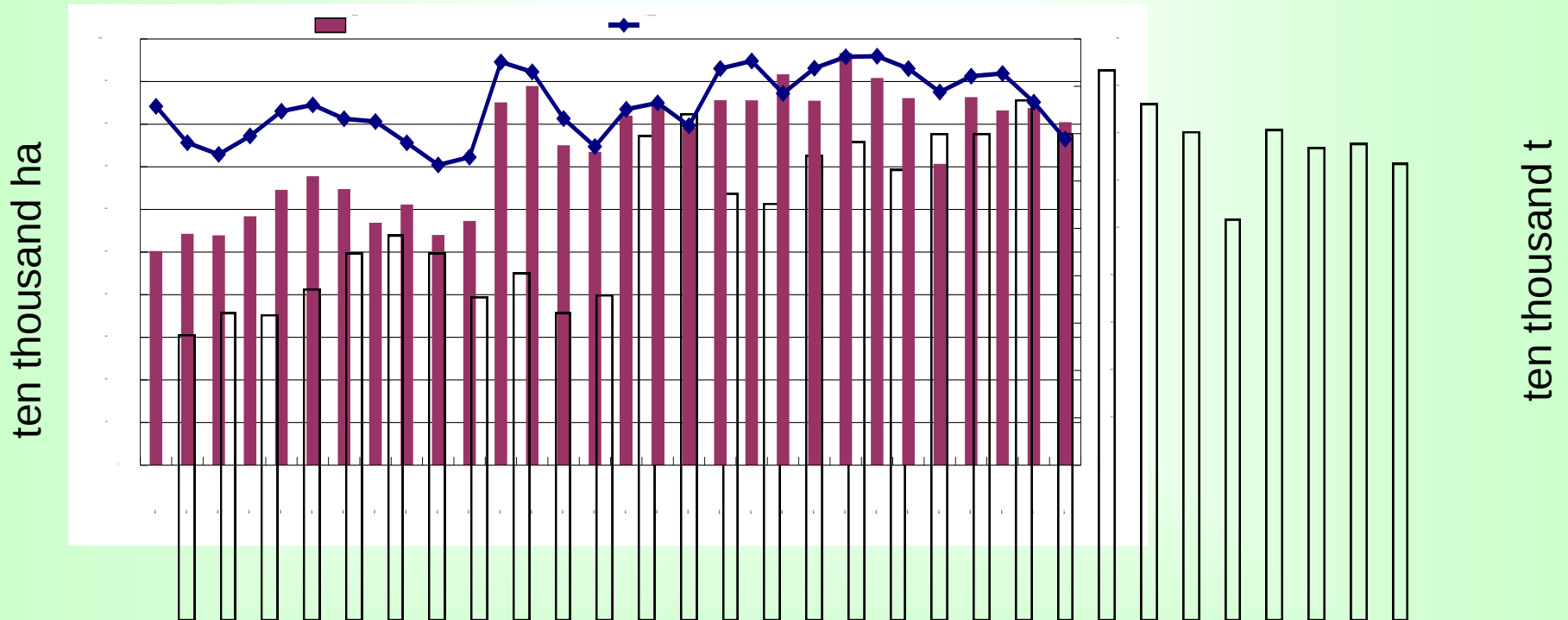


Soybean production ratio decreased



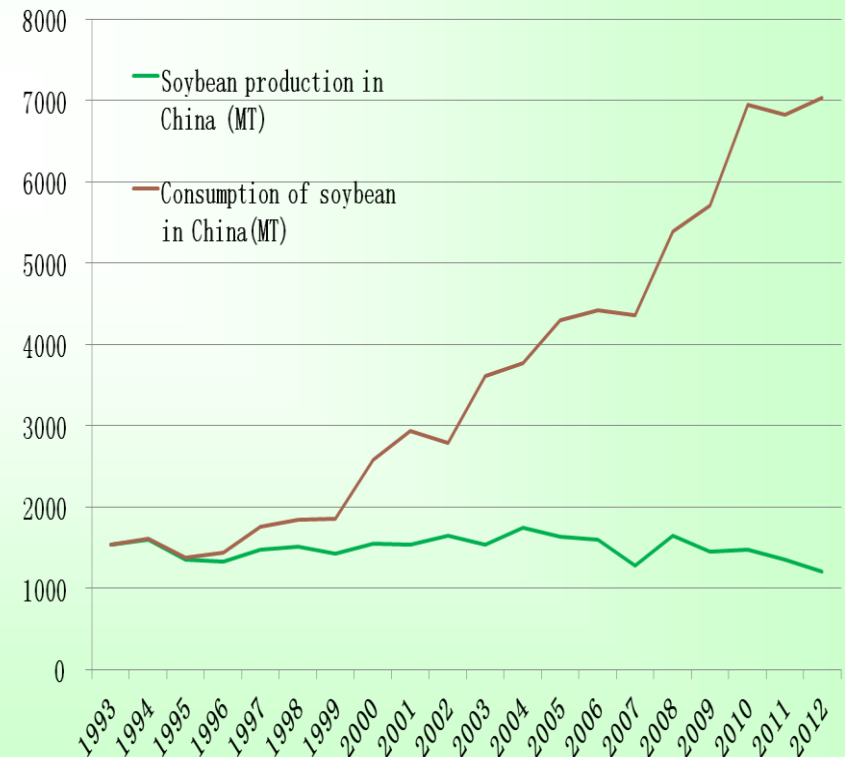
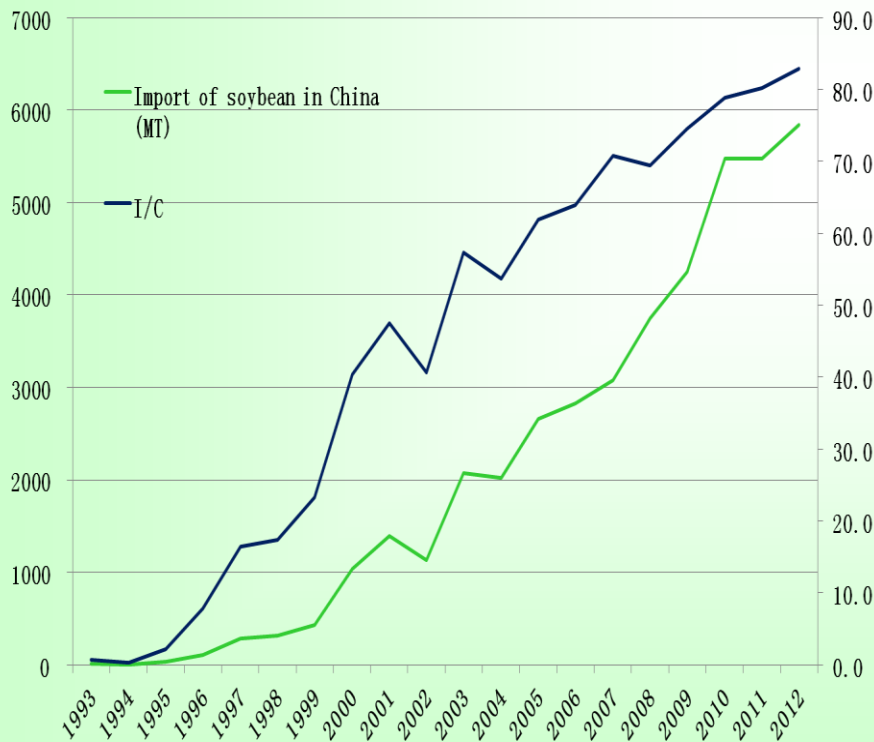
Soybean harvested area tends to decrease

- Harvested area : 8.0 ~ 9.5mha
- 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)

(1,000 tons)

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

Source: China Feed Industry Office; N/A = not available

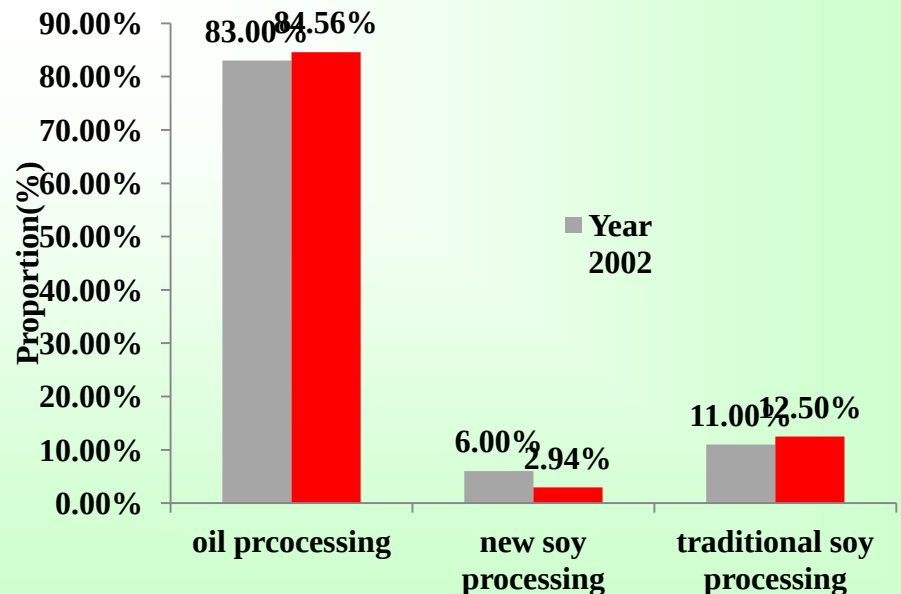
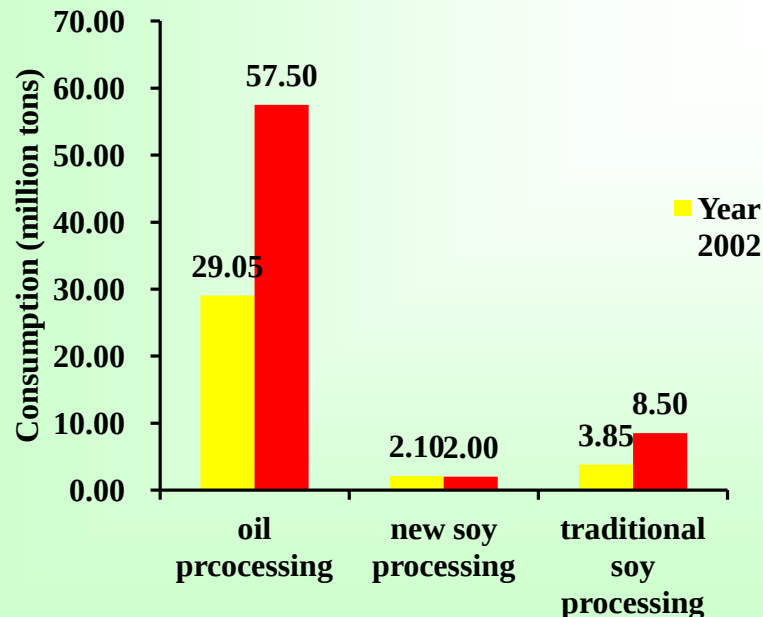
Domestic Consumption of meal and oil in China

