New Delhi, 29 June 2012

Food as Basic Human Right in India

M.S. Swaminathan, FRS
UNESCO Chair in Ecotechnology
M S Swaminathan Research Foundation, Chennai, India
Backdrop to India’s Independence
The Great Bengal Famine (1942-43)

“A hungry person listens neither to reason nor religion, nor is bent by any prayer”

Roman Philosopher Seneca
Some time between 1970 and 1985 the world will undergo vast famines — hundreds of millions of people are going to starve to death. That is, they will starve to death unless plague, thermonuclear war, or some other agent kills them first.

The United States should announce that it will no longer ship food to countries such as India where dispassionate analysis indicates that the unbalance between food and population is hopeless.
2012 : Year of Historic Transition

- From patronage to Right
- From Ship to Mouth to legal entitlement based on home grown food
- How did this transition come about?
From Teosinte to Maize

Beginning of the Green Revolution

Impact of Selection and breeding

Tian F. et al. PNAS; 2009; 106: 9979-9986
Daruma (Japanese semi-dwarf) X Fultz (U.S. winter wheat, high yield)

Fultz-Daruma (semi-dwarf, high yield)

Locals (adapted to U.S. Northwest) X Turkey Red (U.S. winter, high yield)

Norin 10 (semi-dwarf, winter, high yield) (Dr Gonziro Inazuka in 1935)

Gaines (semi-dwarf, winter, U.S. adapted) X Local Strains

New Wheats (semi-dwarf, high yield, adaptable, rust-resistant, fast-maturing, spring)
1962-63: Identification of the new plant type (dwarf stature coupled with long panicles)

1963-64: Visit of Dr Norman Borlaug: extensive multi-location trials of *Semi Dwarf Wheat* selections

1964-65: National Demonstrations in Farmers’ Fields, standardisation of agronomic and irrigation practices

1965-66: Selection of amber grain material, *Kalyan Sona* and *Sonalika*

1966-67: Import and planting of 18,000 tonnes of seeds of *Lerma Rojo 64-A* and other strains

1967-68: Quantum jump in production - onset of *Wheat Revolution*

The duty of scientists is not to predict the future, but to shape it.
Green Revolution Symphony (1968)

Major Components
- Technology
- Services
- Public Policies
- Farmers’ enthusiasm

Indian farmers achieved as much progress in wheat production in four years (1964–68), as during the preceding 4000 years.

Scientific skill, Political will and Farmers’ Toil: major ingredients of the revolution
Deployment of leaf rust resistance genes over North India

PBW 343 (Lr26+34+)
HD2687 (Lr26+34+)
WH 542 (Lr26+34+)
UP 2338 (Lr26+34+)

HS 365 (Lr26+1+)
HS 295 (Lr23+34+)
HPW 42 (Lr26+1+34+)

Annapurna-1 (Lr26+)
Annapurna-2 (Lr1+13)
Annapurna-3 (Lr13+)
BL 1022 (Lr26)
Vinayak (Lr1+13)

K 9107 (Lr 34+)
LOK-1 (Lr 34+)
HP 1731 (Lr 34)
HUW 234 (Lr 14a)
Sonali (Lr 9)

Need for Genetic checkmating of new disease threats
Genetic Containment of Wheat Rusts

Stem, Leaf and Stripe Rusts

1953 : Composite Varieties – phenotypically similar but genotypically diverse

1960 : Gene pyramiding

Genetic Shield – gene deployment strategy

March 2009 : Check-mating UG-99, a virulent stem rust race in wheat
# Combating Stem Rust (Ug99)

## Pedigree Line Response to Stem rust

<table>
<thead>
<tr>
<th>Pedigree</th>
<th>Line</th>
<th>Response to Stem rust</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kalyansona<em>7//Darf</em>6/3Ag3/Kite</td>
<td>HW2021</td>
<td>20R - MR, 80S</td>
</tr>
<tr>
<td>Kalyansona</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NI 5439<em>7//Darf</em>6/3Ag3/Kite</td>
<td>HW 2026</td>
<td>20R - MR, 90S</td>
</tr>
<tr>
<td>NI 5439</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sonalika<em>7//Darf</em>6/3Ag3/Kite</td>
<td>HW 2027</td>
<td>5R - MR, 60S</td>
</tr>
<tr>
<td>Sonalika</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Darf*6/3Ag3/Kite</td>
<td>Darf NIL</td>
<td>10R - MR - 20R MR</td>
</tr>
</tbody>
</table>

