

BREEDING OF HYBRID SOYBEAN ZAYOUDOU NO.1

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Zayoudou 1 was provincially approved and released as the second commercial hybrid soybean in the world with soybean male sterile line W931A with CMS crossed with the restorer line WR016. In Anhui soybean variety regional trials from 2002 to 2003, it yielded a mean of 191.2 kg/667m², a significant 15.4% higher than that of the check Zhongdou 20. The average yield of Zayoudou No.1 was 177.3 kg/667m² in Anhui soybean variety test in 2003, 19.1% higher than that of the check. It was characterized by high yield, disease resistance, lodging resistance in multi-year and multi-sites trials. Zayoudou 1 has a good plant type with a protein content of 43.6%,oil content of 19.0% and growth duration of 111 days. It was released at Jianghua region and Huaibei region in Anhui as a medium-early variety.

Breeding of M-Type Hybrid Soybean Zayoudou NO.1

**Crop Research Institute
Anhui Academy of Agricultural Sciences
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South Africa· 2013**

Breeding of Hybrid Soybean

Utilization of crop heterosis was very important breeding method to increase yield. The heterosis of rice, corn, rapeseed, cotton and other crops had been widely used in production. The first hybrid soybean was bred successfully by JAAS in China in 2002. Then, other 7 hybrid soybeans had been also released by three institutes in China (4 hybrids in Jilin province, 3 hybrids in Anhui province) from 2003 to 2011. Nanjing Agricultural University had completed “three-lines”. Some hybrid crosses were tested in experiment.

Breeding of M-type Hybrid Soybean with CMS

Seven soybean M-type male sterile lines with CMS(G.max×G.max) , W931A, W933A, W936A, W945A, W948A, W018A and S0105A, had been selected by AAAS since 1989. Thirty-eight soybean male sterile materials for different plant areas were obtained with seven male sterile lines above as female parent crossed by various soybean cultivars from different areas and countries.



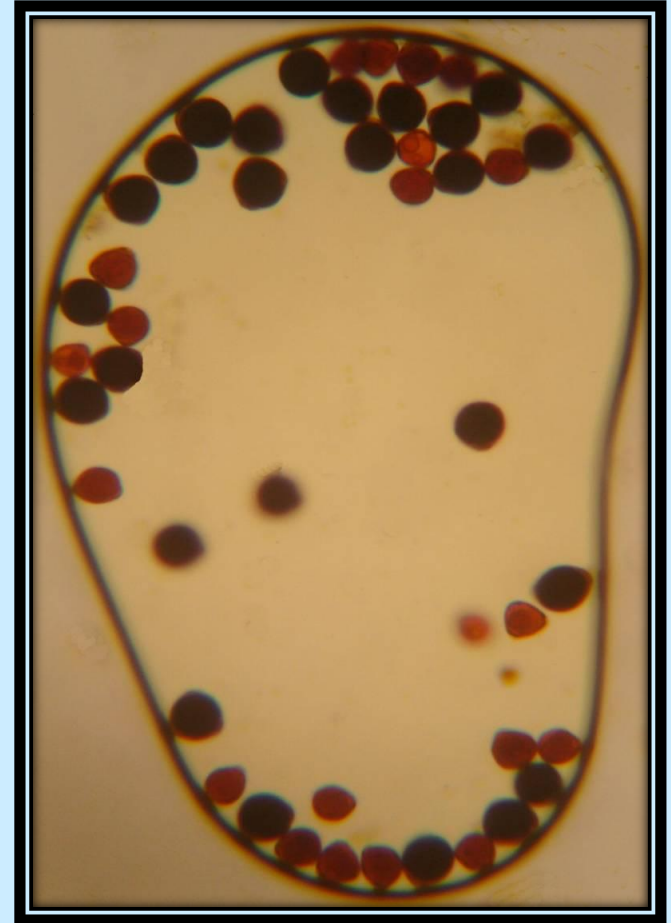
Characters of M-type Male Sterile Lines

- ◆ Soybean M-type male sterility was defined as cytoplasmic male sterility (CMS).
- ◆ The male sterility was stable. The ratio of pollen abortion reached above 98%.
- ◆ Female fertility of M-type male sterile lines is normal, the viability of stigma remains 2-2.5 days.



