



**Improving rice productivity
in lowland ecosystems
of Burkina Faso, Mali and Nigeria
through
Marker Assisted Recurrent Selection
for drought tolerance
and yield potential**

ARM, 20-23 September 2009, Bamako, Mali



Rainfed lowland rice, an important stake in sub-saharan Africa

Ecosystems	Africa	Latin America	Asia	Medit. area	USA	Aust.	World
Irrigated	20%	55	55	100	100	100	55%
Rainfed lowland	34 %	-	28	-	-	-	31%
Deep water	8 %	-	8	-	-	-	5%
Rainfed upland	38 %	45	9	-	-	-	10%
Total (M ha)	9.1	6.6	136	2.5	1.4	0.1	156
Production (M t)	20.2	24	572	11	8,9	0,4	636 M t
Yield (t/ha)	2.1	4.0	4.1	4.4	6.6	6.7	3.9 t/ha

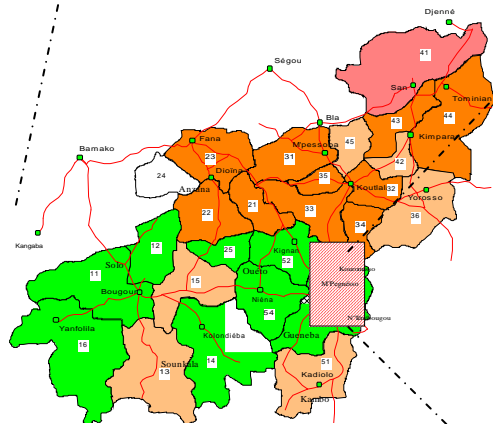
FAO (2005)

Rainfed lowland rice, an important stake in the target countries

Ecosystem	Burkina Faso	Mali	Nigeria	Africa
Irrigated	46%	22%	17%	20%
Rainfed lowland	50%	13%	47%	34 %
Deep water	0%	64%	6%	8 %
Rainfed upland	4%	1%	30%	38 %
Total (M ha)	0.05	0.45	3.70	9.1
Production (Mt)	0.095	0.877	3.54	20.2
Yield (t/ha)	1.87	1.94	0.96	2.1

