

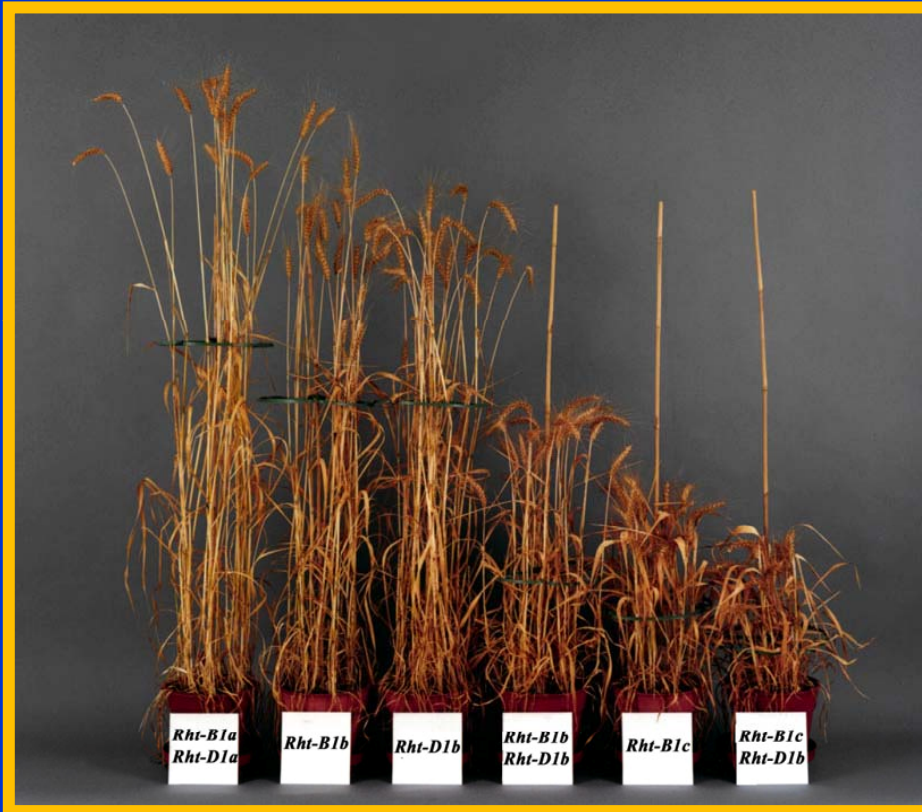
Genetically – engineered Bt- and Ht- crops : Not suitable for an evergreen revolution

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The Green Revolution in Wheat and Rice Transformational Genes



The effects of different *Rht* alleles on plant height in wheat (cv. April Bearded). The wild-type contains *Rht-B1a* and *Rht-D1a*, which are homoeologous (corresponding) genes on the B and D genomes. *Rht-B1c* is a more severe allele at the *Rht-B1* locus



Comparison of woo-gen (right) and dee-geo-woo-gen strains, the latter containing the *sd1* mutation

Source: <http://5e.plantphys.net/>

Ref: Swaminathan, MS 2013 J. Agri. Research

Vision Of Prof. M. S. Swaminathan for “Evergreen Revolution” - Indian Science Congress held at Varanasi in January 1968



“Intensive cultivation of land without 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 initiations 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.”

Green Revolution and the Paradox of Grain Mountains and Hungry Millions

(Food security at National but not at individual household level)

- 'GR' provided food security at the national level (i.e. enhanced food Availability), but not at the household level of millions of resource-poor marginal and small farming, fishing and landless rural families.
- 'GR' did not create more on-farm and off-farm livelihoods.
- 'GR' not integrated with sustainable rural development (i.e. safe drinking water, sanitation etc). So, Absorption/Utilisation was also not addressed.
- 'GR' largely monocropping ; loss of agrobiodiversity; future food security jeopardized especially in an era of climate change

