The Chinese Pipeline of GM Crops

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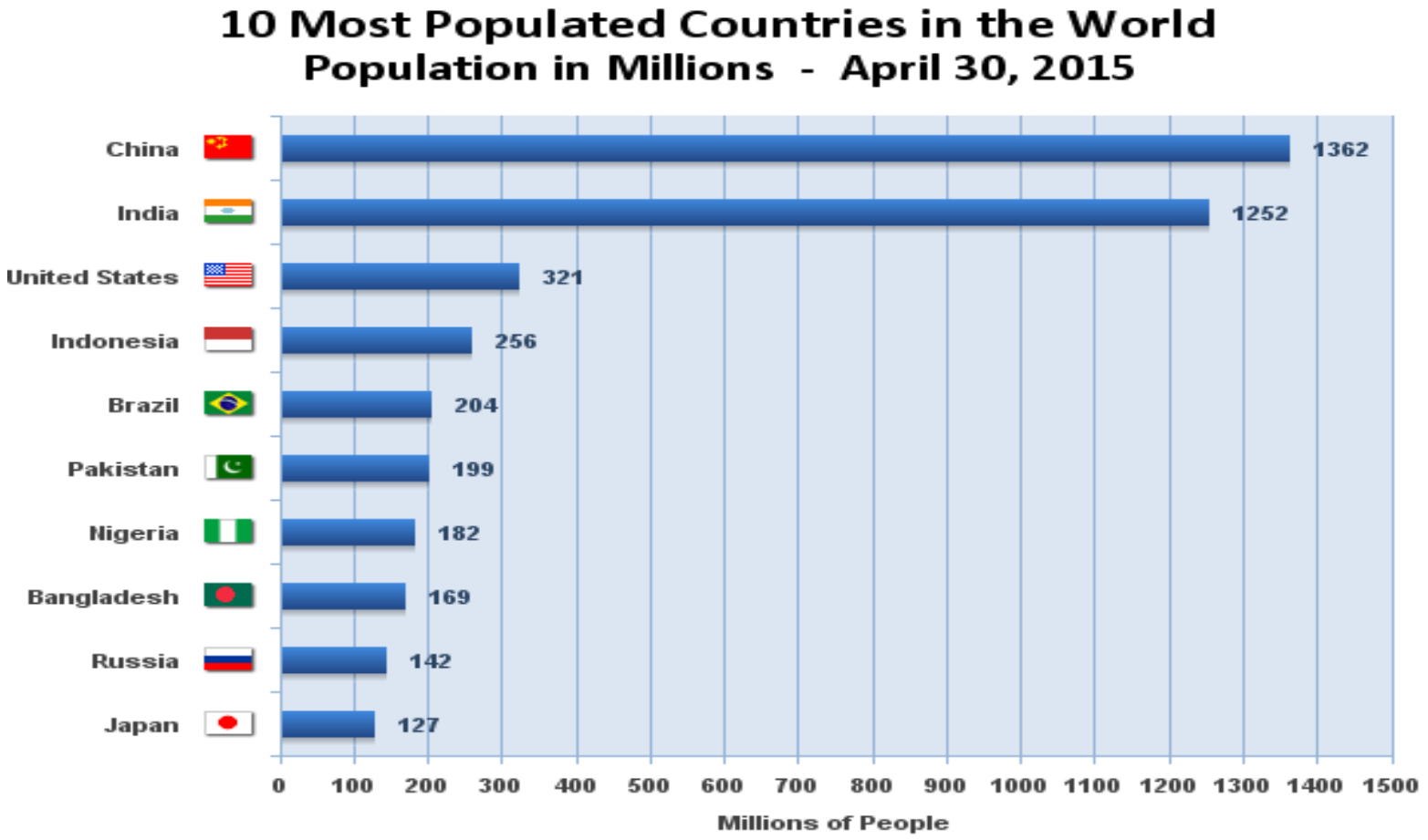
Outline

- Challenging of the Key Demands
- GM Crops in China
- Biosafety Assessment and Management
- Important Issues