Lowlands, a very complex ecosystem

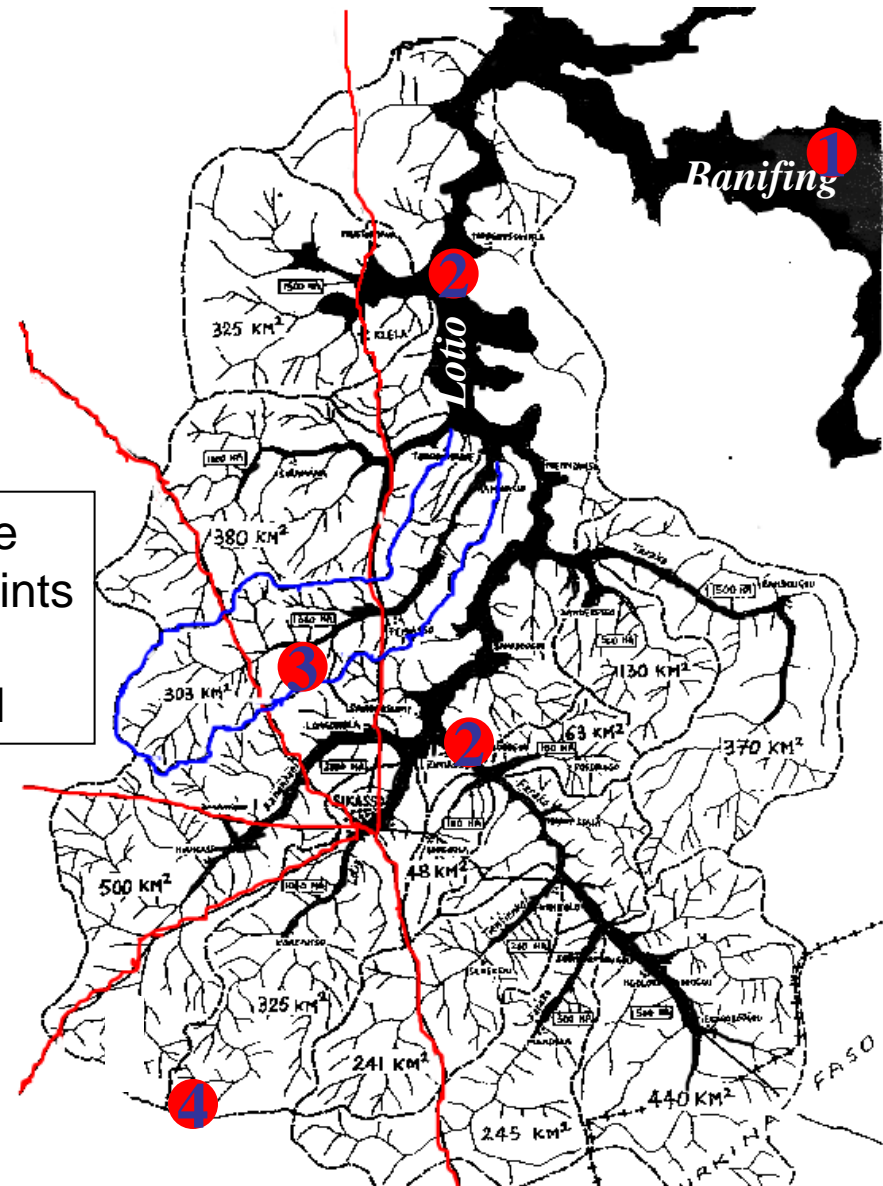
Mali



South-Mali

High variability of the hydrological constraints and drought profile along the watershed

- 1: Large riverside plain
- 2: Permanent riverside plain
- 3: Inland valley
- 4: Head of inland valley



← 10 Km →

Loto watershed

Objectives

- Develop drought tolerant rice cultivars, with medium to high yields in normal years for the rainfed lowland ecosystems of Sub-Saharan Africa
- Build capacity for rice breeding and introduce new tools and new breeding approaches in the breeding programs of the target NARS and WARDA

Strategy

- Consolidate the knowledge bases
 - Characterize the lowland ecosystem in terms of drought profile (occurrence & frequency), through the TPE approach
 - Design and describe *ideotypes* fitting major sub-classes of the TPE
- Establish specific facilities for
 - Controlled drought trial
 - Multilocal evaluation of yield potential under the TPE
- Adopt a proven breeding scheme for complex quantitative traits: bi-parental Marker Assisted Recurrent selection (MARS)
- Use, as far as possible, genetic resources and knowledge developed during GCP phase I
- Focus, as a priority, on the most robust and proven tolerance trait: yield under controlled drought stress
- Manage drought stress under controlled conditions according to the drought profiles in different sub-classes of the TPE
- Breed not only for drought tolerance but also for yield potential (5-7 t/ha) under well watered growth conditions
- Evaluate the added value and the feasibility of some emerging concepts and tools for phenotyping for drought tolerance, and integrate the most relevant of them into the MARS scheme
- Build “Community of practice” through training and capacity building

Work packages

Consolidating knowledge

- Characterising lowland environment
- Establishing drought evaluation sites and designs
- Ideotype for TPE
- Capacity building

Phenotyping

- For drought tolerance
- For yield & other traits under various levels of environment control

