Application of Nuclear Techniques in Food and Agriculture

Joint FAO/IAEA Programme of Nuclear Techniques in Food and Agriculture

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Nuclear Techniques in Food and Agriculture

Corporate Mission

Atomic energy for peace, health and prosperity

Sustainable agricultural development, improved nutrition and food security

IAEA

to contribute to sustainable food security and safety by use of nuclear techniques and biotechnology

IAEA

Our Goals:

- Food Security
- Food Safety
- Sustainable Agriculture

Application in Food and Agriculture

IAEA

Insect Pest Control

by Sterile Insect and related Biological Techniques

Animal Production & Health

by serological and molecular techniques

Nuclear Techniques

Plant Breeding & Genetics

by Mutation Techniques

Soil & Water Management & Crop Nutrition

by Isotopic and Nuclear Techniques

Food & Environmental Safety

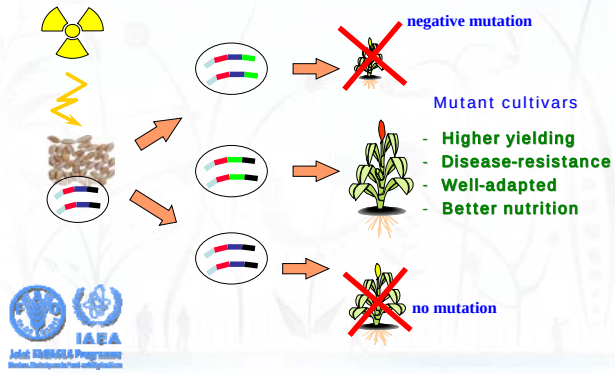
by Food Irradiation and Radio-analytical Techniques

1. Crop improvement by mutation techniques

Technical basis

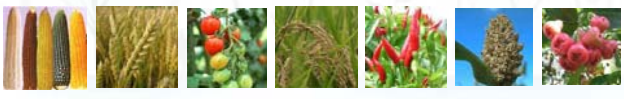
- Variation is the source of evolution
- Spontaneous mutation rate is $1\times10^{-8} \sim 1\times10^{-5}$
- Radiation can cause genetic changes in living organisms and increase mutation rate up to $1\times10^{-5} \sim 1\times10^{-2}$
- Induced mutation is useful for crop improvement
- Induced mutants are not GMOs, as there is no introduction of foreign hereditary material into induced mutants

Crop improvement by mutation techniques



Mutation techniques

- Improving crop cultivars
- Enhancing biodiversity
- Increasing farmer's income

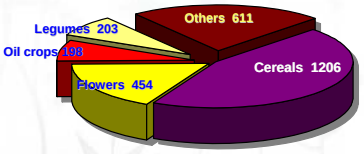


Crop improvement by mutation techniques

MUTANT VARIETIES (2006)

Total Number : 2672

Plant Species : 170



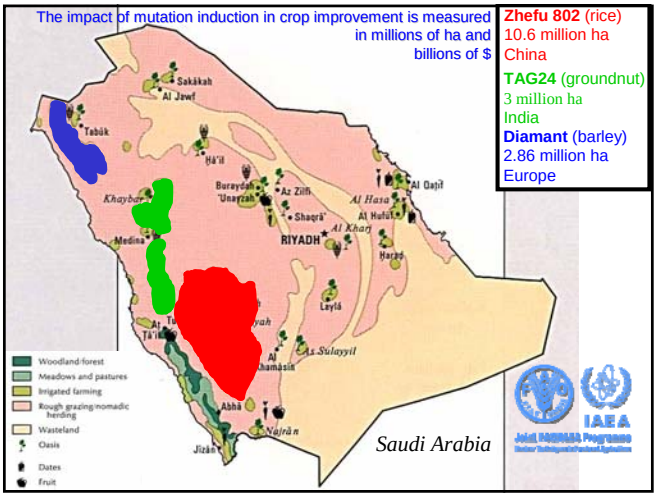
Sources: FAO/IAEA Mutant Varieties Database

