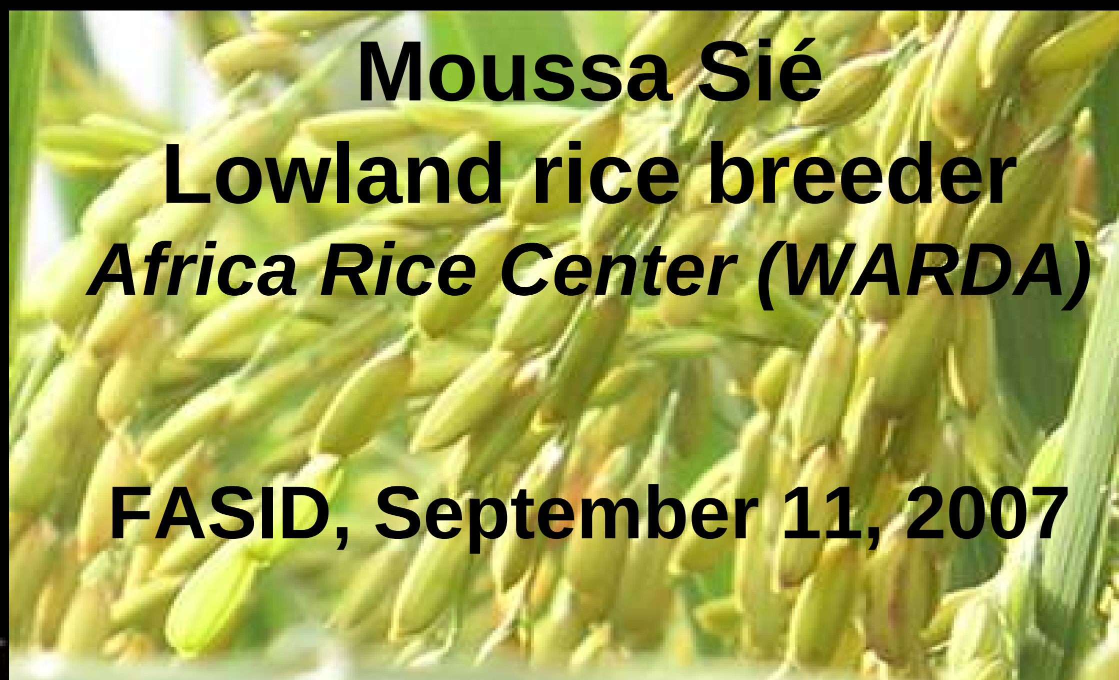
Ongoing research on NERICAs



Moussa Sié
Lowland rice breeder
Africa Rice Center (WARDA)

FASID, September 11, 2007

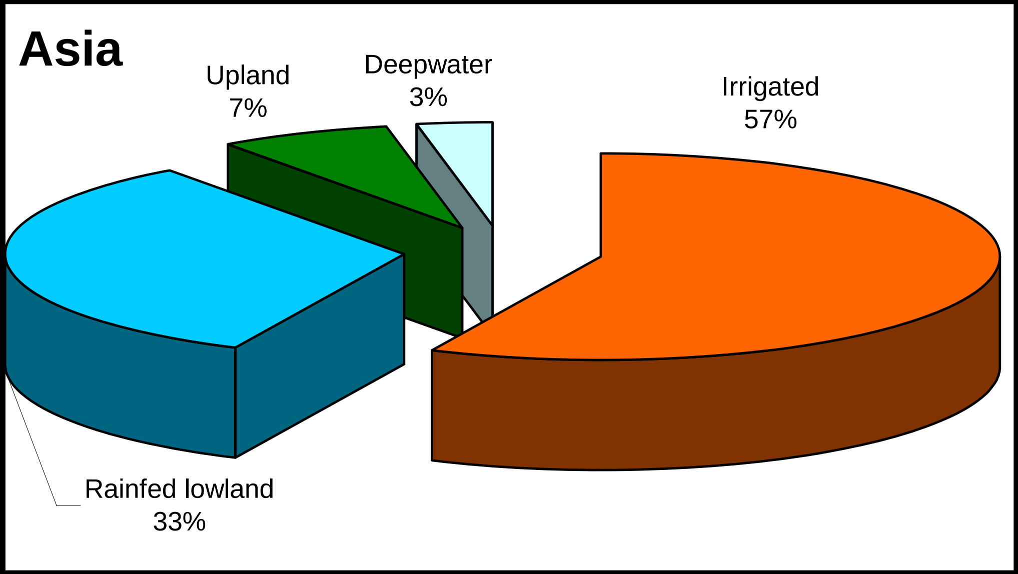
Rice production

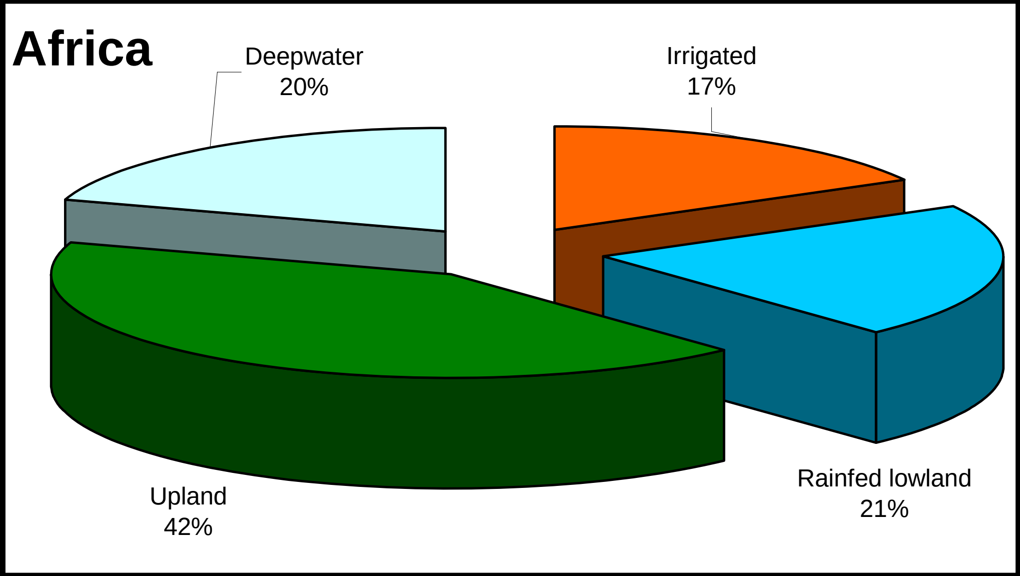
- About 80% of rice production is in the hands of small-scale farmers

