The development of Zhongyouza501, a hybrid variety with super-high yield under dense planting, will lead a Green Revolution in rapeseed

Prof. Xinfa Wang

Reporter: Jiaqin Shi

Rapeseed genetics & breeding research team

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Outline

1. A brief introduction to our team
2. Research Background
3. The breeding of Zhongyouza501
4. The demonstration of Zhongyouza501
5. Summary and future direction

1. Brief introduction to our team

Rapeseed Genetics & Breeding Research Team

● Mission of our team

Chain Research and development

Needs of rapeseed industry and people's consumption

↓

Theory for breeding

↓

Technology for breeding

↓

Varieties cultivation

↓

Integration of innovation, creation and entrepreneurship

◆ Task of our team

Focus on genetic improvement of important traits, including:

(1) The cloning of genes for important traits

(2) The establishment of high-efficiency breeding technology

(3) The breeding of new varieties with favorable traits

(4) The promotion and commercialization of these elite cultivars

The chief scientist of our team

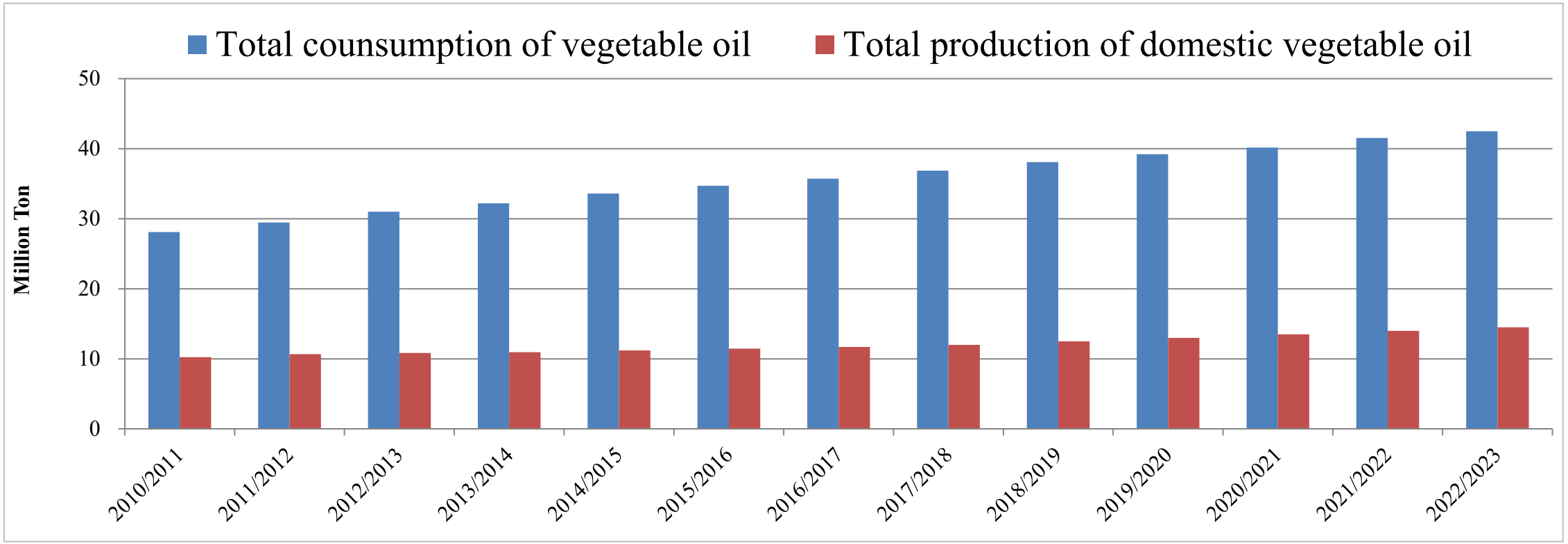
Prof. Hanzhong Wang

- The academician of the Chinese Academy of Engineering
- The chief scientist of national rapeseed industry technology system of China
- The member of International Consultative Group of Research on Rapeseed (GCIRC).
- The national talents of the new century talents project
- The national outstanding professional and technical talents
- The chief scientist of the national basic research and development project
- The leader of the oil expert guidance group of the Ministry of Agriculture and Rural Affairs

He has long been engaged in rapeseed genetics and breeding research and obtained great achievements:

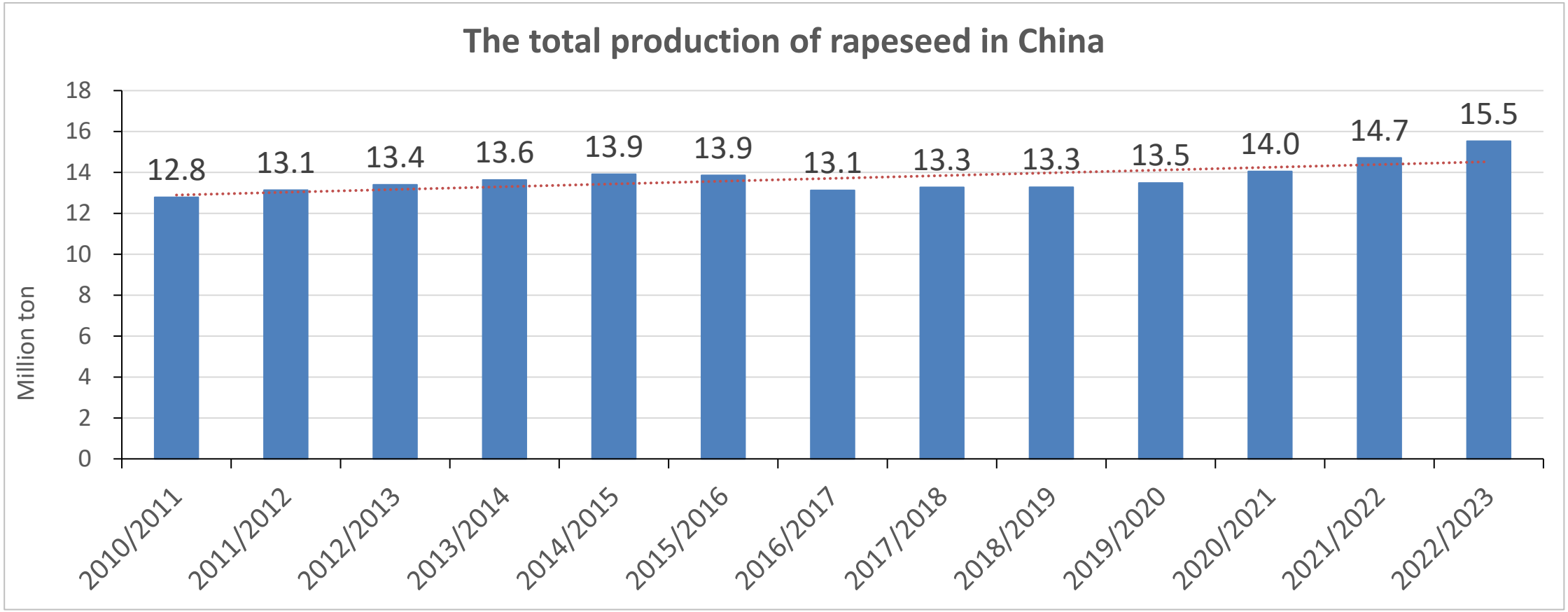
- He has presided > 40 important research projects, e.g., 863, 973, 948 and NSFC key project.
- He has bred >40 varieties, which has been planted >10 million hectares.
- He has won >10 science and technolgy awards, including the second-class prize of technology invention. award of China and the second-class prize of the science and technology progress award of China.
- He has published >120 papers, totally cited > 5000 times, and cultivated >30 masters and doctors.

