High-Level CSD Inter-sessional Meeting:

African Agriculture in the 21st Century:

Meeting the Challenges, Making a Sustainable Green Revolution

Windhoek, Namibia

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Integrating New Knowledge and Experience in Soil and Crop Sciences to Achieve More Productive and Sustainable Agriculture in Africa:

Learning from the System of Rice Intensification (SRI) from Madagascar

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Story of SRI from Madagascar

The **System of Rice Intensification** (also known as *le Systéme de Riziculture Intensive*) was developed in Madagascar in the 1980s by Fr. Henri de Laulanié, SJ, after two decades of working with small farmers to improve their production and incomes without need for buying commercial inputs

Fr. de Laulanié making field visit before his death in 1995

Sebastien Rafaralahy and Justin Rabenandrasana,
Association Tefy Saina, Antananarivo

SRI evaluation in area around Ranomafana Natl. Park

Average paddy yield = 2 t/ha

NCSU evaluated the soils in area:

- pH = 3.8-5.0
- CEC= low to very low in all horizons
- Iron (Fe) and aluminum toxicity
- Available phosphorus = 3-4 ppm
  10 ppm is minimum P expected for

Results with SRI methods around Ranomafana Natl. Park

1994-95	38 farmers	8+ t/ha
1995-96	68 farmers	8+ t/ha
1996-97	78 farmers	8+ t/ha

- With no change in varieties
- No inputs of mineral fertilizer

How was this possible? 4x more is not just 'measurement error'

'Phosphorus Solubilization in Rewetted Soils,' *NATURE*, May 17, 2001

Three-year evaluation of P in the soil solution at 29 locations in England and Wales:

Soils *alternately wetted and dried* had P levels that 185 to 1,900% higher than in same soils when they were *either* wet *or* dry

Contribution of soil microorganisms

ENDOPHYTIC *AZOSPIRILLUM*, TILLERING, AND RICE YIELDS WITH CULTIVATION PRACTICES AND NUTRIENT AMENDMENTS

Results of replicated trials at Anjomakely, Madagascar, 2001 (Andriankaja, 2002)

CLAY SOIL (Methods of cultivation)	*Azospirillum* in roots (10^3/mg)	Tillers/ plant	Yield (t/ha)
Usual with no amendments	65	17	1.8
SRI with no amendments	1,100	45	6.1
SRI with NPK added	450	68	9.0
SRI methods with compost	1,400	78	10.5
LOAM SOIL			
SRI with no amendments	75	32	2.1
SRI methods with compost	2,000	47	6.6

Increasing evidence in favor of agroecological approach

Not to the exclusion of other approaches, but capitalizing upon expanding knowledge of:

- Soil (micro)biology,
- Soil ecology, and
- Epigenetics

- Of special relevance to Africa !

First Proposition:

If we take all of the soil science research for the last 50 years in the whole world:

- 60-70% is soil chemistry
- 25-30% is soil physics, but
- < 10% is soil biology

To date, nobody has challenged this estimate

Second Proposition:

If we take all of the plant science research for the last 50 years in the whole world:

- 90-95% is above-ground and
- <5-10% is below ground

Nobody has disputed this estimate either -- These disproportions are unjustified and unfortunate

Roles of microorganisms – below and above ground

- Nitrogen fixation
- Phosphorus solubilization
- Nutrient cycling
- Access to water and nutrients
- Phytohormone production
- Induced systemic resistance

'Ascending Migration of Endophytic Rhizobia, from Roots and Leaves, inside Rice Plants and Assessment of Benefits to Rice Growth Physiology'