- The region's rice yields are the lowest in the world: about 1 tonne per ha (5 tonnes in Asia)
- Today, rice is the most rapidly growing source of food in Africa. It is grown and consumed in about 40 countries in the continent

Rice-growing environments in West Africa:

Upland - Lowland (irrigated and rainfed) - Mangrove





Source: FAO, 2001

Origin and systematic Species of *Oryza* in Africa

Species	2n	Genome	Origin
O. sativa (cultivated)	24	AA	Asia
O. glaberrima (Cultivated)	24	A^gA^g	West Africa
O. stapfii (weedy species)	24	A^gA^g	West Africa
O. barthii	24	A^gA^g	West Africa
O. longistaminata	24	A^bA^b	Tropical Africa
O. branchyantha	24	FF	W. & Central Africa
O. eichingeri	24	CC	E. & Central Africa
	48	BBCC	
O. punctata	24	BB	Tropical Africa
	48	BBCC	
O. schwein furthianaa	48	BBCC	Tropical Africa

African Rice: *Oryza glaberrima*

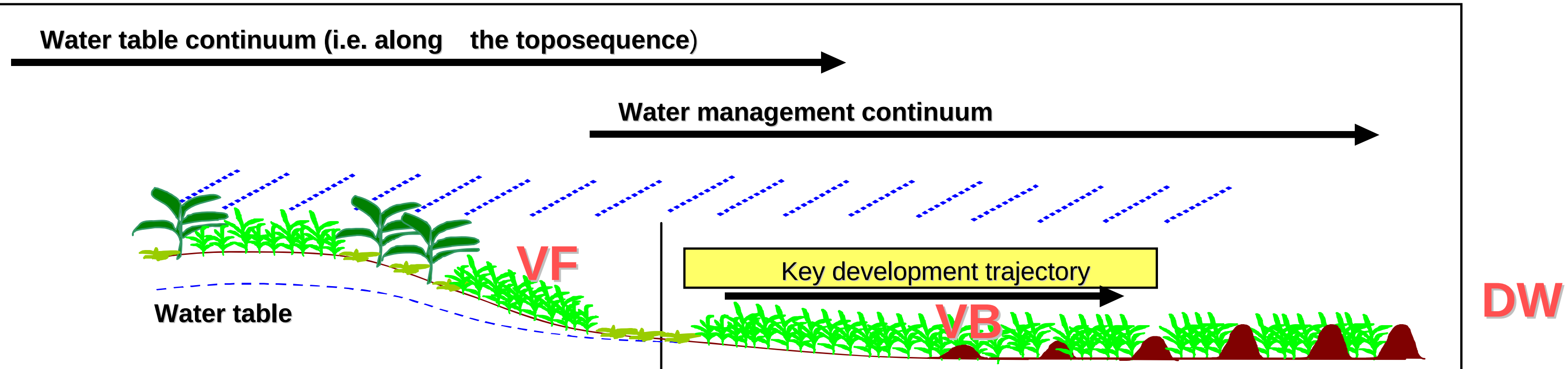
- Originated in West Africa more than 3500 years ago
- Low yielding
- Rich reservoir of genes for resistance to several stresses

- Taste and aroma
- Rapid vegetative growth (suppress weeds, resistance to diseases and pest)
- Tolerate fluctuating water depths, excessive iron, low levels of management, infertile soils, harsh climates, and late planting

Asian Rice: *Oryza sativa*

- Introduced to Africa 1500 years ago by Portuguese traders
- *indica / japonica* subspecies classification with continuous array of intermediates
- many agroecotypes adapted to various growing conditions
- Vulnerable to local stresses
- But high yield potential

… progressively replaced *O. glaberrima*



Ecology	Upland	Hydro - morphic fringes	Lowland	Intensified lowland	Irrigated lowland
Main water supply	Rainfall	Rainfall + water table	Rainfall + water table + unregulated flood water	Regulated flood water	Irrigation
Agro - ecological zone	Guinea savanna – humid forest zone	Guinea savanna – humid forest zone	Sudan savanna to humid forest zone	Sudan savanna to humid forest zone	Sahel to humid forest zone
Main stresses	Drought Weeds Pests and Diseases P and N deficiency Soil erosion Soil acidity	Drought Weeds Pests and Diseases P and N deficiency Soil erosion Soil acidity Fe toxicity	Drought / Flooding Weeds Pests and Diseases P and N deficiency Fe toxicity	Drought / Flooding Weeds Pests and Diseases P and N deficiency Fe toxicity	Weeds Pests and Diseases Salinity Alkalinity P and N deficiency Fe toxicity

