Sustainability and Security in Rice Agriculture - The case of water scarcity

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600 million tonnes for 2.6 billion people

Despite declining population growth rate and changing diets, more rice needed in future

Projected increase in demand for rice, 2005-2015

East Asia	-3%
Southeast Asia	11%
South Asia	13%
Central and West Asia	36%
Sub-Saharan Africa	49%
Latin America	17%
World	10%

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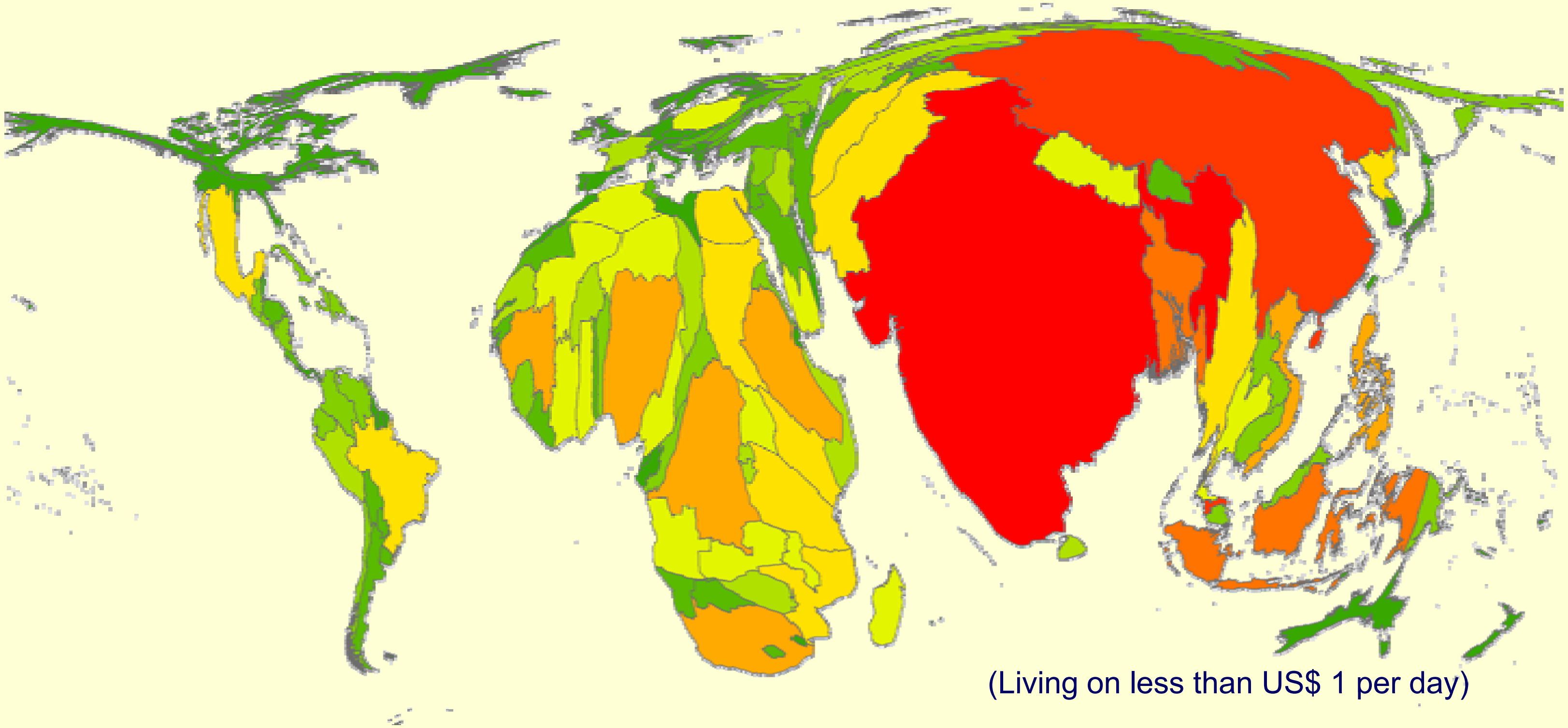
While much better off than 25 years ago, over one billion remain desperately poor



(Living on less than US$ 1 per day)

…and most live in Asia!

Poor rural rice producers need increased income

… while the urban poor demand cheap rice supplies.

Strategy

Increase food security

Alleviate poverty net rice consumers
Stimulate macro-economy

Alleviate poverty rice producers

Increase yield => keep price low

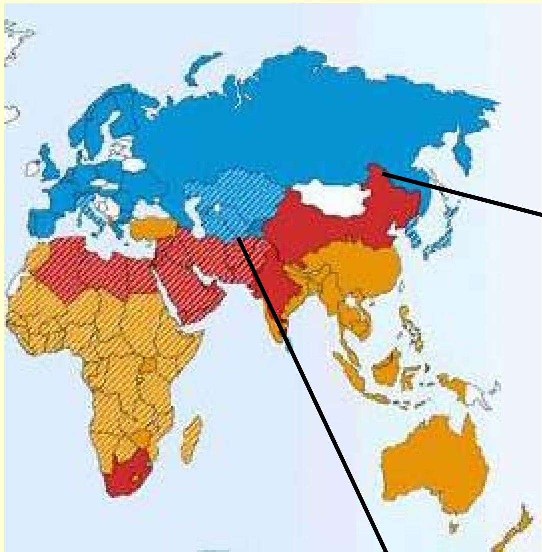
Increase factor productivity => reduce costs

Reduce environmental externalities

Some challenges ahead

- Increasing rice demand, decreasing production growth => Decrease world rice stocks
- Volatile prices
- Labor shortages and high wages
- Land shortage (land converted to other use, erosion)
- Water issues:
  - Shortage
  - Uncontrollable flooding
  - Salinity
- Climate change and variability

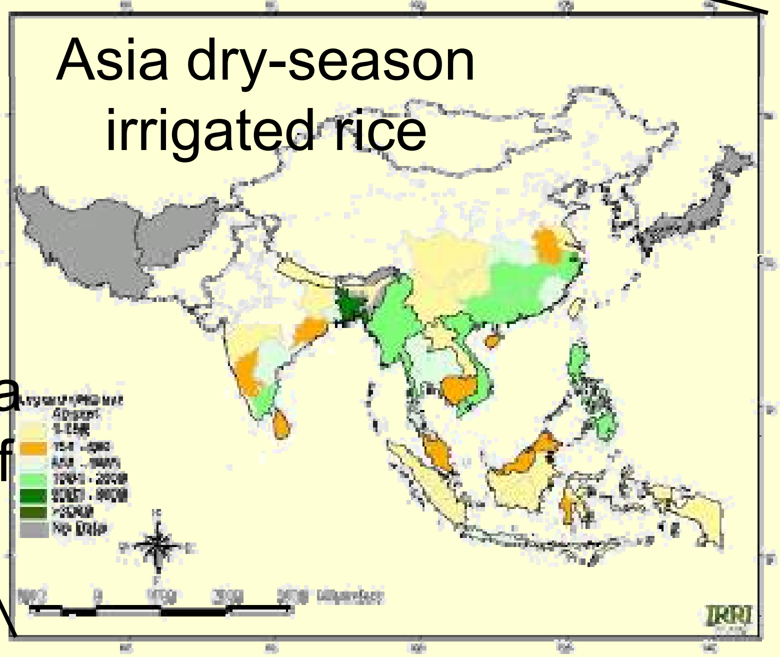
The problem of not enough water



Projected water scarcity
in 2025

IWMI Global Water Scarcity Study, 2000

- Irrigation: >80% of the freshwater resources in Asia
- By 2025, 15-20 million ha of irrigated rice will suffer some degree of water scarcity



IRRI database (GIS laboratory)