Rhizo-bium test strain	Total plant root volume/ pot (cm^3)	Shoot dry weight/ pot (g)	Net photo-synthetic rate ($\mu mol^{-2}\ s^{-1}$)	Water utilization efficiency	Area (cm^2) of flag leaf	Grain yield/ pot (g)
Ac-ORS571	210 ± 36^{A}	63 ± 2^{A}	16.42 ± 1.39^{A}	3.62 ± 0.17^{BC}	17.64 ± 4.94^{ABC}	86 ± 5^{A}
SM-1021	180 ± 26^{A}	67 ± 5^{A}	14.99 ± 1.64^{B}	4.02 ± 0.19^{AB}	20.03 ± 3.92^{A}	86 ± 4^{A}
SM-1002	168 ± 8^{AB}	52 ± 4^{BC}	13.70 ± 0.73^{B}	4.15 ± 0.32^{A}	19.58 ± 4.47^{AB}	61 ± 4^{B}
R1-2370	175 ± 23^{A}	61 ± 8^{AB}	13.85 ± 0.38^{B}	3.36 ± 0.41^{C}	18.98 ± 4.49^{AB}	64 ± 9^{B}
Mh-93	193 ± 16^{A}	67 ± 4^{A}	13.86 ± 0.76^{B}	3.18 ± 0.25^{CD}	16.79 ± 3.43^{BC}	77 ± 5^{A}
Control	130 ± 10^{B}	47 ± 6^{C}	10.23 ± 1.03^{C}	2.77 ± 0.69^{D}	15.24 ± 4.0^{C}	51 ± 4^{C}

Feng Chi et al., *Applied and Envir. Microbiology* 71 (2005), 7271-7278

What Is Agroecology?

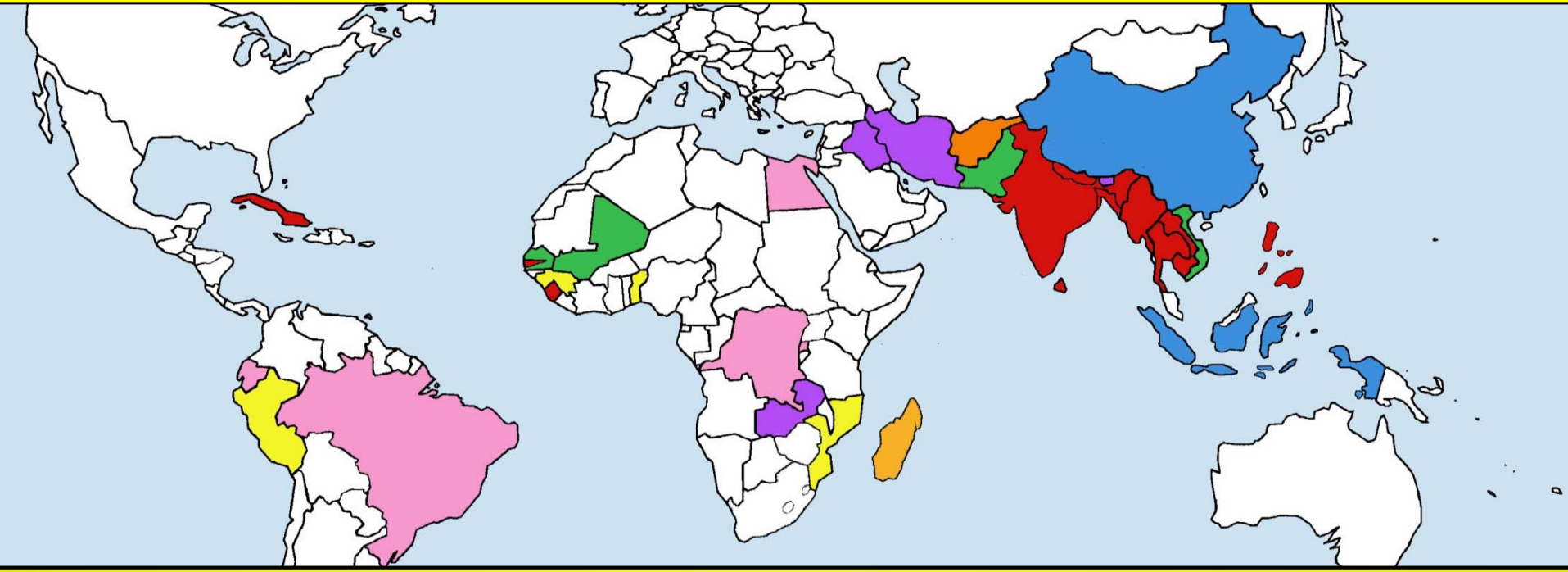
- Starts with understanding that crops and animals do not exist in isolation from environment
- Manage growth environment to capture benefits of symbiosis and synergy, nutrient cycling, energy conservation, etc.
- *Plants are not 'little machines'*

What Is Agroecology?