M-Mol wt ladder, 1- Darf, 2-K’Sona, 3- HW 2021, 4-Sonalika, 5-HW2027, 6-Lok 1, 7-HW2094, 8-C 306, 9- HW 2023, 10-NI5439, 11-HW2026, 12-Water control
“Man has lost the capacity to foresee and to forestall. He will end by destroying the earth”

- Albert Schweitzer

Origin of Integrated Pest Management Methodologies
War on Weeds Loses Ground

Glyphosate – resistant pigweed 
(*Amaranthus palmeri*)
Glyphosate is the main ingredient in Roundup

Fatigue of the Green Revolution

Growth rates of yields for major cereals are slowing in developing countries

Average annual growth rate, %

Source: FAO 2006a. Note: Data smoothed by locally weighted regressions.

“Intensive cultivation of land without conservation of soil fertility and soil structure would lead ultimately to the springing up of deserts. Irrigation without arrangements for drainage would result in soils getting alkaline or saline. Indiscriminate use of pesticides, fungicides and herbicides could cause adverse changes in biological balance as well as lead to an increase in the incidence of cancer and other diseases, through the toxic residues present in the grains or other edible parts. Unscientific tapping of underground water would lead to the rapid exhaustion of this wonderful capital resource left to us through ages of natural farming. The rapid replacement of numerous locally adapted varieties with one or two high yielding strains in large contiguous areas would result in the spread of serious diseases capable of wiping out entire crops, as happened prior to the Irish potato famine of 1845 and the Bengal rice famine of 1942. Therefore, the initiation of exploitative agriculture without a proper understanding of the various consequences of every one of the changes introduced into traditional agriculture and without first building up a proper scientific and training base to sustain it, may only lead us into an era of agricultural disaster in the long run, rather than to an era of agricultural prosperity.”

M.S. Swaminathan

Indian Science Congress, Varanasi, January 4, 1968
<table>
<thead>
<tr>
<th>Green Revolution</th>
<th>Evergreen Revolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commodity-centred increase in productivity</td>
<td>increasing productivity in perpetuity without associated ecological harm</td>
</tr>
<tr>
<td>Change in plant architecture, and harvest index</td>
<td>Organic agriculture: cultivation without any use of chemical inputs like mineral fertilizers and chemical pesticides</td>
</tr>
<tr>
<td>Change in the physiological rhythm-insensitive to photoperiodism</td>
<td>Green Agriculture: conservation farming with the help of integrated pest management, integrated nutrient supply and integrated natural resource management</td>
</tr>
<tr>
<td>Lodging resistance</td>
<td></td>
</tr>
</tbody>
</table>
Mainstreaming Ecology in Technology Development and Dissemination

From Green to Evergreen Revolution
Indian Agriculture: Performance and Challenges

MS Swaminathan
MSSRF / WFP: Food Insecurity Atlas

Food and Water Security will be the greatest Victims of climate change

Hunger
- Chronic
- Hidden
- Transient

Food Security
- Availability
- Access
- Absorption

Awareness – Analysis – Action
Food Prices: Increasing Volatility

The future belongs to nations with grains and not guns.

Source: FAO, US Energy Administration and www.indexmundi.org (data updated as on June 11, 2012)
Social Protection for Ending Hunger

Social Protection

- Intra-generational
  - Nutrition support programmes on a life cycle basis

- Inter-generational
  - Nutrition support to end maternal and foetal malnutrition and thereby the birth of children with low birth weight
National Food Security Act, 2011

Goal: Eliminate under and mal-nutrition in the country

Special Features:

- Legal Entitlement to Priority Groups
- Life-cycle approach in entitlement
- Enlarged Food Basket (including nutri-cereals)
- Woman as the Head of the Household
Food Security Act: Issues to be resolved

- Targeted versus Universal PDS – Can PDS become universal in the 200 High Burden Districts identified by the Prime Minister’s Nutrition Advisory Council?
- Price of food grains for the better off sections of the community
- Convergence and synergy among food, drinking water, sanitation and health care
- Method of ensuring pan-political support and oversight – National Commission on Farmers had recommended the setting up of a National Nutrition Food Security Chaired by the Prime Minister, with a few Chief Ministers from surplus and deficit States and Leaders of Political Parties and appropriate Union Minister.
Super Hybrid Rice Plant Type

Upper 3 leaves: long, erect, narrow, V-shape thick

Height of canopy: > 1.2 m

Designing New Plant Types

Anticipatory Research
Impact of Technology on Cotton in India
The bottom line of our national agricultural biotechnology policy should be the economic well being of farm families, food security of the nation, health security of the consumer, biosecurity of agriculture and health, protection of the environment and the security of national and international trade in farm commodities”

(M S Swaminathan Panel 2004)
Around 50% of India’s currently favourable, high potential, wheat production area may be reclassified as a heat-stressed, lower-potential short-season growing environment by 2050.