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

Items		2008/ 09	2009/ 10	2010/ 11	2011/ 12	2012 /13
Meal	Total	49.56	56.43	62.88	67.74	70.68
	Soy meal	31.67	37.55	43.38	47.44	51.00
	%	63.90	66.54	68.99	70.03	72.16
Oil	Total	24.74	26.91	27.69	29.24	30.67
	Soy oil	0.95	1.04	1.11	1.19	1.29
	%	3.84	3.86	4.01	4.07	4.21
	Import soy oil	0.25	0.15	0.13	0.15	0.15

Soybean Processing Industry in China

- ➡ 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.

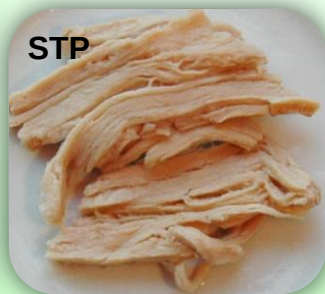


Soybean Processing Industry in China

B: Soybean protein industry

protein flour 1.6 mt/yr

- **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

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

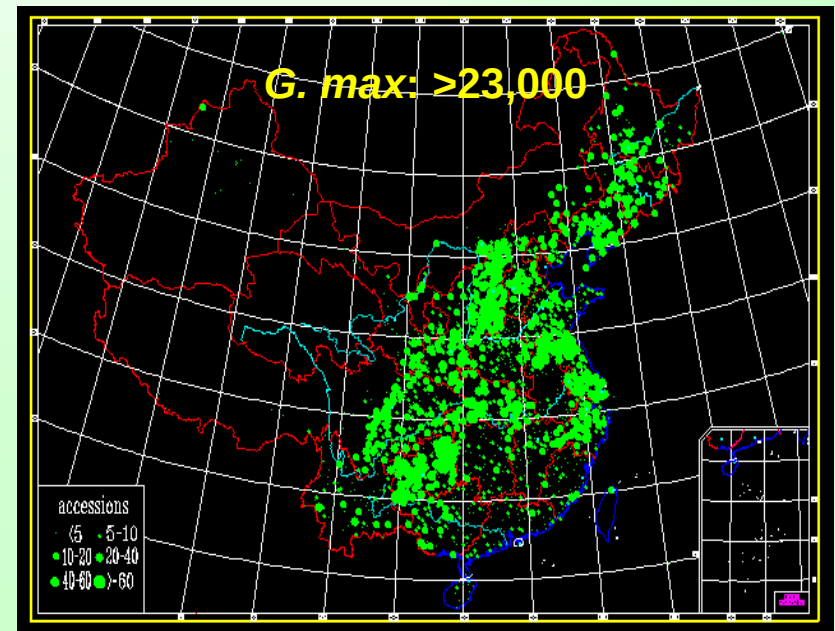
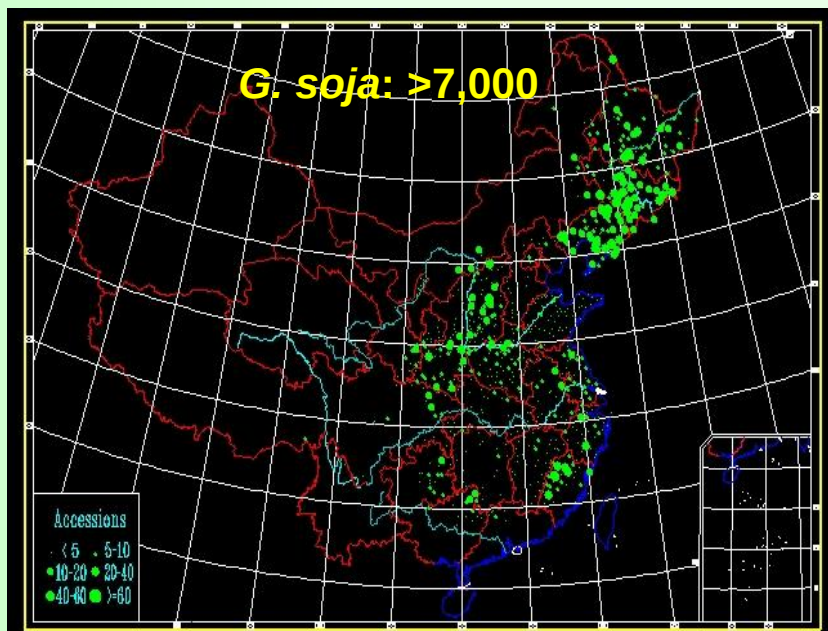
- Isoflavones

> 6 processing lines with capacity of 100 t/yr

- Oligosaccharides, hull fiber etc.

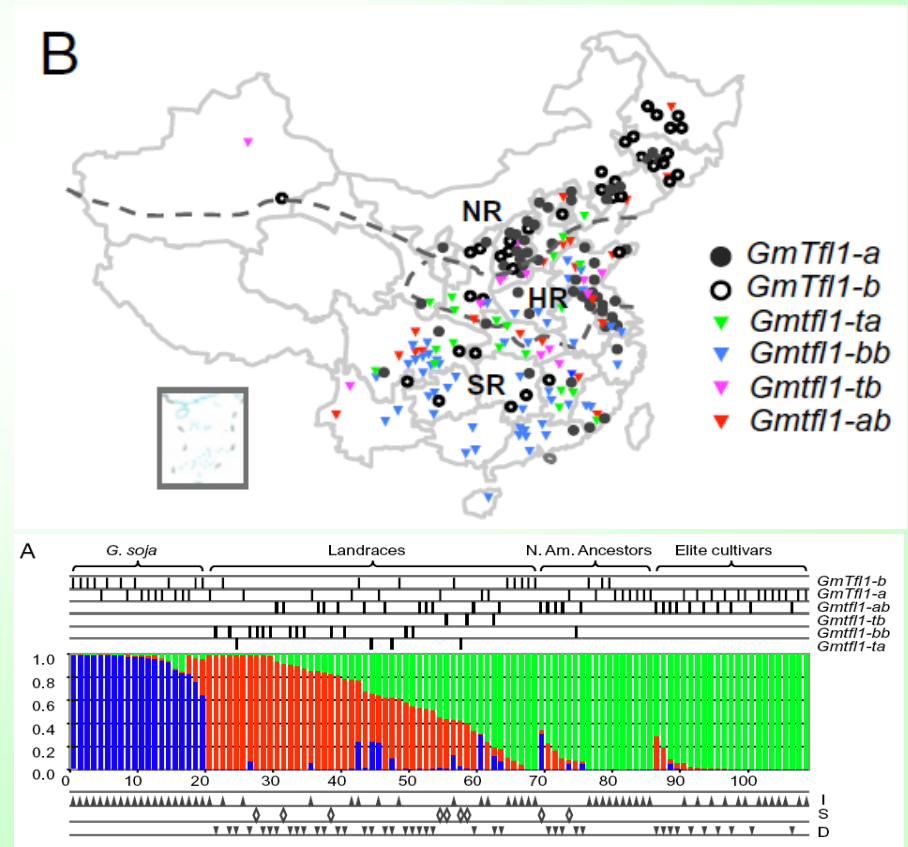
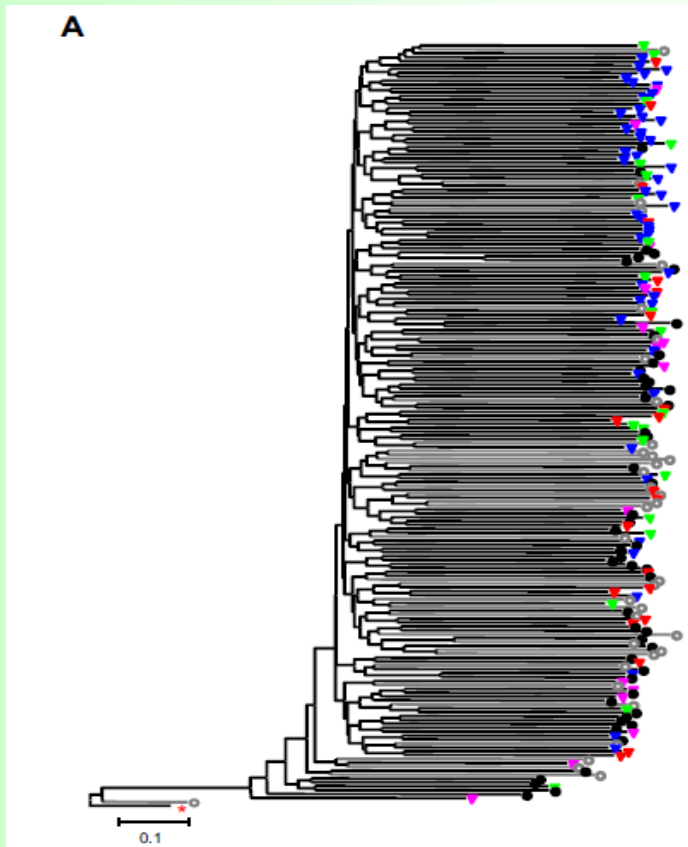
Soybean Germplasm in China