2. Research background



- Over the past decade, the total vegetable oil consumption in China was much more than its domestic production, with the self-sufficiency rate of about 30%.
- The increase of vegetable oil consumption (annual rate: 4.3%) was also faster than that for domestic production (2.6%), which is a threat to edible oil supply security.

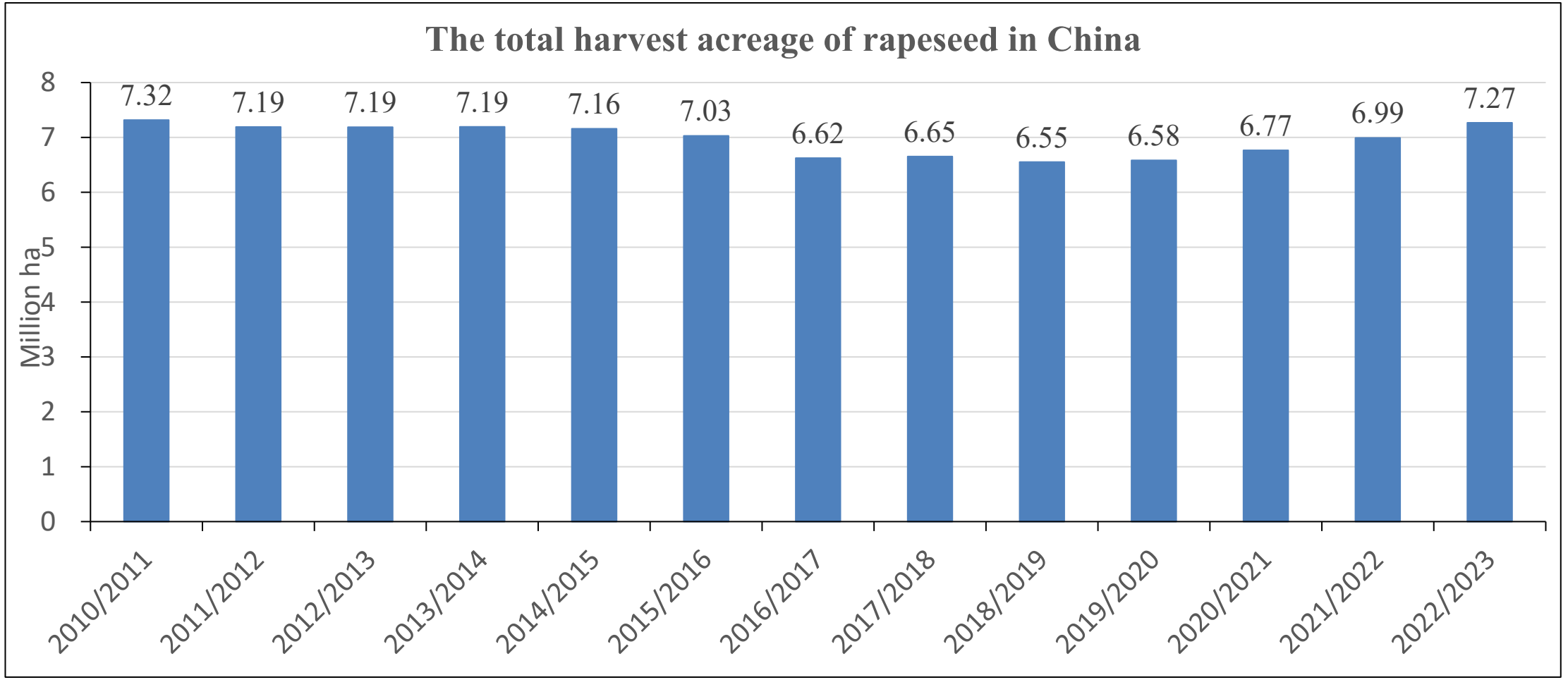
➢ Of the total domestic vegetable oil production in China, rapeseed oil accounts for more than half and is the key to maintain the national edible oil supply safety.



Data from https://data.stats.gov.cn/

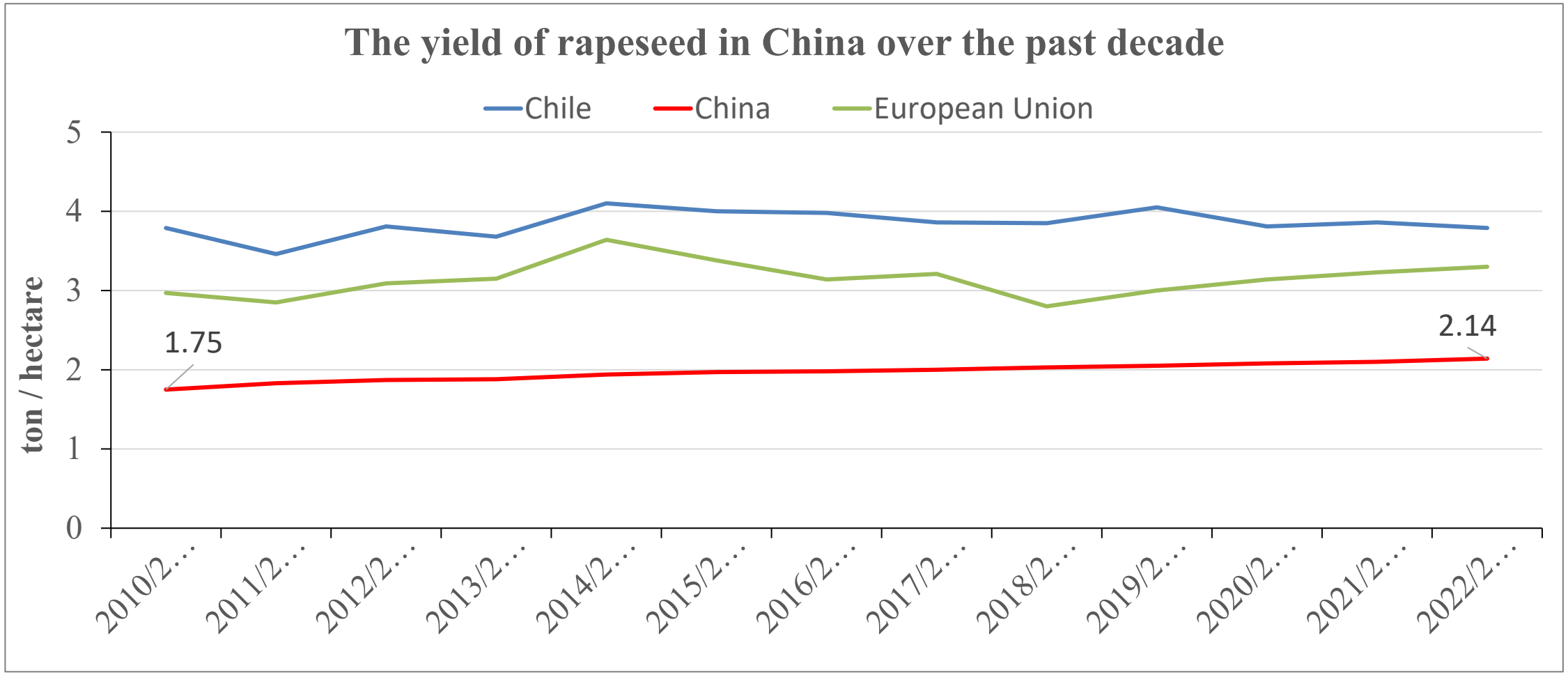
- **Although the total production of rapeseed in China has a slow increase with annual rate of 1.76%, it can't fill the huge gap with consumption.**

- Over the past decade, the harvest acreage of rapeseed in China has shown a trend of first decreasing and restorative increasing, which is difficult to increase largely.



