ACIAR project ”Establishing Sustainable Solutions to Cassava Disease in Mainland Southeast Asia”

Cassava germplasm evaluation and variety breeding in China

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Alliance

Bioversity International

CIAT

International Center for Tropical Agriculture

CATAS 1954

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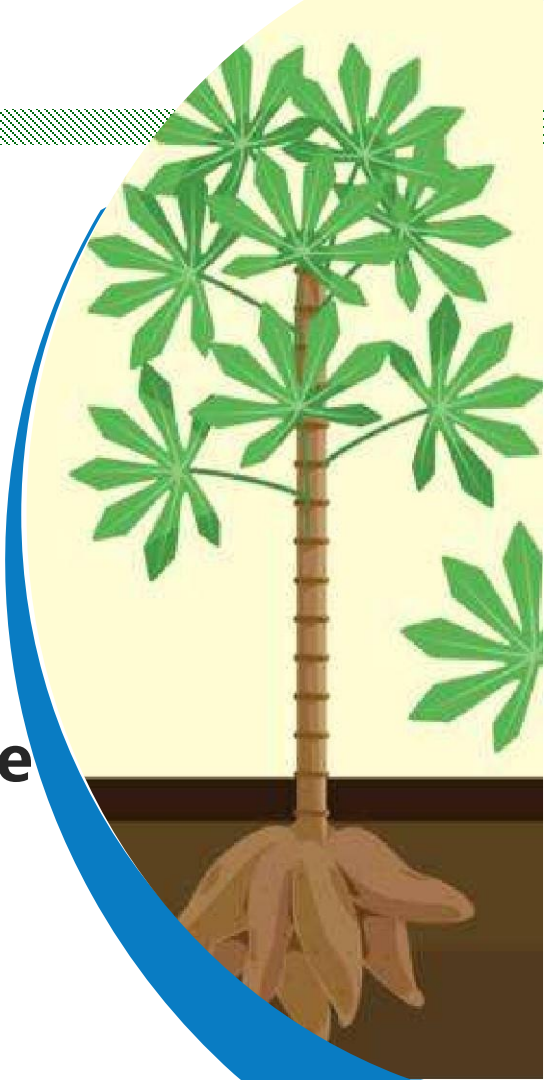
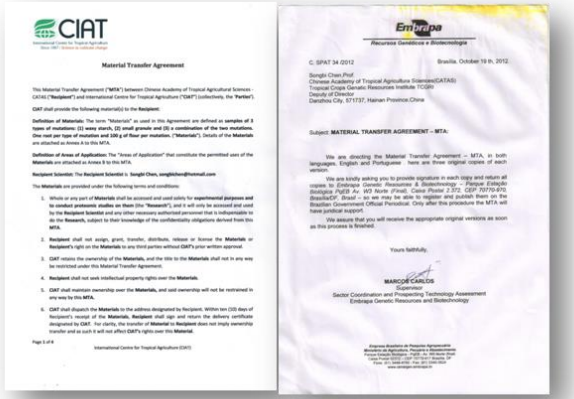


1. Accurate Evaluation of Cassava Germplasm Resources

Cassava germplasm resources

- Through the project cooperation with Prof. Luiz Carvalho from Embrapa and Prof. Hernan Ceballos from Alliance of Bioversity-CIAT, the germplasm samples from CIAT and Embrapa were introduced.

MTA signed by Embrapa and CATAS



CIAT special cassava resources

Brazilian precious cassava resources

Supported by NSFC-CGIAR cooperative projects (No. 31361140366) and NSFC (No. 31271776, No. 31371684)

Collection and preservation of cassava resources

国家木薯种质资源圃


木薯野生近缘种W14


低淀粉、多纤维矮化木薯


高支链、淀粉含量低于1%黄心糖木薯

高番茄红素粉红木薯


紫叶黄心木薯


抗寒木薯品种SC124


抗细菌枯萎病木薯RXC9


感细菌性枯萎病品种桂热4号


高抗花叶病木薯I93与感病品种嫁接


耐PPD木薯SC14

- Chinese National Repository of Casava germplasm Resources have collected more than 3000 cassava accessions, and the genetic diversity index has reached above 0.5, which greatly meets the needs of genetic improvement of cassava in China.

Accurate evaluation of cassava germplasm resources

- **Generation of Phenotypic accurate evaluation model:** The accurate evaluation model of quality phenotype group of cassava germplasm resources was constructed by starch content, cyanide content, β-carotene content, resistance (low temperature, postharvest physiological deterioration (PPD), mosaic disease) and mean net photosynthetic rate of leaves; 15 cassava germplasm with excellent quality indexes were evaluated.

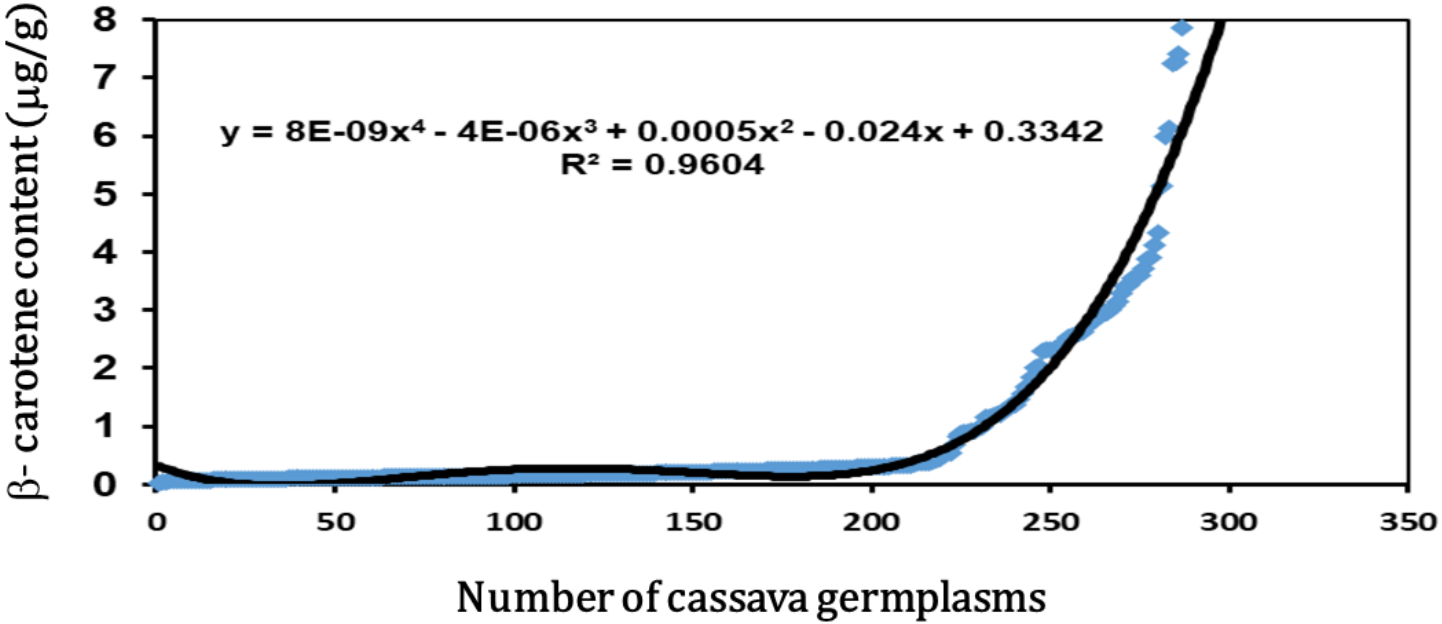
$$Q = \sum_{i=1}^{n} \binom{n}{k} x_i^m a^j$$