Production risk ←

Production costs →

Production potential →

Input use →

Water control →

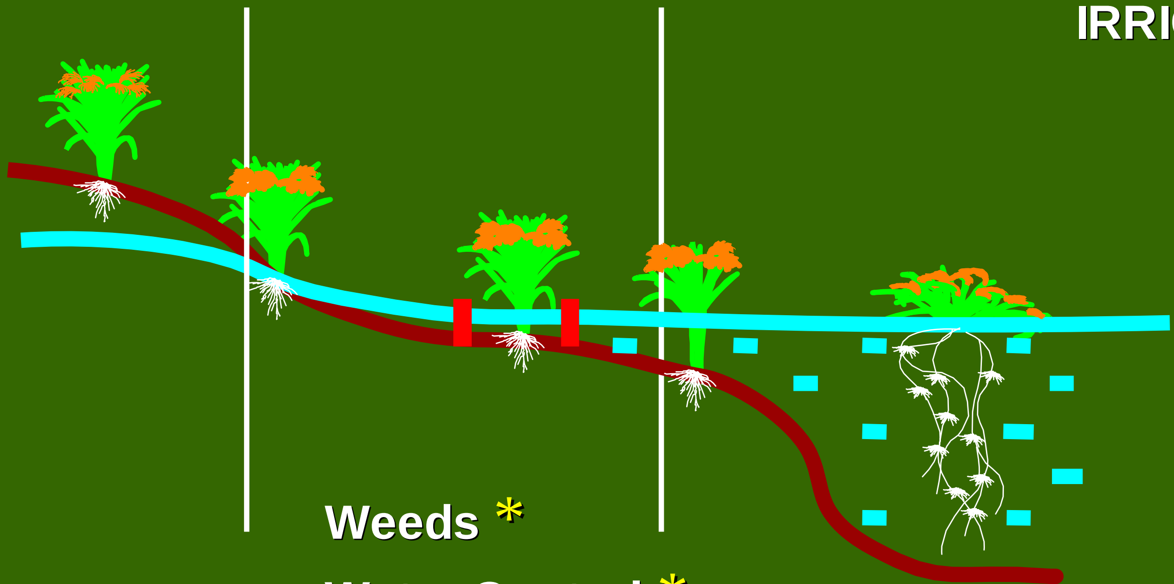
← ***Oryza sativa (japonica)***

Oryza sativa (indica) →

← ***O. glaberrima*** →

Major problems by rice - ecosystem

UPLAND | HYDROMORPHIC | LOWLAND | SAHEL IRRIGATED



Drought *

Weeds Blast *

N and P deficiency

Erosion

Acidity/Acidity

Stemborers

Termites*

Weeds *

Water Control *

N Deficiency *

Drought *

Iron Toxicity *

Stemborers *

Africa Rice Gall Midge *

Rice Yellow Mottle Virus *

Bacterial leaf blight *

Poor Water Control

* Extreme temperat

* N Deficiency

* Salinity

Alkalinity/Acidity

* Bacterial leaf blig

Where we started?

Early success came with the development of **OS6, Sahel 202** and **Sahel 108** which played major roles in rice research in SSA but…

- There was limited impact due to the greater diversity of conditions in Africa
- Poor on-farm performance due to susceptibility to biotic and abiotic stresses in Africa
- Therefore, WARDA explored innovative research pathways to better cater for unique African conditions

NERICA Development

Breeding strategy for NERICA development

1. **Basic concept**

- **Combination of the assets of the two species**

  African rice (*O. glaberrima*) : resistance to local constraints

  Asian rice (*O. sativa*): high yielding ability

2. **Technologies adopted**

- Conventional backcrossing breeding
- Anther culture
- Embryo rescue

NERICA is a partnership success

Cornell University
IRD
Gene-tagging for resistance to RYMV, AfRGM and drought.
Genetic diversity of *O. glaberrima*

IRRI
CIAT
Development of new interspecific progenies.
Evaluation of WARDA's interspecifics.
Providing new interspecifics to WARDA for evaluation in SSA.

YAAS
Determination of sterility genes in interspecific hybrid rice production.

Coordination and implementation.
Technology generation, dissemination and training.
Africa Rice Center (WARDA)

Nihon University
JICA
JIRCAS
Physiological characterization of new interspecifics.

NARES
Development agents
Farmers
Assessment of new interspecific progenies in their own environments.
Involvement in participatory research.

Partnership with national programs through WARDA's research network

- Screening and evaluation of the first progenies
- Selected material sent to three countries (Burkina Faso, Togo and Mali)
- Shuttle Breeding: WAS122-IDSA1-FKR-2-TGR-8
- Through rice research network (ROCARIZ)

NERICA success: the network role

- Multidisciplinary task force mechanism of ROCARIZ rice network
- Acclaimed by NARS as a major strength for collaborative research
- Played a central role in development of lowland NERICAs
- Facilitated shuttle-breeding approach to accelerate selection
- In <20 years, NARS capacity for rice research enhanced

Participatory Varietal Selection (PVS)

Participatory approaches were key to speeding the development, release and adoption of NERICAs

Why PVS?

- Shortens the time lag between varietal development and release (3 years for PVS / 7 years for conventional breeding)

- Accelerates the rate of adoption of promising rice varieties from WARDA

- Elicits farmer criteria for choosing/adopting rice varieties so such information is available to researchers further refining technology