- **Collection:** >30000 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



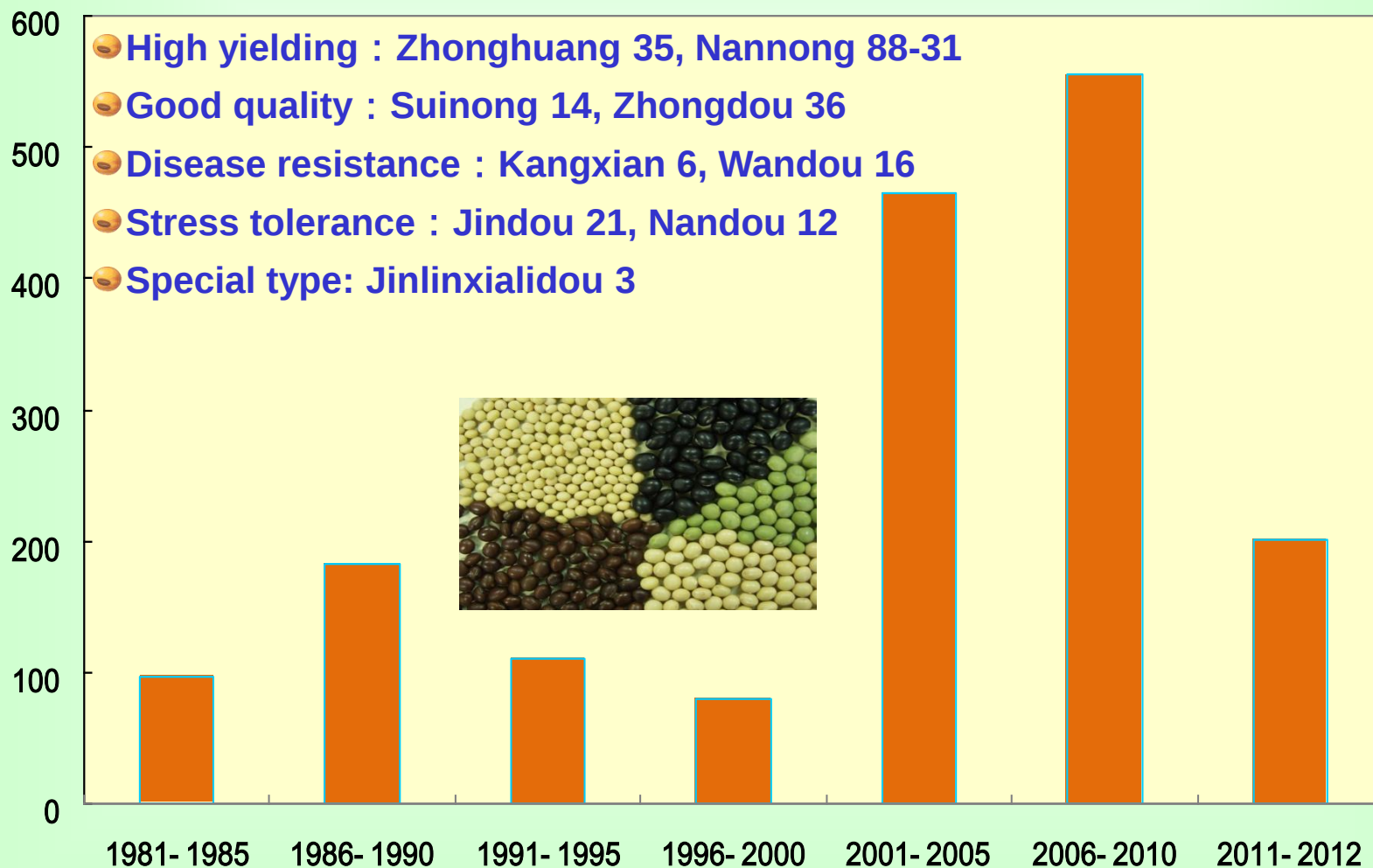
Artificial Selection: Alleles Distribution of *GmTfl1/Dt1* related to the cultivation habitat

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



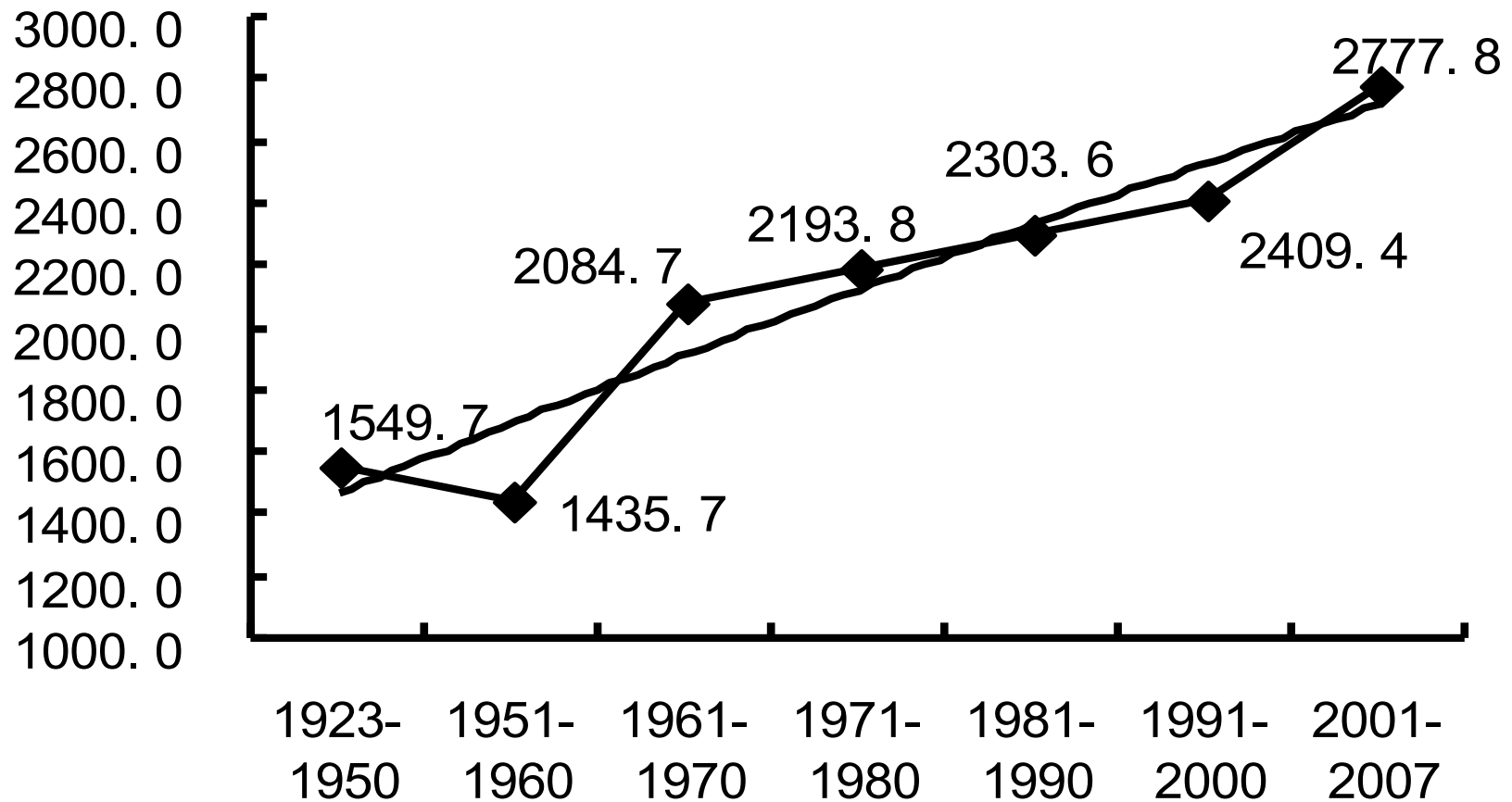
(Tian et al., PNAS, 2010)