Q = 木薯种质资源品质评级
i = 1，……，5（代表第 i 种表型特性的序号）；
n = 5（总共5种表型特性）；
k = 1，……，5（代表从第k种表型特性起开始累计）；
x_i= SC，或HA，或PPD，或βC，或PR（代表5种表型特性中的第 i 种特性）；
x_i^m：代表第 i 种表型特性的数据分布型；
a^j：代表5种表型特性中的任意一种的权重系数及其数据分布型。

淀粉含量（%）分级用橙色标注，级差为 4	氰苷含量（μg/g）分级用蓝色标注，级差如下	耐 PPD 分级用红色标注，级差为 1	β-胡萝卜素含量（μg/g）分级用黑色标注，级差如下	叶片净光合速率（$\mu mol \cdot m^{-2} \cdot s^{-1}$）分级用绿色标注，级差为 1.5
A 级，SC≥38	A 级，HA≤10	A 级，PPD=6	A 级，βC≥3	A 级，PR≥18
A⁻ 级，34＜SC＜38	A⁻ 级，10＜HA≤20	A⁻ 级，PPD=5	A⁻ 级，1≤βC＜3	A⁻ 级，16.5≤PR＜18
B 级，30＜SC≤34	B 级，20＜HA≤30	B 级，PPD=4	B 级，0.3≤βC＜1	B 级，15≤PR＜16.5
B⁻ 级，26＜SC≤30	B⁻ 级，30＜HA≤50	B⁻ 级，PPD=3	B⁻ 级，0.2≤βC＜0.3	B⁻ 级，13.5≤PR＜15
C 级，22＜SC≤26	C 级，50＜HA≤100	C 级，PPD=2	C 级，0.1≤βC＜0.2	C 级，12≤PR＜13.5
C⁻ 级，SC≤22	C⁻ 级，HA＞100	C⁻ 级，PPD=1	C⁻ 级，βC＜0.1	C⁻ 级，PR＜12

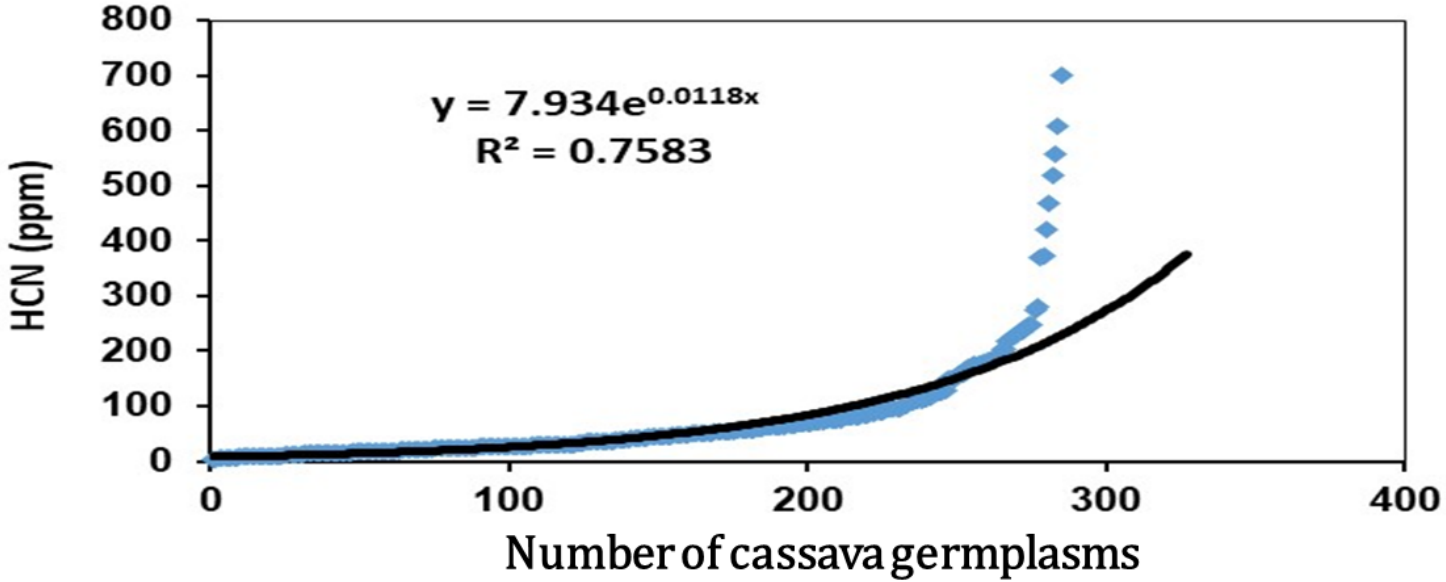
Germplasm number	Score	Germplasm number	Score	Germplasm number	Score
GPMS1029L	89.5	MS000020	75.5	MS000308	72
MS000315	86	GPMS0981L	75.5	GPMS1009L	72
GPMS0977L	79	MS000436	75.5	MS000223	72
GPMS0980L	75.5	MS000532	72	GPMS1027L	72
MS000545	75.5	MS000514	72	MS000241	72

- The germplasm GPMS1024L β-carotene content was up to 7.853μg/g



Analysis of β-carotene content in cassava germplasm resources

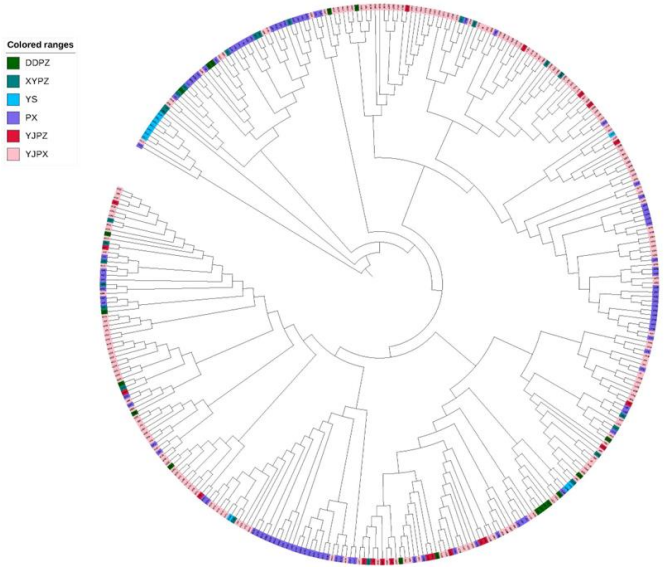
- The germplasms in low cyanoside contents of tuberous root were excavated, as low as 4.161ppm