- The arable land area in China is decreasing year by year and the multiple-cropping index is still high, therefore the expansion of rapeseed acreage will be limited except for winter fallow fields.

- **Whereas, the yield of rapeseed in China has increased from 1.75 to 2.14 t/ha, although the annual growth rate is only 1.14%.**

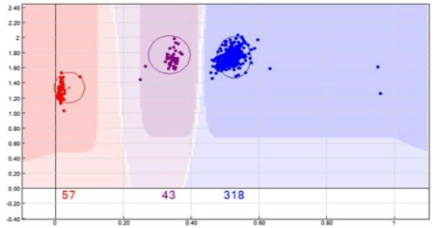


- **Currently, the China rapeseed yield is only two thirds of European Union and half of Chile, which still have a large potential for improvement.**

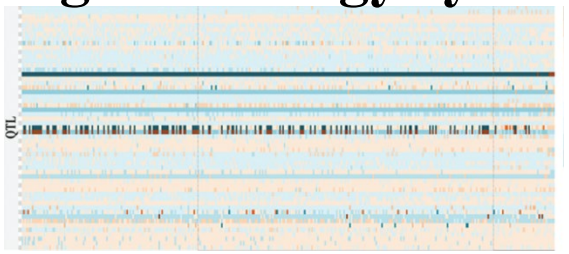
3. The breeding of elite hybrid variety Zhongyouza501

(1) Establish a high-efficiency marker assisted pyraming breeding technology system

Excellent germplasm (n)



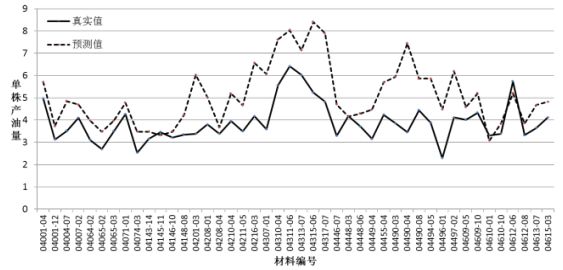
high-throughput genotyping



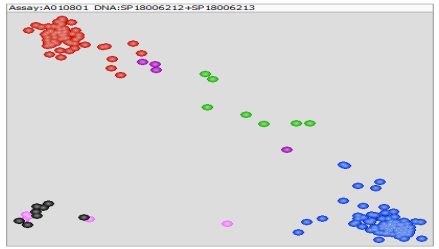
alleles matrix for traits genes/QTL

Phenotyping test

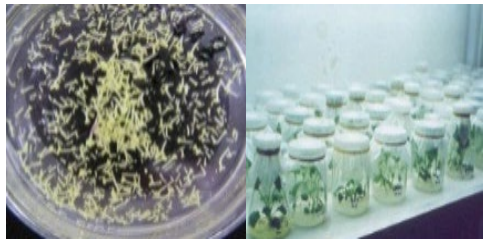
- **The efficiency of recombination, homozygosity and stability of the favorable characters of parents were significantly improved.**
- **The hybrid combination with strong heterosis could be obtained quickly.**