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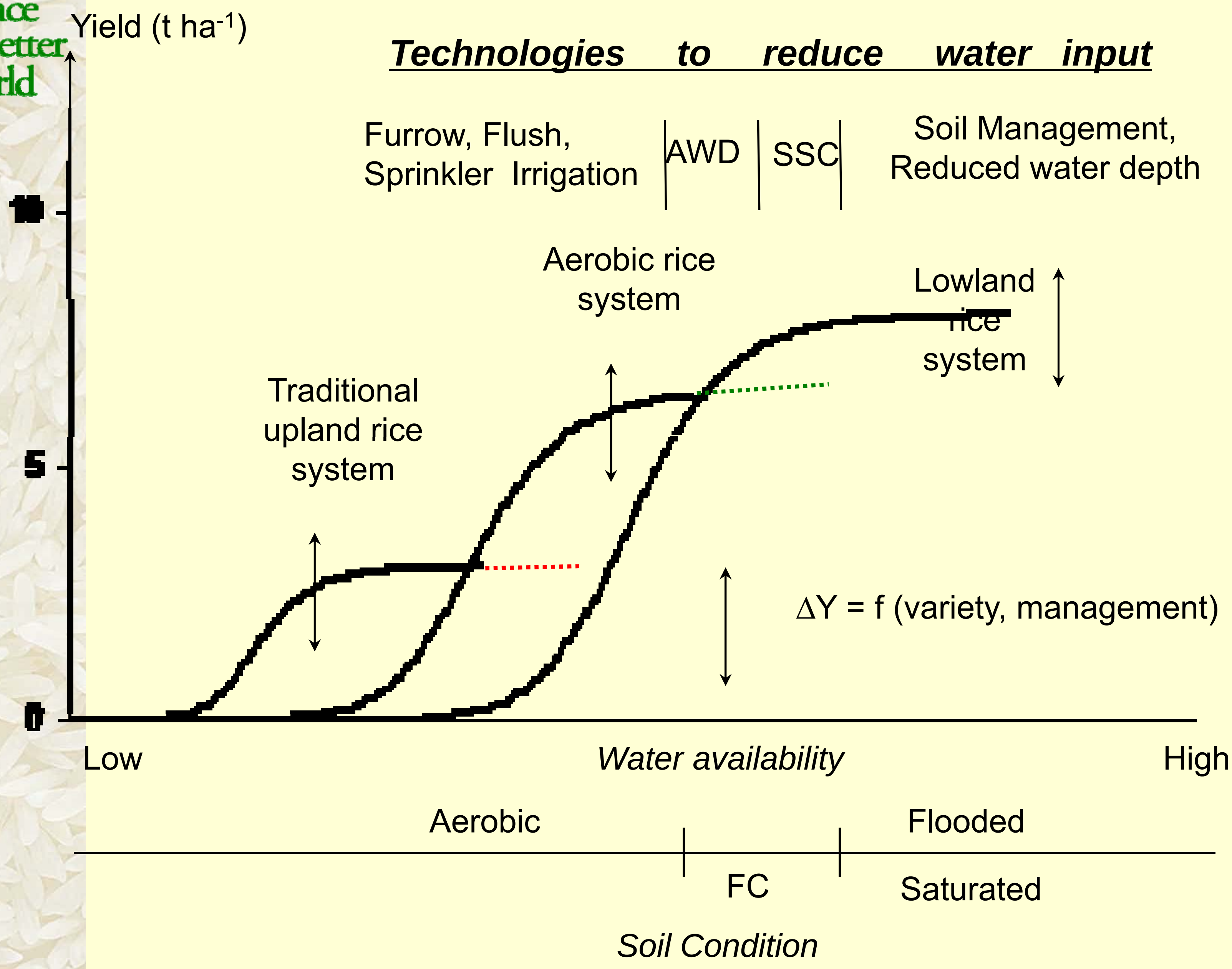
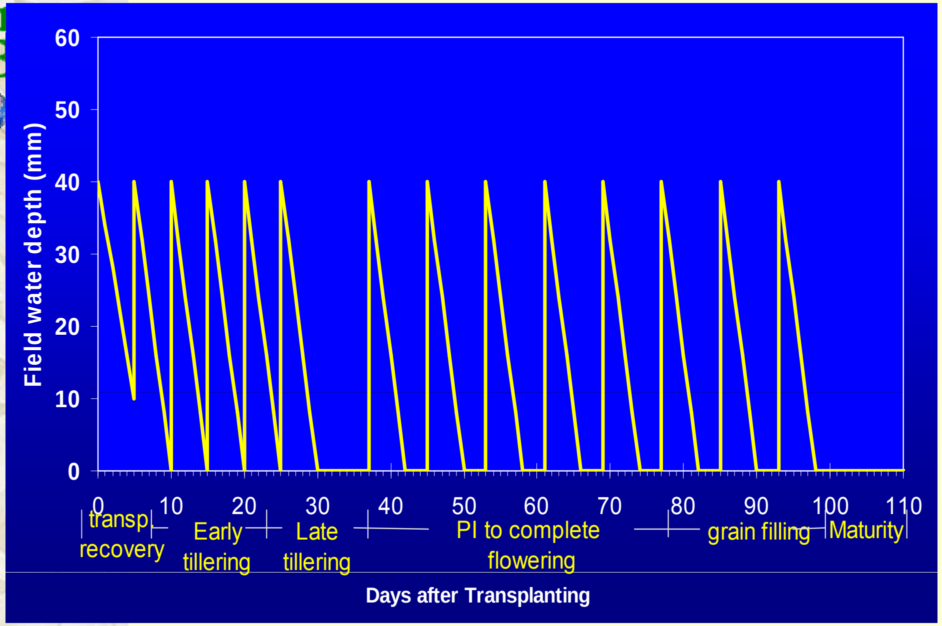
Technologies to reduce water input





Alternate wetting and drying (AWD)

Intermittent irrigation (II)

Controlled Irrigation (CI)

One of key components in SRI

“Safe AWD practice” using simple tool

1. Start 10 DAT or 20 DAS

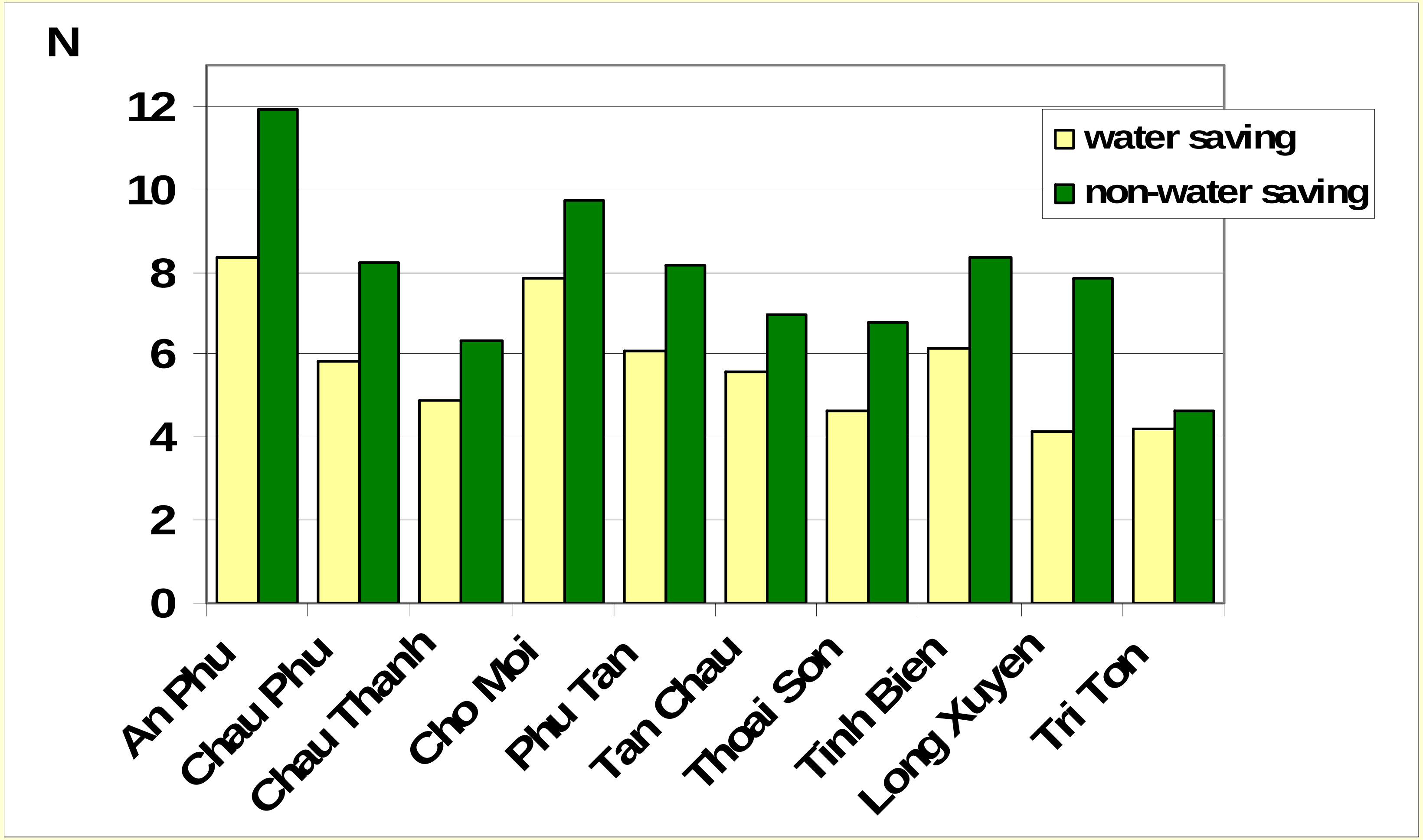
2. Irrigate when water is 15-20 cm deep (simple tool)