- Both plants and animals are *thoroughly dependent on* and *interdependent with* microbes
- The 'tree of life' diagram used in science classes is good taxonomy -- but poor biology
- Plants and animals are really systems, rather than organisms

Up to 1999: SRI was known and practiced only in Madagascar

2009: SRI benefits have been validated in 35 countries of Asia, Africa, and Latin America



Before 1999: Madagascar
1999-2000: China, Indonesia
2000-01: Bangladesh, Cuba Cambodia, Gambia, India, Laos, Myanmar, Nepal, Philippines, Sierra Leone, Sri Lanka, Thailand
2002-03: Benin, Guinea, Mozambique, Peru
2004-05: Senegal, Mali, Pakistan, Vietnam
2006: Burkina Faso, Bhutan, Iran, Iraq, Zambia
2007: Afghanistan, Brazil
2008: Egypt, Rwanda, Costa, Rica, Ecuador, Timor Leste

> 1 million farmers/acres

INDONESIA: Rice plants of same age and same variety in Lombok province

Largest evaluation done in Indonesia: 9 seasons of on-farm comparisons Nippon Koei DISIMP team, 2002-06

- Number of trials: **12,133**
- Total area covered: **9,429.1 hectares**
- **78% yield increase** with SRI (**3.3 t/ha**)
- **40%** reduction in **water requirements**
- **50%** reduction in **fertilizer use**
- **20%** reduction in **costs of production**
- Net increase in **income/ha** up to **5x**

Two Paradigms for Agriculture:

- GREEN REVOLUTION strategy was to:
  (a) Change the genetic potential of plants, and
  (b) Increase the use of external inputs -- more water, more fertilizer and insecticides

- SRI (AGROECOLOGY) changes instead the management of plants, soil, water & nutrients:
  (a) Promote the growth of root systems, and
  (b) Increase the abundance and diversity of soil organisms to better enlist their benefits

The goal is to produce better PHENOTYPES

NEPAL:
Single rice plant grown with SRI methods, Morang district

IRAN:
SRI roots and normal, flooded rice roots: note difference in **color** as well as **size**

AFGHANI-STAN:
SRI plant with 133 tillers at 72 days after transplanting

Farmer's yield was calculated as 11.56 t/ha

AFGHANISTAN: Farmers planting 13-day seedlings in Baghlan Province at 1,700 masl – 10.2 tons/ha ave.

Can These Methods Work in AFRICA?

- Madagascar results not unique
- *Merits of SRI methods have been shown also in The Gambia, Sierra Leone, Guinea, Benin, Rwanda, DR Congo, Zambia, Mozambique, maybe elsewhere*

THE GAMBIA: SRI trial plot at Sapu Agricultural Research Station, 2000

Dr. Mustapha Ceesay, Director of Research and Development, National Agricultural Research Institute, in SRI plot at Sapu

"The effects of repeated soil wetting and drying on lowland rice yield with System of Rice Intensification (SRI) methods"
Mustapha Ceesay, W.S. Reid, E.C.M. Fernandes, and N. Uphoff
INTL. JOURNAL OF AGRIC. SUSTAINABILITY (2006)

METHOD (water applied)	Spacing	Yield (tons/ha)	Water productivity (kg/water)	Total production cost ($/ha)	Net returns ($/ha)
CONTIN. FLOODING (1800 mm)	20x20	2.5	0.14	120	105
	30x30	1.7	0.09	115	38
	40x40	1.3	0.07	110	7
Average		1.8	0.10	115	50
SRI (1000 mm)	20x20	7.3	0.73	120	537
	30x30	6.6	0.66	110	484
	40x40	4.7	0.47	105	318
Average		6.2	0.62	112	446

Data reported are average for 3 cultivars (ET 3137, ITA 306, BG90-2) from 3 seasons (2000, 2001, 2002)

February 6, 2004

New Techniques Improve Rice Harvest in Rural Sierra Leone

A new "System of Rice Intensification“ being promoted in lowland swamps by USAID partner World Vision is improving rice harvests in rural Sierra Leone.