Components of Food Security at Individual Household Level

1. **Availability:** Function of food production/Importing food to make food available in market
2. **Access:** Function of income generating livelihoods
3. **Absorption:** Function of clean drinking water

Note: India has enough availability of food, but famine of rural livelihoods is the cause of hunger

Achieving Productivity in Perpetuity for Food and Nutrition Security: Evolutionary Perspectives

(Based on numerous research papers and books of Professor M.S. Swaminathan)

- **Green Revolution:** Broke the inertia in the yield increment of cereal grains ; Not sustainable as predicted, it degenerated into a '**Greed Revolution**'
- **Evergreen Revolution:** **Sustainable**; achieving productivity in perpetuity **without** accompanying ecological and social harm. Suitable for small farms with resource-poor farmers. With appropriate farming systems, these can provide food and nutrition security, income to access food and agricultural remedies for nutritional maladies

From Green to an Ever-green Revolution Pathways (Ecoagri + Ecoenterprises in rural areas)

Green Revolution : Commodity-centred increase in productivity



Change In plant architecture, and harvest index

Change in the physiological rhythm-insensitive to photoperiodism

Lodging resistance

Evergreen Revolution : increasing productivity in perpetuity without associated ecological harm



Organic agriculture : cultivation without any use of chemical inputs like mineral fertilizers and chemical pesticides

Green Agriculture : conservation farming with the help of integrated pest management, integrated nutrient supply and integrated natural resource management

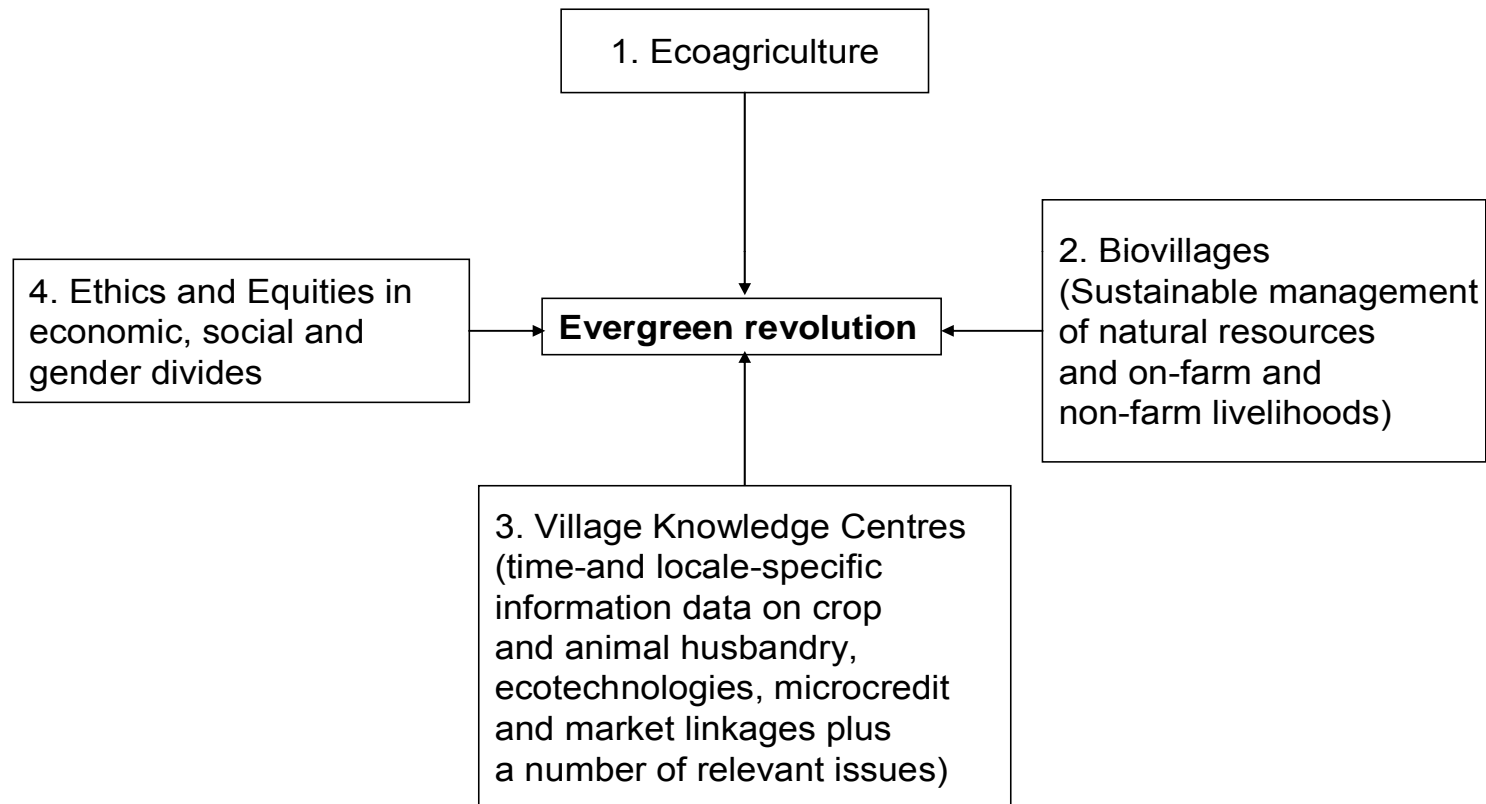
If farm ecology and economics go wrong, nothing else will go right