3. Keep 5-cm flooded at flowering

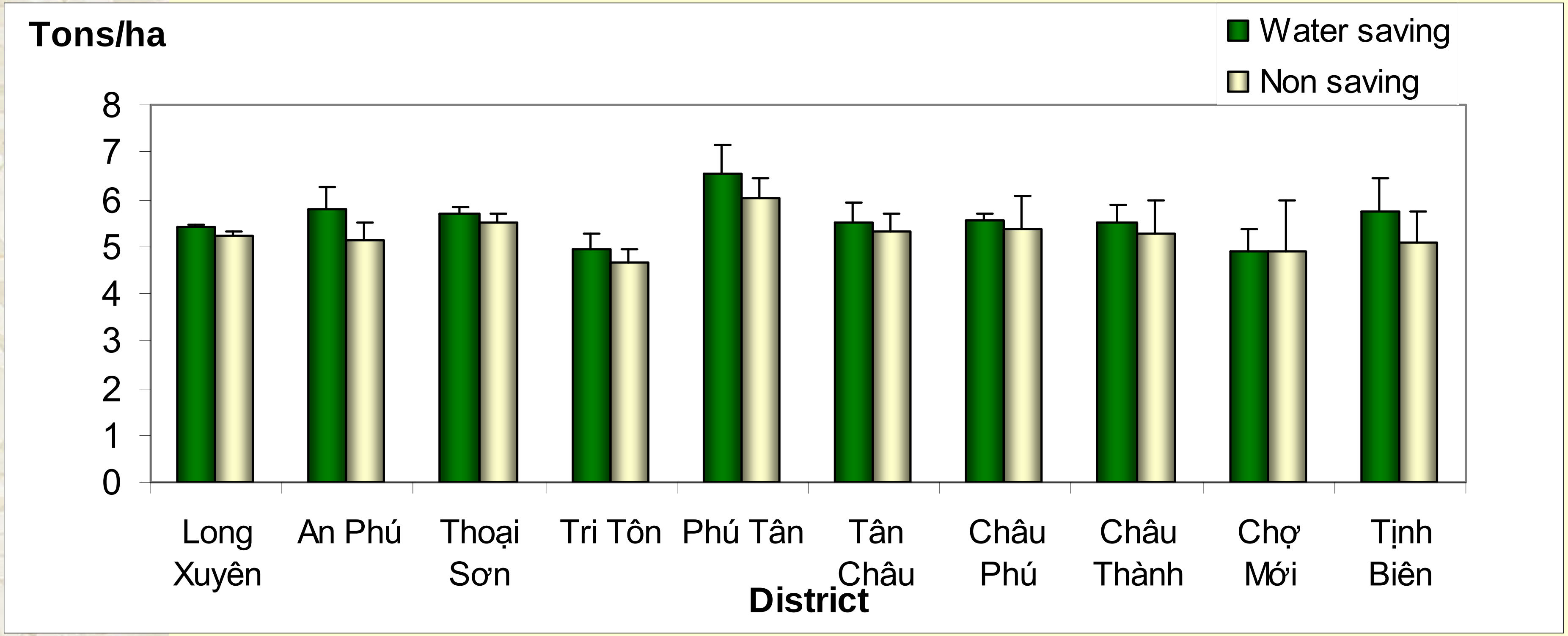
Main idea to convey:

- Water is there even when you can’t see it
- Create confidence by farmers
- Farmers then to experiment with threshold value
- No recipe for soil type, hydrology, variety, ..

Average number of pumping irrigation in water saving and non-water saving fields by district, An Giang Province, Vietnam (2006)



Yield under saving and non-water saving fields by district, An Giang Province, Vietnam (2006)



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Aerobic rice

Key characteristics: no puddling, no standing water, no soil saturation, dry land preparation, direct dry seeding, “high” inputs => high yields, special “aerobic rice” varieties

Target domain: water-short irrigated lands, favorable uplands and rainfed lowlands (where water is Insufficient to grow flooded rice)

Upland rice

Breeding: ——

Aerobic soil
Drought tolerant →
Weed competitive
Adverse soil conditions
Low inputs (!)
=> Stable but low yields