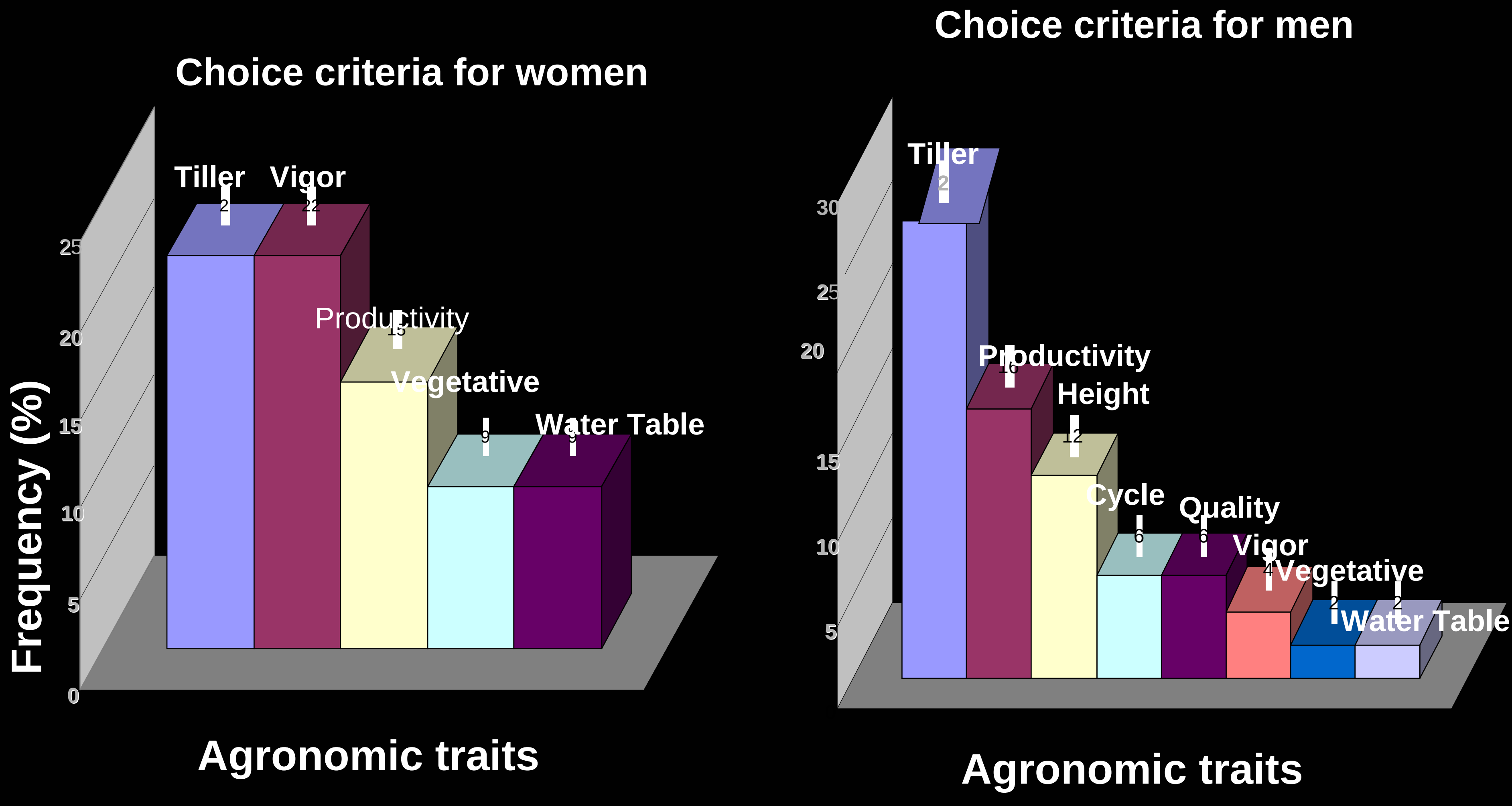
Methodology of PVS

A tool for efficient transfer of improved rice technologies to farmers

A 3-year program

- 1st year: farmers are exposed to a range of promising cultivars (30-60 varieties in a rice garden)
- 2nd year: Farmers plant selections from among previous varieties
- 3rd year: Farmers adopt preferred varieties

What PVS can show



Performance of NERICAs at Ndiaye and Fanaye DS (Senegal)

Lines	Mat	Yld Fan	Yld Nd	Mean
WAS 161-B-4-B-1	135	10.5	6.9	8.7
WAS 161-B-2-B-1	141	9.5	6.6	8.0
WAS 161-B-9-2	140	9.4	6.6	8.0
WAS 122-IDSA-10- WAS-4-3	134	9.3	6.2	7.8
WAS 122-IDSA-10- WAS-1-1	138	9.0	7.0	8.0
WAS 131-IDSA-1-WAS-4-B-1	137	8.6	6.9	7.7
WAS 122-IDSA-10- WAS-4-2	132	8.2	7.8	8.0
Sahel 108	131	10.4	6.3	8.3
IR 64	138	8.1	6.5	7.3
IR 31851	130	7.6	6.3	6.9

Yield performance (kg/ha) of NERICAs tested for salinity tolerance

Designation	Fresh water	Saline water	Yield reduction %
WAS 208-B-1	6335	5160	19
WAS 73-B-B-231-4	5959	5047	15
WAS 191-10-4-FKR 1*	5722	5038	12 NERICA
IR 63731-1-1-1-4-2	5470	4819	12
WAS 73-B-B-231-2	5319	4841	9
WAS 122-IDSA-10-WAS 10-WAB-2-WAS 1*	5209	4451	15 NERICA
WAS 182-B-1-1	5204	4998	4
WAS 207-B-B-3	5186	4858	6
WAS 122-IDSA-11-WAS 8-2*	5096	4675	8 NERICA
WAS 122-IDSA-10-WAS1-1-FKR 1*	5004	4866	3 NERICA
IR 4630 (RES CHECK)	4320	3652	15
IKP (RES CHECK)	6061	4683	23
IR 31 785 (SUSC CHECK)	4165	1561	63
SAHEL 108	6536	4521	31
WAS 183-B-6-2-2	4427	416	91
WAS 206-B-1	3703	3663	1