The impact of mutation induction in crop improvement is measured in millions of ha and billions of $

Zhefu 802 (rice)
10.6 million ha
China

TAG24 (groundnut)
3 million ha
India

Diamant (barley)
2.86 million ha
Europe



Saudi Arabia

VND99-3
High quality for export
Short duration (100 days)

3 rice harvests per year in the Mekong Delta

VND95-20
High quality
Tolerance to salinity
Key rice variety for export

"National Prize of Science and Technology of Viet Nam 2005" for its "significant socio-economic contribution"

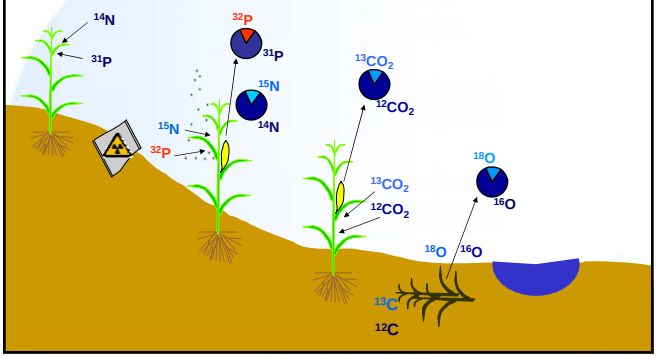
8 new high quality rice mutant varieties have been developed and adopted by farmers in Vietnam, where rice export is one of their main revenues.

2. Soil-Water-Crop Nutrition Management

Technical basis

- Both stable and radioactive isotopes can be used as tracers in soil and water management & crop nutrition.
- Isotopes are atoms with:
  - the same chemical properties
  - the same number of protons and electrons.
  - different number of neutrons and mass number (atomic weight).
- Isotopes can be either stable or radioactive
  - stable isotopes: different masses (^{18}O and ^{16}O).
  - radioactive isotopes: radioactive decay (^{32}P).

Soil-Water-Crop Nutrition Management



Carbon isotopes in crop water productivity assessment

Plants can be grouped according to ^{13}C discrimination

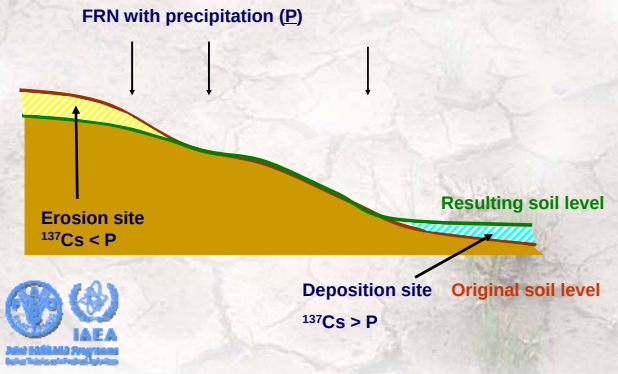
C3 plants: $\delta^{13}C = -26‰$

rice, wheat, forest, vegetation

C4 plants: $\delta^{13}C = -12‰$

maize, sorghum, sugarcane, some tropical herbs

Radionuclide in soil erosion-conservation



Isotopic and nuclear techniques in soil-water-crop nutrition

- **Enhance sustainable use of soil-water-nutrient resources.**
- **Quantify biological nitrogen fixation.**
- **Minimize effects of soil erosion and degradation.**
- **Enhance water use efficiency by crops.**
- **Optimize production of drought and salt-tolerant crops.**
- **Evaluate effects of crop residue incorporation on land productivity and food security.**
- **Improve water (nutrient) use efficiency thus minimize losses beyond the plant rooting zone.**