- Capacity building

Breeding

- Developing breeding populations

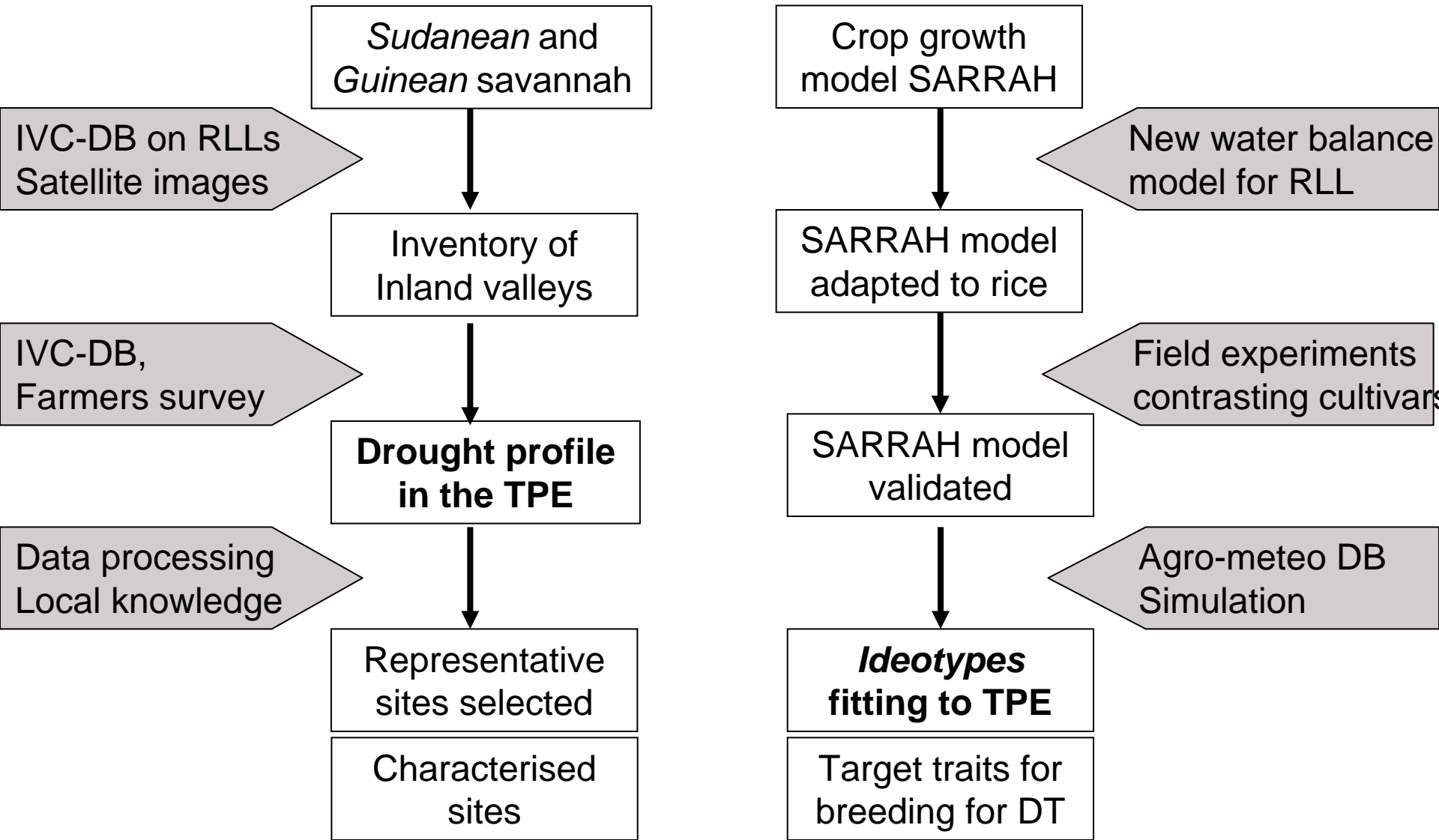
- Genotyping
- QTL analysis

- Combining favourable alleles at target QTLs

- Capacity building

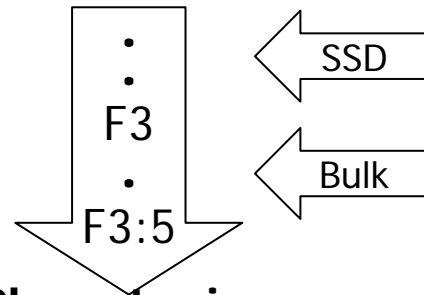
Information management

Consolidating the knowledge bases



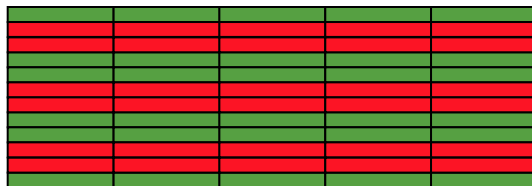
Phenotyping

Elite donor 1 x Elite donor 2



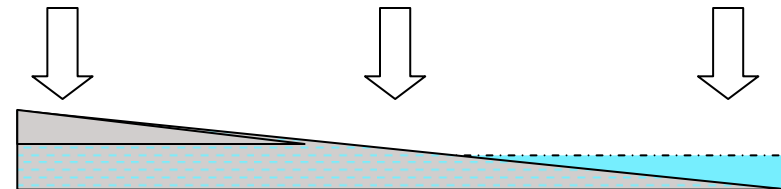
Phenotyping
200 lines

For drought tolerance
controlled drought
(rainout shelter)



Drought
Control

For yield potential
natural hydrologic contrasts
(toposequence)



- Soil water status
- Traits for direct selection for DT
- Traits for indirect selection for DT
 - Morphogenetic responses (*EcoMeristem*)
 - Canopy transpiration (IR thermography)
 - WUE (C^{13} isotope index)
 - Physiological stress (leaf fluorescence)

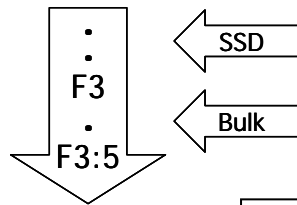
- Weather & soil water status
- Yield and yield components
- Other traits of interest
 - Plant architecture & phenology
 - Leaf rolling and senescence
 - diseases, grain quality, ...