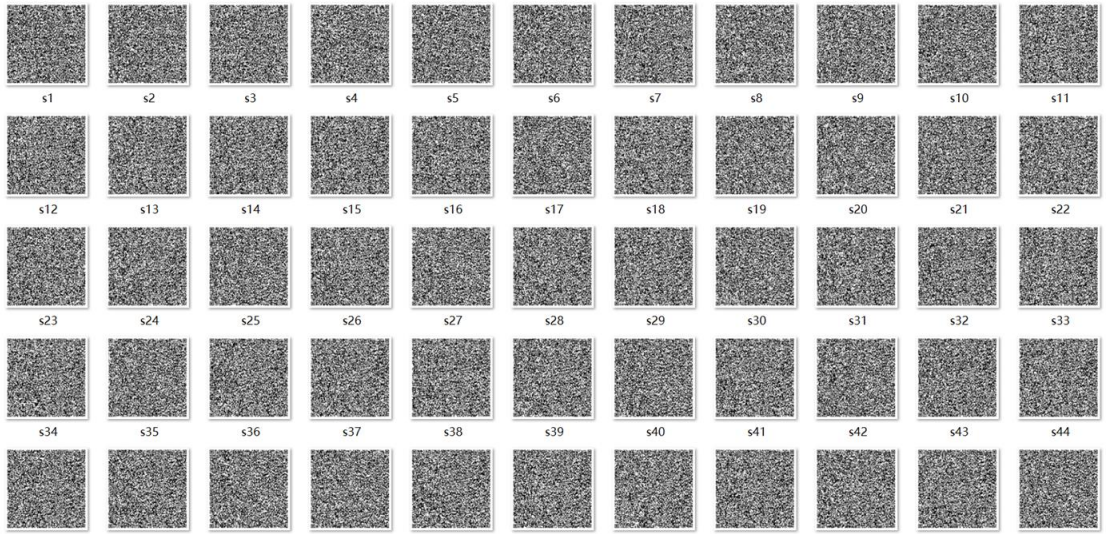


Analysis of cyanoside content in cassava germplasm resources

Construction of cassava germplasm fingerprints

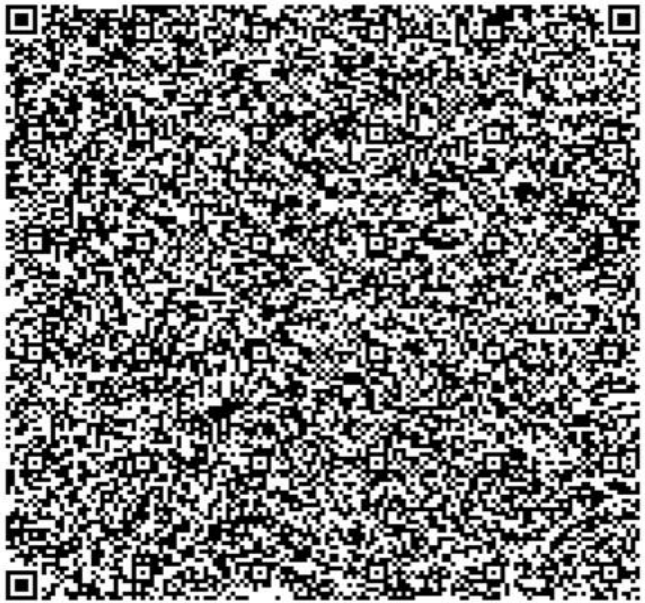
- Using whole genome resequencing, **503 loci** were filtered using minimum allele frequency, Hardy-Weinberg equilibrium, and linkage disequilibrium, etc to construct **368** cassava germplasm fingerprints and then get **368 QR code** of cassava germplasm molecular identity card.





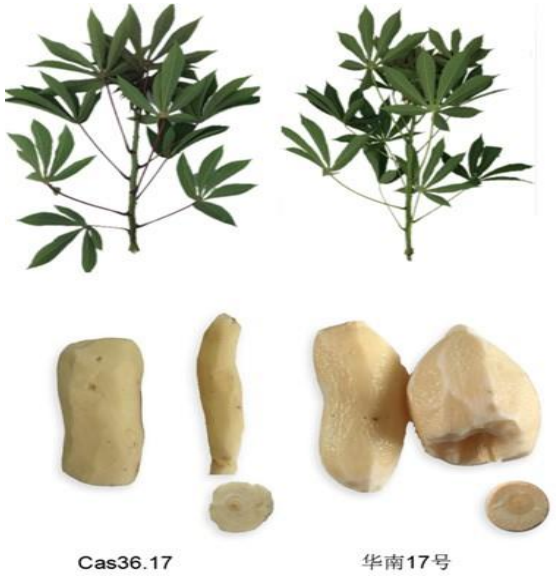
The excavation of backbone parent

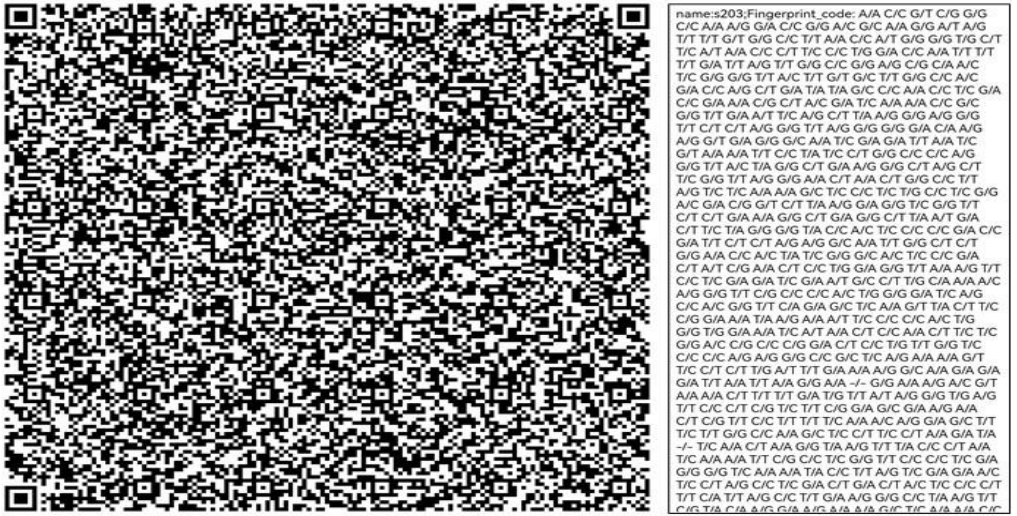
- Cassava germplasm **GPMS1029L** with the highest score and its molecular ID card QR code and fingerprint map



The excavation of backbone parent

- **High β-carotene content sugar cassava South China No. 17:** In the tuberous root, β-carotene content is 6.5 μg/g in (SC9 2.6 μg/g) and sucrose content is 28.66 g/kg (SC9 8.98 g/kg).





SC 17 morphological characteristics, QR code and molecular ID card

The excavation of backbone parent

- **Leaf high anthocyanin cassava South China No. 20.** β-carotene content is rich in root, leaves are purple, and the anthocyanin content in leaves is 413 ng/g, much higher than SC9 (12.39ng/g)