Fatigue of Green Revolution Yield Gains

- Joel K. Bourne (2009, *Natl. Geographic*) “The end of plenty” – fragile food web. Green Revolution has nothing to do with the ecofriendly green label in vogue today
- Dhillon et al (2010, *Curr. Sci.* 98, 33 – 36) – The plateauing of the productivity of wheat and rice in Punjab that started in the 1990s has continued through 2007 – 2008

Components of Evergreen Revolution

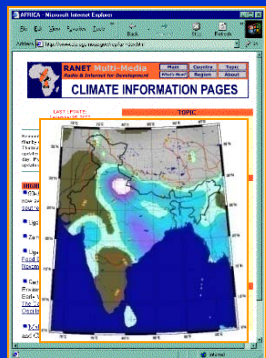
Components of evergreen revolution



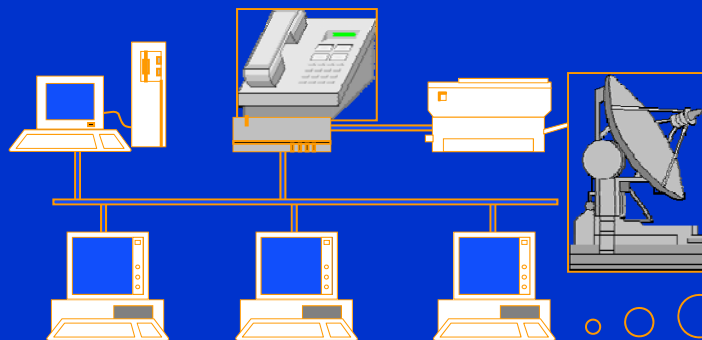
(P.C. Kesavan and M.S. Swaminathan, 2007 *ASM J.* **1**, 161 – 168)

ICT-enabled knowledge flow - Hub and Spokes Model

Lab to Lab, Lab to Land, Land to Lab, Land to Land



Web based
interactive
portal



State Level Hub (MSSRF)

