



Opportunities and Challenges of Accelerated Breeding: Case of Philippines

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Philippines

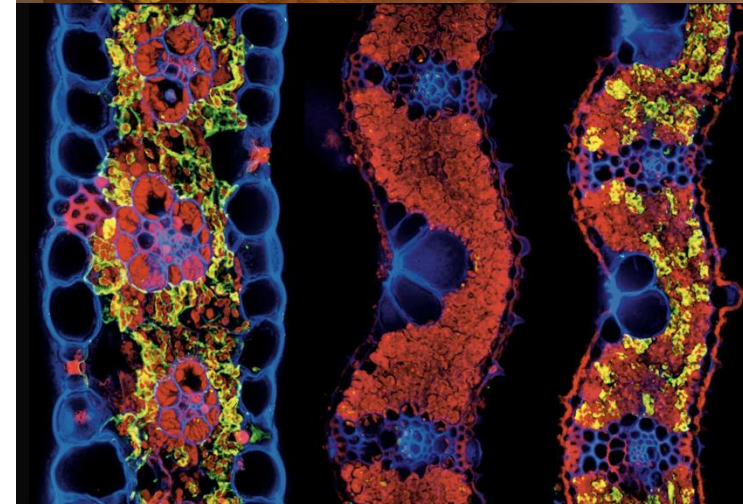
The Philippines has 7,641 islands, with diverse agro-ecological zones -- irrigated lowlands, rainfed systems, and upland env'ts.

- ❑ Rice is “everything”. However, the production systems are highly vulnerable to climate-related stresses such as typhoons, drought, and flooding, and salinity. Also pest and diseases!
- ❑ **Rainfed systems dominate in area (~2.7 M ha) but not in productivity**
- ❑ **Irrigated systems in area (~1.2 M ha) dominate in production and yield**
- ❑ This mismatch is a major justification for **accelerated breeding especially for rainfed ecosystem or stress resilience:**