Rainout shelter at IER, Sikasso-Mali

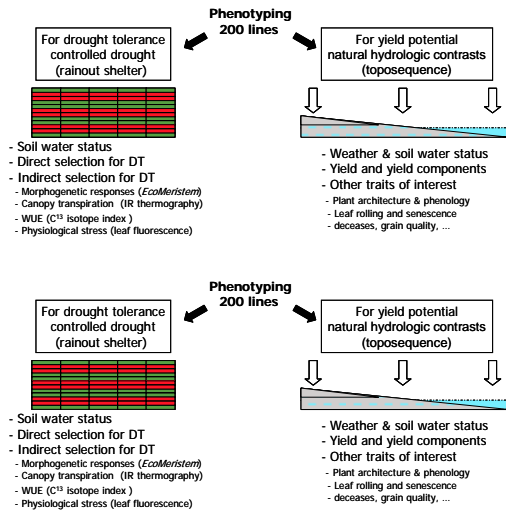


Elite donor 1 x Elite donor 2

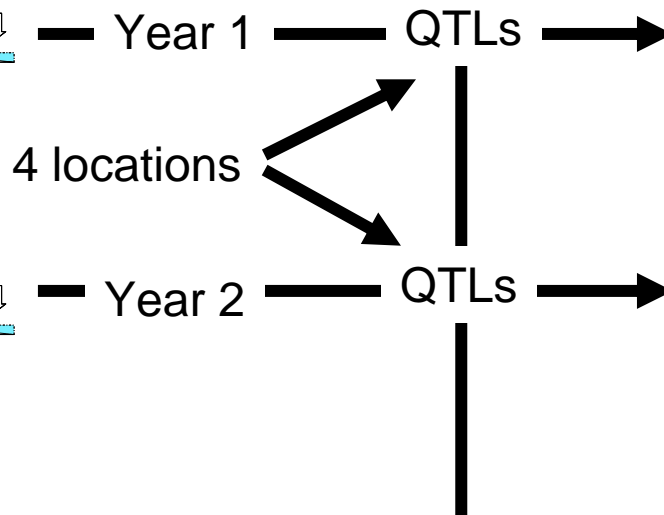


Breeding

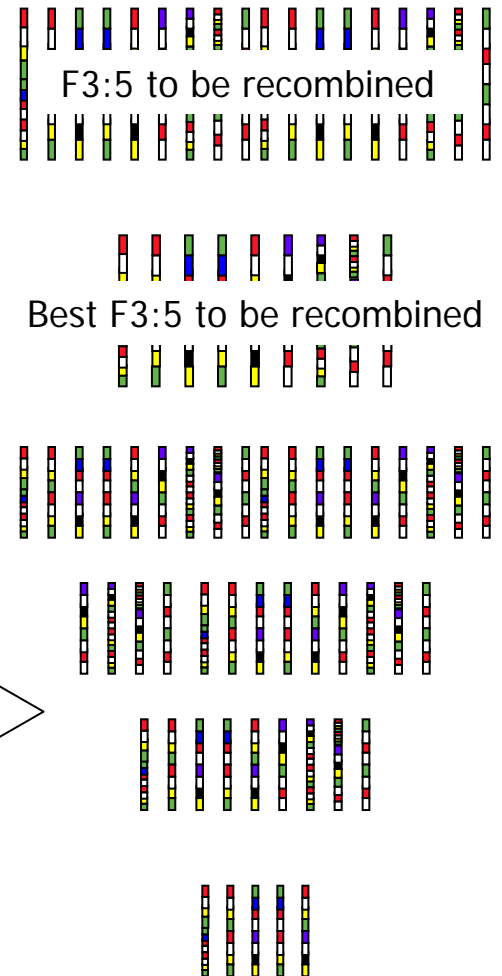
Phenotyping



Genotyping



Breeding

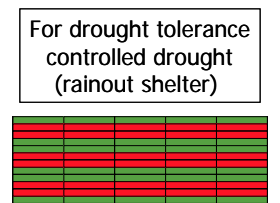
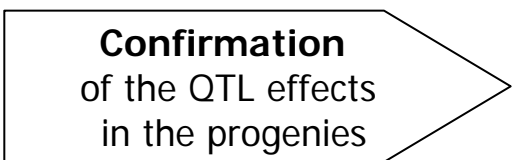
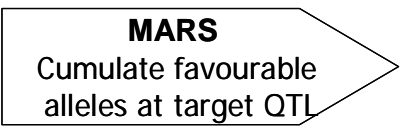
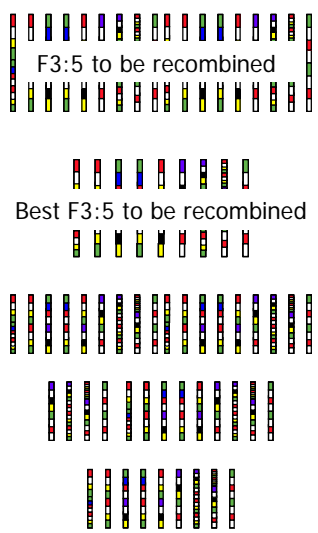
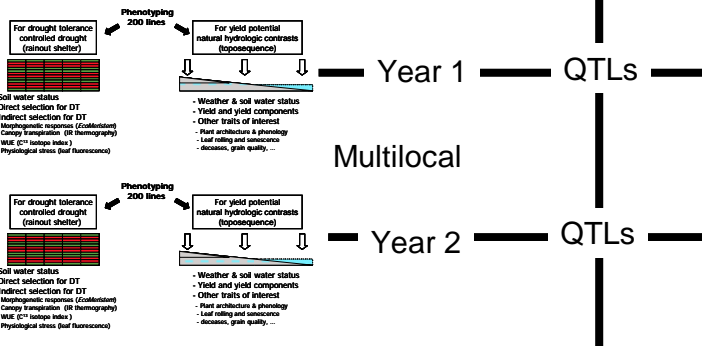
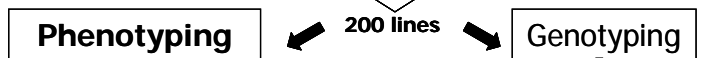
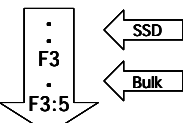


Cumulate favourable alleles at target QTLs

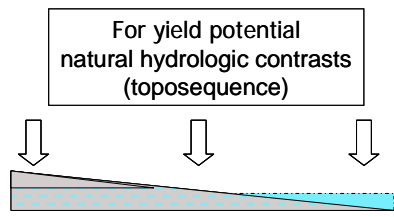
- Recombination of complementary lines (R)
- MAS of the best recombinations
- Iteration of R & MAS = **MARS**

Evaluation & Dissemination

Elite donor 1 x Elite donor 2



- Soil water status
- Direct selection for DT
- Indirect selection for DT
- Morphogenetic responses (*EcoMeristem*)
- Canopy transpiration (IR thermography)
- WUE (C¹³ isotope index)
- Physiological stress (leaf fluorescence)



- Weather & soil water status
- Yield and yield components
- Other traits of interest
- Plant architecture & phenology
- Leaf rolling and senescence
- diseases, grain quality, ...



Time table for the first population (P1)

		2010		2011		2012		2013		2014		2015		2016		2017	
		6	12	18	24	30	36	42	48	54	60	66	72	78	84	90	96
WP1	TPE																
	Ideotype																
WP2	Population development																
	Controlled drought 1			T													
	Controlled drought 2				T												
	Field evaluation Year				T												
	Field evaluation Year 2						S										
WP3	Genotyping																
	QTL mapping					T		S									
	RS1								T								
	RS1																
	RS3																
	RS4																
	Confirmation																