Released Soybean Varieties

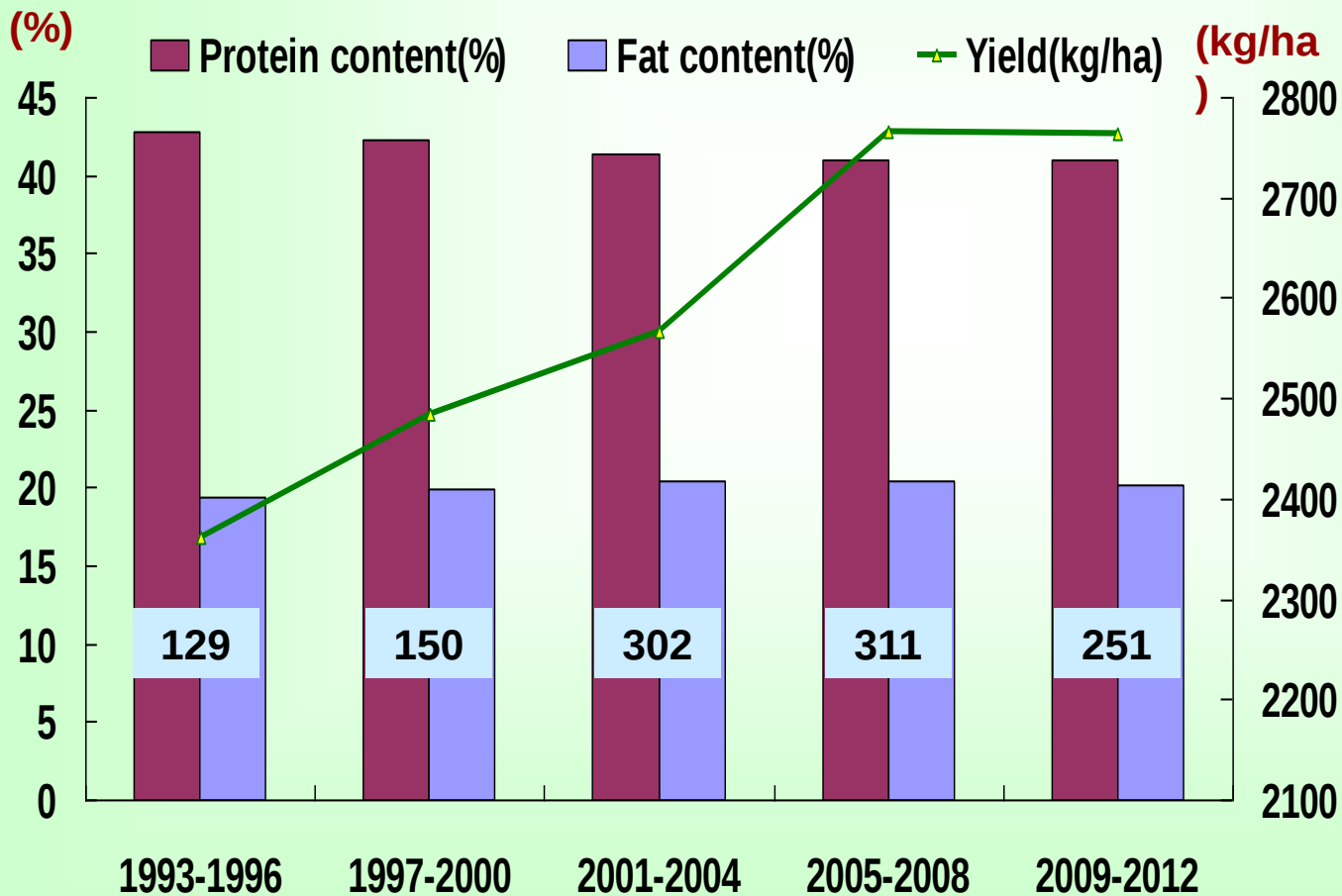


~1% Ancestral lines

The genetic gain of soybean yield is 1.07%

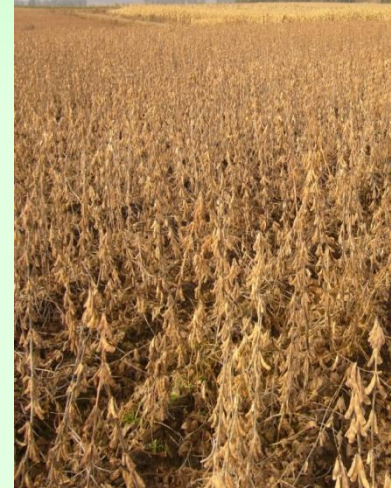


- Recently released varieties had higher mean seed yield



Jiyu 202:

Oil content 25.31%



Yudou 12

Protein content 50.18%



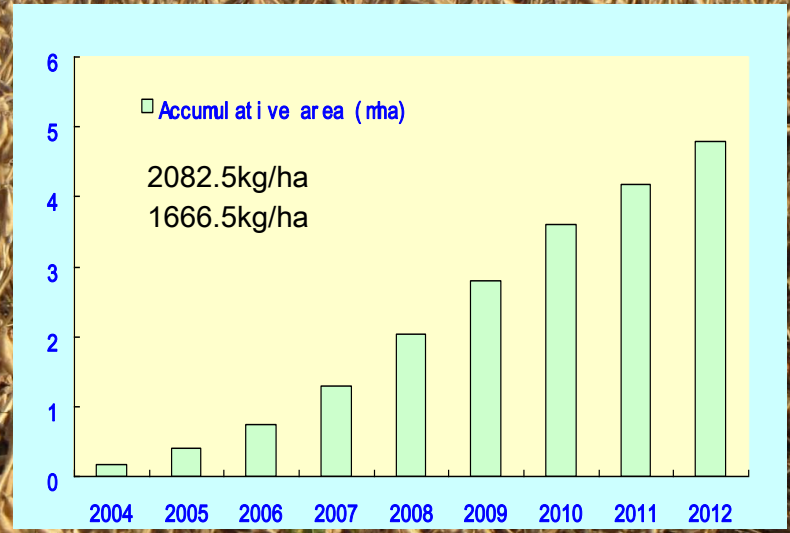
29.42 N

Planting area

□ Accumulative area (mha)

2082.5kg/ha
1666.5kg/ha

Year	Cumulative area (mha)
2004	0.2
2005	0.5
2006	0.8
2007	1.4
2008	2.1
2009	2.8
2010	3.6
2011	4.2
2012	4.8