Pollen sterility of male sterile line

◆ Soybean M-type male sterility was defined as gametophyte sterility. The fertility of restorer lines was controlled by one pair of major dominant genes, probably some minor modifier genes.



F1 pollen fertility of M-type hybrid soybean

Fertility of Progenies from Crosses

Cross	Generation	The ratio of pollen fertility (%)	Fertile plants	Sterile plants	The ratio of fertile plants(%)
W913A (sterile line)	Female parent	1.7	0	816	0
W206 (maintainer line)	Male parent	99.5	827	0	100
WR99032 (restorer line)	Male parent	100.0	671	0	100
W931A×WR99032	F ₁	52.2	511	2	99.6
W931A×WR99032	F ₂		463	5	98.93
W931A×F ₁ (W931A×WR99032)	BC ₁ a		108	2	98.18
(W931A×WR99032) F ₁ ×W206	BC ₁ b		172	168	50.59
WR0088 (restorer line)	Male parent	97.5	734	0	100
W931A×WR0088	F ₁	54.5	428	0	100
W931A×WR0088	F ₂		393	4	98.99
W931A×F ₁ (W931A×WR0088)	BC ₁ a		87	2	97.75
(W931A×WR0088) F ₁ ×W206	BC ₁ b		157	159	49.68
WR0108 (restorer line)	Male parent	99.5	685	0	100
W931A×WR0108	F ₁	48.8	396	0	100
W931A×WR0108	F ₂		118	1	99.16
W931A×F ₁ (W931A×WR0108)	BC ₁ a		101	4	96.19
(W931A×WR0108) F ₁ ×W206	BC ₁ b		178	163	52.20

Approaches to Select Restorer Lines

- ◆ The model for effectively adjusting the flowering period of soybean cultivars spacing over 20 degrees on latitude was studied to make them meet with the flowering period of M-type male sterile line W931A.
- ◆ Soybean cultivars from different production areas were widely used as male parents to test-cross.
- ◆ New restorer materials from descendents of crossed restorer lines with fine cultivars.
- ◆ Sixty-eight restorers had been found in 2214 test-crossing combinations.

Soybean Cultivars with Restoring Gene for M-type CMS Line W931A

295 soybean cultivars from China and several other countries were selected to test-cross with soybean M-type male sterile line, W931A, for screening restoring lines and analyzing the geographic distribution of restoring genes. **The results showed the geographic distribution of the cultivars with the restoring genes was obviously uneven in various ecological regions.** The cultivars with strong restoring genes mostly existed in southern China, whereas the cultivars from northeast China mostly were maintainers. Cultivars from Japan, South Korea and northern United States mostly were maintainer as well(2007).

Hybrid Crosses with High-yield Selected

- ✓ Heterosis of F_1 yield of 22 hybrid crosses with soybean M type male sterile line W931A as female parent had been tested. The results showed that average over-parent heterosis of F_1 yield reached 44.22%, ranging from 3.78% to 132.16%. Average over-standard heterosis of F_1 yield of 19 hybrid crosses reached 31.06%, ranging from -0.93% to 66.06%.
- ✓ The results of test also indicated that heterosis of F_1 yield was closely related to the geographical original of restorers.

