Introduction of inbreeding in cassava genetic improvement

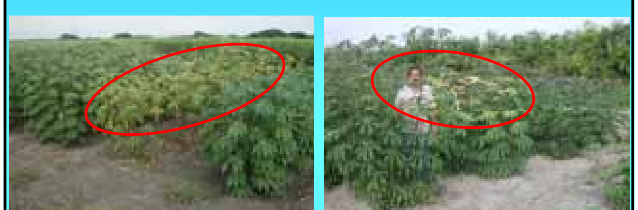
- Introduction
- Field activities
- Tissue culture work
- The future

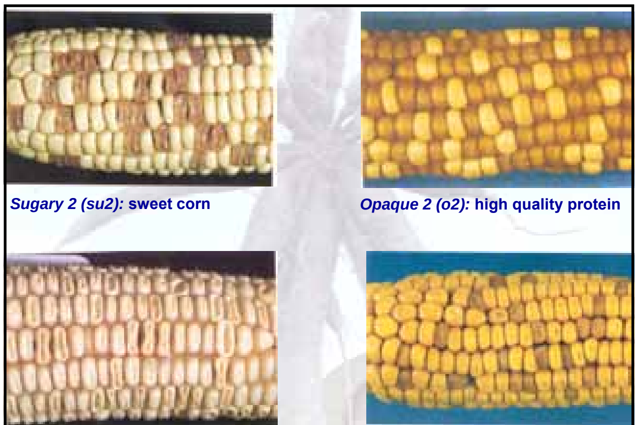
Cassava breeding is difficult because:

- Maintains a large "genetic load" in our populations
- We never "capture" genetic superiority
- We never separate properly SCA (non-additive) from GCA (additive) genetic effects
- Hybrids are not "designed", just found

Inbreeding offers many advantages for cassava genetic improvement

Exposes recessive traits: eliminate bad ones exploit good ones





Sugary 2 (su2): **sweet corn**

Opaque 2 (o2): **high quality protein**

Shrunken (sh1): **other type of sweet corn**

Amylose expander (ae1): **Increases amylose content**

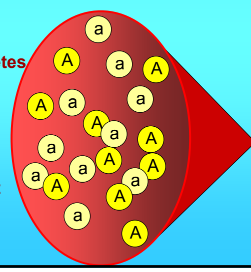
Results from three diallel studies in different environment

Genetic Parameter	Fresh Root Yield	Dry Matter Content	Harvest Index		
σ^2_A					
Sub-humid	17.88	1.452	0.0009	Thrips	0.419*
Acid Soils	1.485	3.379	0.0015	SED	0.523*
Mid-altitude	11.9	1.43	0.0029*	Mites	0.571*
				WF	0.994*
σ^2_D					
Sub-humid	23.87*	0.765	0.0027*	Thrips	0.231**
Acid Soils	9.028	0.873	0.0011	SED	0.092
Mid-altitud	152.1*	2.47**	0.0018**	Mites	0.170*
				WF	-0.210
Epistasis test					
Sub-humid	100.40**	4.257**	0.0013	Thrips	0.259*
Acid Soils	15.054**	0.872	0.0014	SED	0.242
Mid-altitud	168.9**	-0.32	0.0001	Mites	-0.225
				WF	-0.221

Dominance effects cannot be transmitted

Imagine that the phenotypic values for the three possible genotypes in a given locus are

AA = 2
Aa = 5
aa = 2



When a plant produces gametes the special phenotypic effect (value = 5) that resulted from the specific combination of alleles A and a is lost.

Gametes transmit alleles, not allelic combinations…

Epistatic effects cannot be transmitted

Complementary gene action is a typical example of simple epistatic efects between two loci in Mendelian genetics.

Aa Bb —Self pollination→

Frequency	Genotype		Phenotype
1	AA BB	=	18
2	AA Bb	=	18
1	AA bb	=	6
2	Aa BB	=	18
4	Aa Bb	=	18
2	Aa bb	=	6
1	aa BB	=	5
2	aa Bb	=	5
1	aa bb	=	2

Aa Bb —Self pollination→

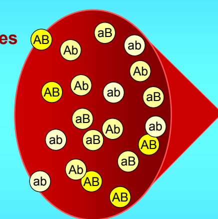
9	A- B-	=	18
3	A- bb	=	6
3	aa B-	=	5
1	aa bb	=	2

Epistatic effects cannot be transmitted

Complementary gene action is a typical example of simple epistatic efects between two loci in Mendelian genetics.

When a plant produces gametes the special phenotypic effect (value = 18) that resulted from the specific combination of alleles A and B is lost.