China has the largest population with a great demand for agricultural products



Source: Internet World Stats - www.internetworldstats.com/stats8.htm
7,259,749,564 world population estimated for April 30, 2015

Challenging— Ecological Safety

Water Resources

- Water in agriculture takes about 70% of the total water resources, and rice is taking about 70% of the agriculture water resources
- The area of drought stress is about 4.7mha per year
- If water usage efficiency increase 10%, the saved amount **of water is relevant to the yellow river**

Challenging: Environmental Safety

- **Agricultural medicines are 43 mt per year, 4 times of that in US, resulting more residual**
- **Chemical fertilizer applies was twice times of the US, only 30% efficiency**

Challenging—Health Safety

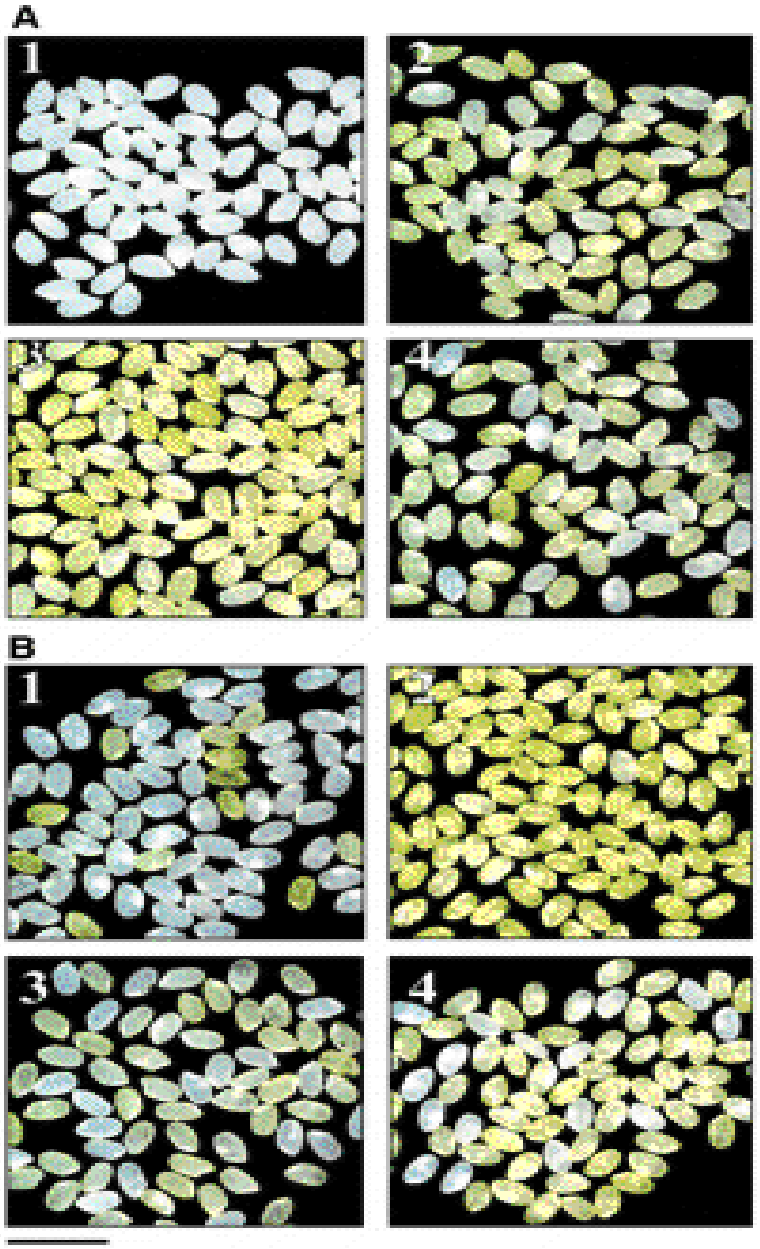
- **Fe: Anaemia is 50% for rural children of 6-12 month and 27% for citizen**
- **Vitamin A： moderate deficiency， such as Guangxi children reach up to 42%**
- **High blood pressure etc: more than 17% population**

Non-GM or GM Crops

- **More production and good quality**
  - **High yield, good quality**
  - **Diverse agricultural products and foods**
  - **Nutrition**
- **Lower investing**
  - **Decreasing fertilizers and chemicals**
  - **Decreasing applied water, occupied field and working farmers**
- **Friendly environment**
  - **Limited pollution and favored to human health**
  - **Decreased environment pollution to secure sustainable agriculture**
  - **Sustained diversity of organism**

Prospect Example:
Golden Rice

Transform 3 genes involved in β-carrot syntheses for developing vitamin A richen rice.