Hybrid Soybean: Heterosis exploitation

2nd prize of national science and technology invention

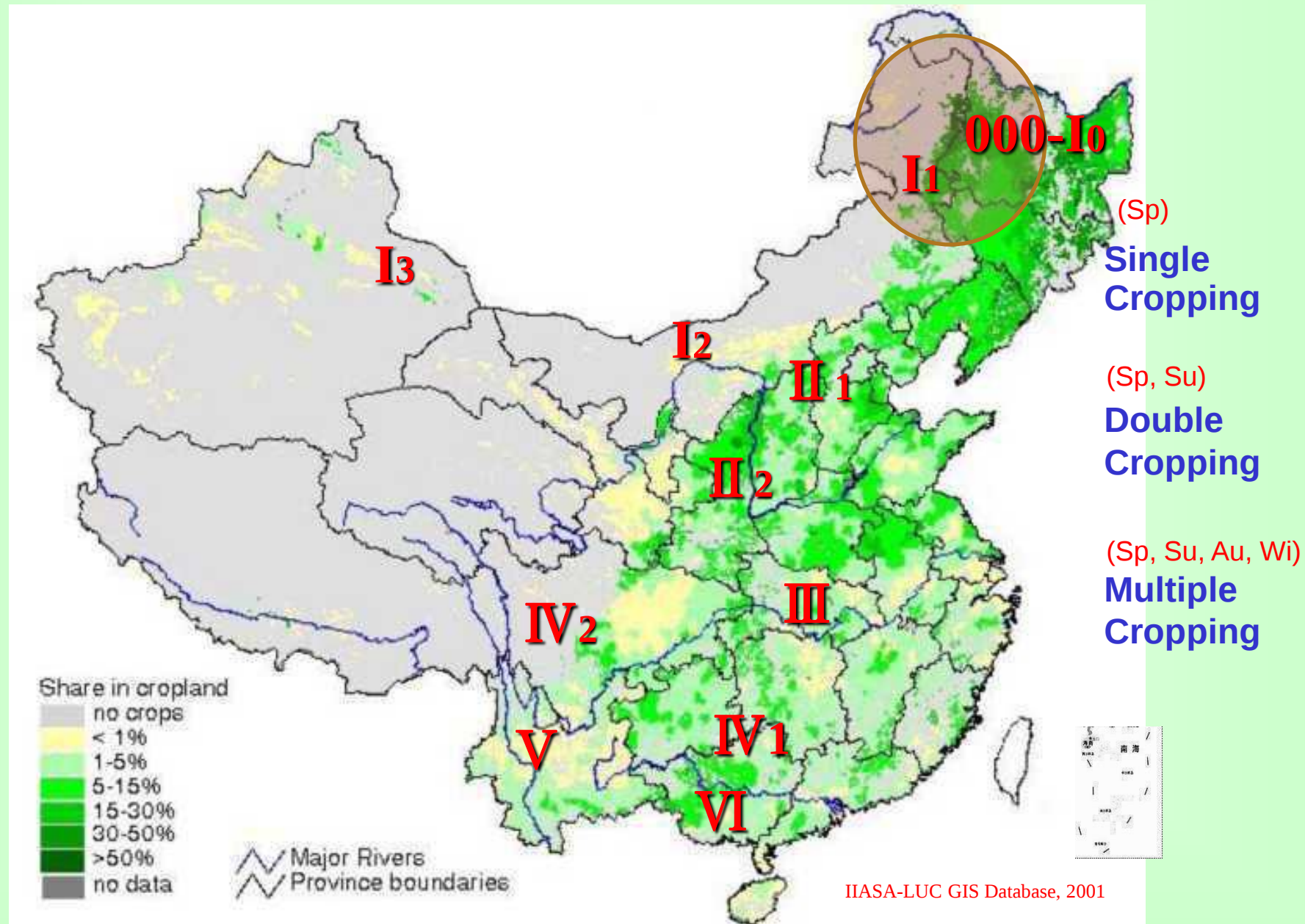
CMS lines: higher outcrossing rate

Pollinators: alfalfa leaf cutting bee, bee, natural insects

Producing seed: >1003kg/ha, 1M:2F



Planting regions of soybean in China



Multiple Cultivation Systems

Inter-row mulching on the ridges



Intercropping and relay model



Maize/Soybean

Cotton/soybean

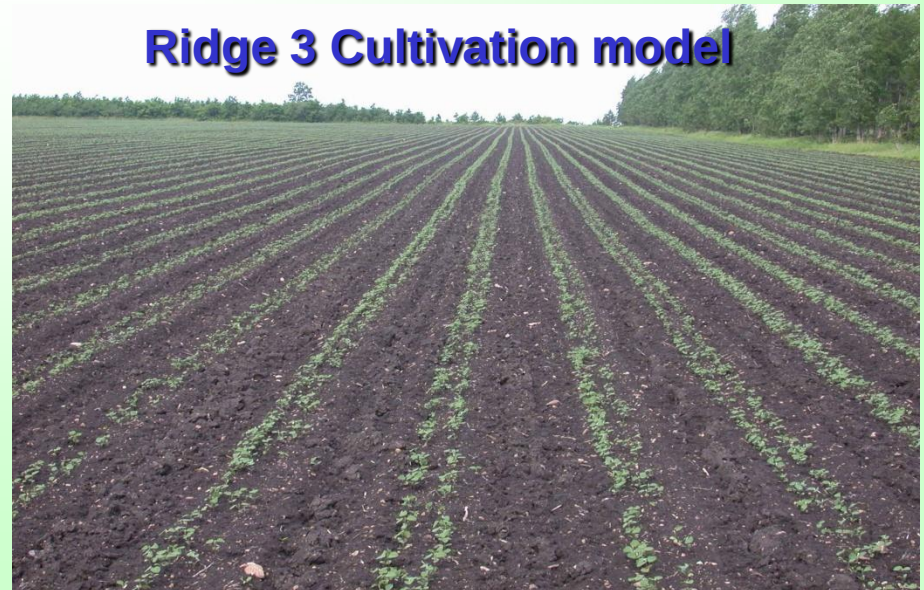
Tea/Soybean

Wheat/Maize/Soybean

Dense within wide row model



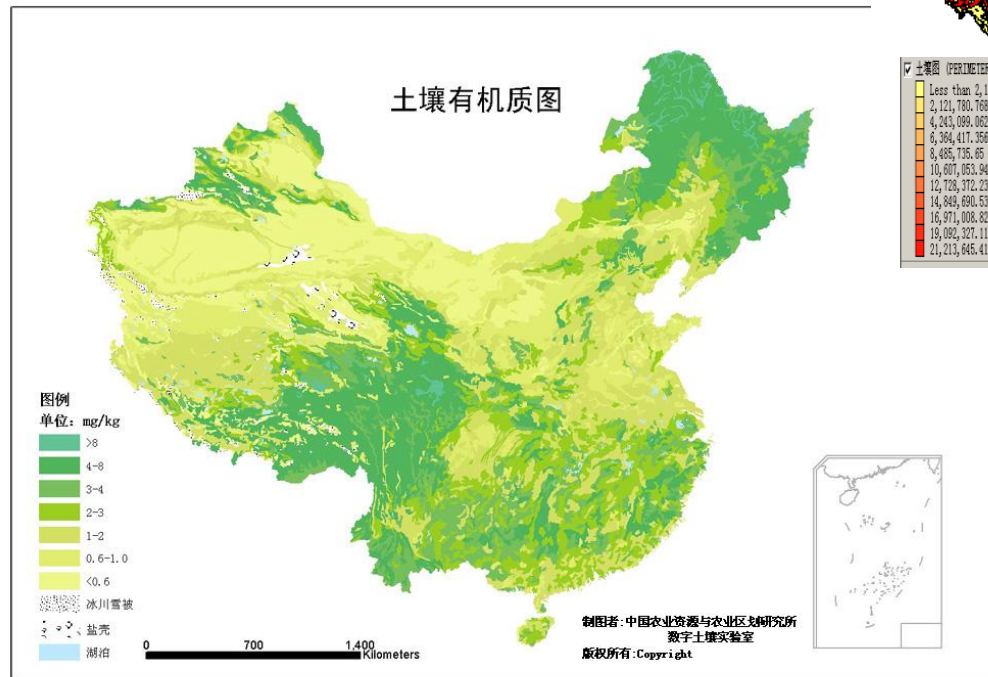
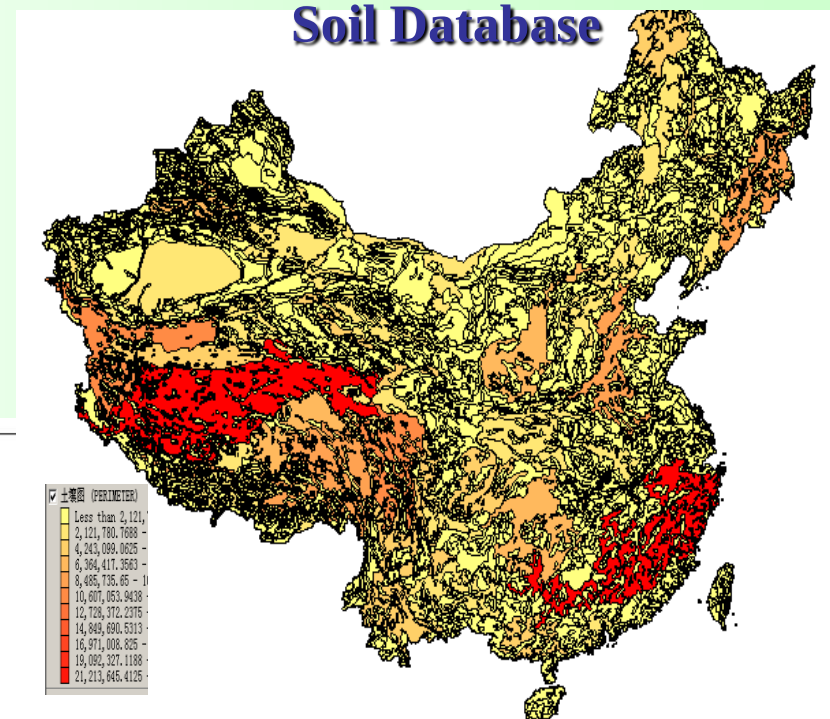
Ridge 3 Cultivation model



Machinery



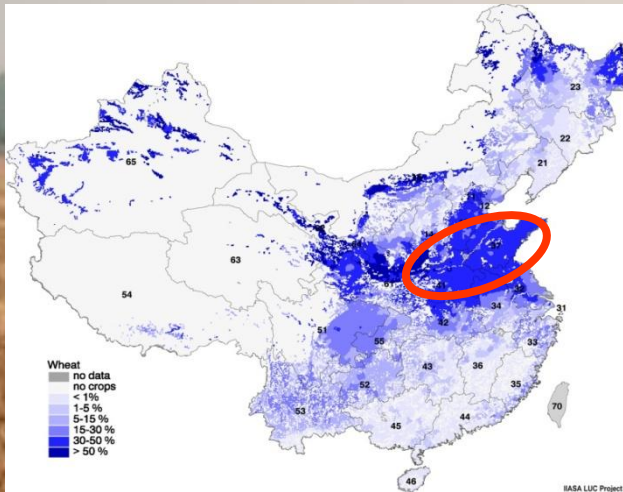
Soil nutrition and management



**Inoculating
Rhizobia
(Bradyrhizobium)**



Management of Post-wheat Soybean



🌾 2.6 M ha straw handling

No-tillage and Straw Mulching Precise Sowing Technique

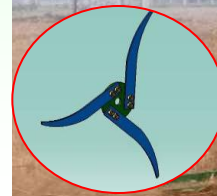
➤ Technical points

- 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

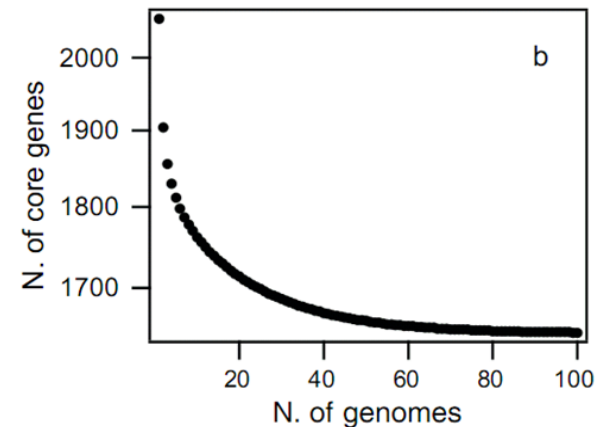
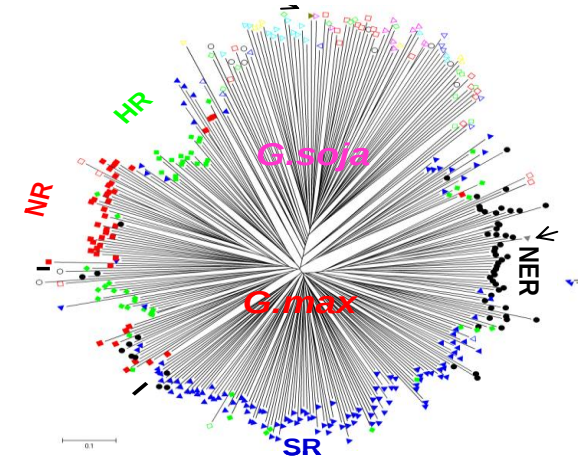
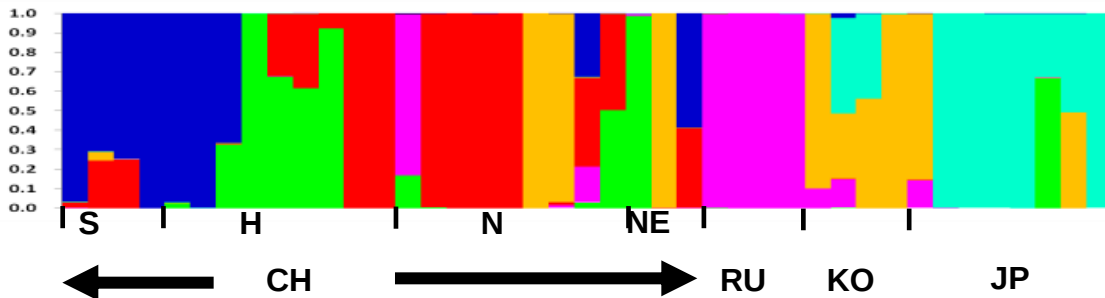
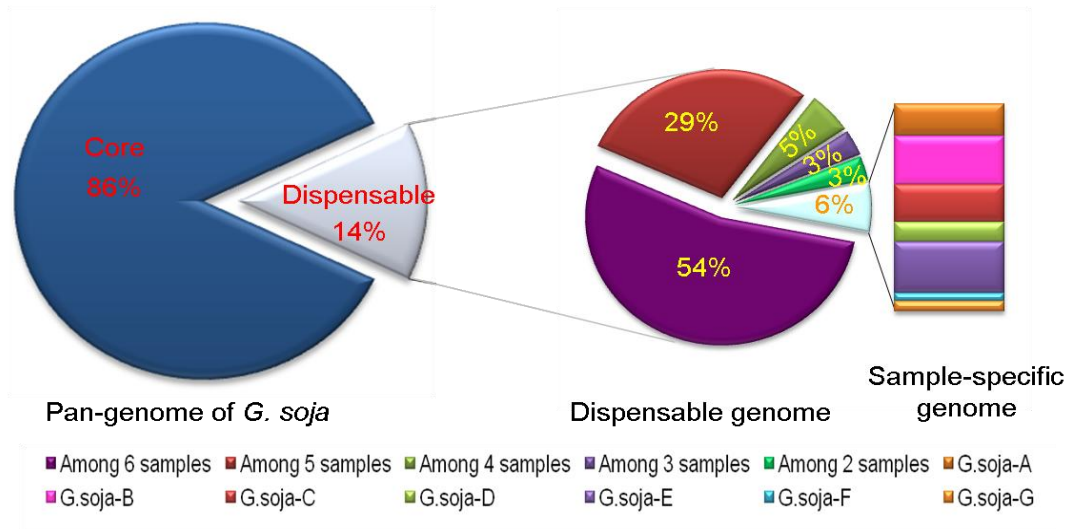


