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KWAZULU-NATAL  
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## Safe and secure nuclear technology in plant mutation breeding to climate change adaptation and resilience

**Hussein Shimelis**

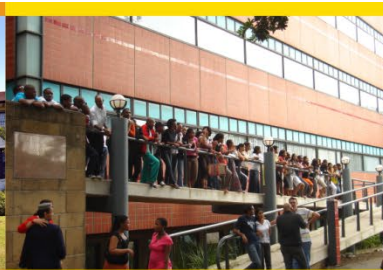
Webinar Coordinated by Vienna Centre for Disarmament and non-Proliferation (VCDNP)  
Tuesday 7<sup>th</sup> December 2021



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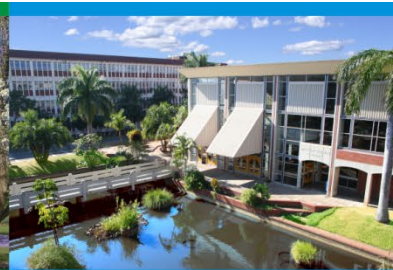
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# Challenges of Agriculture and Food Production

- Increased **demand** for food, feed, bioenergy & bio-factory plants
- **Population** growth
- **Malnutrition**
- **Urbanization**
- **Changing lifestyles**
- **Climate Change** – agricultural production (land, water and energy)
  - Africa has low adaptive capacity to climate change and climate variability
- **Low productivity of agriculture**

# Agricultural Transformation

- The **agricultural sector** is vital to ending hunger, achieving **food security** and improved nutrition, and promoting sustainable **development**
- **Climate change** presents significant pressure on agriculture, the stability and sustainability of **food systems, livelihoods, ecosystems biodiversity, water availability**, and **local, regional** and **global trade**
- **Smallholders** mostly women produce most of Africa's food today with minimal resources
- **Modern technologies** are necessary for climate change adaptation and resilience and to enhance agricultural production and productivity, one of which is applying **nuclear science and technology (NS&T)** and innovations
- There is enabling policy support for agricultural transformation in the region through safe and non-power use of NS&T

# Applications of Nuclear Science and Technologies (NS&T) and Innovations for Agricultural Development

- **Plant mutation breeding and biotechnologies**
- **Food safety and quality**, and environmental health
- Enhancing the use and management of agricultural **water resources**
- Integrated control and eradication of transboundary **animal and zoonotic diseases**
- **Animal production and health management**
- Developments of sterile insect technique (**SIT**) to eradicate tsetse flies and **animal and human trypanosomosis**
- Agricultural production **decision support systems**



**Plant mutation breeding**

# Nuclear Science and Technologies and Innovations for Agricultural Development

- Peaceful application of NS&T has been pursued globally
- The NS&T delivered improved technologies and innovations to enhance agricultural productivity and human health
- The new technologies are directly impacting food production, food security, human well-being, and local, regional and global trade
- These technologies will transform agriculture at the small- to medium-size family farms and commercial farms

# Climate Change (CC) Impacts on Agriculture

CC is associated with extreme earth's temperatures (e.g. warming) and greenhouse gases

- Droughts – rainfall patterns, drying, water scarcity, desertification [Mediterranean Africa, northern Sahara, southern Africa]
- Hotter/colder days – change in crop adaptation, fires
- Shift or reduced crop growing seasons
- Floods – waterlogged conditions, salinity [Eastern Africa]
- New pests and diseases
- Ecosystems degradation – agro-forestry
- Spatial and temporal transmission of disease vectors, e.g. malaria, dengue fever,
- Sea level rise – coastal agriculture
- Sea temperatures - fish stocks depleted
- **Reduced agricultural productivity: food insecurity and drags economic development**

# Crop Improvement Strategies for Climate Change

## Adaptation and Resilience

Adaptation: to cope with current problems and uncertain future  
Plant breeding improves the resilience and productivity of crops

- Drought tolerance and water use efficiency
- Heat tolerance
- Salinity tolerance
- Existing and emerging pests & disease resistance – Fall armyworm (FAW), locusts, maize lethal necrosis (MLN), *Striga* parasites
- Waterlogging tolerance
- Nitrogen- and phosphorus-use efficiency
- High biomass and carbon sequestration
- Biological nitrogen fixation
- Postharvest handling of products (transport and storage: grain pests, fruit and vegetables, cassava and sweetpotato)