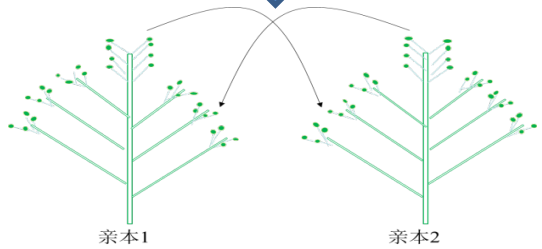
Combining ability prediction



Marker-assisted selecion

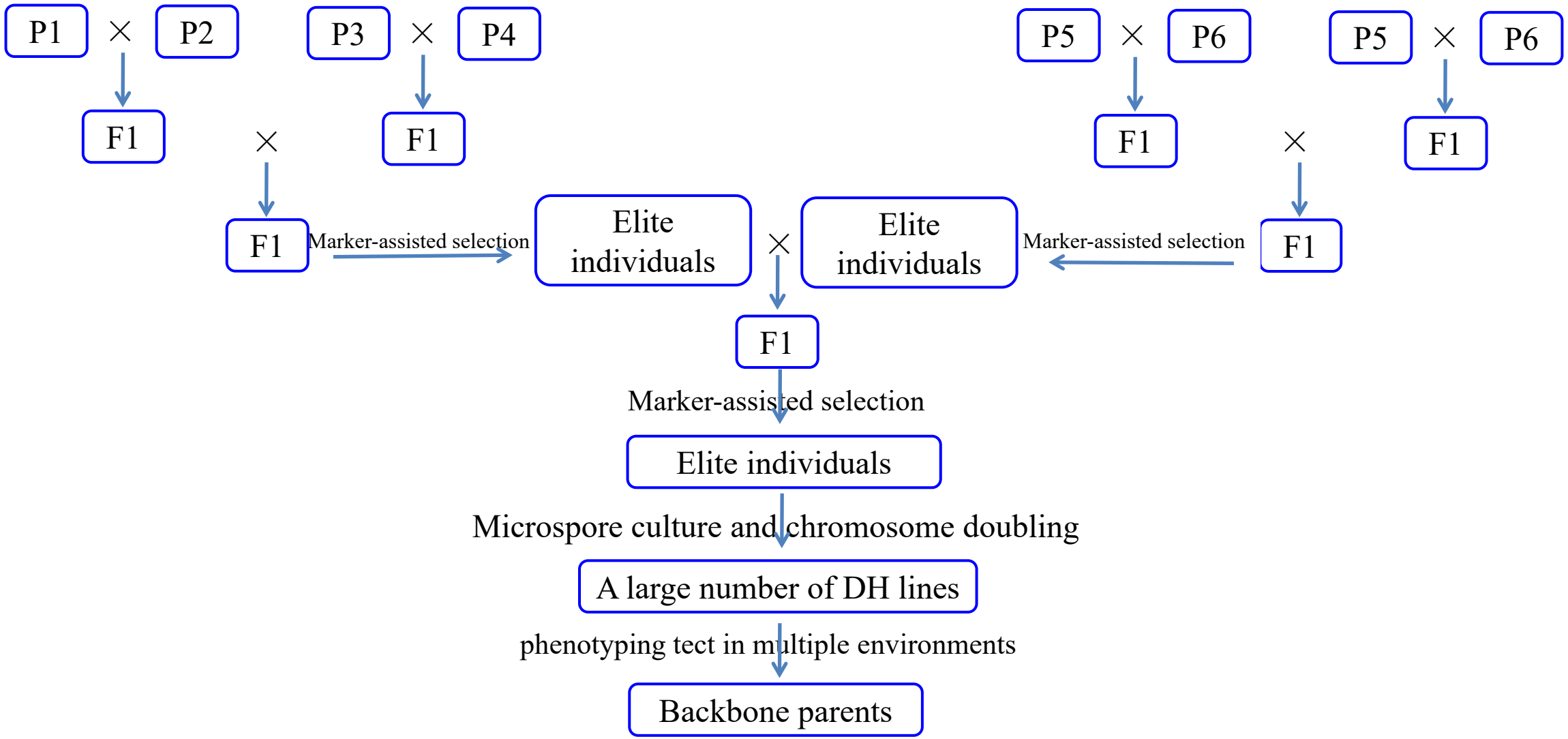


Large-scale microspre culture



Hybrid combination

(2) The development of backbone parents



(3) The breeding of elite hybrid variety zhongyouza501

Male sterile line 5DH2900CA ♀ × **Female fertile line ZY8033 ♂**

More branches (9-10)
Short silique
Medium number of seeds per silique (17-20)
Medium seed size (TSW: 3.6-4.0g)

Hight oil content: >50%
Low glucosinolates content: 20-26 μmol/g
Low erucic acid content: 2-4%

Medium resistance to sclerotinia disease
Resistance to lodging
Resistance to freezing

Medium number of branches (7-8)
Medium length of silique
More seeds per silique (26-28)
Small seed size (TSW: 2.9-3.3g)

High oil content: >55%
Low glucosinolates content: 27-33 μmol/g
Low erucic acid content: 0-1%

Resistance to sclerotinia disease
Resistance to lodging
Tolerance to dense planting

① **For the yield traits with significant heterosis, the performance of two parents are complementary**
② **For the quality traits with weak/no heterosis, the performance of two parents are both favorable**
③ **For the resistance traits, the female parent is also tolerant to dense planting.**

(4) Performance in Regional test

- 2019-2021 New variety test in the lower reaches of Yangtze River (Seeding density: 300,000-375,000/ha）
  - Growth period: 222.3d, CK-Fegnyou737+1.6 d
  - Plant height: 161.9 cm
  - The effective branch number: 8.7
  - The effective silique number per plant: 391.8
  - Seed number per silique: 24.1
  - Thousand-seed weight: 4.21g
  - **Yield: 3.20 t/ha, CK+12.7%**
  - **Oil yield: 1.61 t/ha, CK+26.93% (Rank first among the test varieties)**
  - High Oil content: 50.4%
  - Low erucic acid content: 0.02%
  - Low glucosinolate content: 23.2 μmol/g(meal)
  - Strong resistance to lodging
  - Middle resistance to sclerotinia

- 2020-2022 new variety test in the upper reaches of Yangtze River (seeding density:345,000-405,000/ha ）
  - Growth period: 199.6d, CK-Rongyou18+2.7 d
  - Plant height: 175.9 cm
  - The primary effective branch number: 6.3
  - The effective silique number per plant: 248.9
  - Seed number per silique: 20.7
  - Thousand-seed weight: 3.52g
  - Yield: 3.14 t/ha, CK+8.51%
  - High oil yield: 1.60 t/ha, CK+22.47% (Rank first among the test varieties)
  - Hilgh Oil content: 50.97%
  - Low erucic acid content：0.0222%
  - Low glucosinolate content: 21.6 μmol/g (meal)
  - Reistance to sclerotinia
  - Resistance to lodging