For each 1 degree Celsius rise in mean temperature, wheat yield losses in India are likely to be around 6 million tonnes per year, or around $1.3 billion at current prices.

Implication for Research: Shift selection from per crop productivity to per day productivity.
Agro-Forestry System involving Fertilizer Trees for Climate Change Mitigation

Building Soil Carbon Banks
Mitigating Climate Change: Role of Terrestrial Carbon Banks

- Global net primary productivity (NPP) = 120 Gt/c/year
- Most of it is returned to the atmosphere through plant and soil respiration
- If 10% of NPP is retained in the terrestrial biosphere (i.e., soil, plants, wetlands, mangrove ecosystems), 12 Gt/c/year can become part of a terrestrial carbon bank
- Increasing soil C pool by 1 ton c/ha/year in the root zone can increase food production by 30 to 50 million tonnes

Source: Dr Rattan Lal
## Mitigation (Reducing Green Gas Emissions)

<table>
<thead>
<tr>
<th>Gas</th>
<th>Mitigation Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon dioxide</td>
<td>Reducing deforestation and forest degradation and promoting afforestation (REDD)</td>
</tr>
<tr>
<td>Methane</td>
<td>Biogas Plants</td>
</tr>
<tr>
<td>Nitrous Oxide</td>
<td>Neem Coated Urea</td>
</tr>
</tbody>
</table>

> A Biogas Plant, a few Fertilizer Trees and a Farm Pond in every Farm
Deepwater (floating) rice has three special adaptations:

1. Ability to elongate with the rise of water levels;
2. Develop nodal tillers and roots from the upper nodes in the water;
3. The upward bending of the terminal part of the plant called 'kneeing' that keeps the reproductive parts above the water as flood water subsides.
**Submergence-prone rainfed lowlands**

**SUB1**

Mega varieties that survive under submergence

**SUB1**<sup>Plus</sup>

Survives longer under submergence
Survives submerg. and stagnant flooding (SF)

**AG + SUB1**

for direct seeding

Tolerance to submergence during germination (anaerobic germ.)

**SUB1 + SF + AG tolerance**

Under development

Allele mining emphasized

Courtesy DJ Mackill, E. Septi
C4-re-engineering photosynthesis to develop physiologically efficient rice

C4 rice could:
• increase rice yield by 25-50%
• double water-use efficiency
• improve nitrogen-use efficiency

C4 photosynthesis is one of the few evolutionary mechanisms that could deliver these superior combination of benefits.

Evolutionary Change

Genetic alterations

C3 + Anatomy Change + Biochem Change + Fine Tuning = C4

P. Quick & J. Sheehy, IRRI
Impact of Plant Introduction:

Introduction of rubber in South Asia from Kew in 1875 by Sir Henry Wickham led to a multi-billion dollar industry.
# Demand Supply Gap

## Demand for NR in India exceeds its domestic supply

<table>
<thead>
<tr>
<th>Year</th>
<th>Projections (‘000 tonnes)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Production</td>
<td>Consumption</td>
<td>Deficit</td>
</tr>
<tr>
<td>2010-11(Actual)</td>
<td>862</td>
<td>948</td>
<td>86</td>
</tr>
<tr>
<td>2011-12</td>
<td>902</td>
<td>977</td>
<td>75</td>
</tr>
<tr>
<td>2016-17</td>
<td>1166</td>
<td>1218</td>
<td>52</td>
</tr>
<tr>
<td>2019-20</td>
<td>1341</td>
<td>1389</td>
<td>48</td>
</tr>
<tr>
<td>2025-26</td>
<td>1631</td>
<td>1809</td>
<td>178</td>
</tr>
</tbody>
</table>

Deficit projected can be substantially higher if:

- FDI in rubber products manufacturing sector expands at a higher rate
- Indian economy grows at a faster rate
Estimated % reduction in rubber yield for every degree rise in temperature from the present (Direct effect only)
High productivity is top priority; equally important is to increase total production through area expansion.