In Wanjama village, the rice harvest is bountiful this year, thanks to the System of Rice Intensification (SRI) introduced around the rural Kono area by USAID-sponsored non-governmental Agency World Vision. By using good-quality seeds from the southern districts of Sierra Leone, 6 kg of rice are typically producing 55-60 bushels of rice, a harvest that is being celebrated in the area as farmers resume their agricultural activities after the war.....

SIERRA LEONE: USAID magazine, *Reintegration*, 2/6/04

Yield and yield components of rice grown with SRI and farmers' practice, World Vision program, Sierra Leone, 2001

	SRI Techniques (N=8)		Farmer Techniques (N=8)	
	Mean	Range	Mean	Range
Hills/m^2	16	10 – 25	52	42 – 64
Tillers/hill	38	20 – 69	8.6	8 – 9
Panicles/hill	28	20- 45	6.5	6-7
Spikes/panicle	122	118 – 149	95	83 - 120
Yields (t/ha)	5.3	4.9 – 7.4	2.5	1.9 – 3.2

Data are from reports of 8 groups, each with 20 members, so the total number of farmer results was 160.

GUINEA: Test plot using SRI methods with Chinese hybrid variety – yield of 9.2 t/ha, 2003

MALI: SRI training program in Goundam circle, Timbuktu region, 2007


MALI: Mahamadou Hamadou
in his SRI field before harvest

Plant development with SRI, 2008
Shorter crop cycle by 1-2 weeks

Rice grain yield for SRI plots, control plots and farmer-practice plots, Goundam circle, Timbuktu region, Mali, 2008

	SRI	Control	Farmer Practice
Yield t/ha*	**9.1**	**5.49**	**4.86**
Standard Error (SE)	0.24	0.27	0.18
% Change compared to **Control**	+ 66	100	- 11
% Change compared to **Farmer Practice**	+ 87	+ 13	100
Number of Farmers	53	53	60

* adjusted to 14% grain moisture content

ZAMBIA: Land selection

by **Esek Farmers' Cooperative Society, Solwezi**, in **Northwest Province** -- a **food-deficit area** with WFP aid.

Current rice yields are **1-2 tons/hectare**

Land preparation

Land was leveled in readiness for water management and seedling transplanting. Pegs and measuring ropes were used to determine field size: 12.5 x 12.5 m. Field preparation was by hoes, shovels and rakes using human labor.

Nursery management

Sowing of seed in the nursery was on 10th December 2005, followed by careful watering, using tin cans. Weeds were removed by hand.

Transplantation

Transplanting was done 25th December 2005, 15 days after sowing of the seeds in nursery. Seedlings had 2-3 leaves, spacing 25x25 cm.

Water management

Zambia experiences annual rainfall of about 1,400 mm. However, there is the danger of water shortages. A dam was dug to supplement rainwater for SRI field. The field was kept wet for 6-7 days and was subsequently dried for 4 days.

Demonstration SRI plot at Solwezi in Northwest Province, >300 persons came to see harvest of yield (6.144 t/ha)

Can These Methods Work for OTHER CROPS?

Farmers and NGOs in India are now using these methods with:

- Wheat
- Finger millet
- Sugar cane
- Cotton
- Vegetables, etc.

SRI RAGI (FINGER MILLET), Rabi 2004-05
60 days after sowing – Varieties 762 and 708

Results of trials done by ANGRAU

VR 762

VR 708

***Age at which seedlings were transplanted from nursery**

SRI Ideas being Extended to Other Crops: Uttarakhand / Himachal Pradesh, India

Crop	No. of Farmers	Area (ha)	Grain Yield (t/ha)		% Incr.
2006			Conv.	SRI	
Rajma	5	0.4	1.4	2.0	43
Manduwa	5	0.4	1.8	2.4	33
Wheat	Research Farm	5.0	1.6	2.2	38
2007					
Rajma	113	2.26	1.8	3.0	67
Manduwa	43	0.8	1.5	2.4	60
Wheat (Irrig.)	25	0.23	2.2	4.3	95
Wheat (Unirrig.)	25	0.09	1.6	2.6	63

Rajma (kidney beans)

Manduwa (millet)

- URL for SRI website: http://ciifad.cornell.edu/sri/

- Email: ciifad@cornell.edu or ntu1@cornell.edu or
- Email: tefysaina.tnr@simicro.mg for Francophone communication