Total= 200 lines screened * interspecifics

Creation of intra & interspecific varieties adapted to lowland cultivation

Genomic composition of 51 lowland NERICA

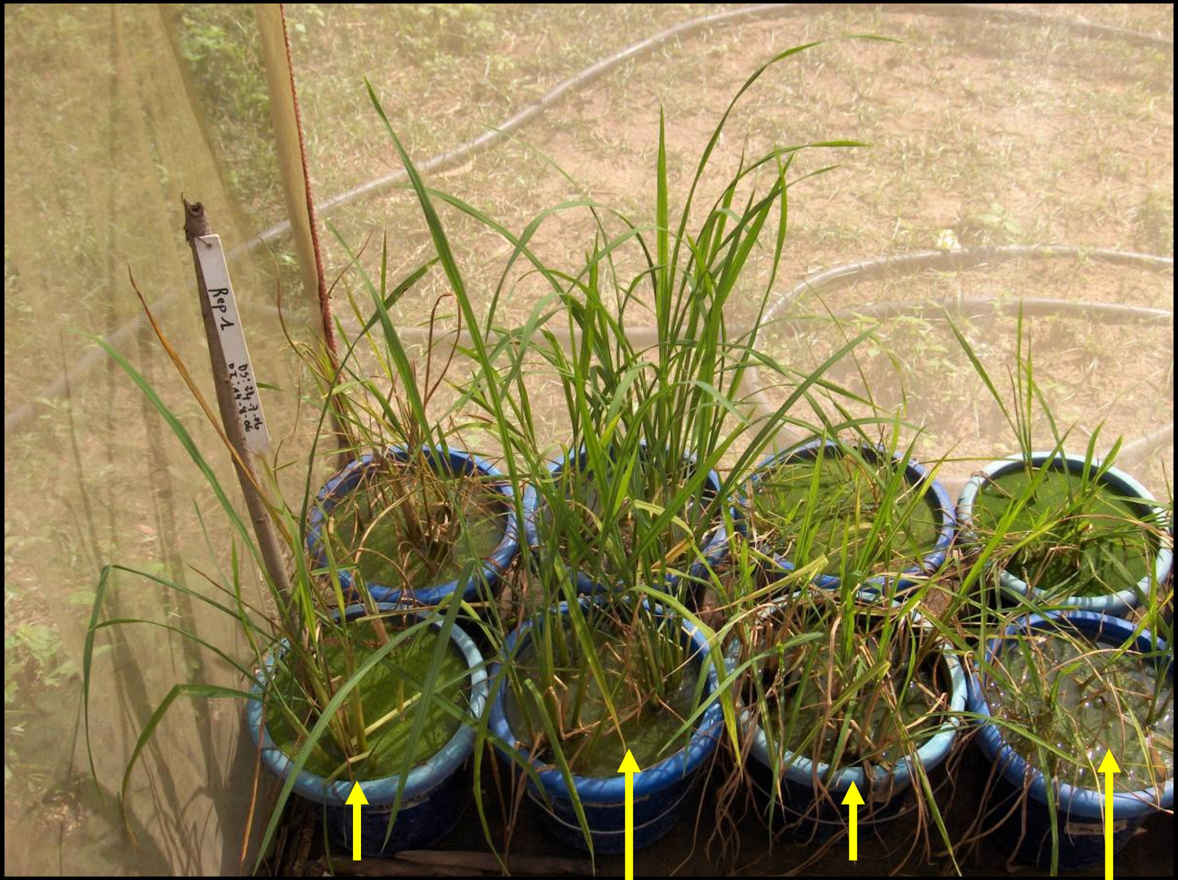
	Donor Genome content	Recurrent parent content	Heterozygote	Missing	Non-parental
Minimum	1.54	41.54	0.00	0.00	0.00
Maximum	9.09	62.12	4.55	33.85	50.77
Mean	4.09	52.14	0.54	10.46	32.78

Genomic composition of 70 upland NERICA

		CG14	WAB56-104	Het.	Missing	Non pa.	Total(cM)
All 70 lines	Minimum	0.9	79.0	0.0	0.0	0.0	1724.6
	Maximum	12.1	94.4	3.4	13.6	5.5	1724.6
	mean	6.3	87.4	0.4	3.7	2.2	1724.6
7 Nericas	Mean	8.2	88.2	0.2	0.3	3.0	1724.6
Other 63 lines	Mean	6.0	87.4	0.4	4.1	2.1	1724.6
DHs n = 26)	Mean	5.5	87.5	0.5	5.2	1.3	1724.6
Pedigree lines (n = 44)	Mean	6.7	87.4	0.4	2.8	2.7	1724.6

Identify and characterize the level of resistance of lowland and irrigated breeding lines to RYMV

Sixty lowland NERICAs and 7 parents screened



Highlights: Blast

Of 568 breeding material, 207 were resistant to blast at four hot spots in 4 countries (Burkina Faso, Nigeria, Mali & Guinea) including 9 NERICAs:

1. WAB 881-1-10-37-18-25-P3-HB
2. WAB 880-1-38-18-8-P3-HB
3. WAB 881-10-37-18-15-P1-HB
4. WAB 881-10-37-18-24-P1-HB
5. WAB 881-10-37-18-14-P1-HB
6. WAB 880-1-38-20-23-P1-HB
7. WAB 881-37-18-18-12-P3-HB (NERICA 18)
8. WAB 450-B-136-HB (NERICA 9)
9. WAB 880-1-38-18-20-P1-HB

O. barthii, the closest wild relative of *O. glaberrima*, making its way into NERICA

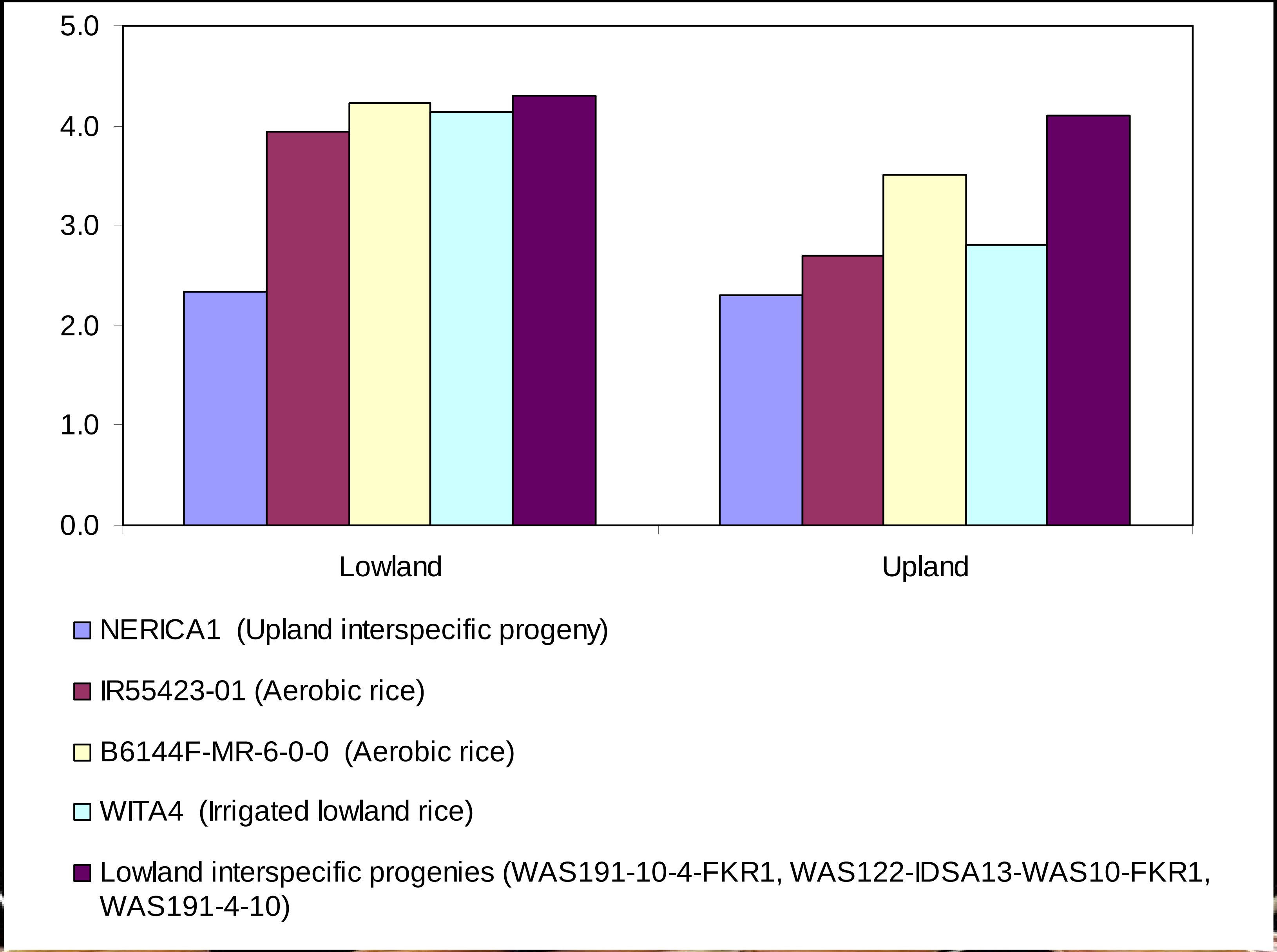
- Early maturity:

60-90 days after sowing

- High tillering ability
- Plasticity (rainfed-irrigated)
- Tolerance to blast/drought
- Very good grain yield

- Long slender grains
- A new hull color
- Large panicles

Yields of selected rice cultivars under upland and lowland conditions



Highlights: Varietal resistance / tolerance to stem borers

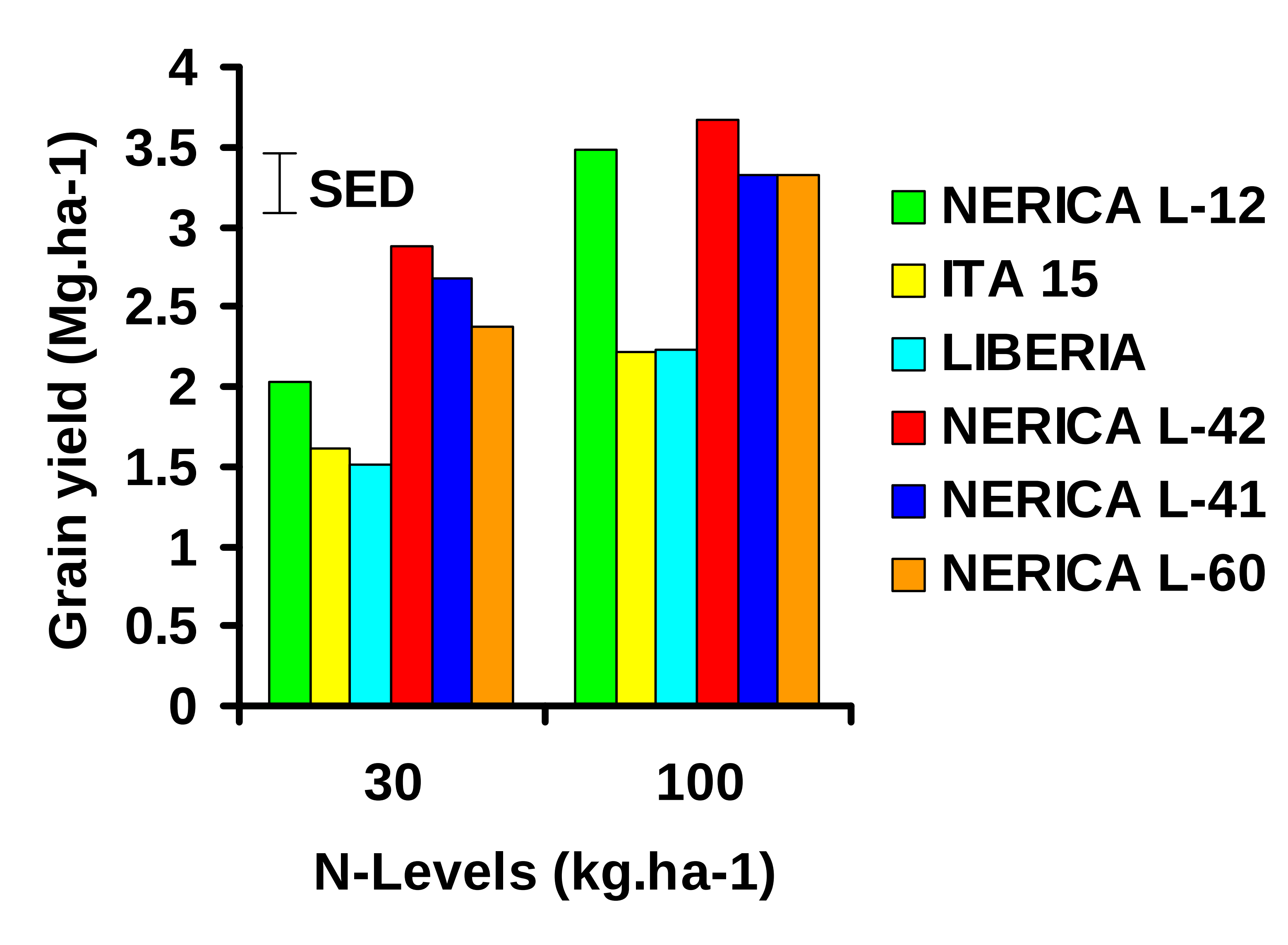
- NERICAs 14, 13, 9, 6, 5 and 1 had less than 10% tiller infestation (deadhearts & whiteheads). Of these, NERICA 14 was rated as the most resistant variety

- *Maliarpha separatella* was the most predominant species followed by *Sesamia* species