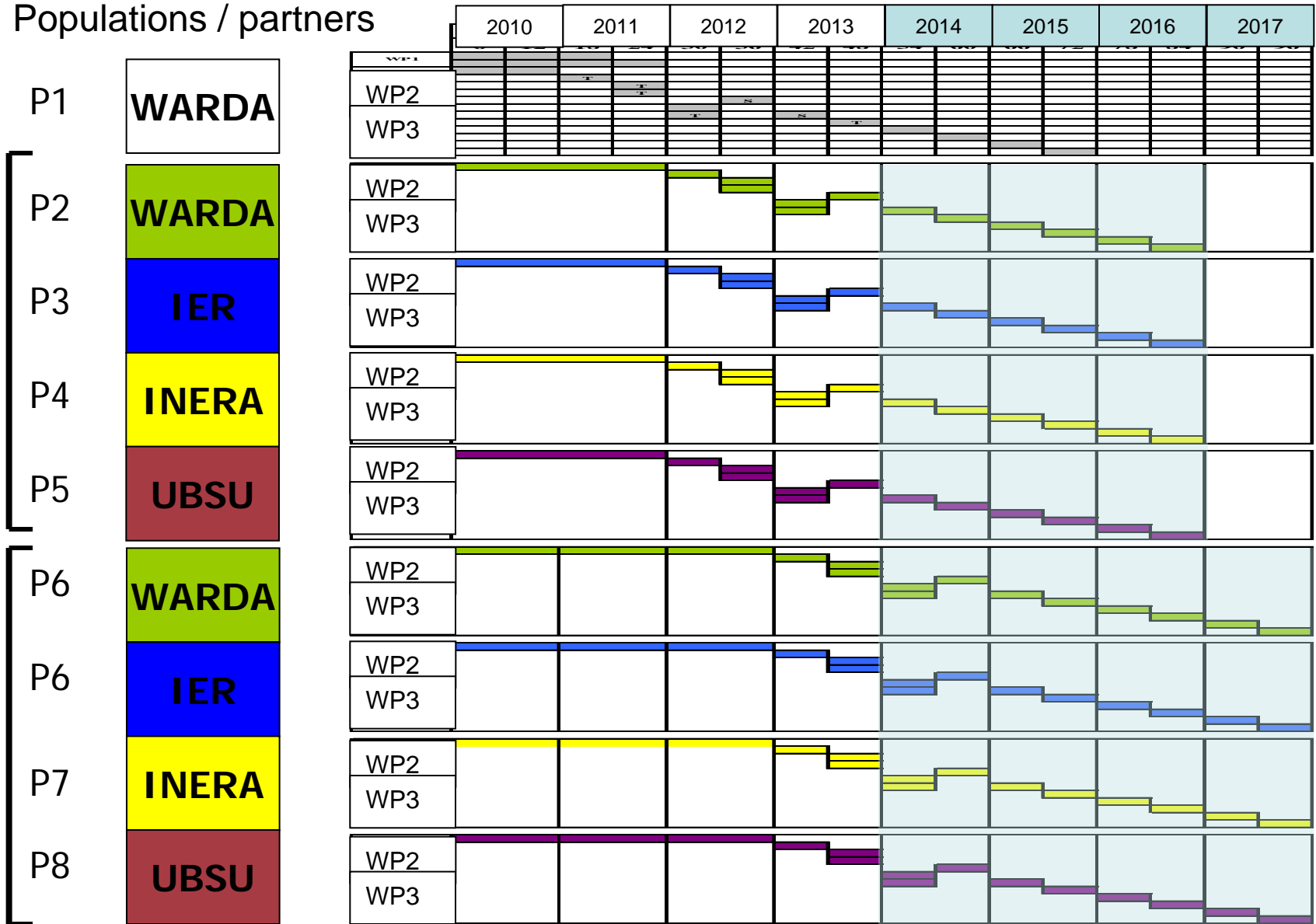
← Breeding cycle →

← Project duration →

T: Training
S: Supervising

Time table for routine MARS

Populations / partners



The challenges

- Integration of the outcome of the modelling tools (TPE, ideotype,...) in the MARS scheme
- Logistics of phenotyping and MARS
- Information management
- Human resources & capacity building
- Changing our stat of minds regarding
 - The breeding scheme (MARS/conventional)
 - The genotyping activity
- Evaluation of efficiency of the MARS breeding scheme



Rice Challenge Initiative workshop, Cotonou, 24-26 Jun 2009

Breeding

Elite donors

QTL detection on F3:5 progenies

- Multiple trait: drought, yield potential, ...
- Multiple environment: 2 years, 4 sites, ...

Cumulate favourable alleles

at QTLs of interest

- Recombination of complementary lines (R)
- MAS of the best recombinations
- Iteration of R & MAS = **MARS**

Expected results

- Gain of time
- Genetic gain: recombination of very low probability