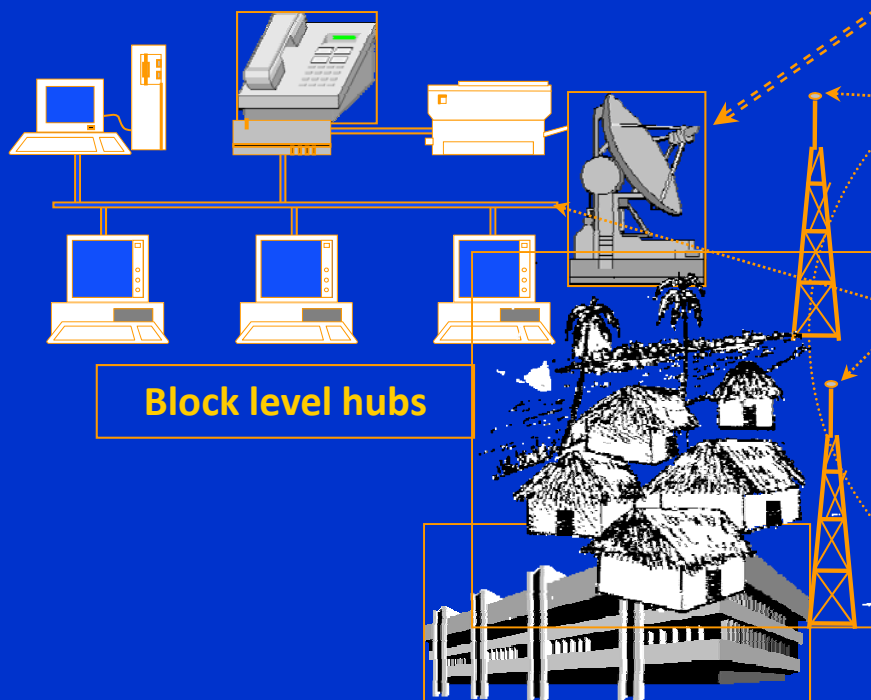
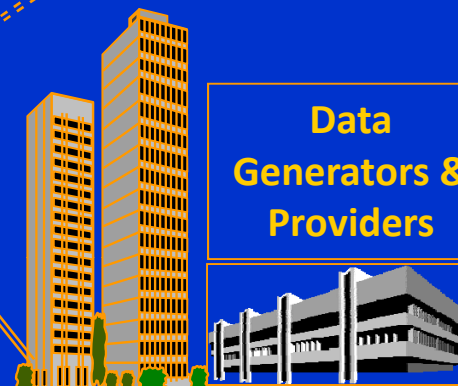
Data Managers (both connectivity and content)

Internet

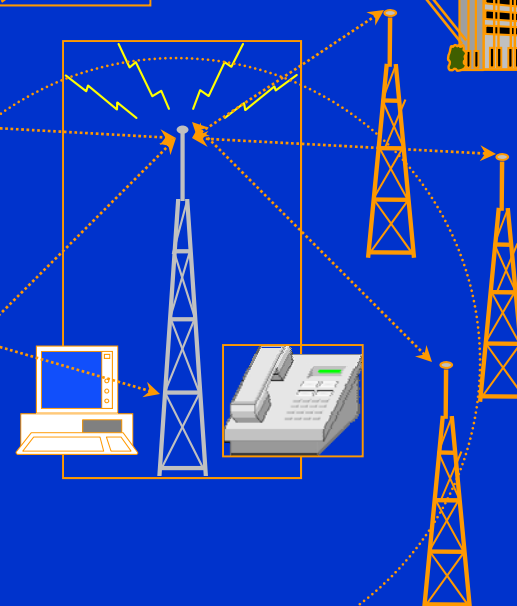


ISRO Uplink
Satellite

Data
Generators &
Providers



Block level hubs



Information Users (Rural families)

Eco-enterprises for sustainable livelihood



Mud crab – Middle Andaman



Mushroom production



Vermiform compost



Trichogramma egg parasitoid production

Biological Software for Sustainable Agriculture



Self-help Groups for **Trichogramma** Production

Basic – ‘unsolved’ problems with Genetic Engineering

- Incomplete understanding of the response of the ancient conserved genome to insertion of ‘cis’ or ‘trans’ gene by methods other than natural evolutionary processes
- ‘Unintended effects*’, ‘insertional mutagenesis’, ‘pleiotropic effects’, gene silencing
- **Alteration of C1 metabolism** in the genetically engineered plants: - accumulation of formaldehyde and reduction in glutathione → enhanced oxidative stress – consequences – computational biology-based; **needs experimental verification**
- Roles of microRNA – (miRNA)