Unfavorable uplands

Different idea of rice like upland crop

Breeding: from upland rice…

Aerobic soil ← ***Lowland HYV traits***

Input responsive

Lodging resistant

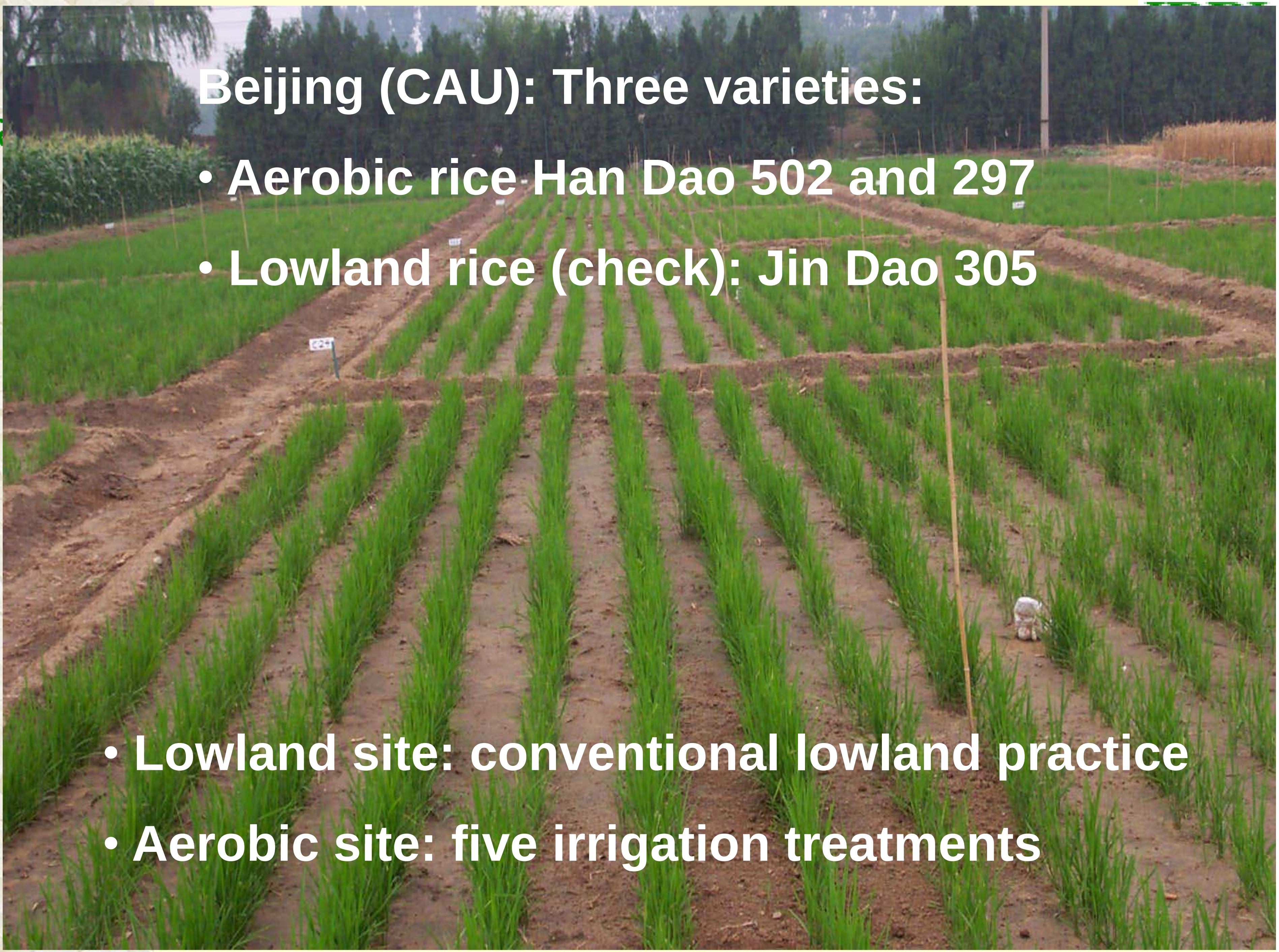
Weed competitive

=> Stable and high yields

↓

Water-short irrigated areas

'Favorable' uplands



Beijing (CAU): Three varieties:

- **Aerobic rice Han Dao 502 and 297**
- **Lowland rice (check): Jin Dao 305**

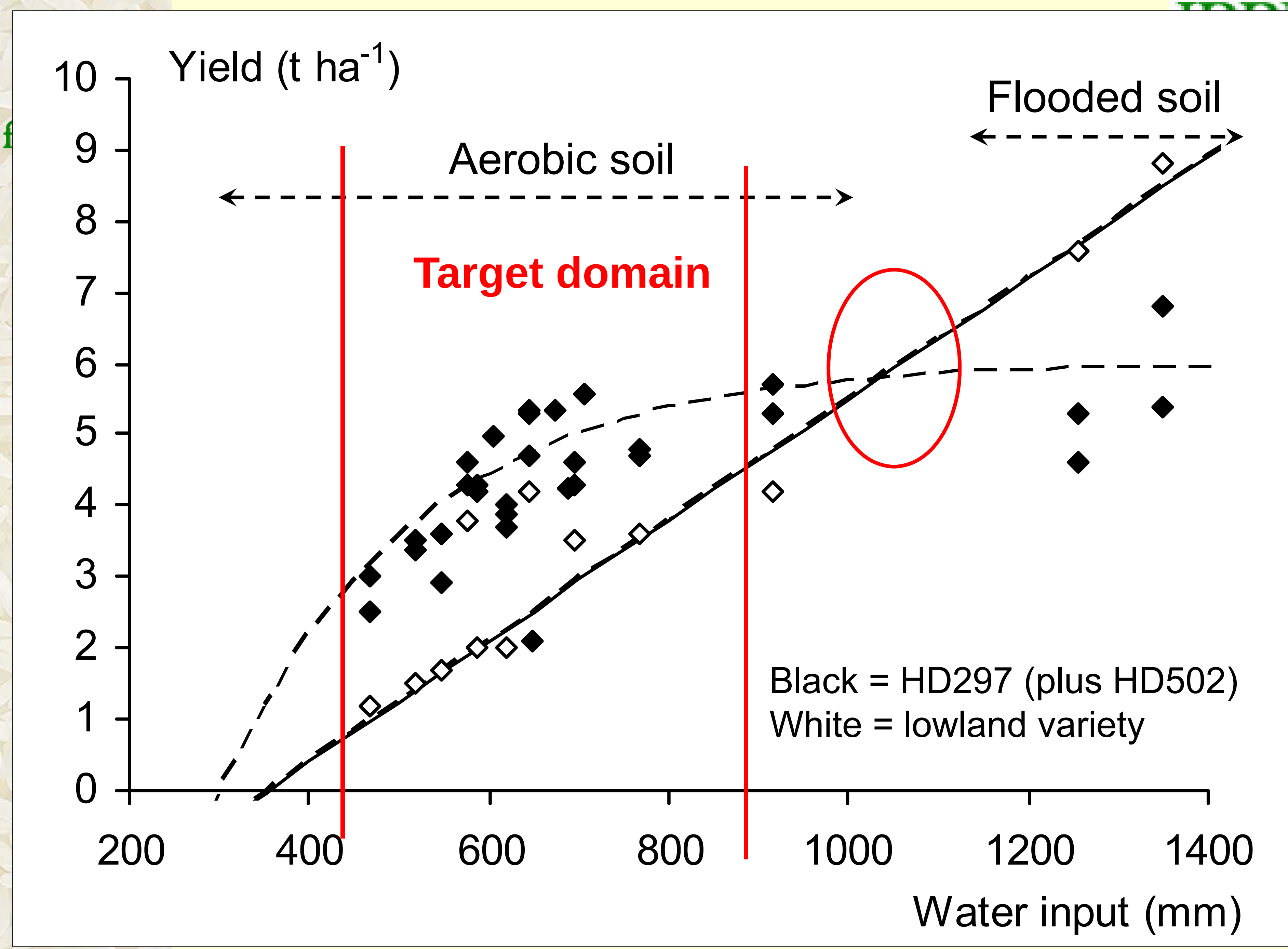
- **Lowland site: conventional lowland practice**
- **Aerobic site: five irrigation treatments**

Water input (rainfall + irrigation) mm

	2001	2002	2003	2004	2005	2006
Flood	1351	1255				
W0	644	769				
W1	577	708	688	705	668	550
W2	586	620	618	675	526	490
W3	519	695	648	645	484	450
W4	469	547	578	605		

Yield (t ha^{-1}) of HD297

	2001	2002	2003	2004	2005	2006
Flood	5.4	5.3				
W0	4.7	5.3				
W1	4.3	4.7	4.4	5.6	5.1	4.4
W2	4.2	3.9	3.4	5.4	4.7	4.3
W3	3.4	4.6	1.4	5.4	4.7	4.1
W4	2.5	3.0	0.5	5.0		


Yield (t ha-1)
10
9
8
7
6
5
4
3
2
1
0
200
400
600
800
1000
1200
1400
Water input (mm)
Aerobic soil
Flooded soil
Target domain
Black = HD297 (plus HD502)
White = lowland variety

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MEANS OF CROPS 2002	Lowland rice	Aerobic rice	Maize	Cotton
Field size (ha)	0.12	0.12	0.15	0.14
Grain yield (t/ha)	7.31	4.35	7.47	3.10
Irrigation (mm)	1407	217	77	79
Rainfall (mm)	337	337	337	337
Total water (I + R; mm)	1744	553	414	416
WP (g grain/ kg total water)	0.42	0.79	1.81	0.75
Input cost ($/ha)				
fertilizer	106	59	64	54
seeds	93	56	41	23
herbicide and pesticide	39	33	4	19
harvest	22	15	6	0
fuel (except irrigation)	25	37	11	0
irrigation (water, fuel)	94	30	13	11
Total input cost ($/ha)	379	230	140	106
Production value ($/ha)	1097	706	1071	1700
Net income ($/ha)	718	487	906	1594
Hired labor (d/ha)	0	6	0	0
Own labor (d/ha)	116	87	109	238
Net income, labor included	500	312	703	1147

Comparative profitability (US $) of rice production, 2005

	Aerobic Rice	Lowland Rice	Difference	
# of samples (n)	59	16		
Production Value	967	1,316	(349)	***
Total Cost	641	874	(232)	***
Fertilizer Cost	137	178	(41)	**
Pesticide Cost	38	33	5	
Labor Cost	285	460	(175)	**
Irrigation Cost	16	34	(18)	***
Other Cost[1]	165	168	(3)	
Gross Margin	325	442	(116)	