name:s274;Fingerprint_code: G/A C/C T/T C/C A/G
T/T G/G G/G G/A C/T T/T A/C C/C G/A C/G T/T A/G T/A
C/C T/T A/A C/C T/T G/G T/T A/T T/G G/A T/G C/C C/C
A/T A/A C/C T/T T/C C/T T/G A/A C/T G/G T/T A/T C/T
G/A C/T G/G T/A G/G T/T G/G G/G G/G A/A A/C T/C
G/G G/G G/T A/C G/G G/T G/C T/C G/T C/T A/A G/G
A/A A/A C/T G/G –/– T/A C/C A/C G/A C/T T/T G/G G/G
G/A A/G C/G C/C A/C G/A T/T T/A A/A G/G G/G A/G
C/C G/A A/A T/C G/G T/T A/A A/A A/A A/G G/G T/G C/T
C/C A/A A/A T/G A/A G/G G/G G/A A/A G/G A/G G/G
A/A G/G C/C G/G T/T G/G G/A C/C A/A T/T G/G A/A
A/C C/T C/C T/A T/T T/T G/G T/T T/C G/G G/A T/G A/C
T/A G/G C/T G/A G/G G/G C/C A/G C/T C/C G/A C/C
A/G G/A T/T T/T A/T C/C A/G G/G A/T A/G C/C T/T
A/G A/A G/C C/C A/A C/C T/G C/T T/C C/C C/C G/A
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C/T A/G A/A G/C A/A T/T G/A C/T C/T G/G A/G A/A
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T/A A/G A/A T/T T/T T/C T/T A/A T/T T/G T/G G/G G/A
C/C A/A A/A –/– T/T A/A T/T T/C T/C A/A A/C C/C C/C
G/G G/A C/T C/C T/G C/T A/G T/C C/C T/T G/G A/A
G/T T/T G/G T/T A/G G/G A/A G/T T/C T/T C/C T/G A/T
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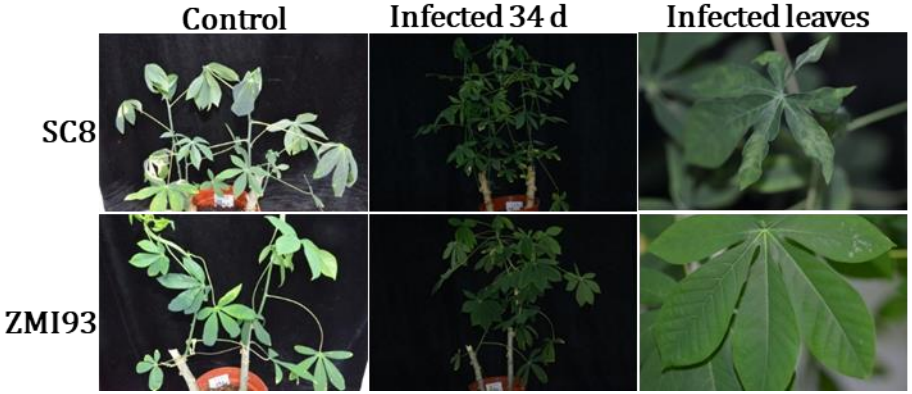
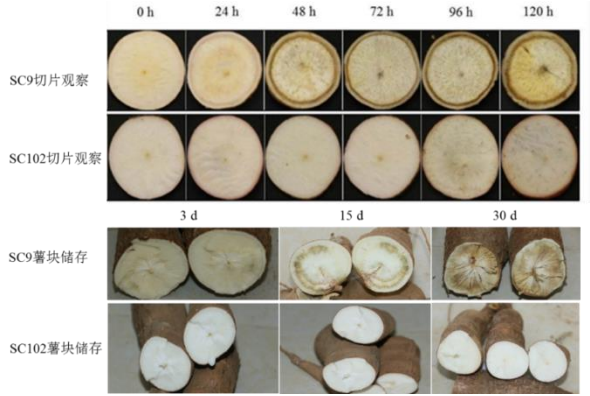
SC 20 morphological characteristics, QR code and molecular ID card

The excavation of backbone parent



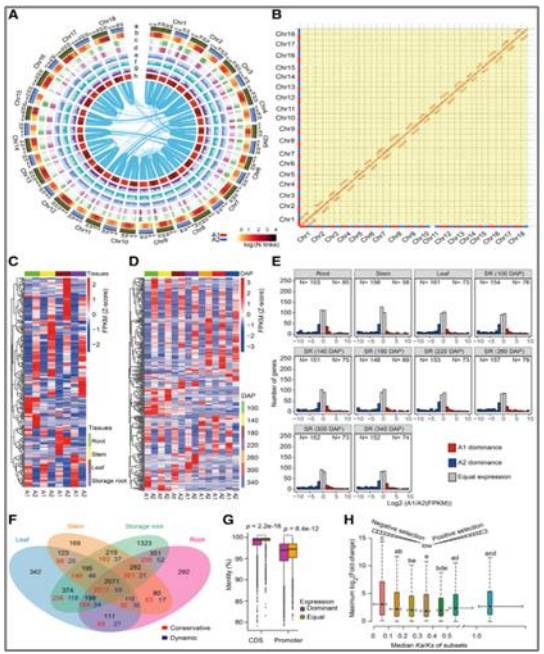
Plants and leaf phenotypes after inoculation with CMD

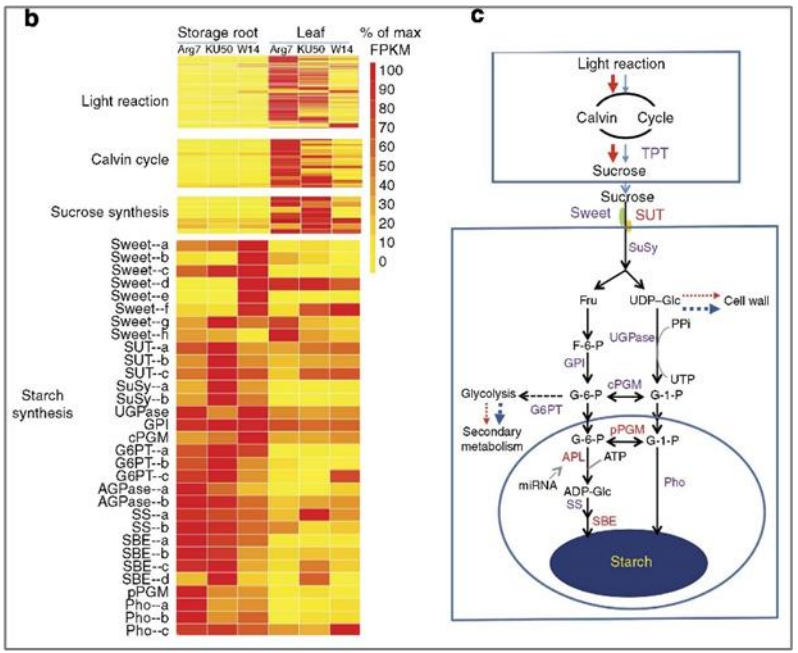


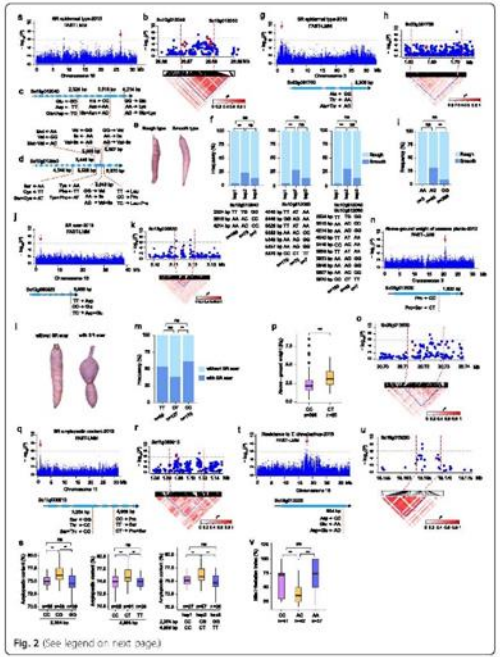
PPD observation of SC9 and SC102 tuberous roots after treatments

- ZMI 93 variety was planted in Cambodia from 2020 to 2022, and found that the SLCMV disease index was 0.
- Cassava SC14 and SC102 can tolerate PPD for more than 15 days, which can reduce the deterioration loss during transportation and processing.