🌾 Yield : 4135.5 kg/ha



Biotechnology

- Established Pan-genome 7 accessions (*G. soja*)
- Sequenced 1 landrace (*G. max*)

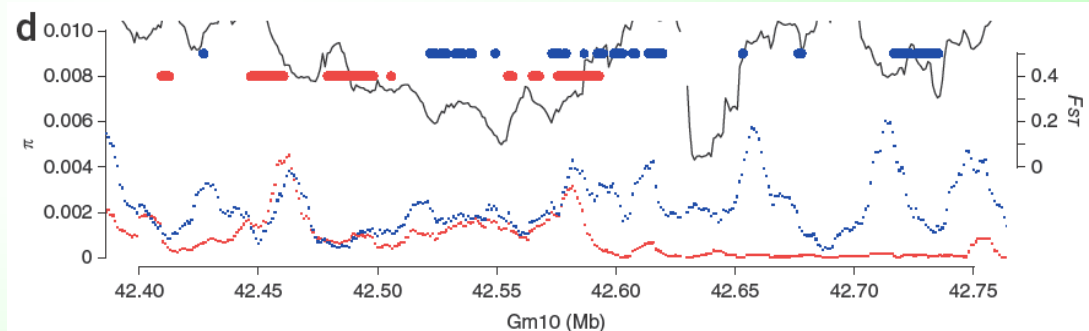
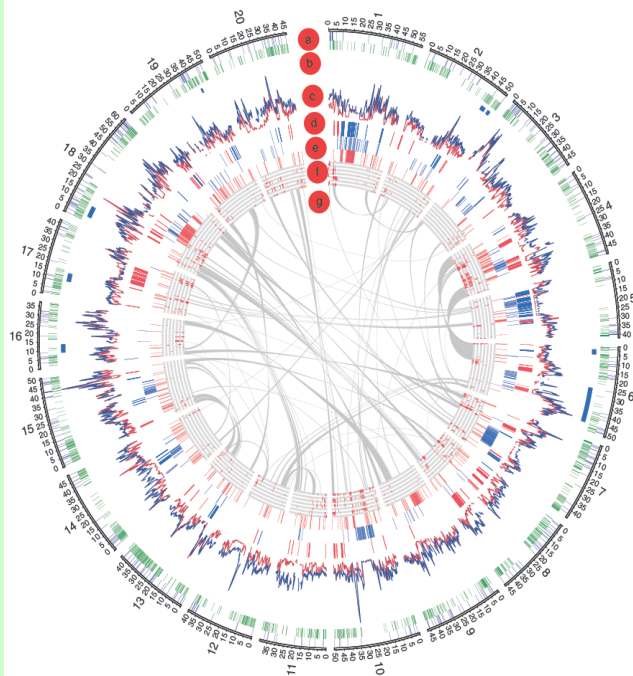


Discovery favorite gene or alleles in soybean

- 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 $\geq 10\%$ 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 (arabidopsis or lotus) or soybean
- Developing functional molecular markers for MAS breeding

Resequencing of soybean genomes identifies patterns of genetic diversity and selection

Whole genome									
	Number of SNPs	θ_{π} (10^{-3})	θ_w (10^{-3})	Non-synonymous SNPs	Synonymous SNPs	Nonsyn/Syn			
Wild soybean	5,924,662	2.966	2.307	106,716	78,701	1.36			
Cultivated soybean	4,127,942	1.894	1.689	77,291	55,883	1.38			
Genic regions									
	CDS			UTR			Intron		
	Number of SNPs	θ_{π} (10^{-3})	θ_w (10^{-3})	Number of SNPs	θ_{π} (10^{-3})	θ_w (10^{-3})	Number of SNPs	θ_{π} (10^{-3})	θ_w (10^{-3})
Wild soybean	185,145	1.063	0.829	74,476	1.768	1.415	621,432	2.002	1.582
Cultivated soybean	132,976	0.723	0.626	53,730	1.118	1.073	426,897	1.318	1.180

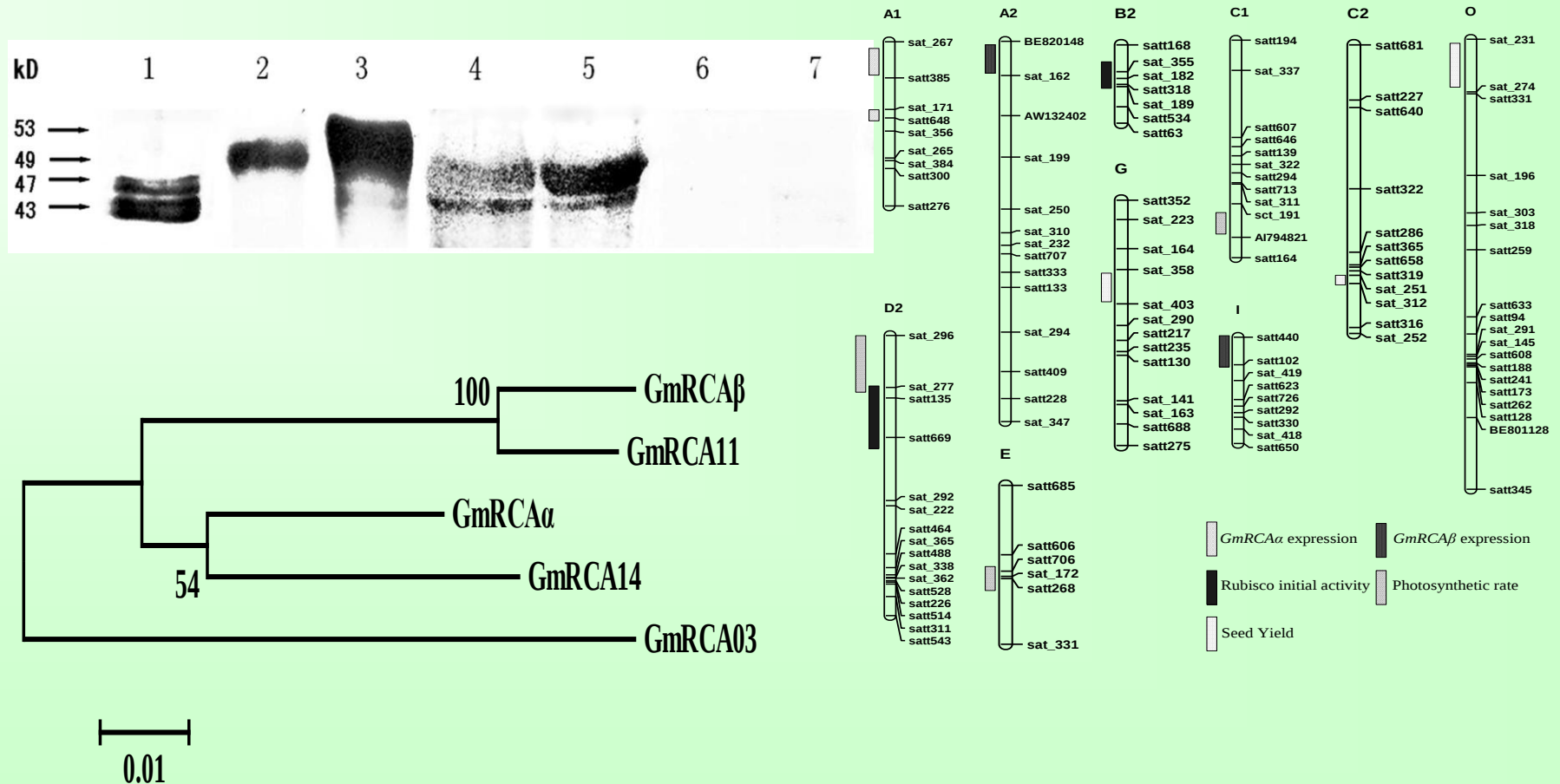


- ❖ Lower level of genetic diversity in cultivated soybeans
- ❖ Selection processes acting on cultivated soybeans different from wild soybeans
- ❖ High LD in soybean genome

(Lam et al., Nature Genetics, 2010)