(5)Variety registeration

非主要农作物品种
登记证书

登记编号：GPD 油菜(2022)420139

作物种类：油菜

品种名称：中油杂 501

申 请 者：中国农业科学院油料作物研究所

育 种 者：中国农业科学院油料作物研究所

品种来源：2900CA×ZY8033

适宜种植区域及季节：适宜在冬油菜区江苏和安徽两省淮河以南、浙江、四川、云南、贵州、重庆、陕西汉中和安康秋播种植。

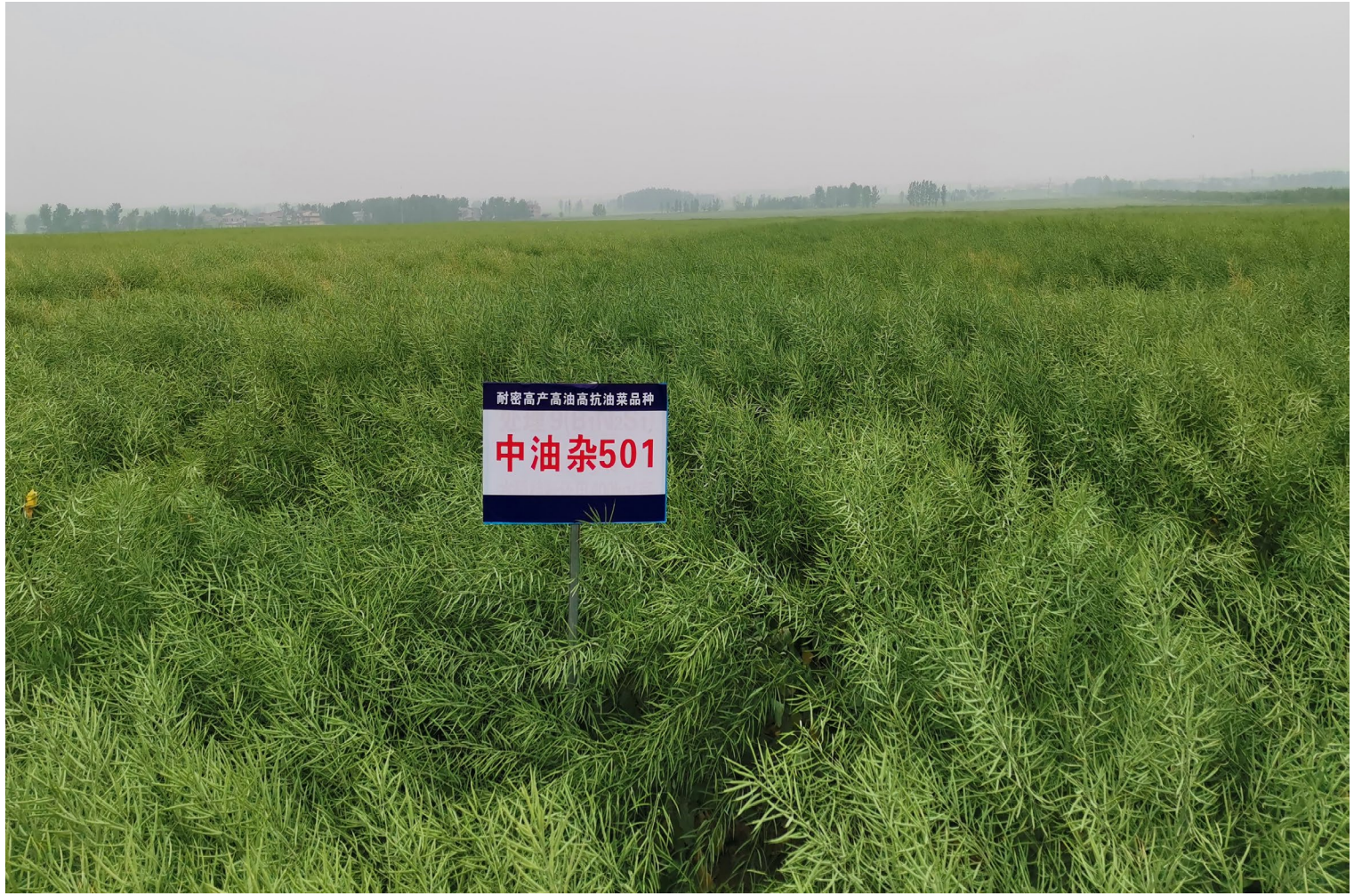
二〇二二年十二月三十日

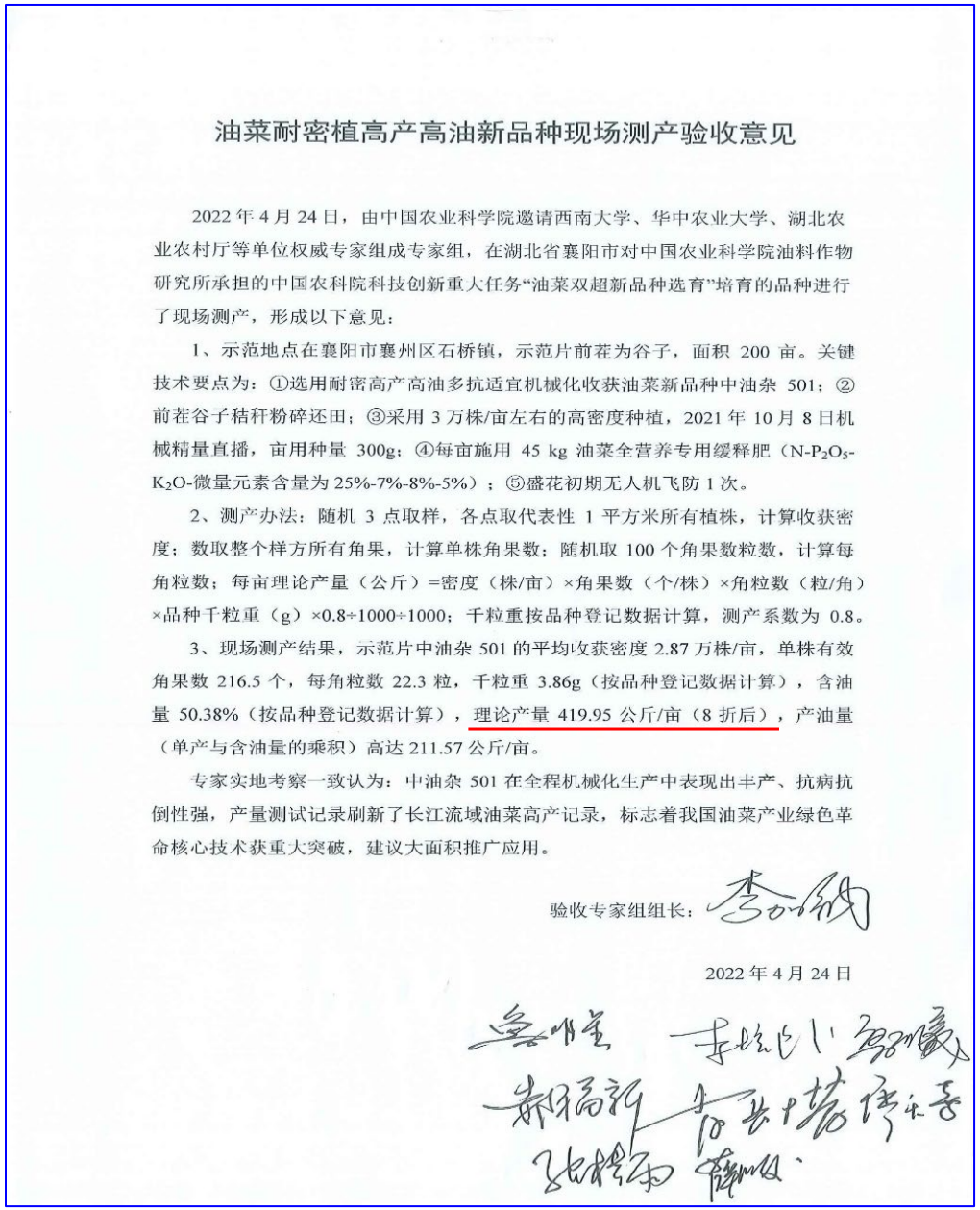
- Registeration No.： GPD油菜(2022)420139
- Breeder: Oil Crops Research Institute of the Chinese Academy of Agriculture Sciences
- Variety origin: 2900CA×ZY8033
- Selected as Seedling type variety in the 2023 National Catalogue of Excellent Crop varieties Promotion

4. The high-yield demonstration of Zhongyouza501

(1) Achieve super-high yield in dry farming demonstration

- On April 24, 2022, the core technology observation meeting of the rapeseed green revolution was held in Xiangzhou District, Xiangyang City, Hubei Province.
- The authoritative expert group from Southwest University, Huazhong Agricultural University, Hubei Provincial Department of Agriculture and Rural Affairs carried out the on-site yield measurement of Zhongyouza501.





油菜耐密植高产高油新品种现场测产验收意见

2022 年 4 月 24 日，由中国农业科学院邀请西南大学、华中农业大学、湖北农业农村厅等单位权威专家组成专家组，在湖北省襄阳市对中国农业科学院油料作物研究所承担的中国农科院科技创新重大任务“油菜双超新品种选育”培育的品种进行了现场测产，形成以下意见：

1、示范地点在襄阳市襄州区石桥镇，示范片前茬为谷子，面积 200 亩。关键技术要点为：①选用耐密高产高油多抗适宜机械化收获油菜新品种中油杂 501；②前茬谷子秸秆粉碎还田；③采用 3 万株/亩左右的高密度种植，2021 年 10 月 8 日机械精量直播，亩用种量 300g；④每亩施用 45 kg 油菜全营养专用缓释肥（N-P_2O_5-K_2O-微量元素含量为 25%-7%-8%-5%）；⑤盛花初期无人机飞防 1 次。

2、测产办法：随机 3 点取样，各点取代表性 1 平方米所有植株，计算收获密度；数取整个样方所有角果，计算单株角果数；随机取 100 个角果数粒数，计算每角粒数；每亩理论产量（公斤）=密度（株/亩）×角果数（个/株）×角粒数（粒/角）×品种千粒重（g）×0.8÷1000÷1000；千粒重按品种登记数据计算，测产系数为 0.8。