Gametes transmit alleles, not allelic combinations…



Aa Bb —Self pollination→

9	A- B-	=	18
3	A- bb	=	6
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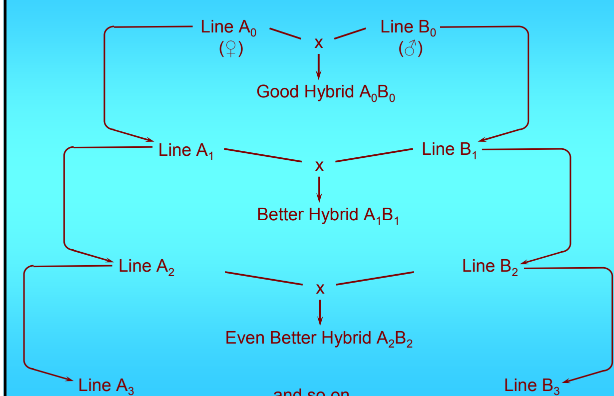
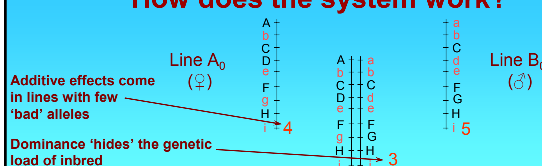
1	aa bb	=	2

How does maize manage to show progress?



How does the system work?



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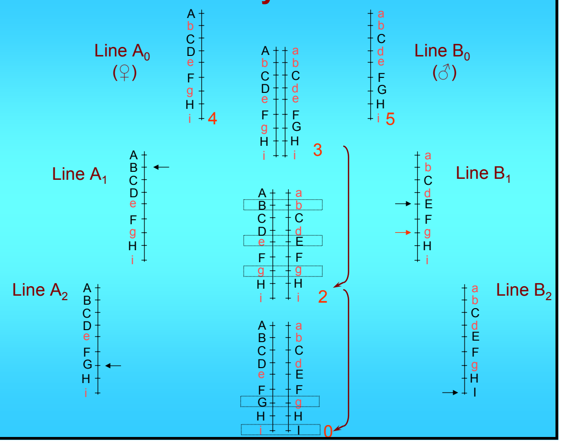

Inbreeding offers many advantages for cassava genetic improvement

Exposes recessive traits: eliminate bad ones exploit good ones

Leads to a more efficient exploitation of non-additive effects

Enhances the value of different traits: backcross scheme

Enhances exchange of germplasm: reduced phytosanitary regulations

Facilitates cleaning of elite clones: remake hybrids trough pollinations

Facilitates conservation of germplasm through botanical seeds

Facilitates genetic/molecular studies providing homozygous parents

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Understanding inbreeding depression and inheritance of relevant traits in cassava

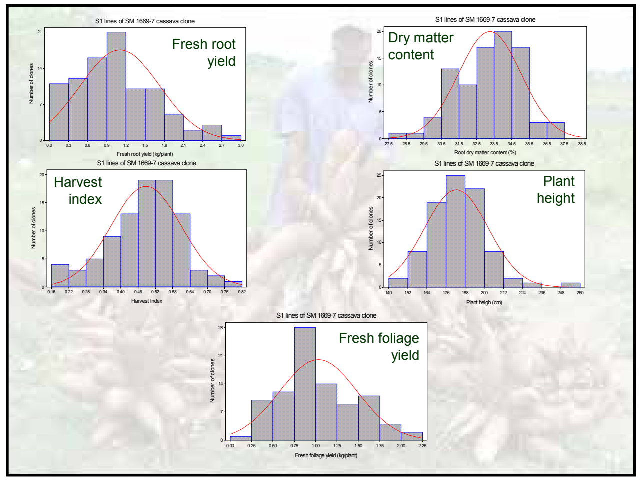
Several hundreds of self-pollinated seed from nine elite clones produced

From each elite parent 100 S_1 clones were planted in trials

Each trial involved three replications, with three plants/replication

Evaluation conducted in a single location

Elite clone		Plant height (cm)	Fresh root yield (kg/pl)	Fresh foliage yield (kg/pl)	Harvest Index	Dry matter Content (%)
SM 1669-7	S_1 ← S_0 ←	182.5 239.3	1.1 3.5	1.0 1.9	0.49 0.65	33.2 35.8
SM 1669-5		191.8 207.6	1.5 4.2	1.3 2.7	0.49 0.61	30.4 31.8
SM 1511-6		193.9 216.8	1.6 4.5	1.0 1.8	0.59 0.71	32.3 35.3
SM 1665-2		164.3 174.8	1.6 3.3	1.6 1.9	0.47 0.63	31.2 32.1
SM 1565-5		188.0 208.0	0.40 1.03	1.3 2.0	0.19 0.33	29.6 29.7
SM 1460 – 1		222.0 223.7	2.1 4.9	1.8 2.6	0.53 0.65	25.7 26.1
SM 1219 – 9		229.1 246.2	3,2 9.9	2.1 2.9	0.57 0.76	27.7 29.7
MTAI 8		171.1 202.7	1.0 4.5	1.1 2.5	0.38 0.6	27.5 30.0
Average S1/S0 ratio		0.90	0.35	0.61	0.75	0.95