Comparison of F₁ Yield Heterosis of Hybrid Crosses

Original of male parent	No. of crosses	Average yield of male parent (kg/ha)	Average yield of F ₁ (kg/ha)	Over-parent heterosis	Over-standard heterosis
South soybean production area in China	11	2505.75	3855.75	53.87%	43.47%
Huanghuai soybean production area in China	11	2378.40	3188.55	34.06%	18.64%

Yield of CK: 2687.75kg/ha

Comparison of F_1 and F_2 Yield Heterosis of M-type Hybrid Soybean

Moreover, heterosis of F_1 and F_2 yield of 17 hybrid crosses were tested from 2010 to 2011. The results showed F_1 yield of 10 hybrid crosses increased from 1.90% to 25.47% as compared with CK. But, all F_2 yield of were lower than F_1 yield respectively. Only one F_2 yield, HS0920 of hybrid cross, was increased by 4.26%. But, the agronomic traits of F_2 were seriously segregated. So, heterosis of F_2 were very difficult to be utilized.

Crosses	Yield of F ₁ (kg/ha)	± CK(%)	Yield of F ₂ (kg/ha)	± CK(%)
HS0901	3183.90	16.16	2494.20	-6.62
HS0902	3320.25	21.14	2553.75	-4.39
HS0903	2970.30	8.37	2139.75	-19.89
HS0904	2376.15	-13.31	2105.70	-21.16
HS0905	2480.40	-9.51	1924.80	-27.93
HS0906	2793.15	1.90	2199.45	-17.65
HS0907	2636.70	-3.80	2268.75	-15.06
HS0911	3439.20	25.47	2225.40	-16.68
HS0912	2188.65	-20.14	2029.20	-24.03
HS0913	2970.30	8.37	2445.00	-8.46
HS0914	2280.90	-16.78	2045.25	-23.42
HS0915	3007.50	9.72	2505.00	-6.21
HS0916	2437.95	-11.05	2301.15	-13.84
HS0917	2501.25	-8.75	2201.10	-17.59
HS0918	3120.00	13.83	2526.00	-5.43
HS0919	3093.75	12.87	2550.00	-4.53
HS0920	3150.00	14.92	2784.75	4.26
CK(zhong huang 13)	2740.95	/	2670.90	/

Released M-type Hybrid Soybean

Zayoudou No.1 (W931A×WR016)



Released in 2004



- Variety regional trials (2 years):
2867.4kg/ha of average yield
increased by 15.37% over CK.
- Variety productive test (1 year):
2656.2kg/ha of yield increased by
19.14% over CK.

Zayoudou No. 2

(46.12% of protein)

安徽省农作物品种审定 证书

审定编号：皖豆 2010005

品种名称：杂优豆 2 号 (HS99071)

育 种 人：安徽省农科院作物研究所

适宜区域：江淮丘陵区 and 淮北区。

二〇一〇年八月三十日



Released in 2010



Produce Hybrid Seed

◆The high efficient pollination insects, honeybees and alfalfa leafcutter bees, were studied in natural field and net condition. The results showed the efficacy of pollinated by alfalfa leafcutter bees mediated was higher than honeybees by 2.04 times(2003).



Comparison the Yield of Hybrid Seed Production by Different Insects Pollinated

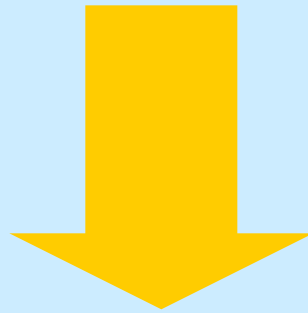
Treatment	Pods per plant			Average	Seed yield per plot (Kg)
	replication I	replication II	replication III		
Pollinated by alfalfa leafcutter bees	25.62	24.60	25.33	25.18	4.83
Pollinated by honeybees	12.01	13.45	11.52	12.33	2.36
No insects(CK)	1.82	1.51	1.35	1.56	/

Notices: The area of the plot was 67.5m², the ratio of male parent to female parent was 1:2

Producing Hybrid Seed under Natural Environment

Firstly, the factors of natural environment:

- ✓ The species of insects must be more.
- ✓ 20-25°C of mean temperature, less than 120mm of rainfall during soybean flower stage.