* Prescott et al (2005) *J. Agric. & Food Chem* **53**, 9023 – 9030) – alpha amylase inhibitor in peas results in altered structure and immunogenicity in bean)

‘Substantial equivalence’ over Precautionary Principles – Failure of world’s first genetically engineered tomato – Flavr Savr.

- 1991 – 92 Development of ‘Flavr Savr’ – delayed ripening tomato*
- 1993 Released into a few supermarkets after the FDA’s clearance on the basis of ‘substantial equivalence’
- 1998 Lawsuit on the basis of adverse health effects of Flavr Savr – causes gastric erosion.
- 1999 Withdrawn from shops/markets

* Engineered to reduce the levels of a naturally occurring enzyme that degrades pectin and to add antisense polygalacturonase (PG) gene

Problems with Bt-transgenic crops with reference to evergreen revolution

I. Biological/ Health

- ↔ Not true that it is specific to organisms with alkaline gut
- ↔ Several studies show the cytotoxicity of Cry1Ab and Cry1Ac on human cells
- ↔ Toxic effects on the small intestine, liver, kidney, spleen and pancreas
- ↔ Immune system disturbances

- Bt-toxin protein not broken down harmlessly in the digestive tract

A Canadian study (Aris A and Leblanc S, 2011, *Reproduct. Toxicol.* **31** pp 28-33) – Bt toxin was found circulating in the blood of pregnant women and the blood supply to their fetuses as well in the blood of non-pregnant women

II. Sustainability of the pest sensitivity to Bt-toxin

- Low concentrations → Survival – Selection pressure – development of resistance
- 'Refuge' – not possible in the context of small and marginal farms, so more rapid development of pest resistance

Cont .. 2..

III. Gene Flow and Development of Resistance

- Reducing the damage to some extent from *Helicoverpa* sp. (borer pest) but damage from sucking pests increases . So, the level of chemical pesticide use **still remains high**.
(See next two slides)
- Bt-sprayed exogenously **does not exert selection pressure** as spraying is done only when the damage is above economic injury levels. The Bt- transgenics produce the insecticide all the time continuously in the cells and tissues

Bt – tetraploid hybrid cotton-intended goals not realized

- Intended goal: Reduction of use of chemical pesticides
- Reality in Bt-cotton fields
- Development of resistance by pests, e.g. Helicoverpa sps.
- Emergence of sucking pests as major pests

See the Table 2, page 5 of Dr. K.R. Kranthi's data in Cotton Statistics and News, 16th December 2014

Year	Total (M tons) insecticides on cotton	Bt area lakh ha	Bt area %	Yield Kg/ha
2003	10045	0.931	1.2	387
2006	4623	34.61	37.73	519
2009	6726	83.0	81.76	486
2011	6828	121.91	91.87	486
2012	7234	108.86	94.23	552
2013	11524	114.58	95.56	567

Compiled by K.R. Kranthi and A.R. Reddy, CICR

Note:

- Stagnation of yield despite increase in land area under Bt-cotton cultivation
- Increased need for chemical insecticides

Bt-Cotton in India (2002 – 2014)

‘Annual farmers’ suicide rates in rainfed areas are inversely related to farm size and yield and directly related to increases in Bt-cotton adoption (i.e. costs)
– High density short season cottons could increase yields and inputs costs in irrigated and rainfed cotton’

(A.P. Gutierrez et al 2015, ‘Deconstructing Indian Cotton: Weather, Yields and Suicides’ *Envir. Sciences Europe* **27**, 1- 17
DOI 10.1186/s 12302-015-0043-8)

What is Herbicide Tolerance (HT)?