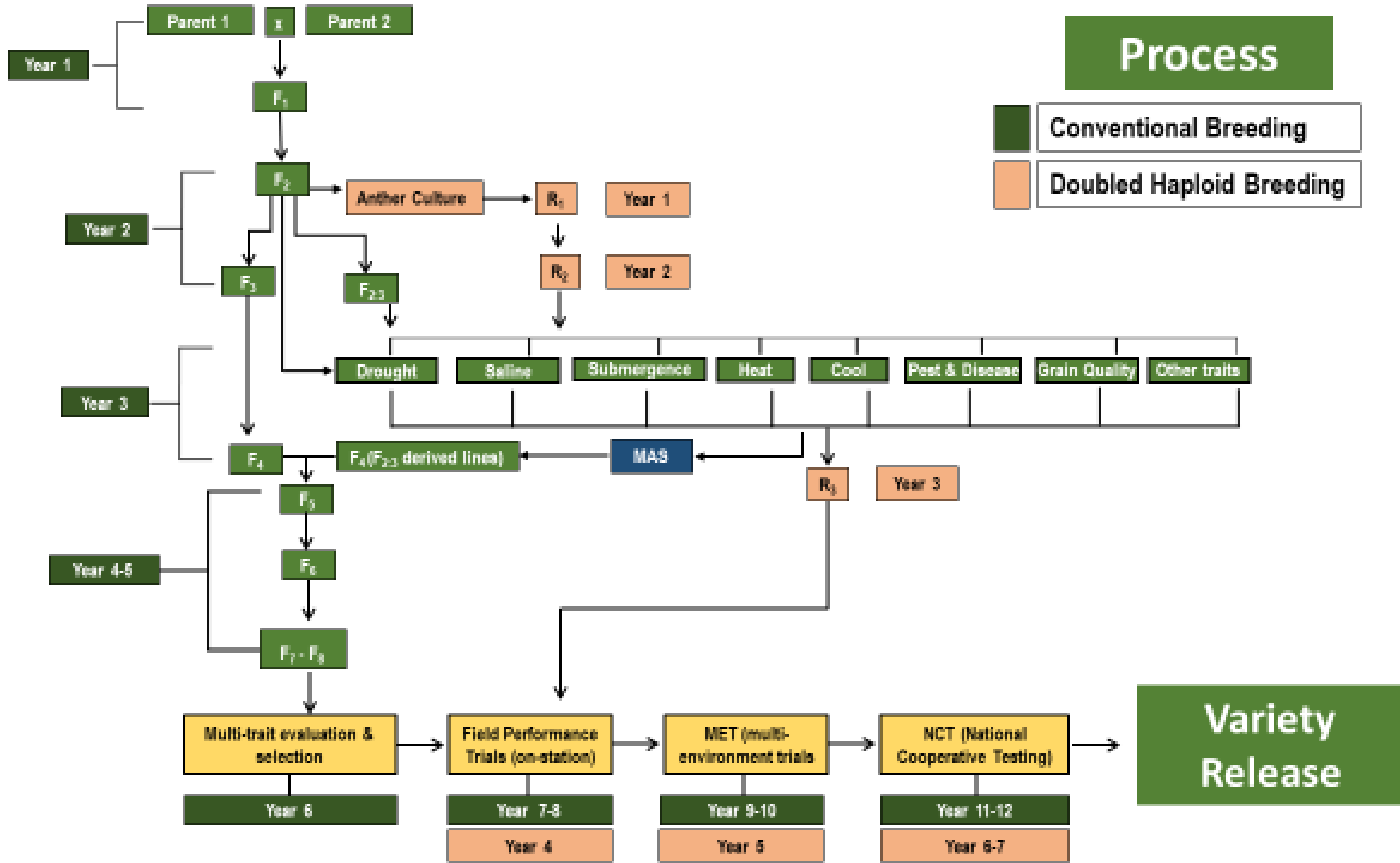
Breeding Programs

- ❑ Philippines- crop breeding is led the PhilRice, UPLB RVIT, and the Department of Agriculture's Crop Biotechnology Center, in collaboration with universities and international partners.
- ❑ Breeding relied on conventional methods, particularly pedigree breeding. However, there has been increasing integration of modern approaches such as marker-assisted selection, hybrid breeding, Tissue culture or AC, GMO, and more recently, gene editing technologies.
- ❑ The Philippines has been a regional leader in biotechnology, being among the first in Asia to adopt biosafety regulations and approve genetically modified crops.