[1] Other cost include seed, power and food cost

Comparative profitability (US $) of other crops - 2005

	Corn	Soybean	Cotton	Peanut
# of samples (n)	101	43	9	7
Production Value	709	423	1,249	1,315
Total Cost	420	290	598	600
Fertilizer Cost	105	65	52	112
Pesticide Cost	11	7	28	6
Labor Cost	225	112	395	283
Other Cost[1]	66	106	121	199
Gross Margin	301	134	652	715

[1] Other cost include seed, power and food cost

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Yield potential and water use efficiency of aerobic rice (*Oryza sativa* L.) in Japan

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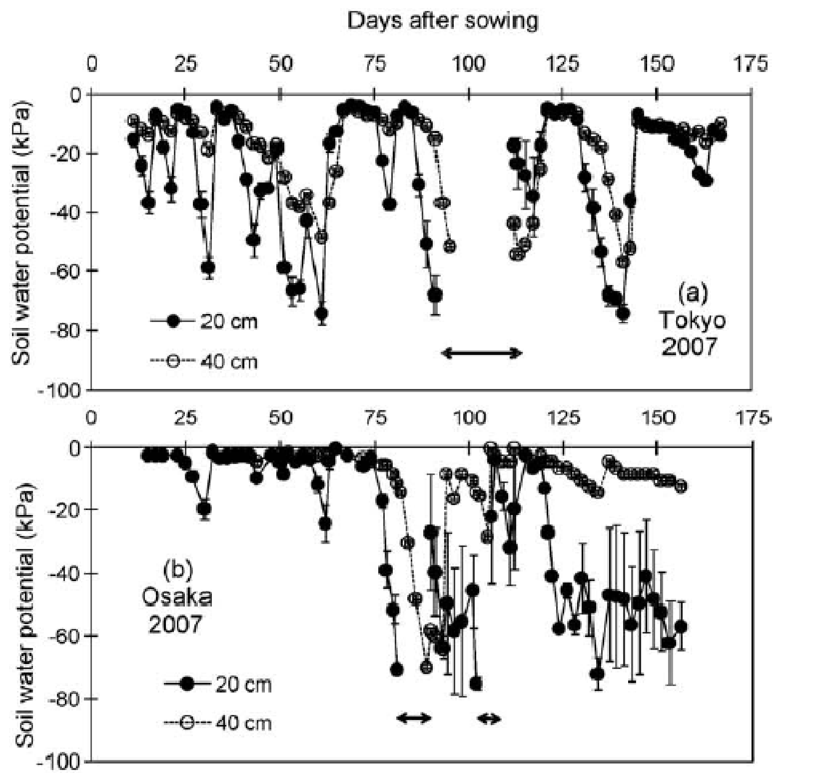
Comparing different varieties under flooded and aerobic conditions, Tokyo, Osaka 2007, 2008



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Aerobic Direct seeded

Flooded transplanted

Flooded Direct seeded

	Grain yield (t ha^{-1})				Water productivity (kg m^{-3})			
	Tokyo		Osaka		Tokyo		Osaka	
	2007	2008	2007	2008	2007	2008	2007	2008
ARDS								
Akihikari	7.4	8.7	6.6	7.3	0.89	0.72	0.84	0.64
IRAT109	7.9	9.0	7.2	9.4	0.90	0.75	0.89	0.82
Lemont	8.1	9.0	7.7	9.8	0.91	0.71	0.85	0.81
Takanari	6.6	10.6	11.4	11.3	0.65	0.82	1.25	0.86
LSD (5%)	0.5	0.7	0.8	1.9	0.05	0.06	0.09	NS
Mean	7.5	9.3	8.2	9.4	0.84	0.75	0.96	0.78
FLTP								
Akihikari	7.5	8.0	7.4	7.3	0.22	0.26	–	0.49
IRAT109	7.3	6.8	7.5	7.4	0.21	0.22	–	0.50
Lemont	7.0	6.8	6.4	7.0	0.20	0.21	–	0.45
Takanari	9.7	11.0	10.8	11.5	0.28	0.34	–	0.73
LSD (5%)	0.6	0.7	0 7	0.6	0.02	0.02	–	0.04
Mean	7.9	8.2	8.0	8.3	0.23	0.26	–	0.54
FLDS								
Akihikari	–	–	–	7.5	–	–	–	0.48
IRAT109	–	–	–	7.1	–	–	–	0.45
Lemont	–	–	–	7.3	–	–	–	0.45
Takanari	–	–	–	9.8	–	–	–	0.58
LSD (5%)				1.1				0.07
Mean				7.9				0.49
Water regime	NS	0.4	NS	0.6	0.03	0.02	–	0.05
Variety	0.4	0.4	0.5	0.7	0.02	0.03	–	0.05
Variety × water	0.5	0.6	0.7	1.1	0.03	NS	–	0.09

Grain yield (unhusked) is expressed at 14% moisture content.

Conclusions

Need to increase rice productivity

Water scarcity increasing and affecting rice growing areas

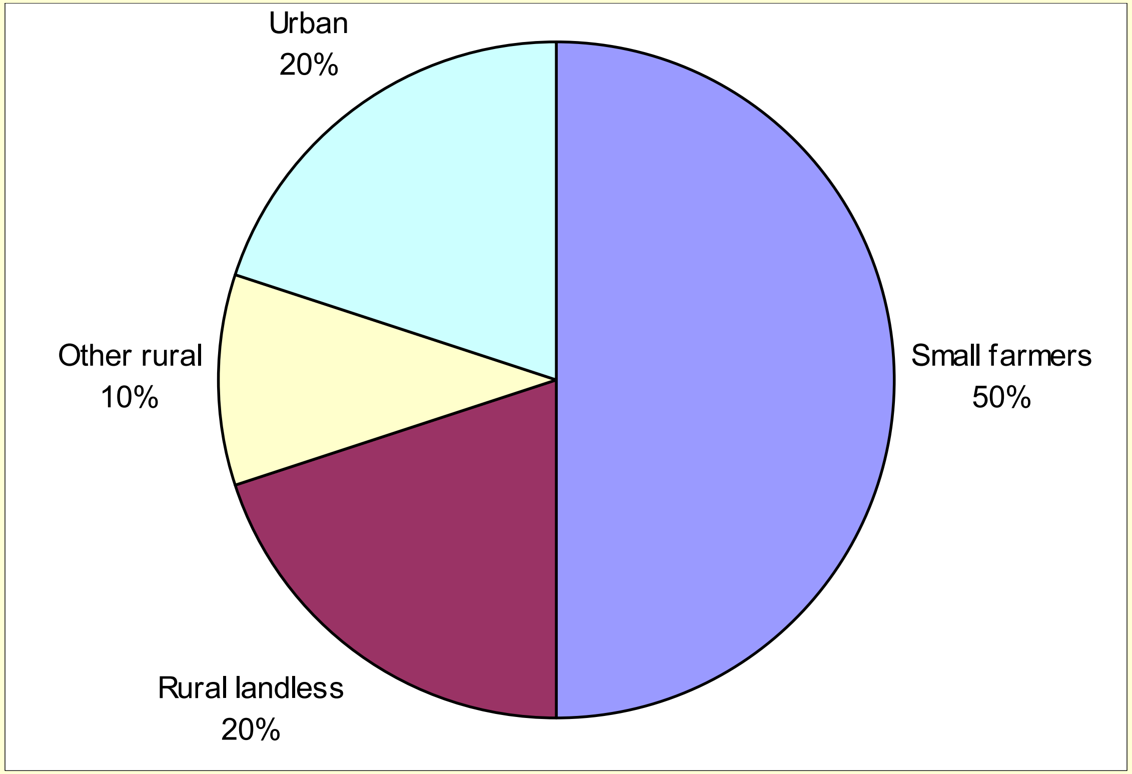
Response options available

some ‘ready to go’ (AWD)

some require further research (AR)

50% of worlds hungry are net staple food consumers and stand to loose

50% smallholders stand to gain (depending on cost/benefit ratio)



Estimates, Millennium Project, Task Force Hunger, 2005)