Examples of major outcomes

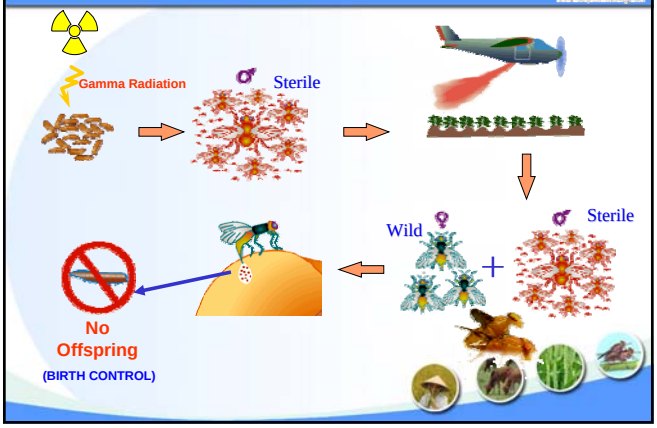
- 41 countries use nuclear techniques to assess soil erosion and develop cost-effective soil conservation measures. China, Morocco, Romania and Vietnam have effectively reduced soil erosion rates by 55-90% .
- 95 Member States use isotopic and nuclear techniques to identify land and water management practices to improve nutrient and water use efficiency (WUE). Some outcomes:
  - At least 25-50% increase in yield, WUE and revenue through efficient soil moisture monitoring and irrigation in Chile, Jordan, Syria, Turkey and Uzbekistan.
  - 30% increase in BNF through improved soil-water-nutrient-crop management practices in Asia and Africa.

3. Insect Pest Control by SIT

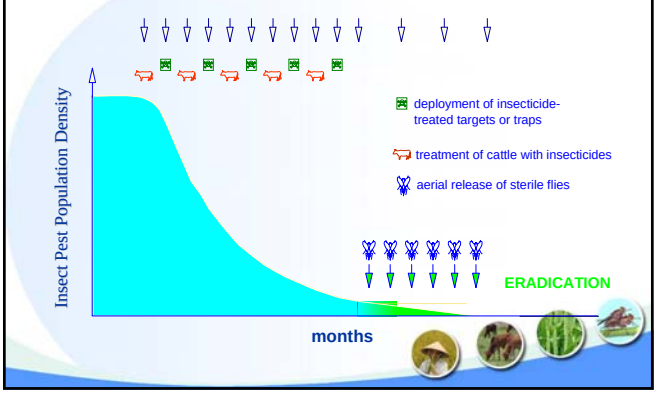
Technical basis

- **Radiation** is used to induce lethal mutations in chromosomes of insect pests to cause sterility.
- Sterile males are released into the field where they compete with wild males for matings with wild females.
- **SIT** relies on:
  - mass production of the target pest
  - sterilization and shipment
  - inundative releases mostly by air
  - matings result in no offspring
- **SIT** integrated with other pest control methods is applied for pest *suppression*, *containment*, or even *eradication*.

3. Insect Pest Control by SIT



Integrated Tsetse Management With SIT Component



Examples of Major Outcomes

SIT developed and transferred to over 30 Member States with substantial socio-economic impact. Some outcomes:

- In Chile, fruit and vegetable exports have climbed to ca. US $1.6 billion in 2005 as a result of fruit fly-free status.
- Medfly-free status in Mexico translates to annual savings of US $2 billion in reduced crop losses and pesticide costs, and access to export markets.
- In Zanzibar, eradication of tsetse and trypanosomiasis resulted in very significant increases of meat and milk production, as well as crop productivity.

Facilitation of Fresh Vegetable Exports from Central America to the USA (2004-2007)

Overcoming *phytosanitary* trade barriers to facilitate access of high-value crops to lucrative export markets

Some Achievements in the Year 2008

- **Fruit fly pests eradicated from two provinces in southern Peru and two areas in Panama declared Medfly free**
- **Establishment of sterile moth SIT company and mass rearing facility in South Africa**
- **Cactus moth eradicated from two islands in Yucatan, Mexico**
- **Emergency assistance to Yemen on screwworm**
- **Technical breakthrough with olive fly mass rearing**
- **International Plant Protection Convention: Approval of "International Standard on Fruit Fly Low Prevalence Areas"**