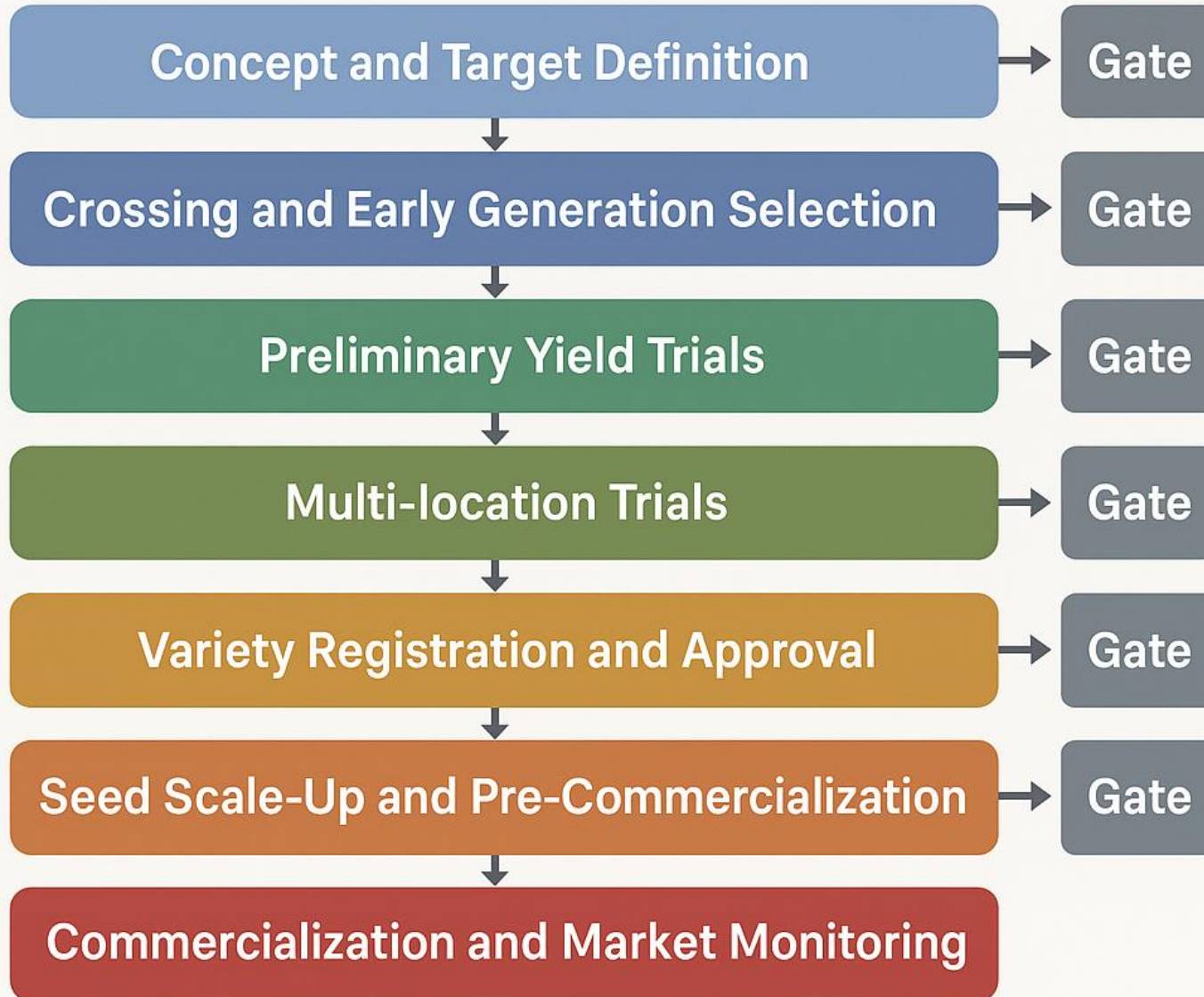


Current Breeding Pipeline

- ❑ Despite some advancements, our breeding pipelines remain relatively slow.
- ❑ The development of a new variety typically takes around 10 to 12 years, with only one to two generations per year. This limits our ability to respond quickly to emerging challenges.
- ❑ Key bottlenecks include long breeding cycles, fragmented workflows, limited use of advanced technologies, and weak integration with seed systems.
- ❑ These constraints are consistent with broader challenges observed across national breeding programs in the Global South.

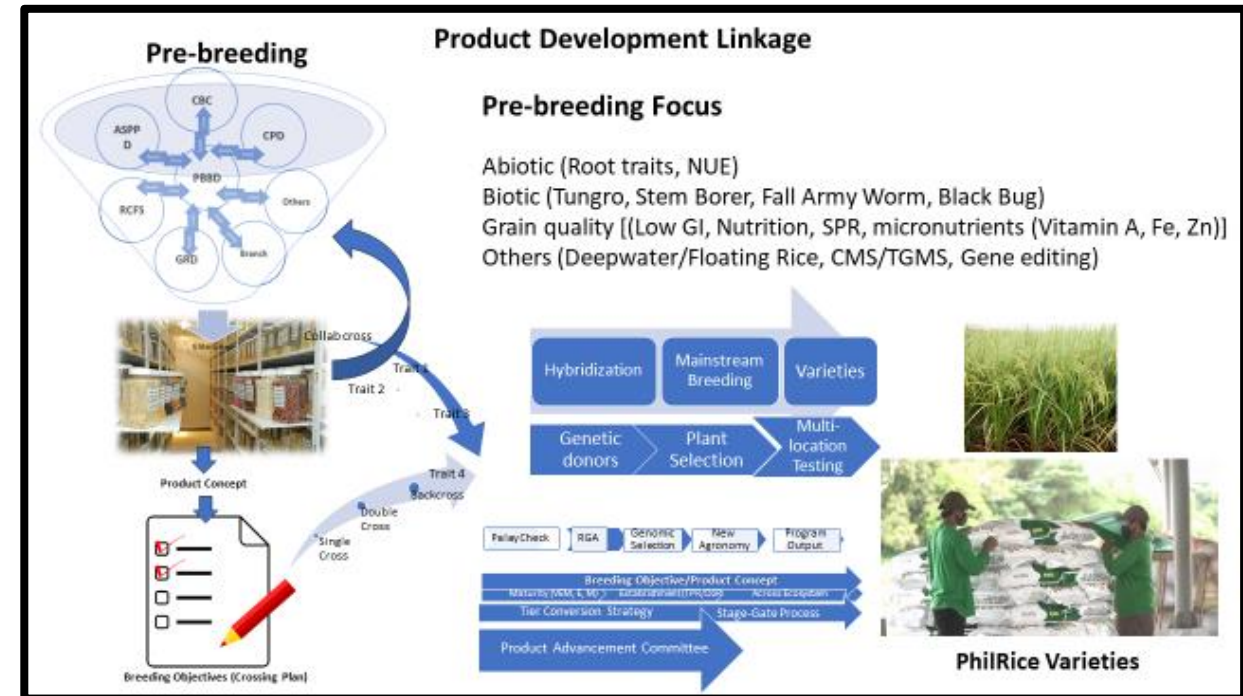


PRODUCT DEVELOPMENT STAGE-GATE



Accelerated Breeding: Philippine Perspective

- ❑ Accelerated breeding (AB) is the strategic integration of technologies, data systems, and optimized breeding processes to increase genetic gain, reduce time and cost required for variety development.
- ❑ AB is critical given the increasing frequency of climate-related stresses and the need for rapid varietal replacements.
- ❑ AB aligns with the principle of maximizing genetic gain per unit time, emphasizing both efficiency, cost and impact.