Cassava genome





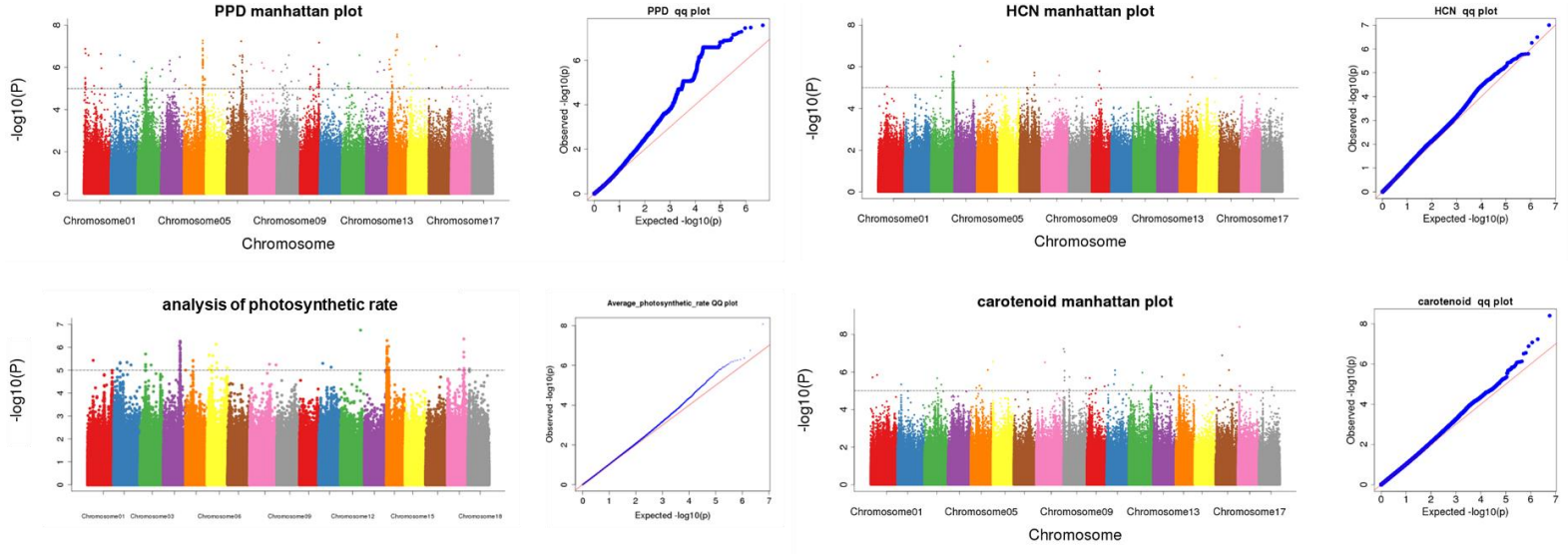


- Completed cassava genome sequence; Proposed the models of transportation of cassava photosynthetic products, and carbon flow distribution and efficient starch accumulation; Allele-defined genome reveals biallelic differentiation during cassava evolution.

Nature Communications (2014), Molecular Plant (2021), Genome Biology (2021)

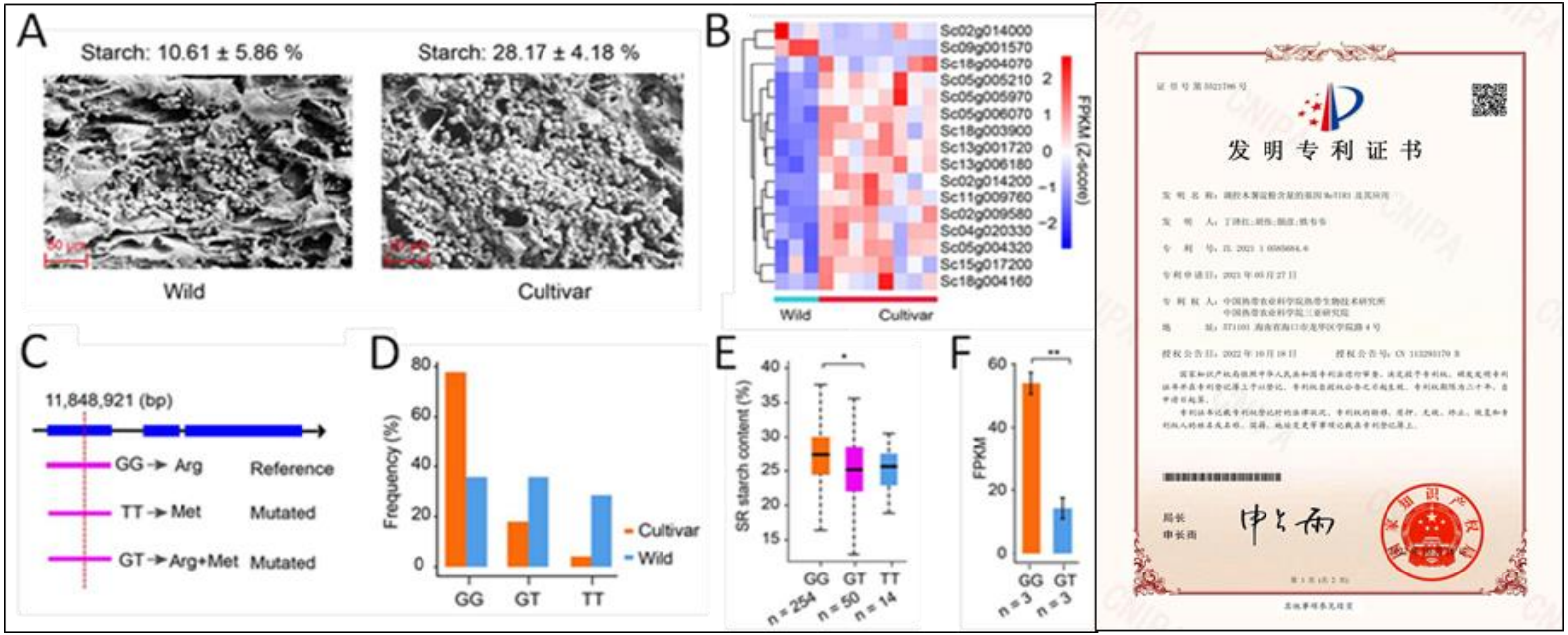
Cassava gene mining

- **Important agronomic traits and GWAS for key gene mining in cassava germplasms.** 33 agronomic traits in 337 germplasms, including root starch content, HCN content, PPD and β-carotene content, performed GWAS of 33 agronomic traits based on 1,313,775 high-quality SNPs, and obtained 42 association signals for 21 agronomic traits.



Manhattan and QQ plots of HCN content, PPD, photosynthetic rate and β-carotene content with GWAS