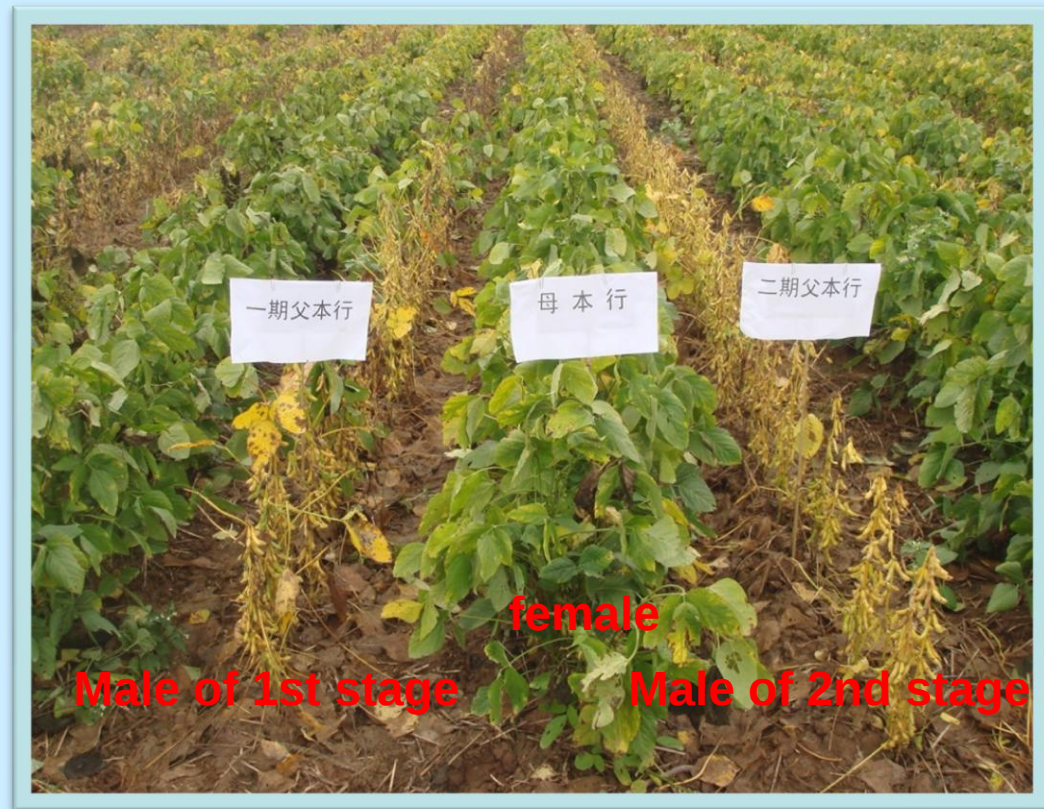
Northwest China

Secondly, the measures of culture technique

◆ Adjust the flowering period of soybean cultivars to meet female parent (sterile line) and male parent (restorer or maintainer line) .

◆ Sowing by stages of male parent can be used enough to permit pollen.

◆ Rows width between female parent and male parent reaches 50cm.



Baoji, 2009



Difficult Tasks:

Due to the varied weather in different years, the yield of producing hybrid seed could not keep a same level in the same field. For example, dry changed to rainy day during soybean flower stage, or the low outcrossing rate of the sterile lines.

How to increase hybrid seed yield in production field?

- ✓ **Select these sterile individuals with high outcrossing rate.**
- ✓ **Select these sterile individuals with stigma exertion.**
- ✓ **Select maintainer lines and restorer lines with more pollen.**

We selected 68 sterile individuals with high seed-setting rate in 2011. These individuals were respectively planted in 2012. Some lines had more pods, but the results needed further study to analyze outcrossing rate.