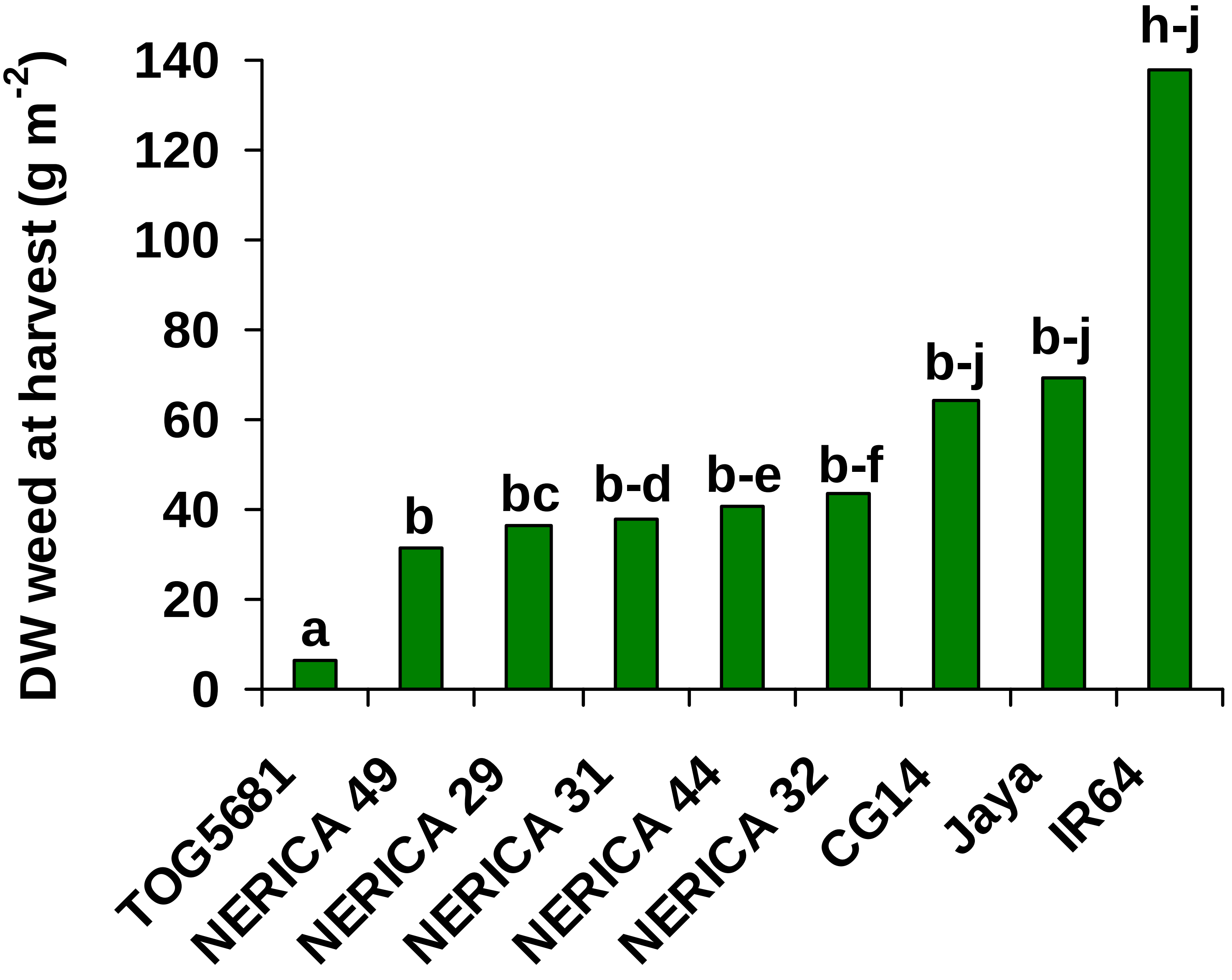
Highlights: Termites

- Neem oil and garri coated with furadan were more effective in the control of termites across the treatments with an attack range of 6.5 to 27.5% followed by neem powder, pawpaw with red palm oil and control
- NERICA 5 was consistently better than all other varieties across the treatment followed by NERICAs 3 and 2
- *Microtermes* was the predominant species followed by *Ancistrotermes, etc.*