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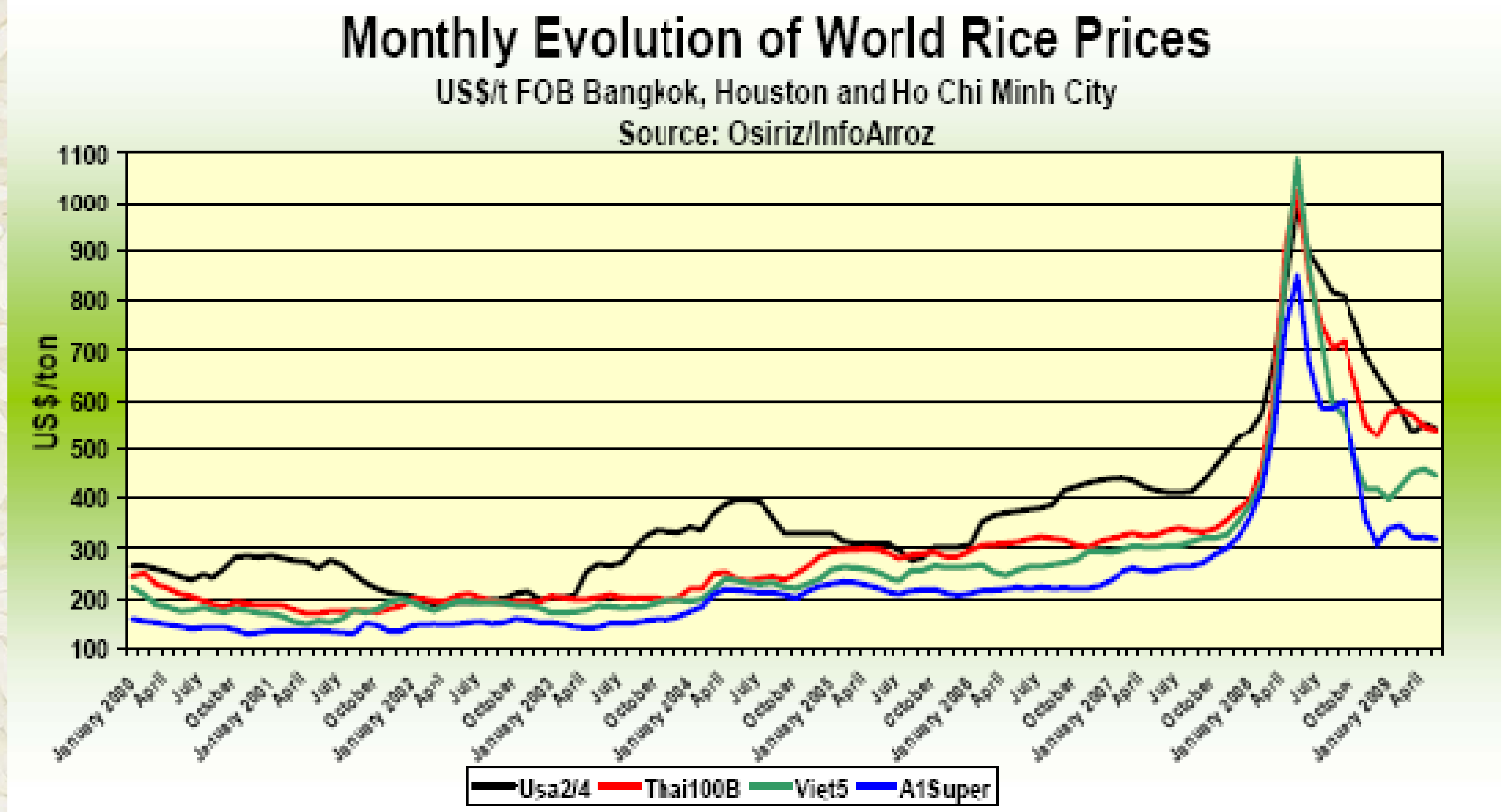
A balancing act…



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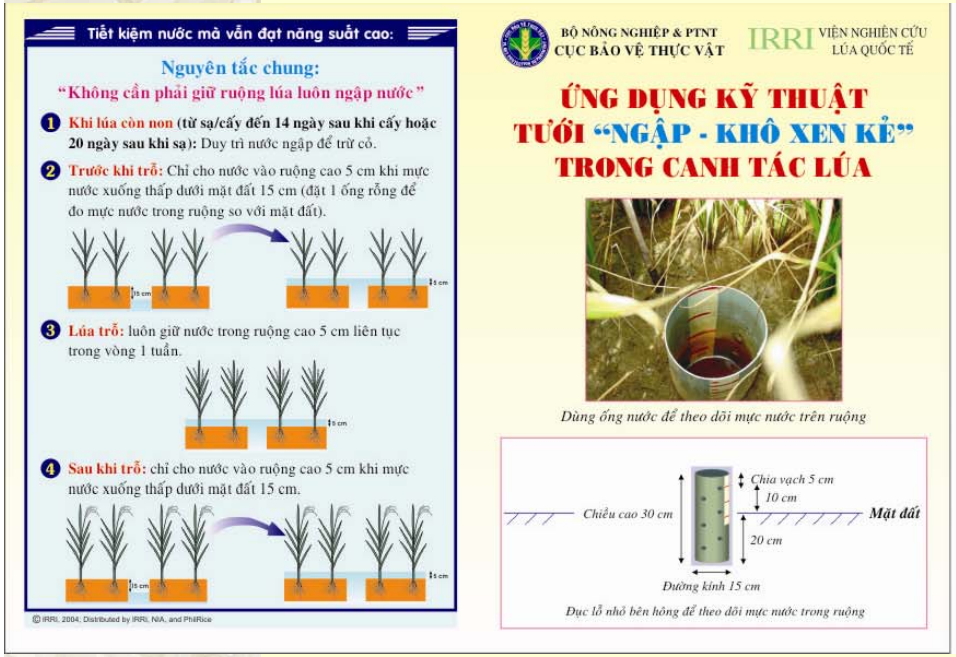

Tiết kiệm nước mà vẫn đạt năng suất cao:
Nguyên tắc chung:
"Không cần phải giữ ruộng lúa luôn ngập nước"
1 Khi lúa còn non (từ sạ/cấy đến 14 ngày sau khi cấy hoặc 20 ngày sau khi sạ): Duy trì nước ngập để trừ cỏ.
2 Trước khi trổ: Chỉ cho nước vào ruộng cao 5 cm khi mực nước xuống thấp dưới mặt đất 15 cm (đặt 1 ống rỗng để đo mực nước trong ruộng so với mặt đất).
3 Lúa trổ: luôn giữ nước trong ruộng cao 5 cm liên tục trong vòng 1 tuần.
4 Sau khi trổ: chỉ cho nước vào ruộng cao 5 cm khi mực nước xuống thấp dưới mặt đất 15 cm.
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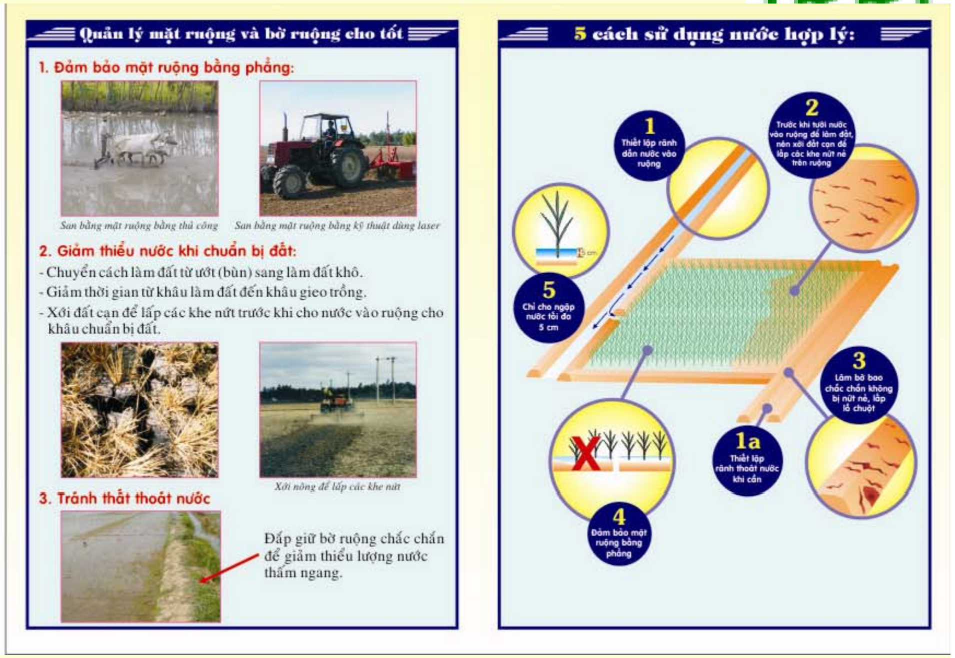
BỘ NÔNG NGHIỆP & PTNT
CỤC BẢO VỆ THỰC VẬT
IRRI VIỆN NGHIÊN CỨU LÚA QUỐC TẾ
ỨNG DỤNG KỸ THUẬT TƯỚI "NGẬP - KHÔ XEN KẼ" TRONG CANH TÁC LÚA
Dùng ống nước để theo dõi mực nước trên ruộng
Chia vạch 5 cm
10 cm
Chiều cao 30 cm
Mặt đất
20 cm
Đường kính 15 cm
Đục lỗ nhỏ bên hông để theo dõi mực nước trong ruộng