Phenotypes of transgenic rice seeds. Bar, 1 cm. (A) Panel 1, untransformed control; panels 2 through 4, pB19hpc single transformants lines h11a (panel 2), h15b (panel 3), h6 (panel 4). (B) pZPsC/pZLcyH co-transformants lines z5 (panel 1), z11b (panel 2), z4a (panel 3), z18 (panel 4).

Ye et al. 2000 *Science* 287:303-305

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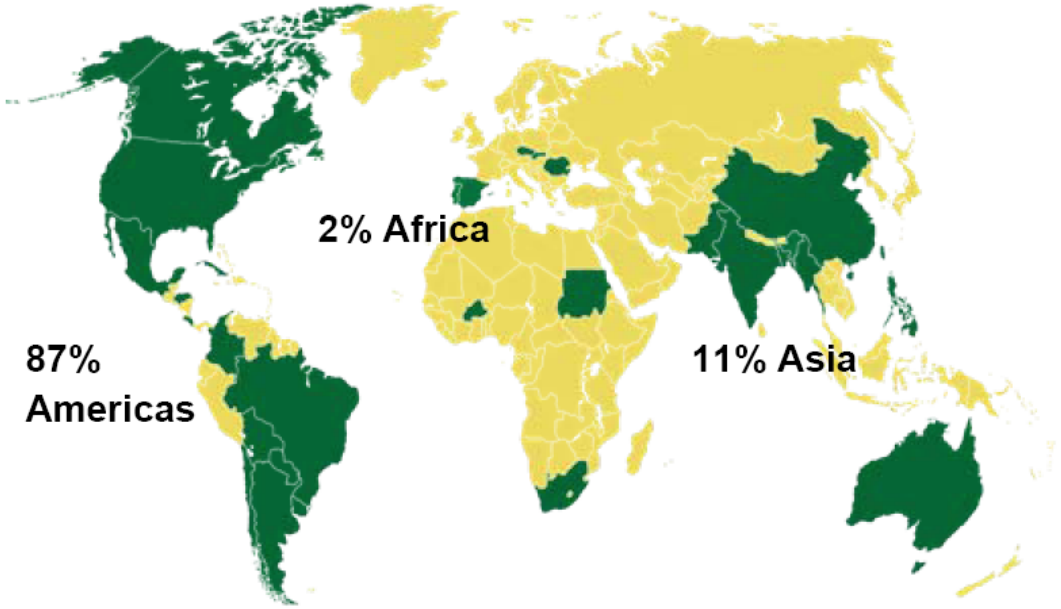
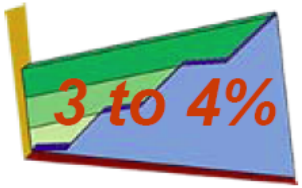
China's GMO crop cultivation ranks at the 6th in the world



28 countries which have adopted biotech crops

In 2014, global area of biotech crops was 181.5 million hectares, representing an increase of 3 to 4% over 2013, equivalent to 6.3 million hectares.

Increase over 2013



Source: Clive James, 2014.