3、现场测产结果，示范片中油杂 501 的平均收获密度 2.87 万株/亩，单株有效角果数 216.5 个，每角粒数 22.3 粒，千粒重 3.86g（按品种登记数据计算），含油量 50.38%（按品种登记数据计算），理论产量 419.95 公斤/亩（8 折后），产油量（单产与含油量的乘积）高达 211.57 公斤/亩。

专家实地考察一致认为：中油杂 501 在全程机械化生产中表现出丰产、抗病抗倒性强，产量测试记录刷新了长江流域油菜高产记录，标志着我国油菜产业绿色革命核心技术获重大突破，建议大面积推广应用。

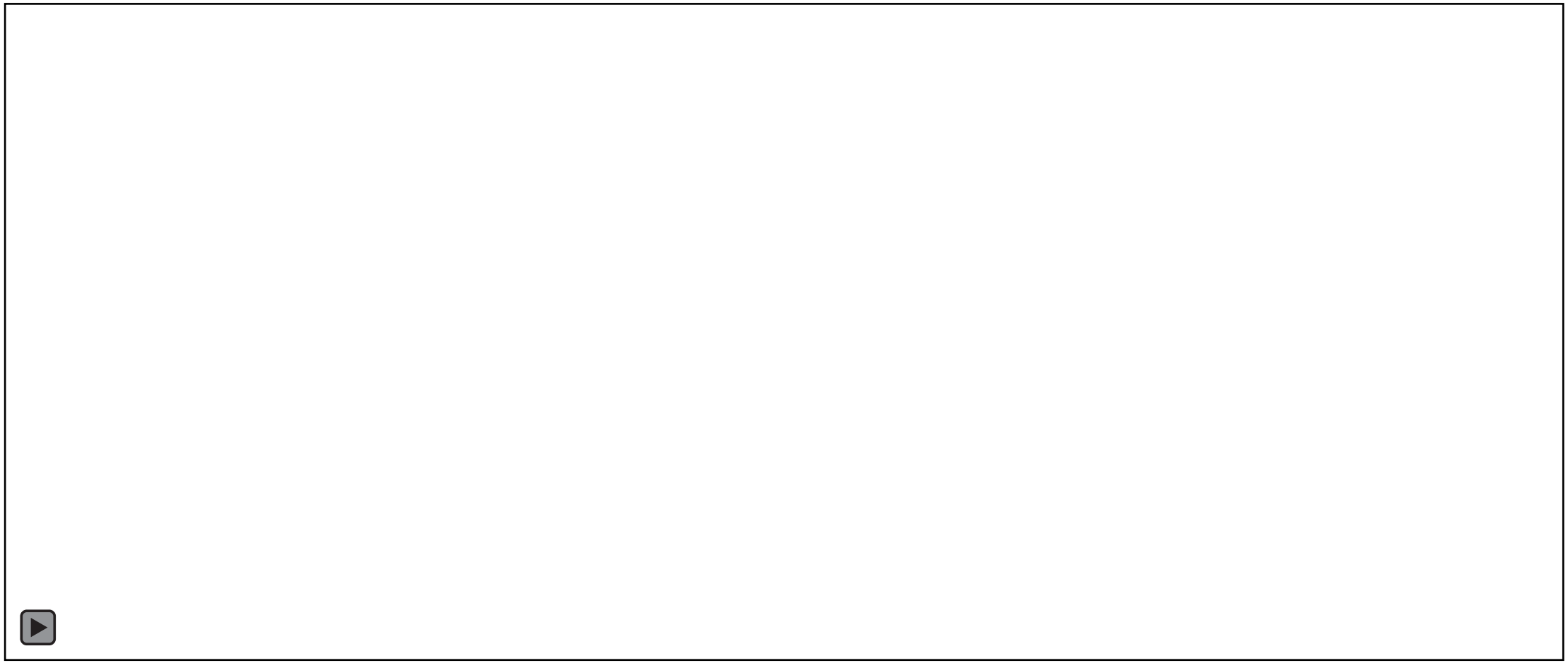
验收专家组组长：

2022 年 4 月 24 日

- Preceding crop: foxtail millet
- Harvest area:13.3 ha
- Harvest density: >430,000/ha
- Silique number per plant: 216.5
- Seed number per silique: 22.3
- Thousand seed weight: 3.86g
- Seed oil content: 50.38%

- Yield: 6.30 t/ha (theoretical); 5.53 t/ha (practical)
- Oil yield: 3.17 t/ha (theoretical); 2.79 t/ha (practical)

✓ **Both the seed yield and oil yield of Zhongyouza501 have created a new record of high-yield rapeseed in Yangtze River basin.**