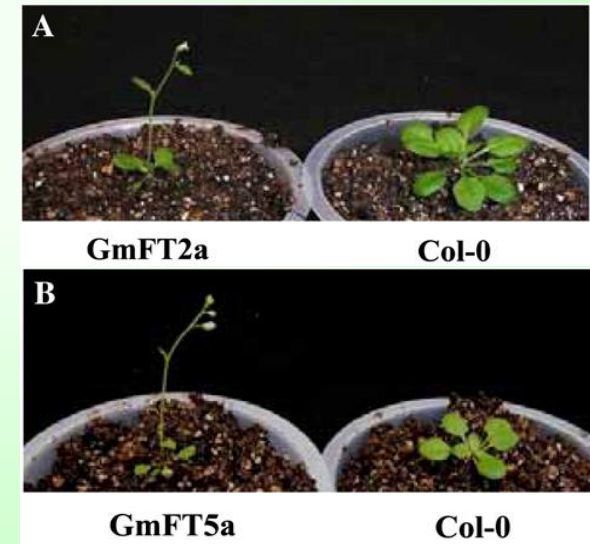
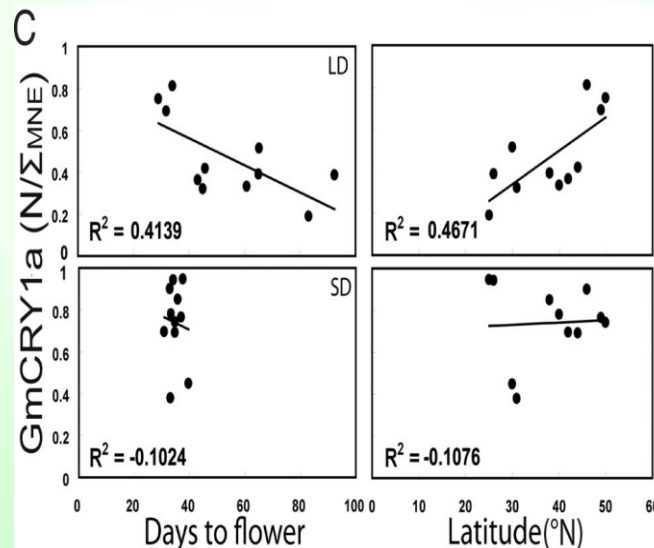
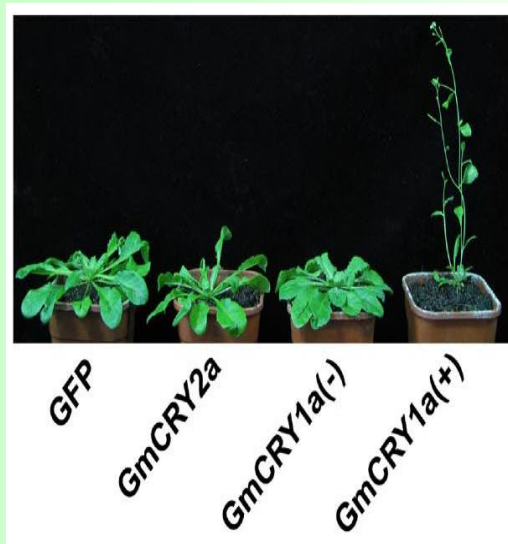
Mapping eQTLs of rubisco activase genes in soybean

- Expression of RCA genes modulate photosynthesis, and potentially, seed yield
- Both GmRCA α and GmRCA β are controlled by two trans-eQTLs



Characterization *GmCRYs* and *GmFTs* in photoperiodic flowering of *G. max*

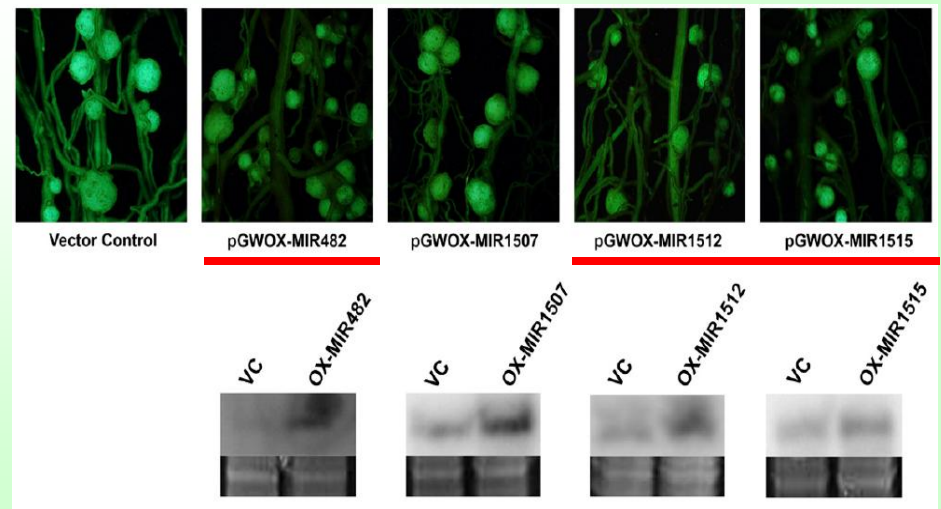
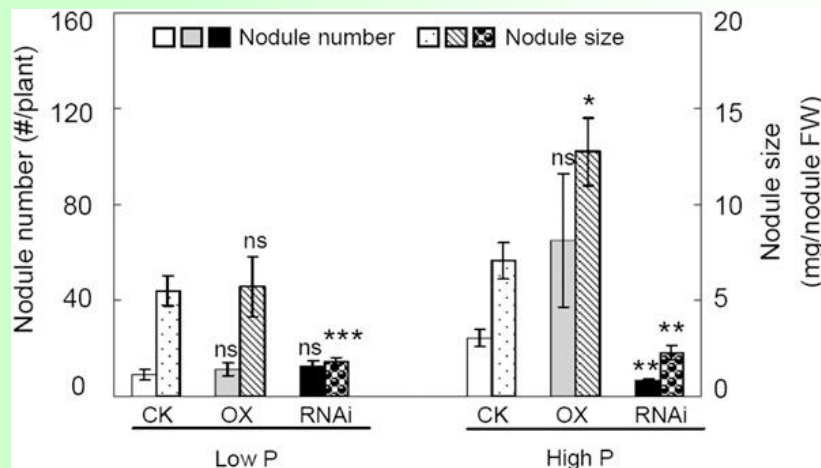
- ❖ *GmCRY1* plays the predominant role in determining flowering time
- ❖ Strong correlation of the circadian rhythmic expression of *GmCRY1a* with photoperiodic flowering and latitudinal distribution of soybean cultivars
- ❖ Two FT orthologs have florigen-like functions and coordinately control flowering



(Zhang et al., PNAS, 2008; Kong et al., Plant Physiol, 2010)

Phosphate transporter GmPT5 and miR482, miR1512, and miR1515 regulate nodulation in soybean

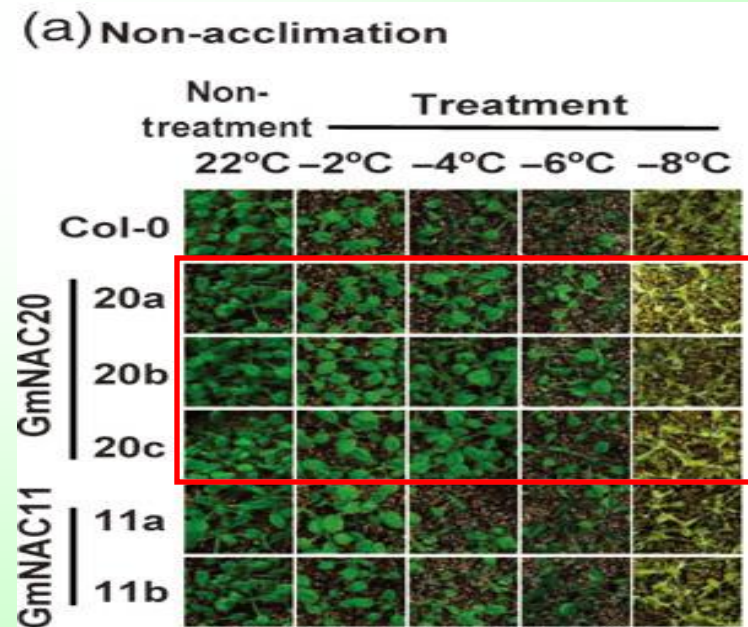
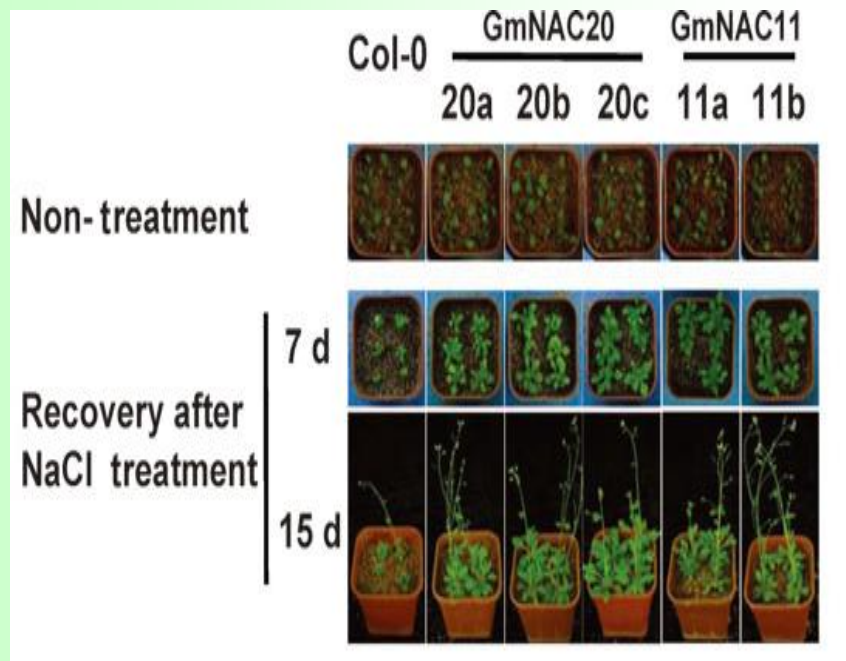
- ❖ Overexpression or knockdown of GmPT5 in soybean altered nodulation and plant growth performance
- ❖ GmPT5 controls Pi entry from roots to nodules and subsequently regulates soybean nodulation and growth performance
- ❖ Transgenic expression of miR482, miR1512, and miR1515 led to significant increases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



(Qin et al., Plant Physiol, 2012; Li et al., Plant Physiol, 2010)