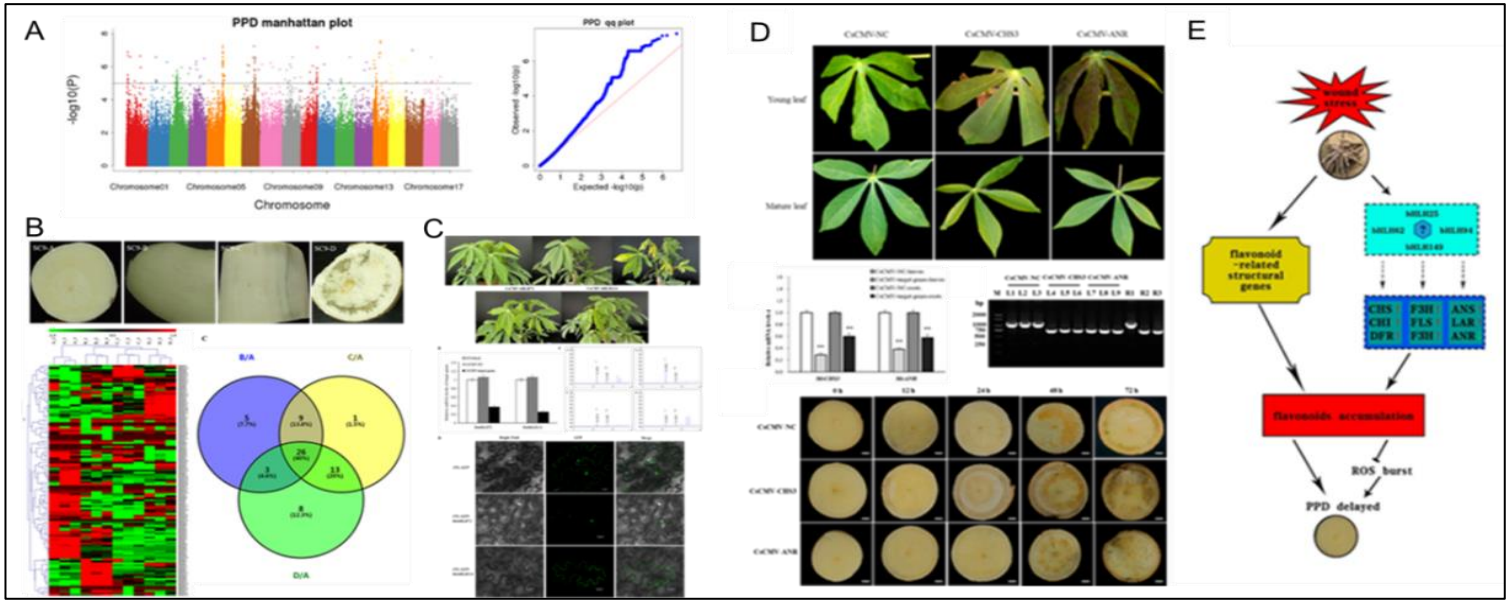
Cassava gene mining



- Selection for homozygous GG allele in *MeTIR1* during domestication contributes to increased starch content. We have verified the positive roles of *MeTIR1* in increasing starch content.

Supported by National Key R&D Program of China: Accurate evaluation and gene exploration of germplasm resources of tropical crops (2019YFD1000500)

Cassava gene mining



- Systematic Analysis of bHLH transcription factors in cassava uncovers their roles in PPD and cyanogenic glycosides biosynthesis. ***Frontiers in plant science (2022).*** The candidate genes *MeCHS3* and *MeANR* and metabolites in flavonoid pathways could participate in PPD regulation. ***Postharvest biology and technology (2023)***

2. Cassava Breeding Program

The direction of cassava breeding

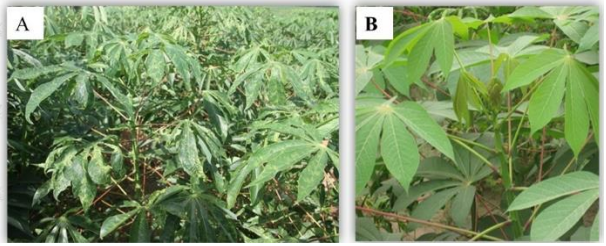
Industrial development request

- Starch industrial raw materials: High photosynthesis, high starch accumulation, and high biomass.
- Food and feed： High carotenoids, high protein, tolerance to PPD and low cyanogenic glycoside content.

Challenges to cassava breeding

- High heterozygosity in the cassava genome (Wild relatives W14: 3.9%， KU50: 3.5%).
- The generation separation is serious, and the cycle of breeding is about 7~9 years.
- PPD leads to the loss of 30 million tons of cassava per year.
- CMD and pests result in reduced root yield and a decrease in leaf quality.

Shuttle breeding technology



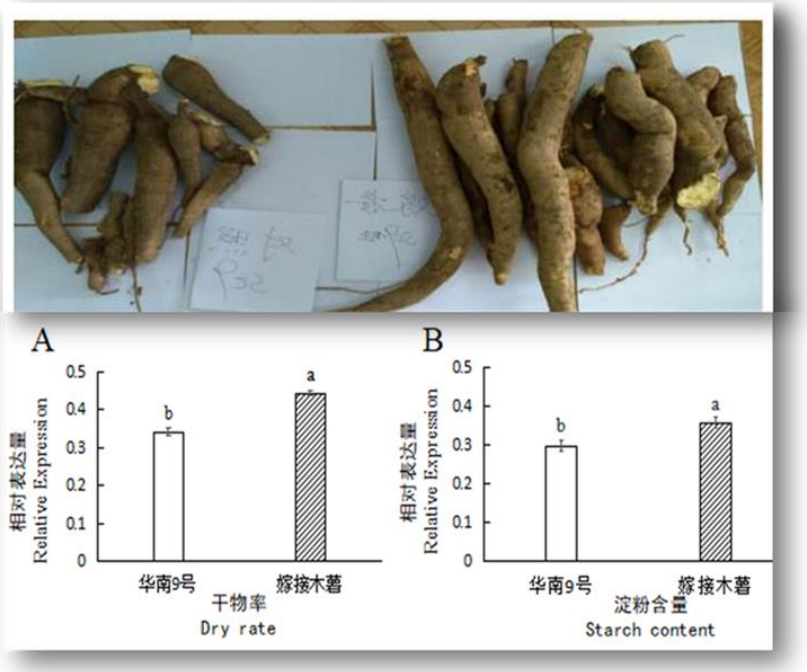
A: Cassava infected SLCMV in Cambodia； B: ZMI93, a resistant SLCMV variety; C: ZMI93 variety

The root yield of ZMI93 was 42t/ha in Chunfeng company, Combodia

Cassava Grafting

A: SC9, B: Grafting SC9/Rubber cassava

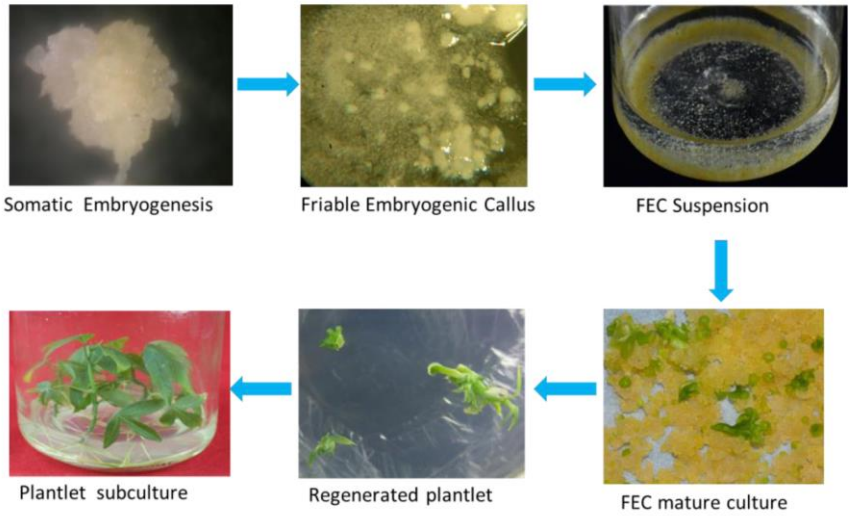
木薯品种 Cassava varieties	净光合速率(Pn) Net Photosynthetic rate	气孔导度 (Cs) Stomatal conductance	胞间 CO_2 浓度 (Ci) Intercellular CO_2 concentration	蒸腾速率(Tr) Transpiration rate	鲜薯单株产量 (Kg) Fresh root yield per plant
SC9	9.96±0.22a	0.28±0.01a	167.60±0.51a	6.24±0.11a	4.520a
嫁接木薯	7.25±0.33b	0.20±0.01a	166.85±2.13a	4.94±0.24a	10.340b