- HT is a weed control technology in which the crop is genetically engineered to become resistant to a herbicide. This allows the herbicide to be used in much larger amounts on the field resulting in essentially “quantitative killing” of all weeds leaving only the engineered crop to grow.

How does HT differ from conventional herbicide treatment?

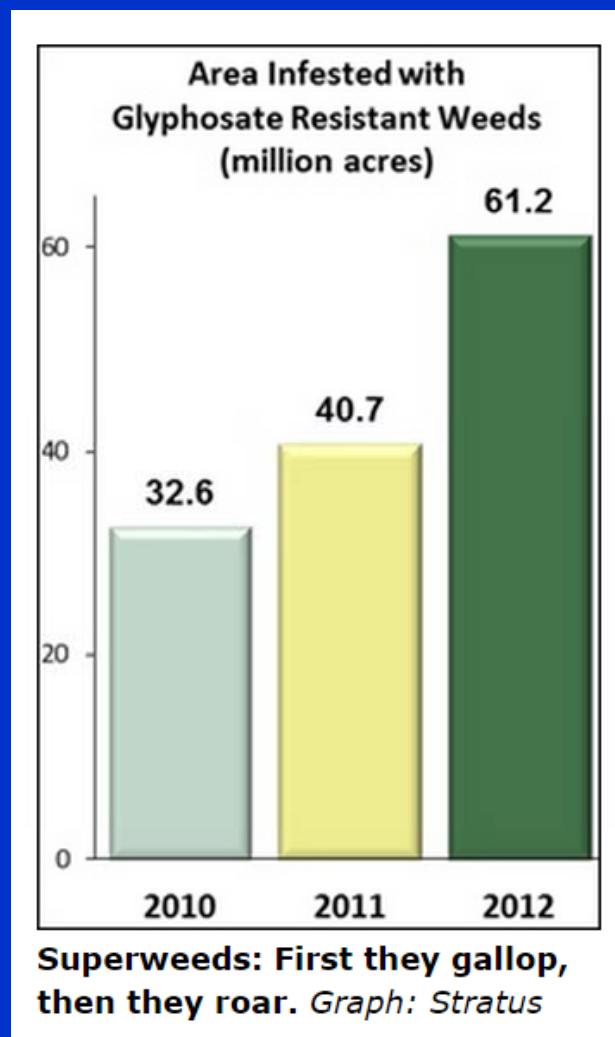
- Conventional herbicide treatment involves treatment with limited amounts of different herbicides in combinations.
- Conventional herbicide treatment is generally used as part of a set of practices (Integrated Weed Management) whereas HT largely replaces all other weed management practices.

HT Leads to Rapid Emergence and Large Scale Spread of HR Weeds

- HR weeds in the USA first emerged 5-7 yrs after start in 1995 of HT adoption. By 15 yrs, 20 different glyphosate resistant weed species had spread to 22 million hectares in the USA.
- Prior to 1995 glyphosate had been used as a conventional herbicide for 20 yrs without HR weeds arising and spreading in the USA.
- Emergence and spread of glyphosate resistant weeds due to indiscriminate overuse of a single herbicide for weed control across successive crop rotations (soybean-corn; soybean-cotton).
- Broad agreement among weed science experts that a diversity of weed control methods is necessary rather than a single method

From Dr. Imran Siddiqi, CCMB, Hyderabad

Spread of Superweeds



Nearly Half of All US Farms Now Have Superweeds

Tom philpott, (*Mother Jones*, Feb. 6, 2013)

<http://www.motherjones.com/tom-philpott/2013/02/report-spread-monsantos-superweeds-speeds-12-0>

Emergence of glyphosate – resistant weed





This is a real and unretouched photo of ag scientist Kurt Hembree posing with 8 ft high horseweed, one of eight mutant weeds that now scoff at Monsanto's Roundup herbicide