Quản lý mặt ruộng và bờ ruộng cho tốt
1. Đảm bảo mặt ruộng bằng phẳng:
San bằng mặt ruộng bằng thủ công
San bằng mặt ruộng bằng kỹ thuật dùng laser
2. Giảm thiểu nước khi chuẩn bị đất:
- Chuyển cách làm đất từ ướt (bùn) sang làm đất khô.
- Giảm thời gian từ khâu làm đất đến khâu gieo trồng.
- Xới đất cạn để lấp các khe nứt trước khi cho nước vào ruộng cho khâu chuẩn bị đất.
Xới nông để lấp các khe nứt
3. Tránh thất thoát nước
Đắp giữ bờ ruộng chắc chắn để giảm thiểu lượng nước thấm ngang.
5 cách sử dụng nước hợp lý:
1 Thiết lập rãnh dẫn nước vào ruộng
2 Trước khi tưới nước vào ruộng để làm đất, nên xới đất cạn để lấp các khe nứt nẻ trên ruộng
3 Làm bờ bao chắc chắn không bị nứt nẻ, lấp lỗ chuột
1a Thiết lập rãnh thoát nước khi cần
4 Đảm bảo mặt ruộng bằng phẳng
5 Chỉ cho ngập nước tối đa 5 cm

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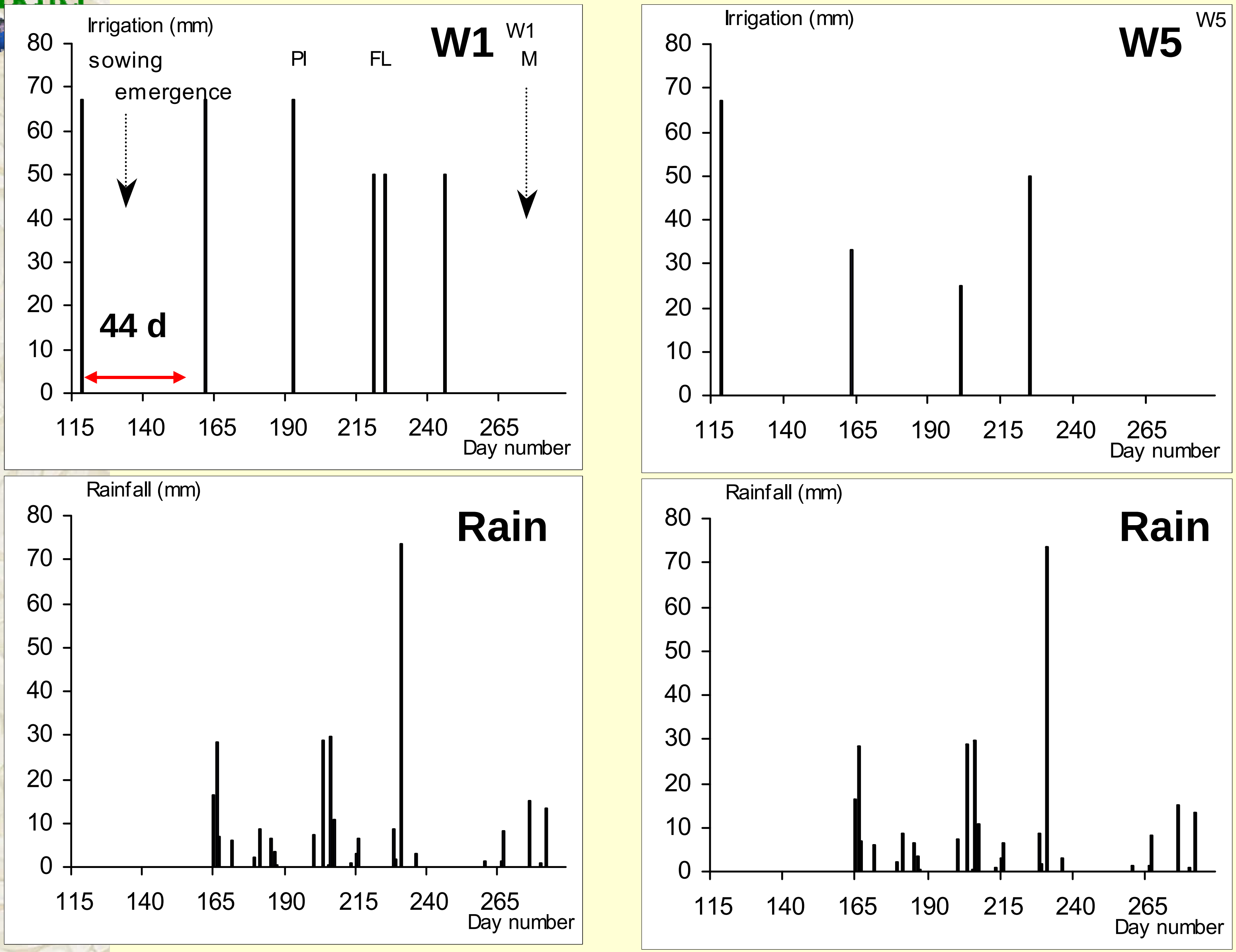
Dissemination in Vietnam, 2005

- Red River Delta: Yên Mỹ district, Hưng Yên(Xuân crop) & Văn Giang district, Hưng Yên (Mùa crop).
- Central North: Hưng Nguyên district, Nghệ An & Đông Sơn district, Thanh Hoá (Mùa crop)
- Central Coast: La Hà corporative, Quảng Ngãi & Quế Xuân 1 corporative, Quảng Nam (AS crop)
- MRD: Mỹ Thới, Long Xuyên, An Giang & Gò Công Tây, Tiền Giang (AS crop)