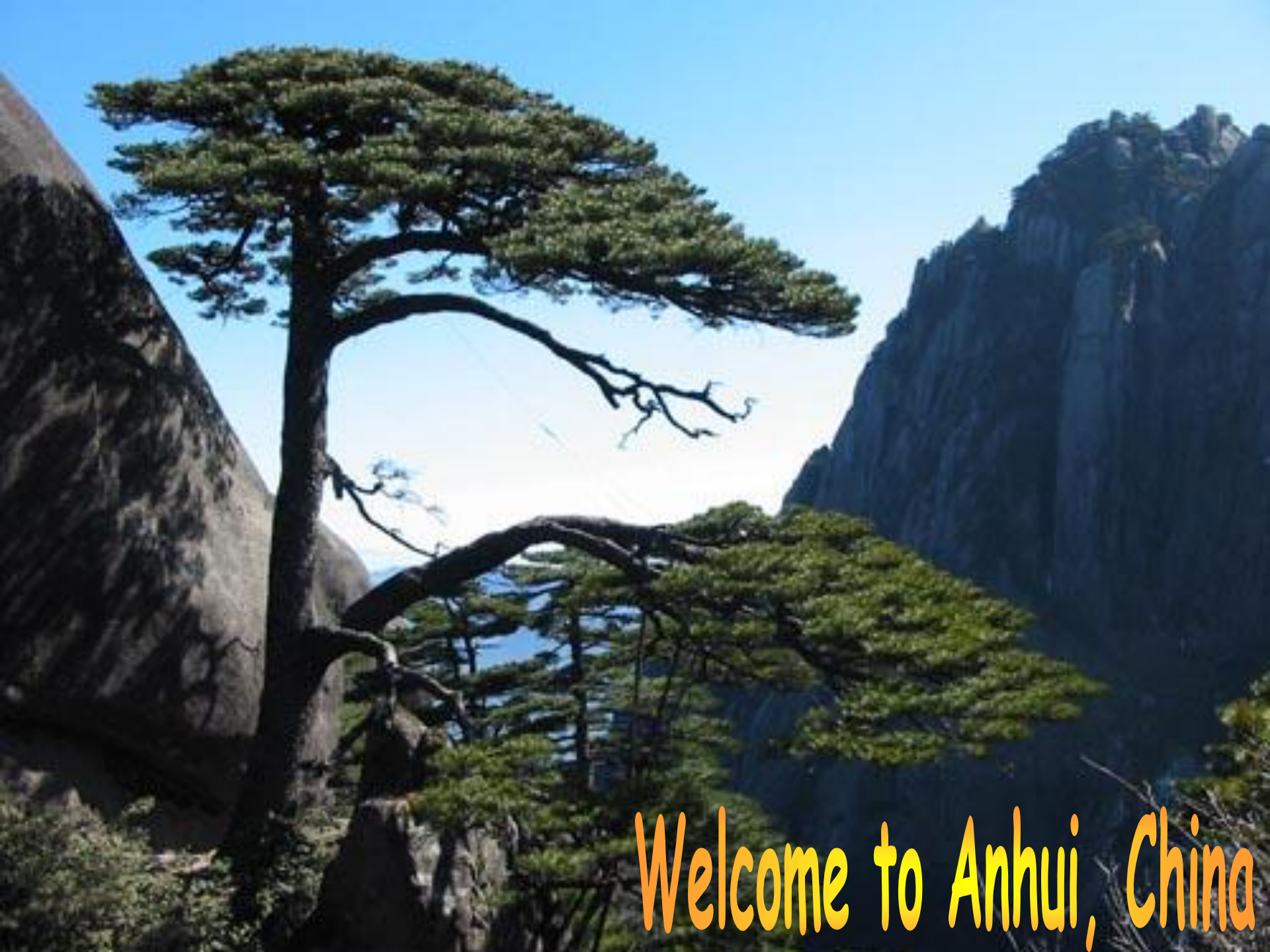
Yuncheng, 2012

Outlook

- ◆ Some hybrid soybeans had been successfully selected, but these were not the best. Many hybrid crosses with high-yield, fine agronomic characters will be put into yield test in the following years.
- ◆ By now the technology for producing hybrid seed needed further studying. As soon as it was stable, hybrid soybean could be used in the scale fields.

The Road is Tortuous,
the Future is Bright!

THANKS!



Welcome to Anhui, China