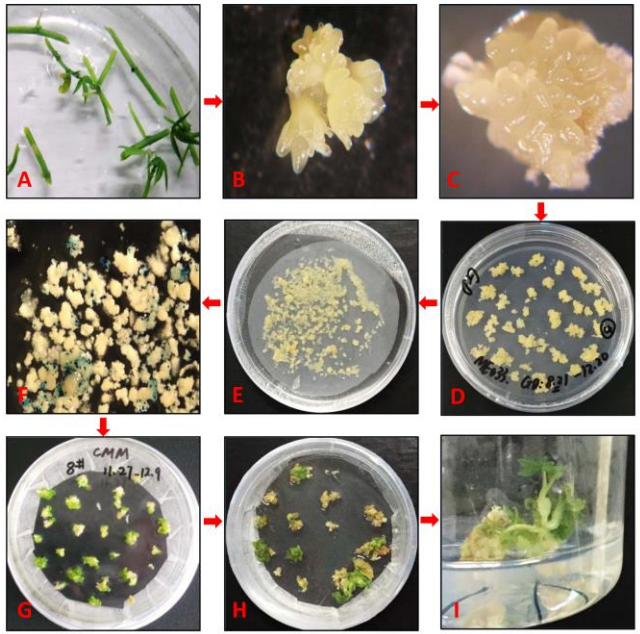
- The starch content of the grafted cassava was 35.72%, significantly higher than the 29.81% of SC9; The dry matter rate of grafted cassava was 44.29%, which was significantly higher than the 33.97% of SC9.

Cassava regeneration & genetic transformation system

Optimization of the regeneration system and genetic system of cassava



华南8号木薯离体植株再生系统与遗传转化体系的优化

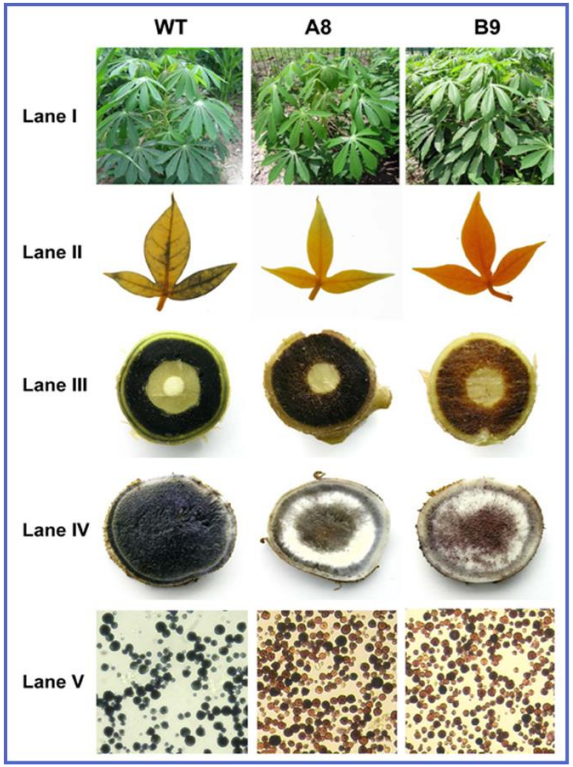


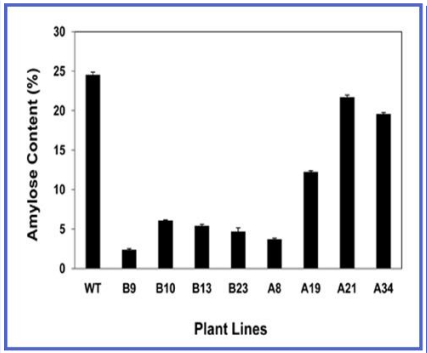
需要更多品种、更高效的植株再生和遗传转化体系

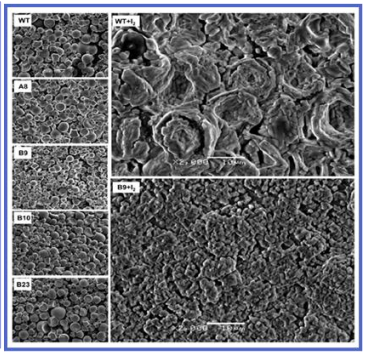
C3、SC8、SC205、SC9、巴西金、NZ199、KU50等

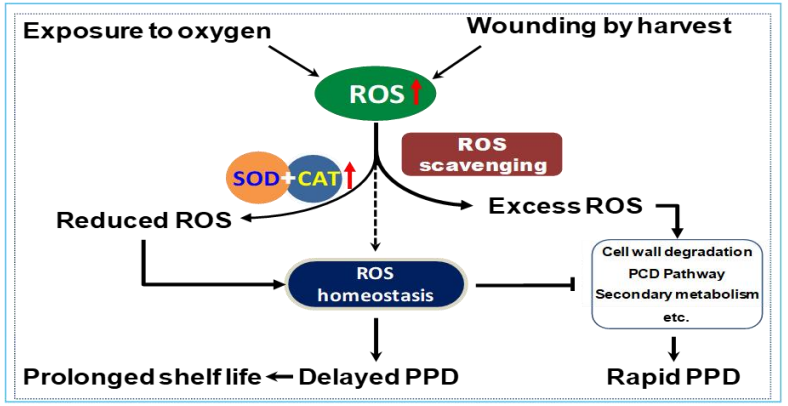
Plant regeneration and genetic transformation of cassava TM60444 plants

Cassava transgenic technology





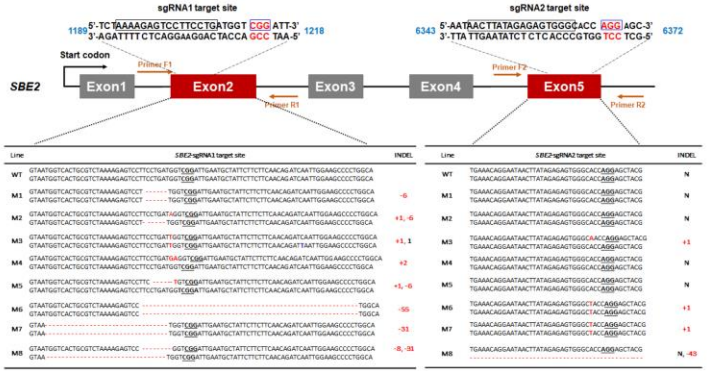




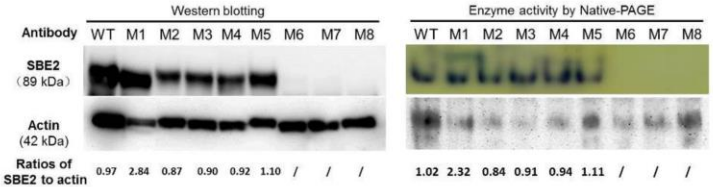
- Using transgenic technology and genetic transformation system, a series of cassava germplasms have been created, such as waxy cassava, PPD tolerant cassava and high-yield cassava.