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IT TAKES TOO LONG !!!

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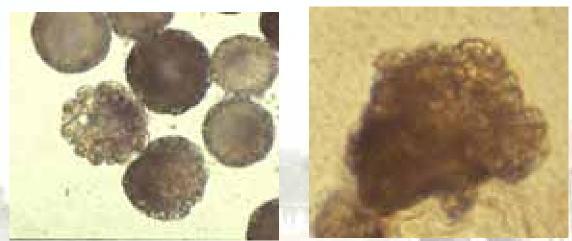
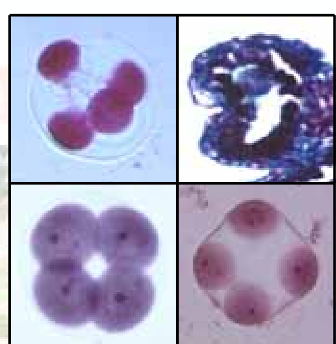
Cassava microspore derived callus



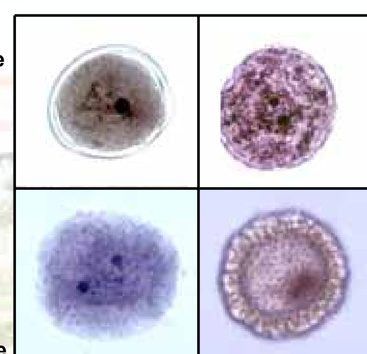
Proof of concept
Non-reproducible
No plant regeneration attained