Different amount and timing irrigation

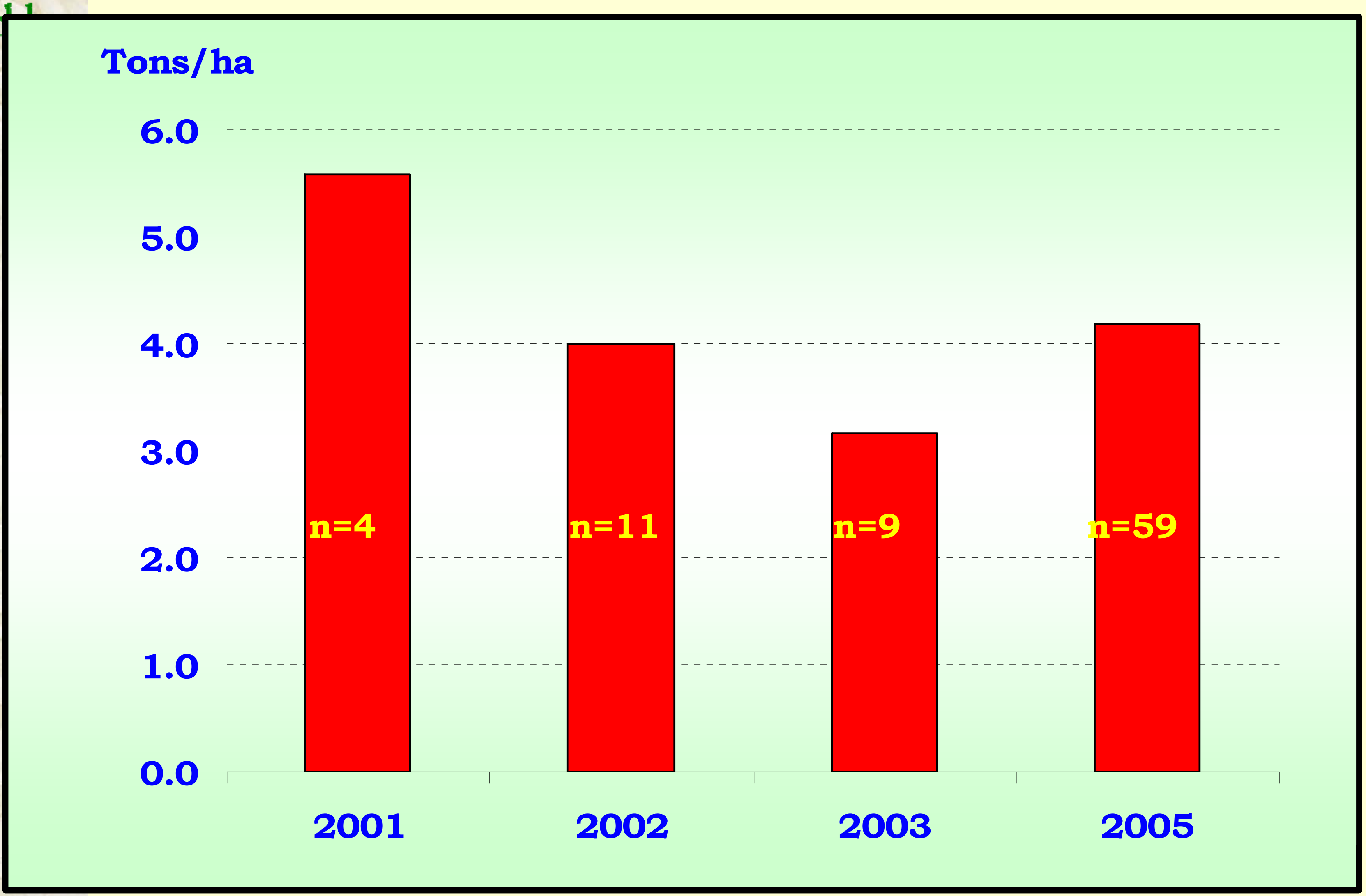
2001



Destroyed cotton and maize fields by flooding, 2004

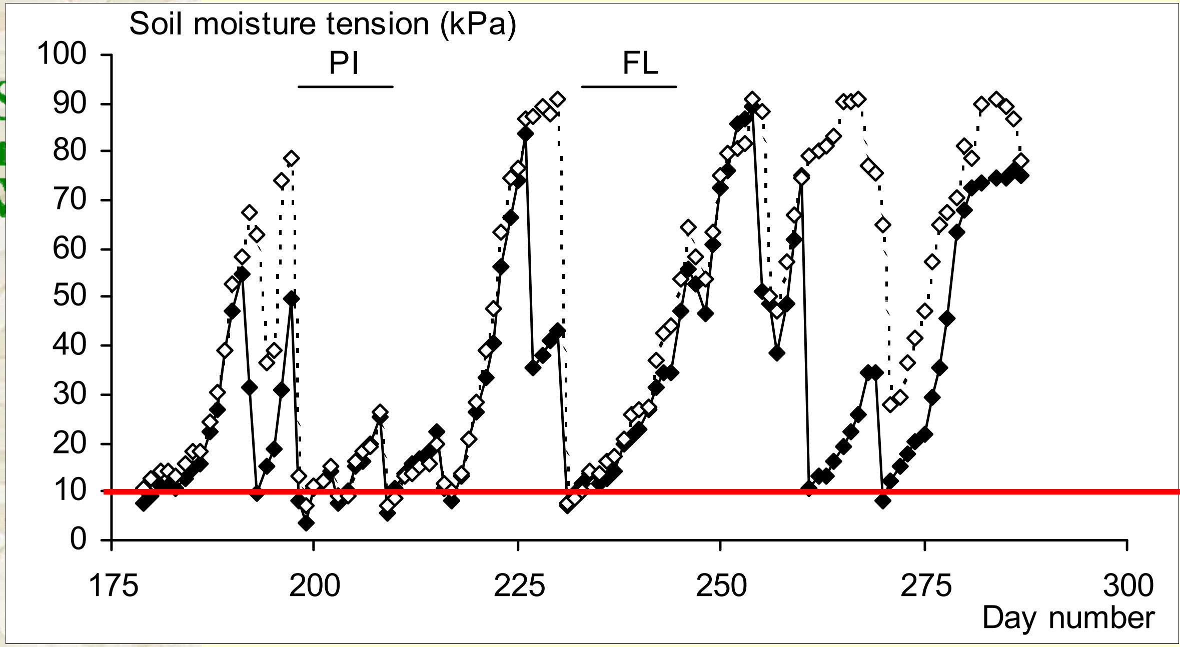
Destroyed sesame and maize fields by flooding, 2002

Yield of aerobic rice, various sites N China 2001-2005



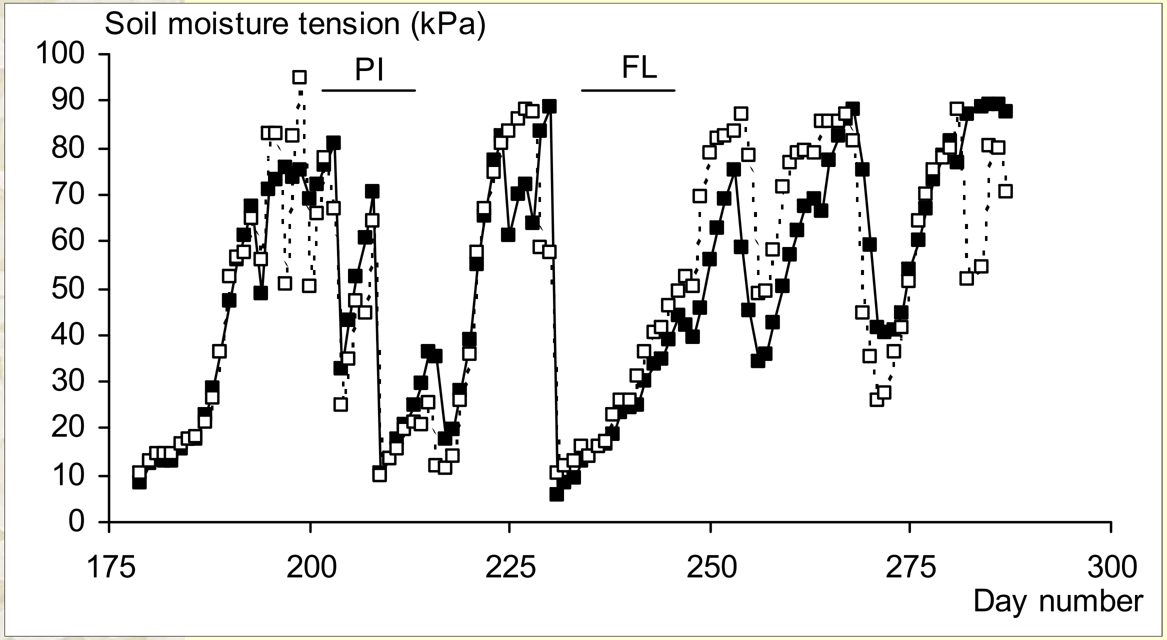
Very dry soil!

Soil moisture tension at 20 cm; 2001



Field capacity

W1, W2



W3, W5