Glyphosate (Roundup) – tumourogenic, teratogenic and carcinogenic (Endocrine disruptor)

- International Agency for Research on Cancer (IARC) – cancer research arm of the World Health Organization has rated glyphosate as a 'Class 2A' (probable human carcinogen) in March 2015
- Studies of Seralini et al* (2012) was unduly criticized for demonstrating tumourogenic activity of Roundup, and his paper was retracted from Food and Chemical Toxicity 2012, 50, 4221 – 4231, but it was republished in 2013 in *Environmental Sciences Europe* 2014, 26, 14 (<http://www.enveurope.com/content/26/1/14>)
- And glyphosate –based herbicides are Teratogenic (Antoniou M et al 2012, *Environ. Analyt. Toxicology*, S:4 (<http://www.omicsonline.org/teratogenic-effects-of-glyphosate-based-herbicides-divergence-of-regulatory-decisions-from-scientific-evidence-2161-0525.S4-006.php?aid=7453>).

*Retraction and republication of Seralini's paper reveals the influence of corporate control over scientific publications and remedial action by scientific community

30 years of genetically – engineered plants in USA (DR Christopher Then, 2013)

(Institute for Independent Impact Assessment in Biotechnology, Munich, Germany)

Info@testbiotech.org

- **Consequences for farmers –**

- (i) “**Arms (pesticides) enhancement in the fields**” – More input costs without substantial/ commensurate increase in yields
- (ii) ‘Superweeds’ flourish than crops
- (iii) Prices of seeds increase and farmers cannot save their own seeds
- (iv) Strong influence of agro-chemical companies restricts/controls the alternative agronomic practices which would effectively reduce the use of herbicide sprays

- **Effects on non-genetically engineered products**

Contamination with non-authorised genetically - engineered plants

- **Consequences for consumers**

US industry has thwarted any attempt to introduce labelling of genetically – engineered products in food. So, any harmful health effects could not be attributed to the Bt and Ht corn, maize etc.

Is HT Technology Necessary for India?

- HT does not increase yield but simplifies weed management in the short term with problems emerging in the medium term. No direct benefit to processing industry.
- Benefits of HT are primarily for larger cropping systems. Mean farm size in India is 2.5 acres whereas in the USA it is 230 acres.
- India is better suited for Integrated Weed Management (IWM) which relies on a diverse set of practices for weed control and is easier to implement on smaller farm sizes. IWM is more stable and causes far less environmental damage. ICAR has worked on IWM/IPM for many crops including soybean.
- HR weeds arising from HT are likely to add significantly to agricultural distress, particularly for small and resource poor farmers.
- Loss in employment opportunities for agricultural workers.

Bt and Ht crops: Findings

- Lack of social and ecological components of sustainable agriculture
- Serious biosafety questions: 'Food safety' is an integral part of UN FAO's definition of food security
- 'Organic Agriculture' (IFOAM) governed by Principle of health, Ecological principle, Principle of fairness, Principle of care (Precautionary Principle) and the 'Green Agriculture' (less rigorous than the organic agriculture form the foundation of the goal of productivity in perpetuity
- Bt and Ht transgenics negate all the abovesaid principles and aim at huge monetary profits for the developers especially when they manufacture chemical pesticides as well
- Millions of resource-poor small and marginal farmers especially in the rainfed regions are unable to meet the cost of seeds and inputs and commit suicide

The chosen technology needs to be pro-nature, pro-poor and pro-women (since unproductive agriculture leads to feminization of poverty) and pro-livelihood

- Bt and Ht transgenics have no genetic basis to enhance 'intrinsic yield' but only to prevent losses by pests; the magnitude of such losses is less when crop rotations, IPM (Integrated Pest Management) are followed
- No other system of pest management induces 'selection pressure' on the surviving pests to develop resistance as the Bt and Ht
- In conclusion, Indian agriculture will be adversely affected in the long run by adopting Ht and Bt transgenic

THANK YOU