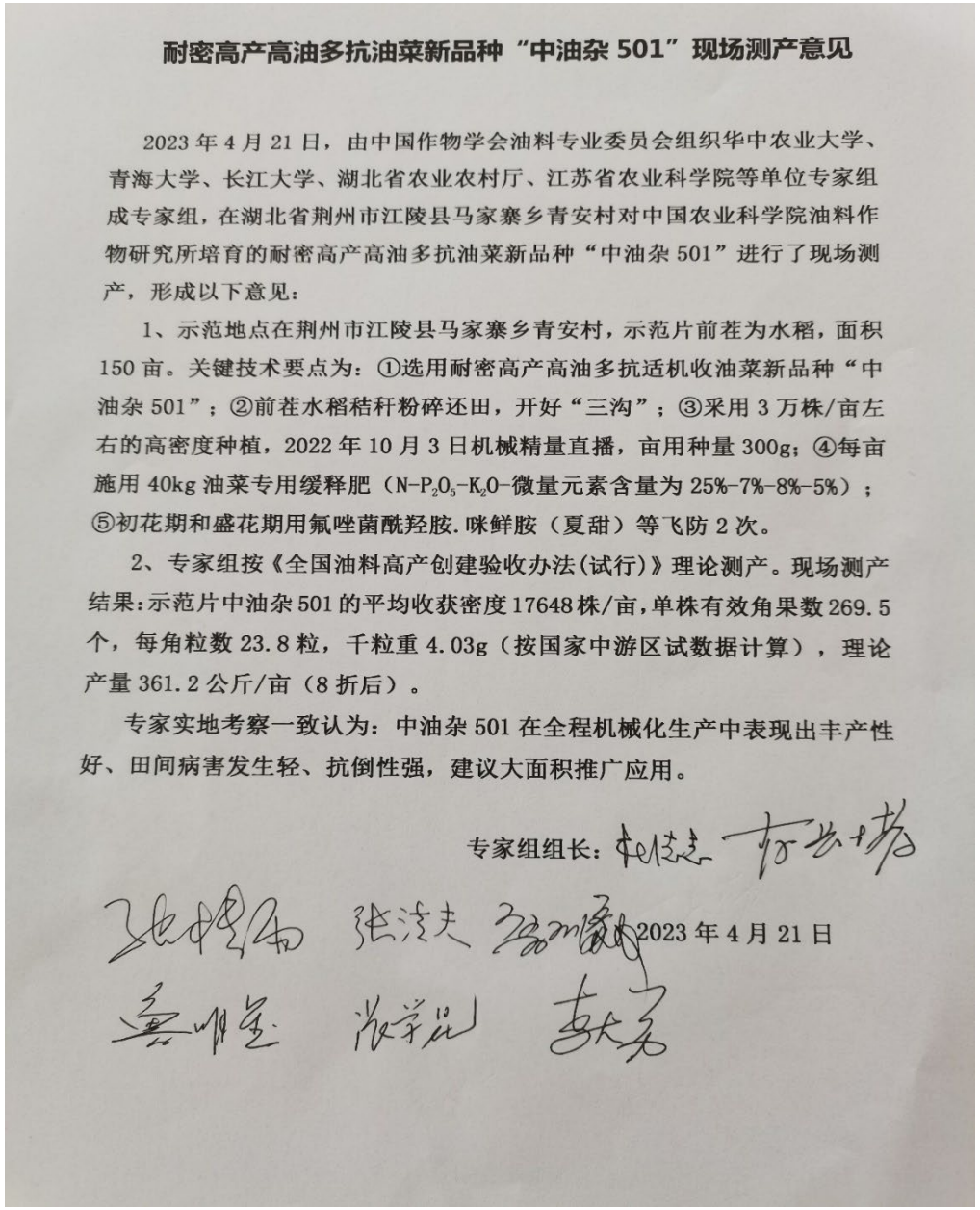


- This represnets a major breakthrough of the core technology of China rapeseed industry, which has been reported by many mainstream media in China, including CCTV1<News broadcast>, Xinhua News Agency, and The People's Daily etc.

(2) Achieve high-yield in rice-rapeseed rotation demonstration

- On April 21, 2023, the observation meeting on high density, high yield and high oil technolgoy model was held in Jiangling county, Jingzhou City, Hubei Province.

- The authoritative expert group from Huazhong Agricultural University, Qinghai University, Changjiang University, Hubei Provincial Department of Agriculture and Rural Affairs and Jiangsu Academy of Agricultural Sciences conducted the on-site yield measurement of Zhongyouza501.



耐密高产高油多抗油菜新品种“中油杂 501”现场测产意见

2023 年 4 月 21 日，由中国作物学会油料专业委员会组织华中农业大学、青海大学、长江大学、湖北省农业农村厅、江苏省农业科学院等单位专家组成专家组，在湖北省荆州市江陵县马家寨乡青安村对中国农业科学院油料作物研究所培育的耐密高产高油多抗油菜新品种“中油杂 501”进行了现场测产，形成以下意见：

1、示范地点在荆州市江陵县马家寨乡青安村，示范片前茬为水稻，面积 150 亩。关键技术要点为：①选用耐密高产高油多抗适机收油菜新品种“中油杂 501”；②前茬水稻秸秆粉碎还田，开好“三沟”；③采用 3 万株/亩左右的高密度种植，2022 年 10 月 3 日机械精量直播，亩用种量 300g；④每亩施用 40kg 油菜专用缓释肥（N-P_2O_5-K_2O-微量元素含量为 25%-7%-8%-5%）；⑤初花期和盛花期用氟唑菌酰羟胺.咪鲜胺（夏甜）等飞防 2 次。

2、专家组按《全国油料高产创建验收办法(试行)》理论测产。现场测产结果：示范片中油杂 501 的平均收获密度 17648 株/亩，单株有效角果数 269.5 个，每角粒数 23.8 粒，千粒重 4.03g（按国家中游区试数据计算），理论产量 361.2 公斤/亩（8 折后）。

专家实地考察一致认为：中油杂 501 在全程机械化生产中表现出丰产性好、田间病害发生轻、抗倒性强，建议大面积推广应用。

专家组组长：

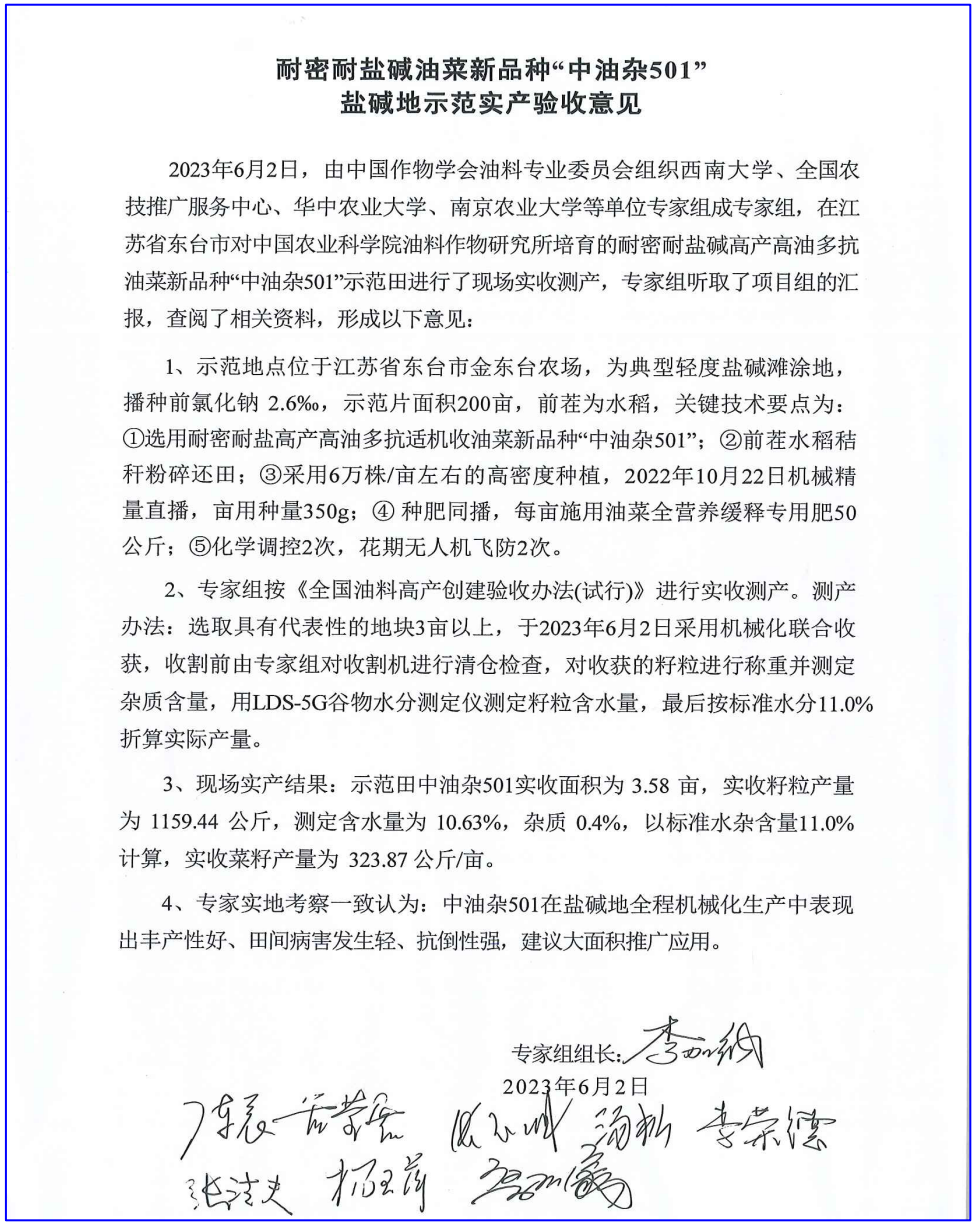
2023 年 4 月 21 日

- Preceding crop: rice
- Harvest acreage:10 ha
- Cropping intenstiy: 450,000/ha
- Silique number per plant: 269.5
- Seed number per silique: 23.8
- Thousand seed weight: 4.03g
- Strong resistance to lodging
- Resistance to disease
- Yield: 5.42 t/ha (theoretical); 4.56 t/ha (Practical)
- Oil yield: 2.73t/ha (theoretical); 2.30 t/ha (Practical)

(3) Achieve high yield in saline-alkali soil demonstration

- On June 2, 2023, the observation meeting of the "Saline-alkali tolerance, High yield, and High Oil" technology mode for rapeseed was held in Dongtai City, Jiangsu Province.