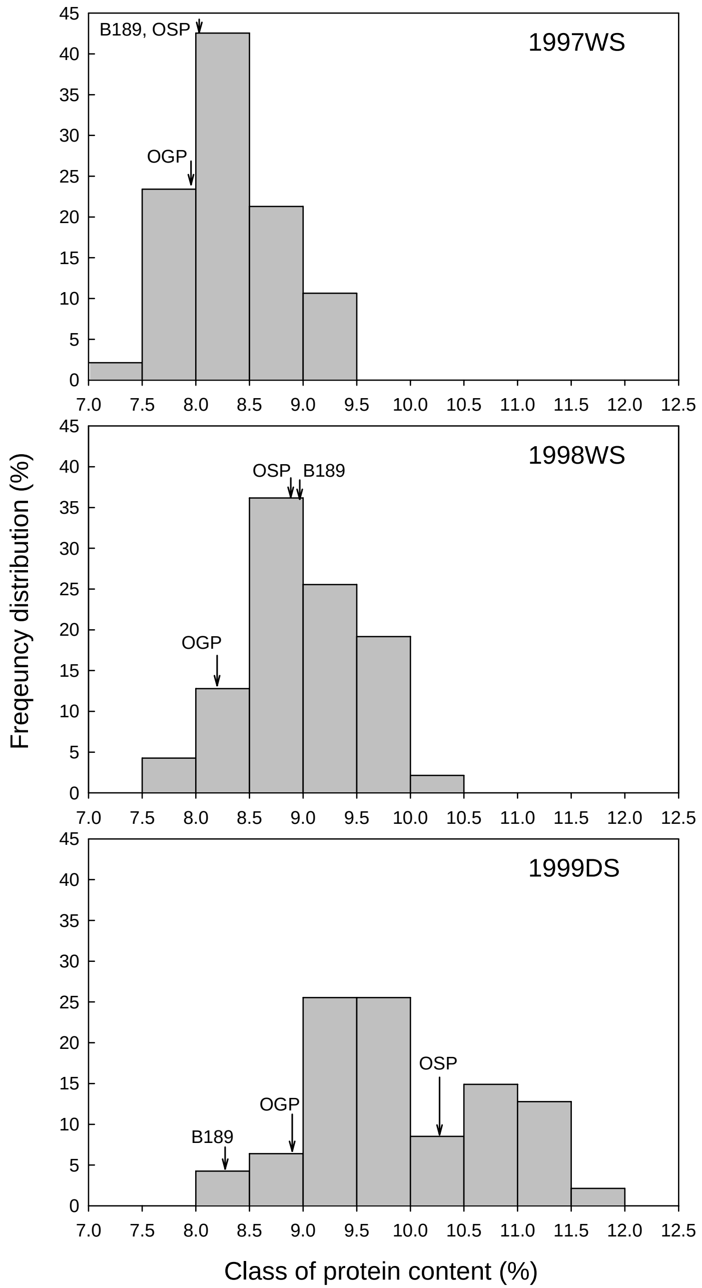
NERICA-L Vs. N Levels, On-farm



Lowland NERICA weed suppressiveness



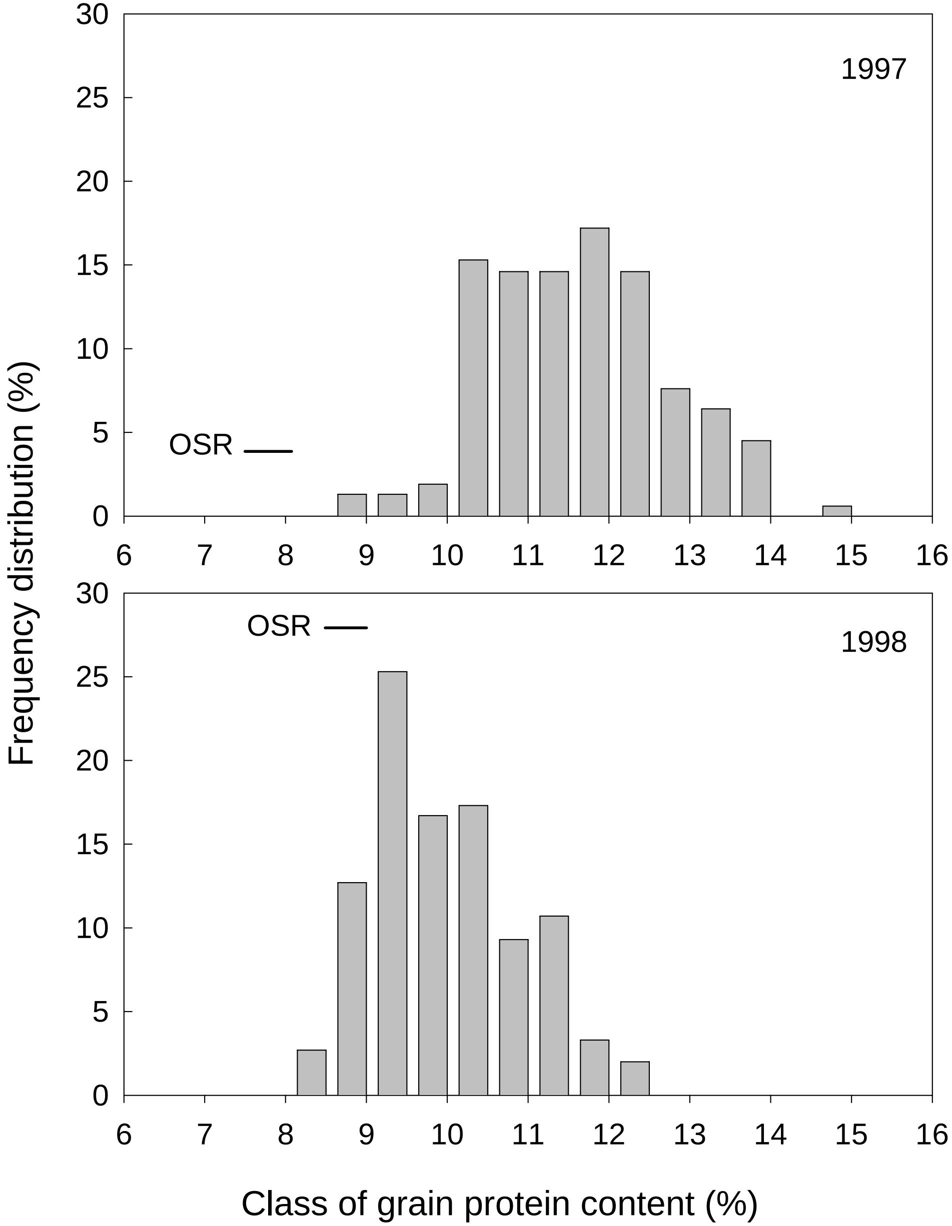
Protein content of NERICAs



OSP, *O. sativa* parent
OGP, *O. glaberima* parent
B189, Bouake 189

(Watanabe et al. 2006)

Protein content of *O. glaberrima*



OSR, *O. sativa*
Reference varieties

(Watanabe et al. 2004)

Challenges

Challenges

- Seed
- Natural resources management
- Policy
- Rice expansion to non-traditional regions
- Capacity building
- Climate change
- Unstable environments
- Doubling rice production by 2015

Seed

- Recurrent bottleneck
- Need for increased farmer access to improved seed
- Strengthen or develop national extension services
- Develop viable private seed sectors
- Improved ratio rice seed price to production costs for competitiveness

Natural Resource Management

- Soil fertility
- Water management
- IPM (insect pests, diseases, and weeds)
- Scaling-up ICM technologies

What could be done better in future?

- Capacity building
- Characterize more *glaberrima* germplasm for better “target” crosses
- Biotechnology research will help to reduce the cost of routine breeding operations in Africa
- Strengthening research on grain quality

…what could be done better in future?

- Sharing of facilities to reduce cost and for better cohesion: reduce duplication costs and build effectiveness through collaboration
- Unraveling the molecular/physiological basis of improved rice varieties
- Understanding the seed / input access syndrome
- Reducing the yield gap

WARDA
ADRAO

Thank you !