Technologies in Use

- Significant progress in adopting modern breeding technologies.
- Marker-assisted selection is widely used, particularly for disease resistance and stress tolerance traits.
- Gene editing is an emerging area, with ongoing work on traits such as High nutrition rice, bacterial leaf blight resistance, tungro virus resistance, and yield improvement.
- However, the adoption of technologies such as genomic selection, digital phenotyping, and doubled haploids remains limited and is still in the scaling phase.

Technology in use	Adoption Level	Notes
Speed breeding	Moderate	Field-based approaches emerging
Doubled Haploids/AC	Limited	Infrastructure constraints
MAS	High	Widely used in rice
Genomic Selection	Emerging	Still scaling
Digital phenotyping	Emerging	Pilot level
Gene editing	Emerging	Still scaling



**Rapid Generation Advance (RGA) nursery
@ PhilRice**

Breeding Strategies

SEED MUTATION



- Mature seeds
- 250 Gy to 350 Gy ^{60}Co

IN VITRO MUTAGENESIS



- Tissue culture + gamma irradiation
- Increase mutation efficiency

ANTHER CULTURE



- Rapid fixation of lines
- Unmask desirable traits

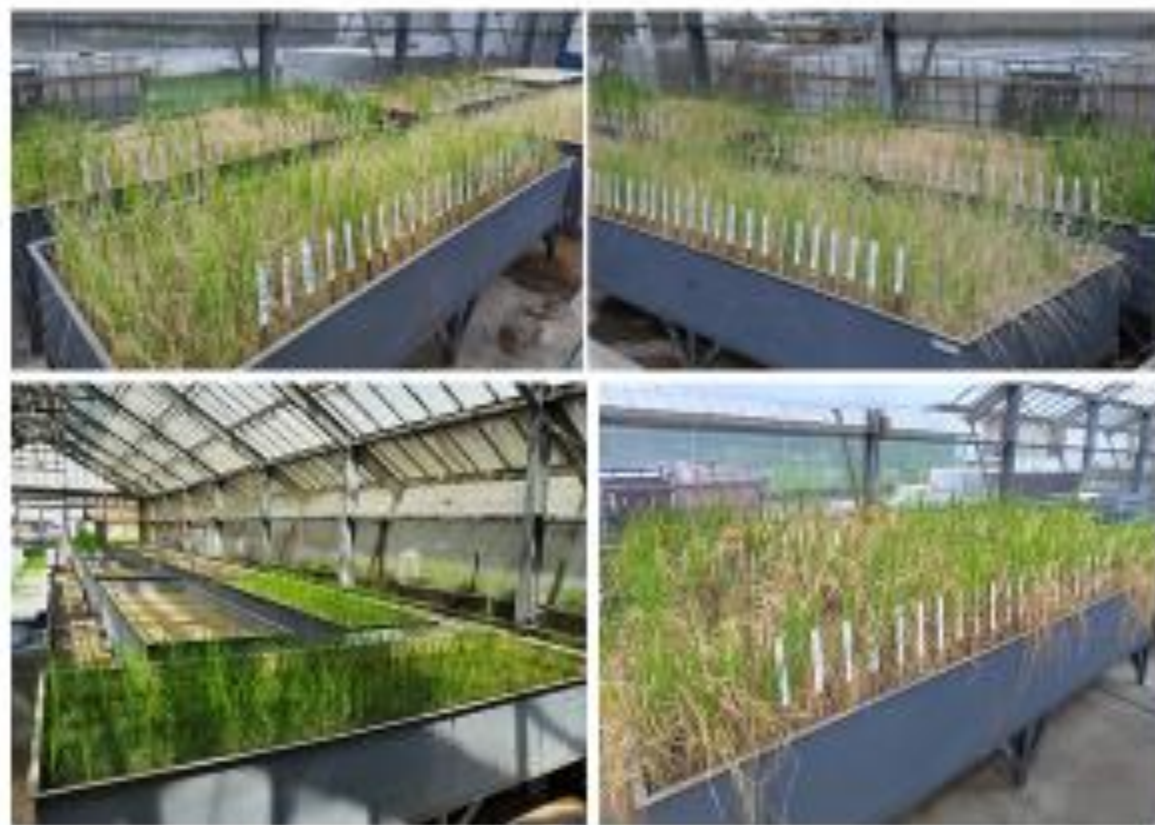