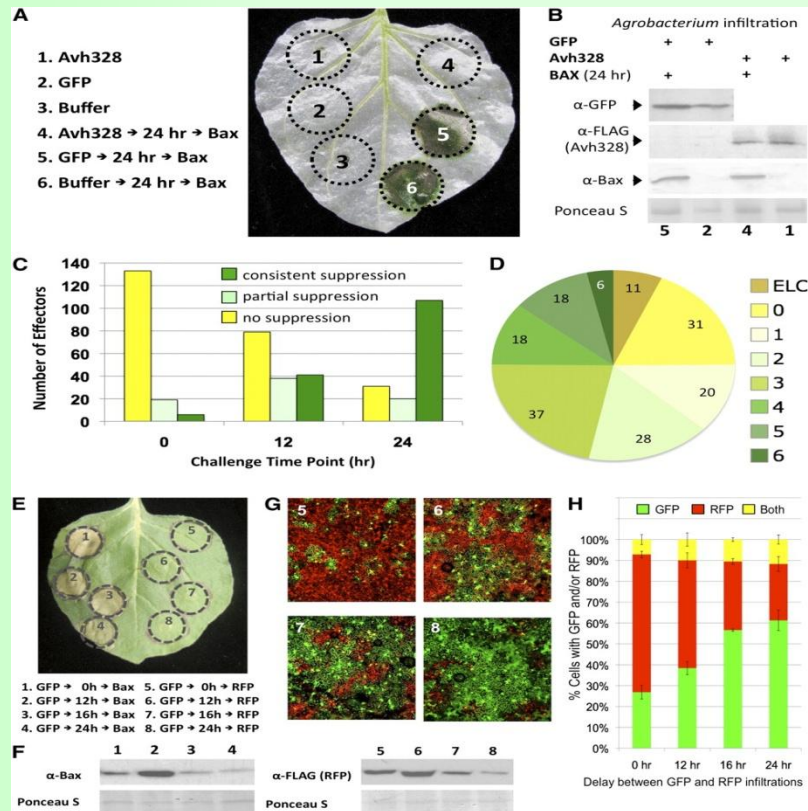
Two Soybean NAC transcription factors promote abiotic stress tolerance in transgenic plants

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

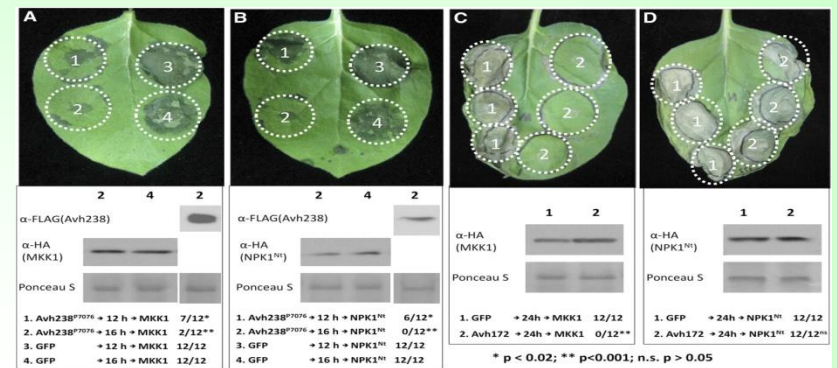


(Hao et al., Plant J, 2011)

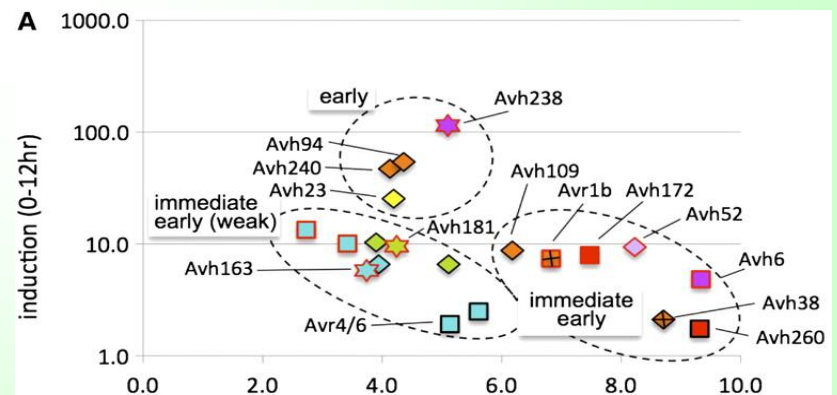
Pathogen: Transcriptional Programming and Functional Interactions within the *Phytophthora sojae* RXLR Effector Repertoire



Suppression of PCD by *P. sojae* Effectors (example Avh328)



Functional Interactions among Effectors Suppressing Cell Death

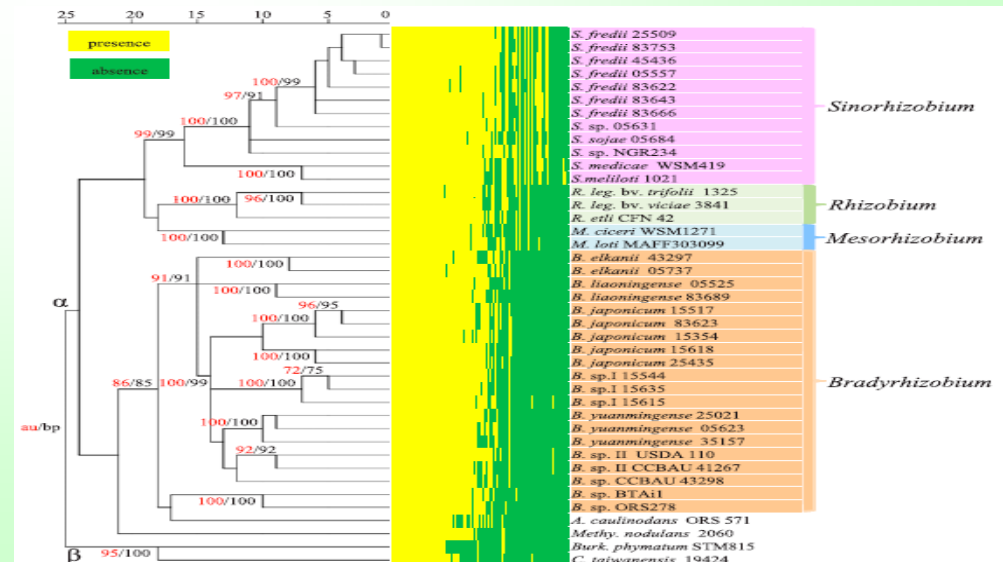
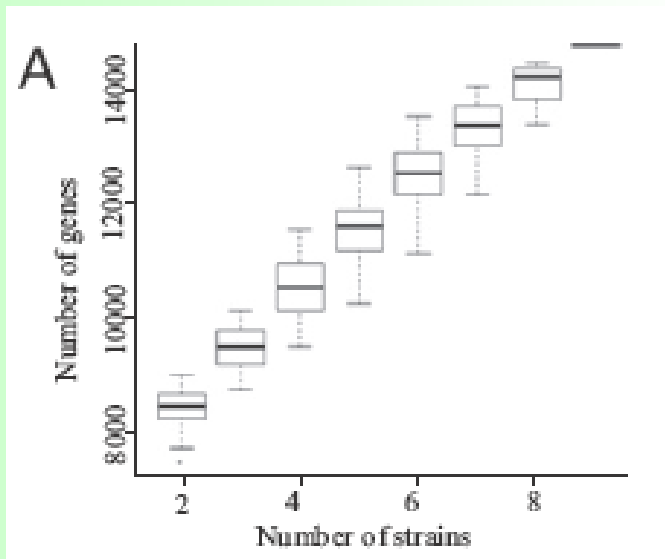


Functional Properties of Key *P. sojae* Effectors.

- ✓ 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

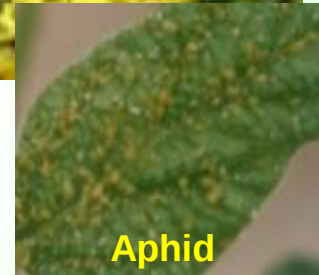


Cercosporidium sofinum
Soybean frog-eye leaf spot

Soybean mosaic virus
/ Seed coat mottling



Phytophthora sojae



Aphid



white mold



Lepidoptera
Soybean leaf-feeding insects



Northeast Giant Black Chafer



Bean borer



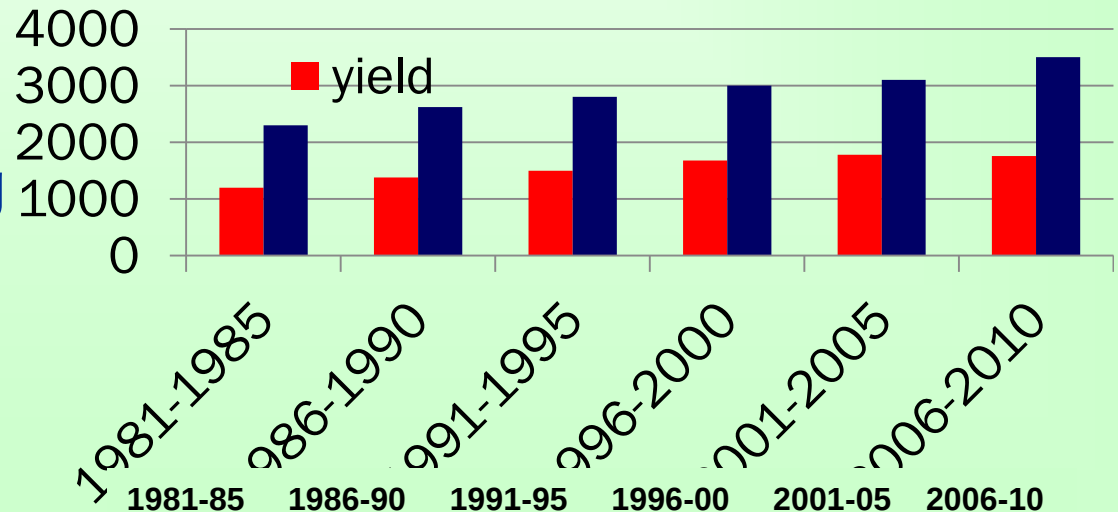
Soybean
cyst nematode

herbicide

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.



Prospects:

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

Items	2010	2015	Annual Growth Rate (%)
Grain Production Capacity (mmt)	>500	> 540	
Grain Acreage (mha)	110	> 106.7	
Meat Production (1,000 tons)	79,260	85,000	1.41
Egg Production (1,000 tons)	27,630	29,000	0.97
Dairy Production (1,000 tons)	37,480	50,000	5.93

Thank you !