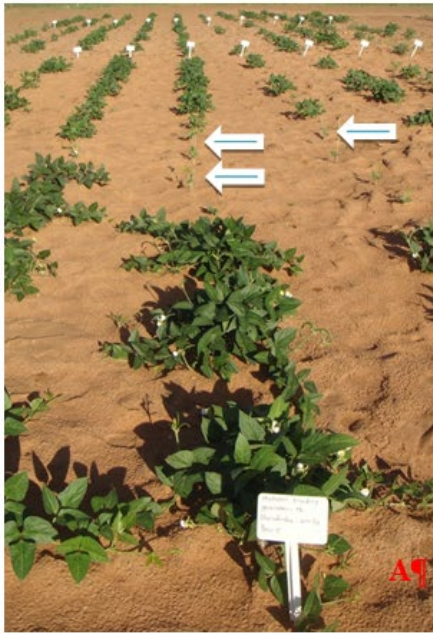
# Technologies and Innovations

For **accelerated breeding** and **genetic gains** (product development: design, profiling and commercialisation)

- Conventional breeding – *in-situ* ideotype breeding, speed breeding
- **Mutation breeding [nuclear science and technology (NS&T)]**- creates useful and heritable genetic variation, genome-wide mutation detection
- Doubled haploidy - fixing desirable genes with additive or dominance genetic
- Genomic tools
  - Marker-assisted selection
  - Genome selection
  - Genome engineering - transgenic-assisted breeding
  - Genome editing - clustered regularly interspaced short palindromic repeats (CRISPRs) or CRISPR-associated system (CAS)
- Proteomics - track quantitative, polygenic traits
- NIR for quality trait evaluations
- Digital technologies

# The Power of Plant Mutation Breeding

- Accelerated and effective development and deployment of **climate-resilient, high yielding** and **farmer preferred** modern **plant varieties** of vital **food security** and **fodder crops**: Namibia, Zimbabwe, Senegal, Sudan, Kenya
- ***Fusarium* wilt disease** has been destroying **banana** plantations in Africa, Asia and Latin America. **Banana mutants** were developed **resistant** to the new race of *Fusarium* wilt disease (TR4). The new mutant variety of Cavendish is released in Asia and Africa
- ***Striga*-resistant** mutant lines of maize, rice, and sorghum are being bred for Burkina Faso, Madagascar and Sudan
- Monitoring and integrated management of **outbreaks of plant diseases** and **insect pests** - **the fall armyworm** (FAW), first reported in Africa in 2016. FAW has spread rapidly to cover nearly all Sub-Saharan African countries



Cowpea mutant selections at the Omahnene Research Station in northern Namibia

(Photo: H. Shimelis)



FAO/IAEA Coordinated,  
Improving Resilience to Drought  
through Mutation Breeding,  
Tsumeb in Namibia, 24-28 April  
2017 (Photo: H. Shimelis)



Farmer Participatory Plant Mutation Breeding in Dissemination of Mutant Cowpea Varieties, Zimbabwe, 22 to 26 February 2016  
(Photo: H. Shimelis)





*Brachiaria* variety development in Kenya.

Mrs. Miriam Wanjiku (dairy farmer, top left) with Ms Annah Indetie (TCP counterpart) at the Wanyororo site demonstrating cultivation, harvesting, processing, storage, and use of the newly developed mutant breeds of *Brachiaria*. (Photo: H. Shimelis)



Large-scale production of the new varieties of *Brachiaria* in Kenya at the Subukia site belonging to Mr. Kenneth Kariithy, a dairy farmer  
(Photo: H. Shimelis)





Plant breeders with the new **Fusarium wilt resistant Cavendish banana varieties** grown in Guangdong, China. (Source: IAEA)



Researchers with the new **sorghum lines resistant to Striga**, at the IAEA's Plant Breeding and Genetics Laboratory in Seibersdorf, Austria (Source: IAEA)



# R&D Support Needs from the IAEA and Partners

- Demand-driven and climate-smart technologies – keep farmer and market preferences
- Speed breeding - greenhouses & artificial light
- Vibrant seed systems - how to get new varieties to millions of small-scale farmers
- Regional champions and networking
- Funding for plant breeding programs: (governments & NGOs)
  - ✓ Train next gen plant breeders
  - ✓ NAREs breeding programs
  - ✓ Independent seed systems
- Policy support



# Outlook and Priorities

- Communication and advocacy on the safe and secure applications of NS&T
- Developing community of practice - NS&T
- Seed enterprises using mutation breeding projects
- Seeking champions and sustained networking and collaboration among regional and international partners
- Assessing the technologies and innovations so far achieved – impact assessment on agricultural productivity
- Knowledge and technology transfer and sustainability
- Catalyzing investment for R&D and capacity development in NS&T in national breeding programs



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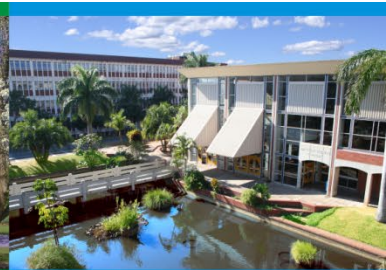
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