Biotech Mega Countries

50,000 hectares (125,000 acres), or more

		Million Hectares
1.	USA	73.1
2.	*Brazil**	42.2
3.	*Argentina**	24.3
4.	*India**	11.6
5.	Canada	11.6
6.	*China**	3.9
7.	*Paraguay**	3.9
8.	*Pakistan**	2.9
9.	*South Africa**	2.7
10.	*Uruguay**	1.6
11.	*Bolivia**	1.0
12.	*Philippines**	0.8
13.	Australia	0.5
14.	*Burkina Faso**	0.5
15.	*Myanmar**	0.3
16.	*Mexico**	0.2
17.	Spain	0.1
18.	*Colombia**	0.1
19.	*Sudan**	0.1

Less than 50,000 hectares

*Honduras** Romania
*Chile** Slovakia
Portugal *Costa Rica**
*Cuba** *Bangladesh**
Czech Republic

* *Developing countries*

Seven GM crops were certificated in China

No.	Crop	Trait	Event	Developer	Year of approval
1	Cotton	IR	GK12	Chinese Academy of Agricultural Science	1997
2	Cotton	IR	GK321	Chinese Academy of Agricultural Science	1999
3	Cotton	IR	MON531	Monsanto company	1997
4	Papaya	VR	Huanong No. 1	South China Agricultural University	2006
5	Petunia	FC	Petunia-CHS	Beijing University	1999[a]
6	Sweet pepper	VR	PK-SP01	Beijing University	1999[a]
7	Tomato	DR	Huafan No. 1	Huazhong Agricultural University (China)	1997[a]
8	Rice	IR	*Bt* Shanyou 63	Huazhong Agricultural University (China)	2009[a]
9	Rice	IR	Huahui-1	Huazhong Agricultural University (China)	2009[a]
10	Maize	HP	BVLA430101	Origin Agritech	2009[a]

Benefits from planting GM cotton in China

- **Reducing application of pesticide**
- **Inceasing economic benefits**

Table 7. Two-Stage Least Squares estimates of pesticide use and cotton yield based on Cobb-Douglas and Damage Abatement Control production functions.

	Amount of *Pesticide Use* (kg/ha)	Cotton yield function LnYield (kg/ha)	
		Cobb-Douglas function	Damage control function
Perception of *Yield loss* (%):	0.135 (0.03)***		
Average pesticide *Price* (yuan/kg)	-0.133 (0.03)***		
Farm size (ha)	-13.259 (3.38)***		
Household characteristics:	0.016	-0.033	-0.030
Age (years)	(0.07)	(0.05)	(0.06)
Education (years)	-1.302 (0.28)***	-0.005 (0.01)	-0.001 (0.01)
Village leader dummy	1.336 (2.25)	0.074 (0.04)*	0.073 (0.04)*
Bt cotton training dummy	-2.717 (1.49) *	0.032 (0.03)	0.029 (0.03)
Conventional inputs:		0.02	0.033
Labor input (Days/ha)		(0.04)	(0.04)
Fertilizer (kg/ha)		0.107 (0.02)***	0.126 (0.02)***
Other inputs (yuan/ha)		0.159 (0.01)***	0.160 (0.01)***
Coated seed dummy	-4.699 (1.71)***	0.061 (0.03)*	0.072 (0.03)**
Hybrid seed dummy	14.429 (2.17)***	0.058 (0.04)	0.047 (0.04)
Bt cotton *Variety dummy (Bt)*	-43.246 (4.03)***	0.083 (0.04)**	0.096 (0.03)***
Bt x T2000	12.60 (4.93)***		
Bt x T2001	10.33 (4.66)**		
Predicted *Pesticide use* (kg/ha)		-0.021 (0.02)	
Damage control parameter estimates *c* (pesticide parameter)			0.593 (0.29)**

Major findings on Bt cotton impacts: (By empirical study, per hectare)

- Increase yield: 9.6% 930 yuan
- Reduce pesticide: 34 kg 923 yuan
- Reduce labor input: 41days 574 yuan
- Increase seed cost: 570 yuan
- Increase net income: 1857 yuan (US$ 225)

Increase in the household income (average sample household): 14%

Sources: Huang et al., ***Science***, 29 Jan 2002: 674-677

- Yield gains:
  - 6.8-10.8%
- High and stability of disease resistance
- High rice quality

Bt and non-Bt rice

Estimated parameters using household fixed effects model for estimating effect of insect-resistant GM rice varieties on farmers' pesticide application and yield of households in pre-production trials in China.