CRISPR/Cas 9 gene editing

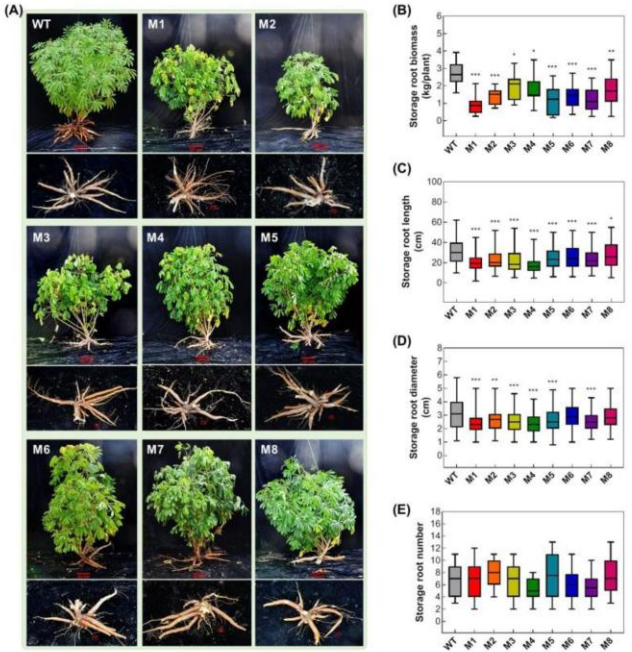
Dual sgRNA-directed knock-out of the *MeSBE2* gene



Absence of MeSBE2 protein and enzymatic activity in homozygous lines



Mutation of cassava SBE2 affects plant growth

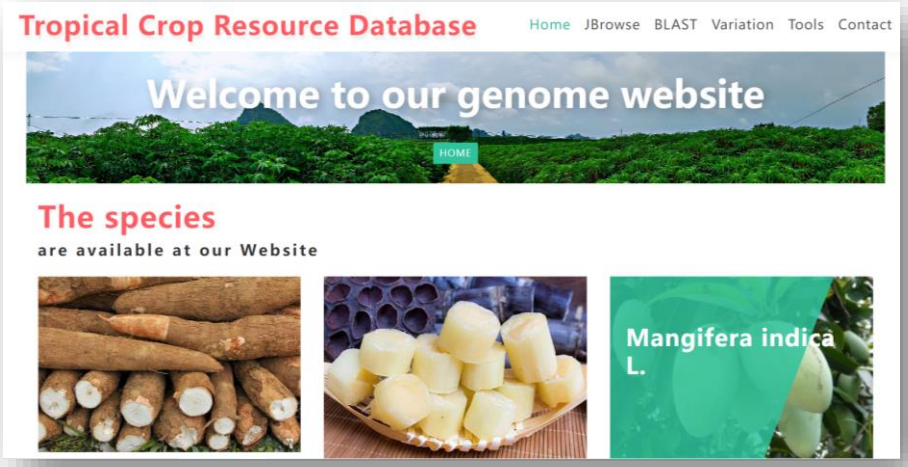


CRISPR/Cas9 基因编辑效率达93%，为培育非转基因高直链木薯提供了技术和材料

New varieties were created based on CRISPR/Cas 9 gene editing

Luo et al., 2021, Plant Molecular Biology

Cassava Database

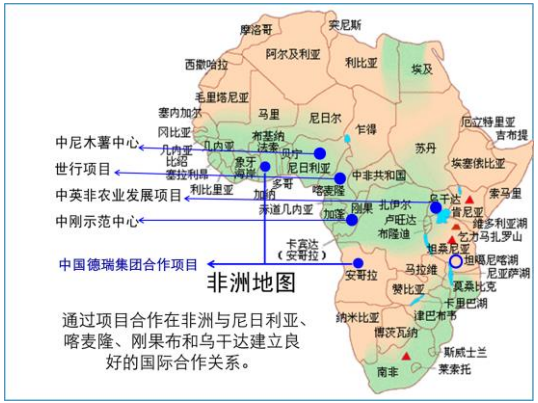


- The cassava resource database contains the sequence alignment module, the genome browser module, the variant module, the phenotype module, and the generation letter tool analysis module. Website: **http://www.tropical-resources.org.cn/.**

Cassava Database Demo

3. Vision for International Cooperative Project

NSFC-CGIAR and AgriTT Cooperative Project will be a driving force for cassava international cooperation



- CATAS in cooperation with Alliance of Bioversity-CIAT, IITA, University of Greenwich and Uganda Institute for Innovation implemented AgriTT project to work for food security in Africa countries.
- Six NSFC-CGIAR International Cooperative Projects supported cassava basic research area between CATAS and Alliance of Bioversity-CIAT.

Mining key genes from wild cassava and serving breeding

Figure 2. *Manihot fallax*. **A** Habit **B** Leaves; note the spiral phyllotaxy **C** Inflorescence; note the showy bracts **D** Staminate flower, frontal view **E**. Pistillate flowers in the inflorescence, lateral view; note the free sepals **F** Fruit.

QUARTA-FEIRA, 15 DE JUNHO DE 2011

Mandiocaba amazônica surpreende cientistas chineses

MONTEZUMA CRUZ

CAMPO GRANDE (MS) – A mandiocaba que os professores Songbi Chen e Ou seguram (foto) foi colhida depois de seis meses de plantada no sítio do técnico agrícola Flávio Ikeda, no município deAbaetetuba, a 101 quilômetros de Belém por rodovia, na região nordeste do Pará. Esses membros do Tropical Crops Genetic Resources Institute e do Chinese Academy of Tropical visitaram a região em maio, acompanhando o pesquisador da Embrapa Biotecnologia, Luiz Joaquim Castelo Branco Carvalho, a convite do Gruo Y. Yamada.

Conheceram a mandioca açucarada amazônica, genuinamente paraense, e também a degustaram, informa Ikeda. Lembra que a recente colheita de um pé de mandioca pesando 37,3 kg plantado três anos antes e com a raridade de três raízes em perfeito estado rendeu frutos. "Resolvi aproveitar todas as manivas que ficaram após a degustação dos cientistas chineses, para multiplicação, com tratamento vip a partir de agora", comenta o técnico.

A cada ano cresce o interesse chinês pelas experiências brasileiras no setor. A China tem procurado a Embrapa para estabelecer parcerias. Inegavelmente tem levado para suas academias os melhores resultados obtidos por pesquisadores. Em 2009, por exemplo, o professor Bin Liu, PhD assistente da direção da Chineses Academy of Sciences edo Beijing Genomics Institute, acompanhou a transformação da mandioca em álcool,em Planaltina (DF). Em troca do aprendizadoos acadêmicos chineses

Support cooperative projects such as “Mining key genes from wild cassava and serving breeding”

Global cassava breeding program

Alliance

Bioversity International

CIAT

KASETSART UNIVERSITY 1943

日本財団 The Nippon Foundation

IITA Research to Nourish Africa

UNIVERSITY of GREENWICH | Natural Resources Institute

UNIVERSITE DE YAOUNDE I

Embrapa

UNIVERSITY of HAWAI'I at MANOA | Research Centers in Minority Institutions (RCMI)
PROTEOMICS CORE FACILITY

CATAS 1954

CCARS

INTERNATIONAL SOCIETY FOR TROPICAL ROOT CROPS

ACIAR aciar.gov.au

CGIAR

WFP World Food Programme

40-year Cooperation between CATAS and Alliance


中华人民共和国
国际科学技术合作奖
The International Science and Technology Cooperation Award of the People's Republic of China
证 书
CERTIFICATE
International Center for Tropical Agriculture
荣获中华人民共和国国际科学技术合作奖，特颁发此证书。
This certificate is issued to International Center for Tropical Agriculture for winning the International Science and Technology Cooperation Award of the People's Republic of China.
2021年9月25日
证书号：2020-HZ-05

Alliance won the International Science and Technology Cooperation Award on 2021. This award was inseparable from the NSFC-CGIAR Cooperative Project grants; Dr Hernán Ceballos won 2022 Chinese Government Friendship Award.


Thanks !
Email: songbichen@catas.cn