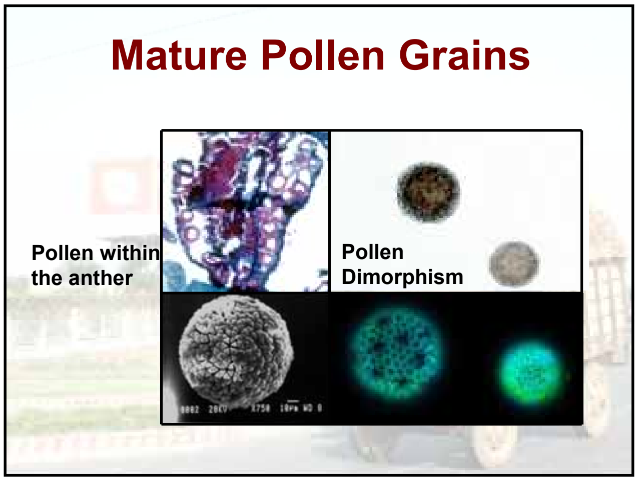
Courtesy William Roca

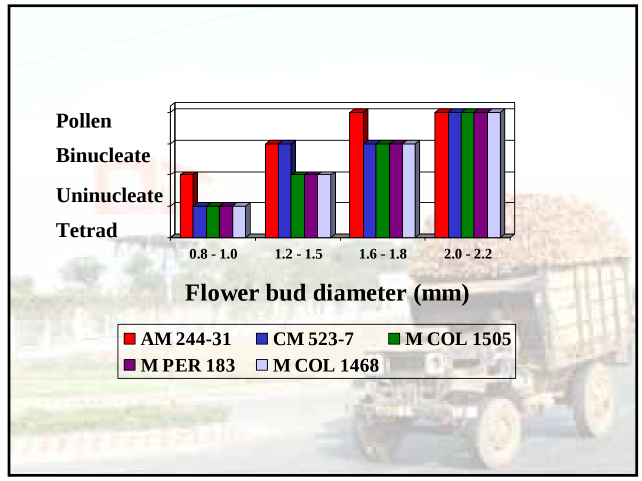
Cassava Tetrad Developmental Stages



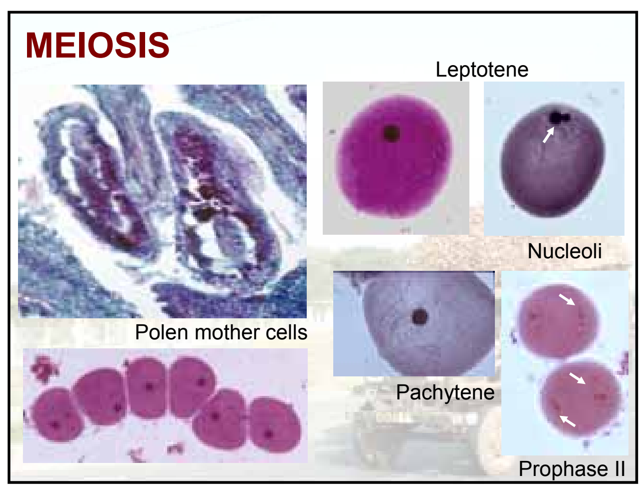
Cassava Pollen Development

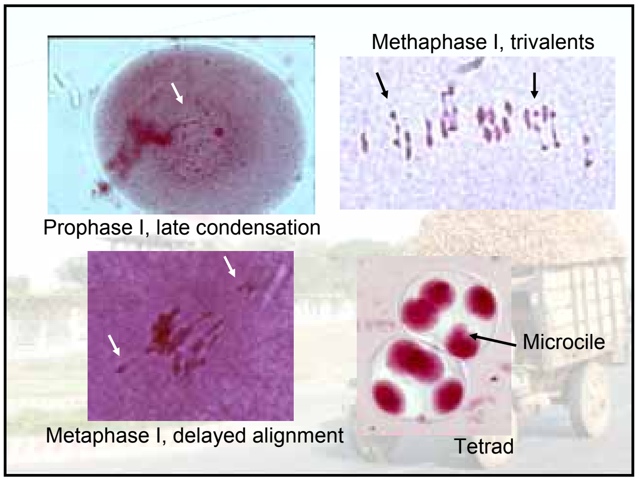



Mature Pollen Grains
Pollen within the anther
Pollen Dimorphism


Pollen
Binucleate
Uninucleate
Tetrad
0.8 - 1.0
1.2 - 1.5
1.6 - 1.8
2.0 - 2.2
Flower bud diameter (mm)
AM 244-31
CM 523-7
M COL 1505
M PER 183
M COL 1468


= 1 mm


MEIOSIS
Leptotene
Nucleoli
Polen mother cells
Pachytene
Prophase II



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  - Microspore isolation
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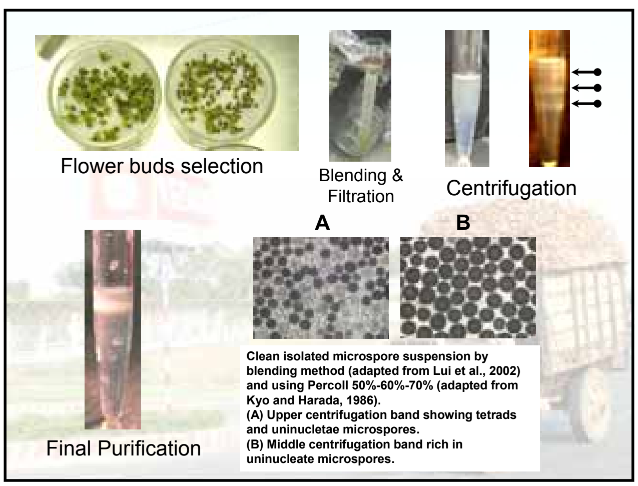
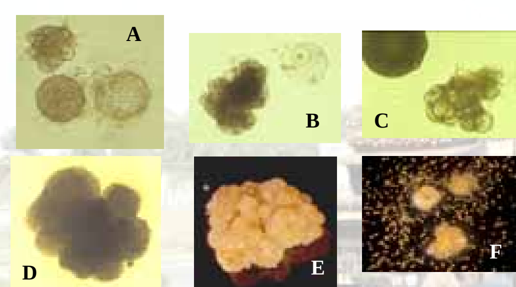
CIAT
Centro Internacional de Agricultura Tropical
International Center for Tropical Agriculture



Cassava microspore division and microcallus formation



Work ahead

- Develop a system that will allow detect cell division in spite of thick wall
- Continue the screening of culture media and pre-treatments that will induce cell division
- Once calli from microspores are developed work out the protocol for regeneration
- Continue self-pollinations of elite germplasm and landraces in search of useful traits and to reduce inbreeding depression in cassava

ขอบคุณครับ

Asenti sa

Thank you !

Danke !

Obrigado !

Gracias !

Merci !

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COLCIENCIAS

Colombia's Ministry of Agriculture