- The authoritative expert group from from Southwest University, National Agricultural Technology Promotion Cneter, Huazhong Agricultural University, Nanjing Agricultural University, conducted the on-site yield measurement of Zhongyouza501 planted in Saline-alkali soil.



耐密耐盐碱油菜新品种“中油杂501”
盐碱地示范实产验收意见

2023年6月2日，由中国作物学会油料专业委员会组织西南大学、全国农技推广服务中心、华中农业大学、南京农业大学等单位专家组成专家组，在江苏省东台市对中国农业科学院油料作物研究所培育的耐密耐盐碱高产高油多抗油菜新品种“中油杂501”示范田进行了现场实收测产，专家组听取了项目组的汇报，查阅了相关资料，形成以下意见：

1、示范地点位于江苏省东台市金东台农场，为典型轻度盐碱滩涂地，播种前氯化钠 2.6‰，示范片面积200亩，前茬为水稻，关键技术要点为：①选用耐密耐盐高产高油多抗适机收油菜新品种“中油杂501”；②前茬水稻秸秆粉碎还田；③采用6万株/亩左右的高密度种植，2022年10月22日机械精量直播，亩用种量350g；④ 种肥同播，每亩施用油菜全营养缓释专用肥50公斤；⑤化学调控2次，花期无人机飞防2次。

2、专家组按《全国油料高产创建验收办法(试行)》进行实收测产。测产办法：选取具有代表性的地块3亩以上，于2023年6月2日采用机械化联合收获，收割前由专家组对收割机进行清仓检查，对收获的籽粒进行称重并测定杂质含量，用LDS-5G谷物水分测定仪测定籽粒含水量，最后按标准水分11.0%折算实际产量。

3、现场实产结果：示范田中油杂501实收面积为 3.58 亩，实收籽粒产量为 1159.44 公斤，测定含水量为 10.63%，杂质 0.4%，以标准水杂含量11.0%计算，实收菜籽产量为 323.87 公斤/亩。

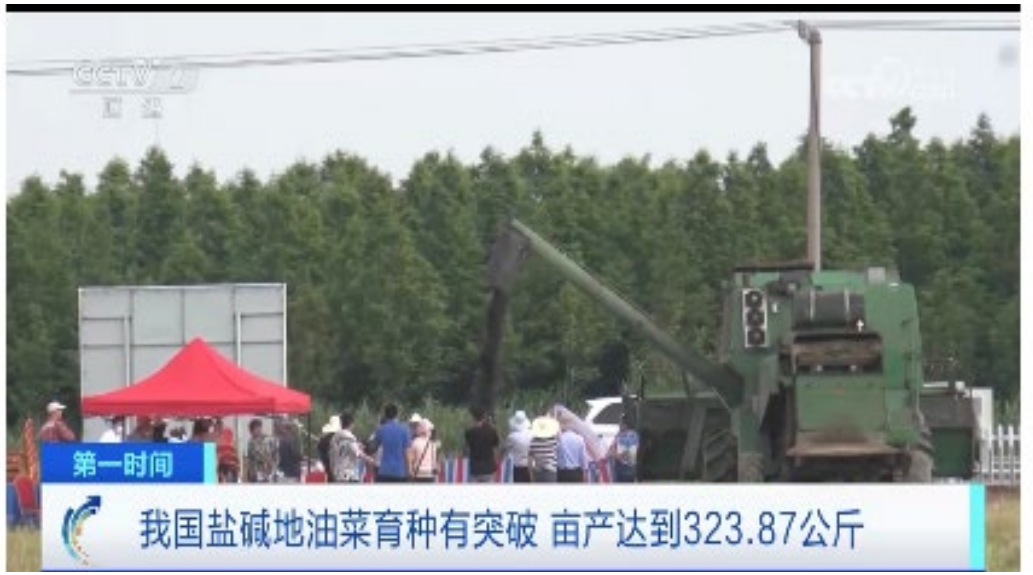
4、专家实地考察一致认为：中油杂501在盐碱地全程机械化生产中表现出丰产性好、田间病害发生轻、抗倒性强，建议大面积推广应用。

专家组组长：

2023年6月2日

- Preceding crop: rice
- Planting acreage: 13.3 ha
- Soil salt content: 0.26%
- High seeding intensity: 900,000/ha
- Yield (practical): 4.86 t/ha, local+59.5%
- Oil yield: 2.45 t/ha, local+82.7%
- Soil salt content: decrease to 0.1%, half of the nearby soil

✓ **This created a new record for high yield of rapeseed in saline-alkaline soil**
✓ **This provided a replicable and promotable comprehensive technical solution for the management and utilization of saline alkali land, and ensuring the safety of edible oil supply**



- ✓ This represnt a breakthrough in breeding of salt tolerant varieties, which has been reported by CCTV1<News broadcast>, CCTV2, CCTV4, CCTV13, The People’s Daily, Guangming Daily etc.

(4) Perform well in the main rapeseed producing areas

Chongqing city, upper Yangtze River region

Zhongxiang city, middle Yangtze River region

Sichuan Province, upper Yangtze River region

Anhui province, lower Yangtze River region

5. Summary and future direction

1. Our group have developed an elite rapeseed hybrid variety zhongyouza501 through conventional breeding and modern biotechnology including scaled microspore culture, marker-assisted pyramiding and heterosis prediction.
2. Zhongyouza501 has achieved a super-high yield under dense planting, both its seed and oil yield have created a new high-yield record in Yangtze River basin of China.
3. The successful breeding and large-area promotion of Zhongyouza501 is expected to lead a new Green Revolution of rapeseed.
4. The high-yield/strong-heterosis mechanism of Zhongyouza501 is unclear and needs further research, which will provide theoretical guidance for the further improvement of rapeseed yield in near future.

Acknowledgements

Rapeseed genetics and breeding team

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2. Core members: Xinfa Wang, Xiaoling Dun, Jiang wei Qiao, Sheng Liu, Jinwu Deng, Zhengna Chen, Nian Wang
3. Research assistants: Jiepeng Zhan, Ze Tian, Lieqiong Kuang, Qing Yang, Li Jin etc.
4. Graduate students

Financial support:

1. China Agriculture Research System of MOF and MARA (CARS-13)
2. Agricultural Science and Technology Innovation Program of Chinese Academy of Agricultural Sciences
3. National Key Research and Development Program of China
4. Natural Science Foundation of China
5. The Handsome Scientist Program of Qinghai Province.


Thanks for your attention!
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