Variables	Pesticide use (kg/ha)		Yields (kg/ha) in log	
	Model I	Model II	Model I	Model II
Intercept	19.93 (1.17)***	19.78 (1.32)***	7.55 (0.50)***	7.61 (0.51)***
Variety dummies (base=other non-GM varieties)				
GM rice, both varieties	-16.77 (1.28)***		0.06 (0.03)*	
Variety-specific dummy variables				
GM Xianyou 63		-17.15 (2.60)***		0.09 (0.05)*
GM II-Youming 86		-25.33 (5.48)***		0.02 (0.10)
Non-GM Xianyou 63		1.04 (2.61)		-0.03 (0.05)
Non-GM II-Youming 86		-1.25 (3.82)		0.07 (0.07)
Control Variables				
Pesticide price (yuan/kg)	-0.02 (0.03)	-0.02 (0.03)		
Natural disaster dummy (affected=1)	8.56 (2.65)***	8.65 (2.65)***	-0.51 (0.05)***	-0.51 (0.05)***
2003 year dummy	-0.17 (1.20)	-0.01 (1.24)	-0.05 (0.02)**	-0.05 (0.02)**
Labor (log)			0.17 (0.07)**	0.17 (0.07)**
Fertilizer (log)			0.04 (0.06)	0.03 (0.06)
Machine (log)			0.00 (0.01)	0.00 (0.01)
Other inputs (log)			0.03 (0.04)	0.02 (0.04)
Pesticides (log)			0.00 (0.00)	0.00 (0.00)
Household Dummy Variables	Included but not reported			
Number of observations	347	347	347	347

Source: Huang et al., 2005a.

Data: GM rice surveys in the fields of farmers … during pre-production trials

Major findings on GM rice impacts: (By empirical study, per hectare):

- **Pesticide: - 75 - 80%**
- **Yield : + 0 - 6%**
- **Labor : - 5.5%**
- **Net income: 844 yuan**

US$ 82~100 /ha

Note: per capita income of sample rice farmers was 2630 yuan in 2003

Huang et al., 2005, *Science*; Huang et al., 2007, EDCC

GM crops at advanced development stage

- **Cotton:** High yield, Good quality
- **Rice:** Insect resistance, Disease resistance
- **Wheat:** Disease resistance, drought tolerance
- **Maize:** Insect resistance, herbicide tolerance
- **Soybean:** Herbicide tolerance, Insect resistance

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Background of Biosafety Managing on Agricultural GEO in China

- 1993： Biosafety Managing Guidelines in Genetic Engineering, State Scientific Committee
- 1996： Guidelines for Safety Assessment (GSA) on Agricultural Organism Genetic Engineering, (AOGE), Ministry of Agriculture
- 1997： Executive Declare of Annocement of (GSA-AOGE) , Ministry of Agriculture
- 1997： Establishment Organizing Biosafety Committee and Biosafety Managing Office of AOGE, Ministry of Agriculture
- 2001： Regulation of biosafety on AOGE, State Council