Tradition region has no more area available for NR cultivation. Non-traditional areas include parts of NE and Karnataka, Northern Konkan as well as parts of Orissa, Jharkhand, Andhra Pradesh etc.
Fighting Genetic Anemia

Community Gene & Seed Banks

National Gene Bank

Svalbard – Global Seed Vault

A similar Seed Vault has been established by DRDO at Chang La in the Himalayas

Conservation continuum
Need: Breed Saviour Award

Genetic Erosion is severe among farm animals

Vechur Cow
National Mission on WAR for Water
(Winning, Augmentation and Renovation)

Priorities

- To develop inexpensive methods of converting saline water into fresh water
- Standardizing methods of harnessing and managing rain water
- To manage flood waters
- To carry out research in rain water harvesting and treatment of waste water
- To ensure water security under conditions of climate instability
Water Security:
Small Water Harvesting Structures (Jal Kund)

Ideal for areas like Sorah (Chirappunji)
Marry intellect with labour

Every Watershed – a Bioindustrial Watershed
“No other human occupation opens so wide a field for the profitable and agreeable combination of labour with cultivated thought as agriculture. Every blade of grass is a study, and to produce two, where there was but one, is both a profit and a pleasure”

Abraham Lincoln, 1859
Wake-up Call
Titanic tsunami of December 26, 2004 in South Asia
Genetic Shield against Sea Level Rise

Mangrove Forests
The present invention relates to a method of producing salt-stress tolerant plants by transforming the plants with an isolated nucleic acid sequences encoding a dehydrin (DHN) protein. The invention further provides a transgenic plant expressing the dehydrin gene of *Avicennia marina*. Using functional genomics, this gene was derived from large-scale EST sequencing of the cDNA library of the salt tolerant mangrove *Avicennia marina*. 

1, Published Mar. 31, 2004)
Thus, nearly 76% of the available freshwater is stored in the glaciers and 23% in aquifers; only 2% of the freshwater is directly available for all living things.
Sea Water Farming
(Sea water constitutes 97% of the world’s water resource)

Rhizophora plantation

Sesuvium plantation

A halophyte
Salicornia bigelovii

- High salinity tolerant ~ 70 g/l

Seeds

- Edible oil: 28%
- Protein: 31%
- Fiber: 5%
Genetic Garden of HALOPHYTES at Vedaranyam

Converting Sea Water into Fresh Water through Halophytes

Obligatory halophytes
- Tolerate high concentration of sodium salts
- > 3 times of seawater salinity
- Even demand high NaCl for survival and reproduction
- 1560 species

Facultative halophytes
- Most of the species tolerate only moderate level of salinity
- Reproduction requires low saline condition
- Mangroves
- 60 species
Innovations in below sea level farming in Kuttanad

ONE RICE - ONE FISH

_Punja_ season
November - February
Low chemical input or Organic
Yield - 4.2 t/ha

April - October
**Monoculture** – Giant Prawn
(*Macrobrachium rosenbergii*)
**Polyculture***- Indian major carps or common carps or Silver carps and grass carps and Giant Prawn
Yield - Rice: 4.2 t/ha
Fish - Prawn: 480 kg;
Carp : 300 kg.

* Recommended practice
Information on Wave Height and location of fish shoal
Transformational Technology
Globally Important Agricultural Heritage System (FAO)

- Kuttanad Below Sea Level Farming System
- Koraput Tribal Conservation Farming System
Challenges ahead: Reaping the Demographic Dividend

Attracting and Retaining Youth in Farming

More jobs and income from Biomass
Every Child A Scientist programme: students with a Paniya lady during a wild food survey

Genetic Literacy
Every Child A Scientist programme students with a traditional healer
Jamsetji Tata National Virtual Academy (NVA) Fellows

Rural Knowledge Revolution
Launching an era of Biohappiness

Convert bioresources into jobs and income in an environmentally sustainable and socially equitable manner

Breaking the dichotomy between the prosperity of Nature and poverty of people
What happens when an infinite-growth economy runs into a finite planet?

Rio + 20 (2012)
The Future We Want

Ending Unsustainable Lifestyles and Unacceptable poverty – pathways for a happy living in a finite planet