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Developing Climate-smart Nutri-cereals with Futuristic Breeding Strategies

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Introduction to Nutri-Cereals

- Nutri-cereals play major role in nutritional security
- More than 20 millets grown, but 8 are important
- Drought tolerant, and can grow in less fertile soils
- Short duration (early maturing) and give good yields
- Have high protein, and good Stover quality
- Gluten free, and rich in fibre
- Micronutrient dense: Ca, Mg, Fe, P, K, Folate and Vit B
- Improve digestion, control blood sugars; have anti-oxidant and anti-inflammatory properties
- Support healthy immune systems

Major Nutri-cereals in India

- Sorghum (*Sorghum bicolor*)
- Pearl millet (*Pennisetum glaucum*)
- Finder millet (*Eleucine coracana*)
- Fox tail millet (*Setaria italica*)
- Proso millet (*Panicum miliaceum*)
- Barnyard millet (*Echinochloa crusgali*)
- Kodo millet (*Paspalum scrobiculatum*)
- Little millet (*Panicum sumatrense*)
- There are other millets and pseudo-cereals

What is plant breeding?

- Plant breeding refers to basket of technologies to create new and improved crop varieties with desired traits
- Applies principles of genetics to crop improvement
- Improve phenotypic traits by crossing and selection;
- Directed manipulation of the genotype at the DNA level, and introduction of desired genes to new lines
- Plant breeding is both ***Science*** and also an ***Art*** of selecting desired plant types (with good eyes: visual evaluation)

Exploitation of Heterosis

- Extend to all crops– currently only 15 out of 100 crops
- Genepool shift for increased heterosis--from 30% to 50%
- CMS systems to be developed for major nutri-cereals
- Apomixis as a tool to make “True breeding hybrids”
- Manipulate sexuality of plants to exploit heterosis
  - Self-pollinated to Cross-pollinated crops to exploit heterosis
  - Cross-pollinated to self pollinated as pollinators are decreasing

Use cutting-edge and emerging technologies

- Use AI, ML and LLM for imaging analysis for precision phenotyping;
- Increased use of Haplotype-based breeding
- Lower costs for genotyping and faster sequencing of genes
- Use Next-gen technologies for genome editing (nano CRISPR, etc.)
- Use Pan genome analysis and Spatial transcriptomics
- Smart Controlled environment facilities for Speed breeding
- Efficient breeding techniques for nutritional traits
- Better weather prediction using AI for precise, local/ field level parameters for field evaluations (to support MLT evaluations)

Upcoming disruptive technologies

- Enhance photosynthetic capacity for higher productivity
- Control stomata opening of plants to enhance drought tolerance
- Exploit bio-mining capacity of plants (Cu, Au, U, Co, Ni, etc)
- Harness plants ability to produce bio-plastics (medical devises, etc.)
- Google's 'Heritable Agriculture' plans to use AI to predict yield, taste, nutritional and photosynthetic capacity of plants
  - Helps breeders to search and explore which genetic changes are profitable
  - Technologies will help perennials that take many years to get new improved varieties
  - Claim that system can breed variety with right genetics in one year!

Conclusions

- Nutri-cereals can innately cope with climate-change
- Although hardy, yield levels are comparatively low
- Great potential for enhancing yield and nutritive value
- Hybrid vigour (heterosis) can increase yield by >30%
- Cutting-edge and emerging technologies can hasten developing improved crop varieties adapted to climate change
- Many upcoming and disruptive technologies in biotech, IT, AI, ML and LLM can aid in efficient crop breeding
- Using Next-gen technologies can improve breeding efficiency, and faster cultivar development

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Thanks for your attention