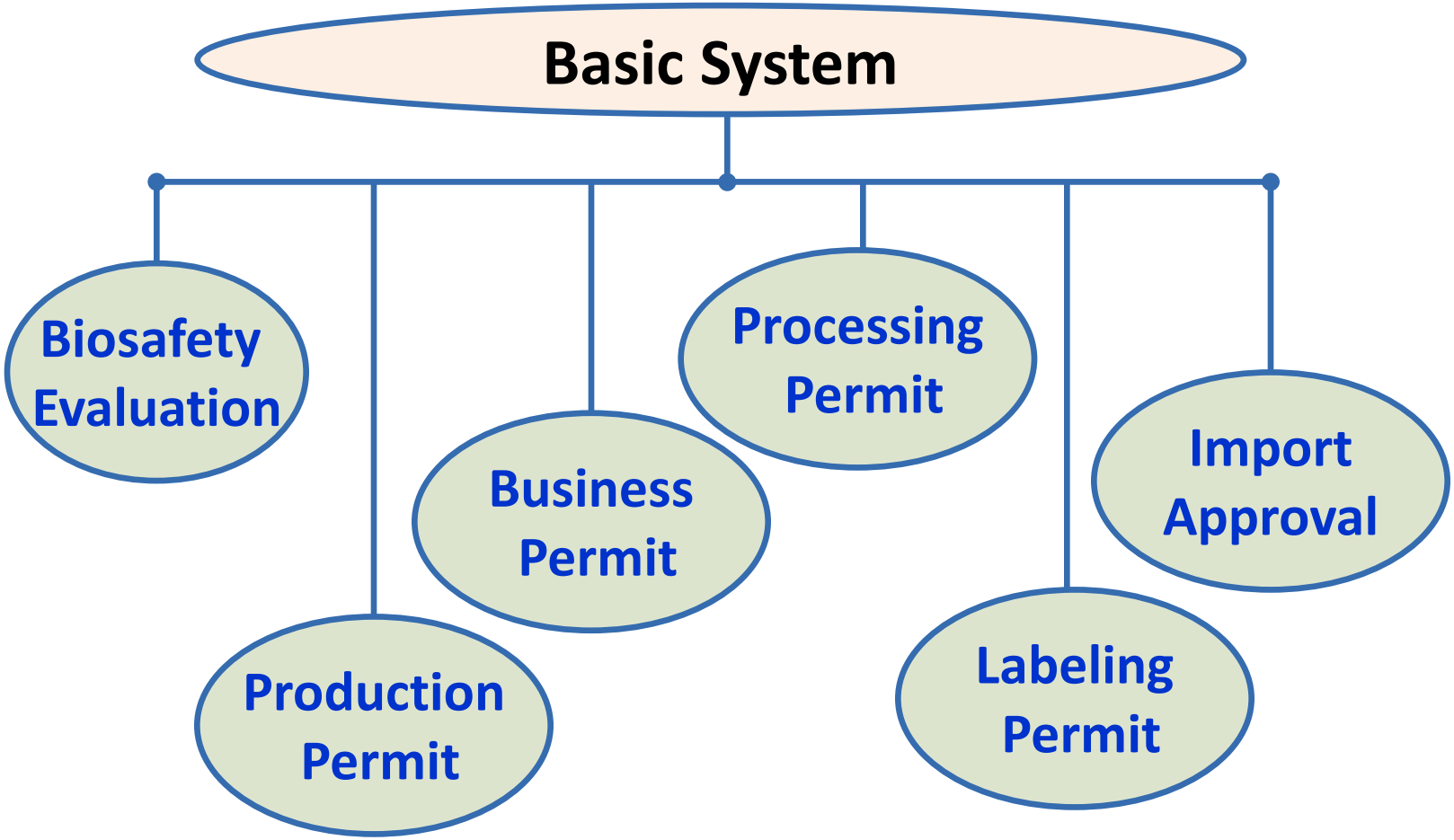
- **Implemented from March 20 , 2002, divided the transgenic into 4 grades from low to high for the first time:**

Safe grade Ⅰ	no risk
Safe grade Ⅱ	low risk
Safe gradeⅢ	moderate risk
Safe gradeⅣ	high risk

Rules of the Regulation in China

- **Rule of Biosafety Evaluation of Agricultural Transgenic Organism (ATO)**
- **Rule of Certification of producing GMA, GMP, GMM**
- **Rule of Certification of Commercialize AOGE**
- **Rule of Labeling ATO**
- **Rule of Import Managing of ATO**

GMO management system



Biosafety evaluation of GMOs in China

Two Forms: Report and approval system

Three Species: Plant, Animal, and Microorganisms

Four Levels: Ⅰ, Ⅱ, Ⅲ, Ⅳ

Five Stages:

Staging Management for GEO in China

- Study in the laboratory
- Experiment test (ET)
- Field trail (FT)
- Production trail (PT)
- Biosafety certification (Commercial release)

Passing procedures usually take 8 years

Commercialized GM Crops in China

Commercialized GM plants:

- **Bt Cotton** (***Cry1A, Cry1A+CpTI***)
- **Papaya** (**PRSV-*replicase***)

- **Bt Poplar trees** (***Cry1Ac***)
- **Tomato** (**CMV-*CP*, *EFE***)
- **Sweet pepper** (**CMV-*CP***)
- **Petunia** (***CHS***)

Only two crops have been widely planted

CK

Insect resistance cotton

Disease resistance papaya

GM crops approved for import

No.	Crop	Trait	Event	Developer	Biosafety certificate validation
1	Soybean	HT	GTS40-3-2	Monsanto	2004–2015
2		HT	MON89788	Monsanto	2008–2014
3		IR	MON87701	Monsanto	2013–2016
4		IR + HT	MON87701 × MON89788	Monsanto	2013–2016
5		OC + HT	DP-305423	DuPont Pioneer	2011–2014
6		HT	DP356043	DuPont Pioneer	2010–2013
7		HT	A2704-12	Bayer CropScience	2007–2013
8		HT	CV127	BASF Plant Science	2013–2016
9	Corn	HT	GA21	Monsanto	2004–2014
10		IR	MON810	Monsanto	2004–2015
11		DT	MON87460	Monsanto	2013–2016
12		IR	MON89034	Monsanto	2010–2013
13		HT	NK603	Monsanto	2005–2013
14		IR + HT	MON88017	Monsanto	2007–2013
15		IR	MON863	Monsanto	2004–2015
16		IR + HT	*Bt*176	Syngenta Seeds	2004–2015
17		IR + HT	*Bt*11	Syngenta Seeds	2004–2015
18		IR	MIR604	Syngenta Seeds	2008–2014
19		IR + HT	Bt11 × GA21	Syngenta Seeds	2011–2014
20		MA	Event 3272	Syngenta Seeds	2013–2016
21		IR + HT	TC1570	Dow AgroScience–DuPont	2004–2015
22		IR + HT	59122	Dow AgroScience–DuPont	2006–2015
23		HT	T25	Bayer CropScience	2004–2015
24	Cotton	IR	MON531	Monsanto	2004–2018
25		HT	MON1445	Monsanto	2004–2018
26		HT	MON88913	Monsanto	2007–2017
27		HT	LLCotton25	Bayer CropScience	2006–2016
28		IR	15985	Monsanto	2006–2016
29		HT	GHB614	Bayer CropScience	2010–2015
30	Canola	HT + F	MS1 × RF1	Bayer CropScience	2004–2015
31		HT + F	MS1 × RF2	Bayer CropScience	2004–2015
32		HT + F	MS8 × RF3	Bayer CropScience	2004–2015
33		HT	T45	Bayer CropScience	2004–2015
34		HT	Topas19/2	Bayer CropScience	2004–2015
35		HT	OXY-235	Bayer CropScience	2004–2015
36		HT	GT73	Monsanto	2004–2015
37	Sugarbeet	HT	H7-1	Monsanto	2009–2015

Soybean

Corn

Cotton

Canola

Sugarbeet

Labelled GM products

- Soybean, Soybean seed, meal, and oil
- Maize, Maize seed, oil and meal
- Rapeseed, rapeseed seed, oil and meal
- Tomato, tomato seed, and sauce
- Cotton seed

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Research and Managing Issues

- **Limited genes with favorite TRAITS were discovered for transformed**
- **Foreign gene functions appeared to be influenced by the background**
- **New technologies such as gene editing**

Biodiversity Issue

- China has wild relatives of crops such as rice and soybean
- Some bio-safety estimation were confirmed that natural pollination could flow from GE rice /soybean to common soybean even wild species
- Need consideration of effect if GE rice or soybean cultivars will use in the agricultural production

Intellectual Property Right System Issue

- **Germplasm is the vector of the genes, which will lead to development of biotechnology, IPRS should consider both of germplasm and genes**

For example: ***One accession of wild soybean was collected in Shanghai and found QTL related to high yield were patented by Monsanto， resulting Chinese farmer will against US patent if they plant material with QTL from Chinese germplasm***

- **Defining range of IPRS for proper benefit inventors so that stimulating innovation**

Thanks for your attention!