- Induced mutation: Enhance genetic variability for rice crop improvement
- Anther Culture/Doubled Haploid Breeding: Unmask desirable traits/Rapid fixation
- Conventional approach (elite x elite cross) – combined abiotic stress tolerance
- Molecular Markers

Infrastructure and Capacity

- Philippines benefited from strong institutional capacity, including well-established research organizations and a pool of skilled scientists.
- Nevertheless, there are notable gaps in infrastructure, particularly in controlled environment facilities for speed breeding, as well as in advanced data management and analytics systems.
- Strengthening these areas will be critical for accelerating breeding progress.

Phenotyping for Drought Tolerance



SEEDLING DROUGHT

- Tolerance score: plant recovery
- Stress imposition: 21 DAS
- Grain yield/plant or plot
- Genotyping: Presence of the genes
- Root plasticity traits



REPRODUCTIVE DROUGHT

- Intermittent drought
- Imposition: 20 DAT
- Re-water: 2 days



ROOT RESEARCH

Source: NL Agustin, 2020

Phenotyping for Submergence Tolerance



SUBMERGENCE AT SEEDLING

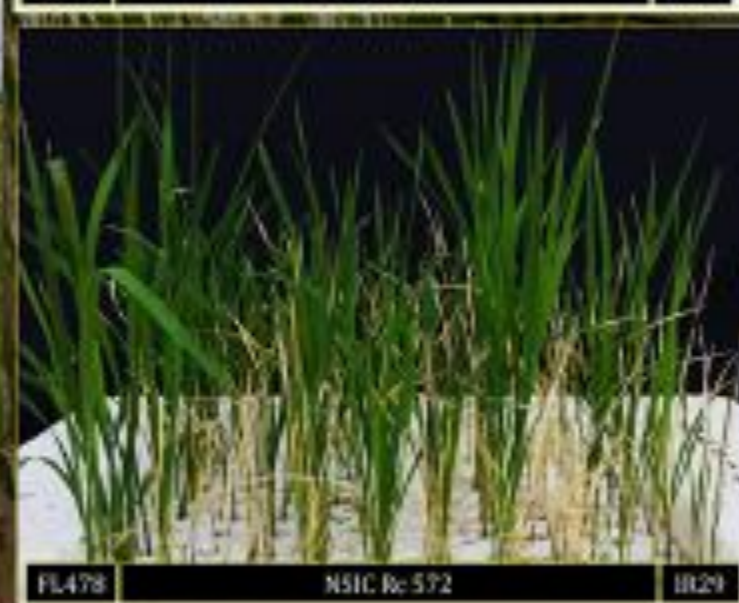
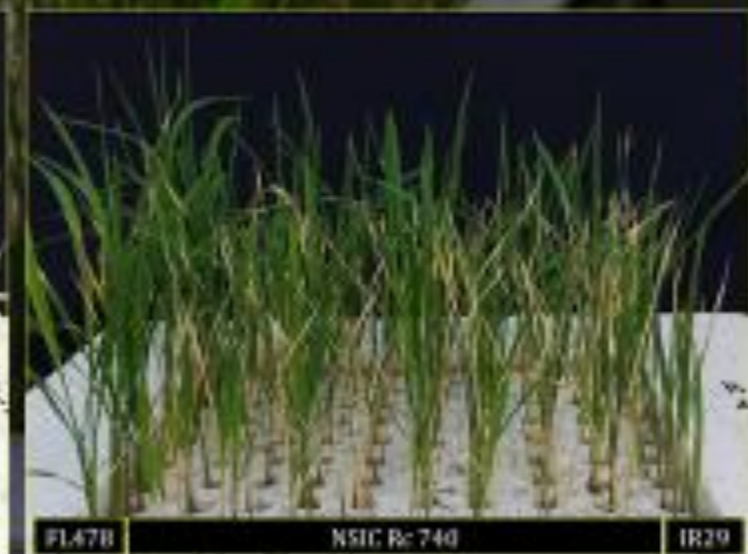
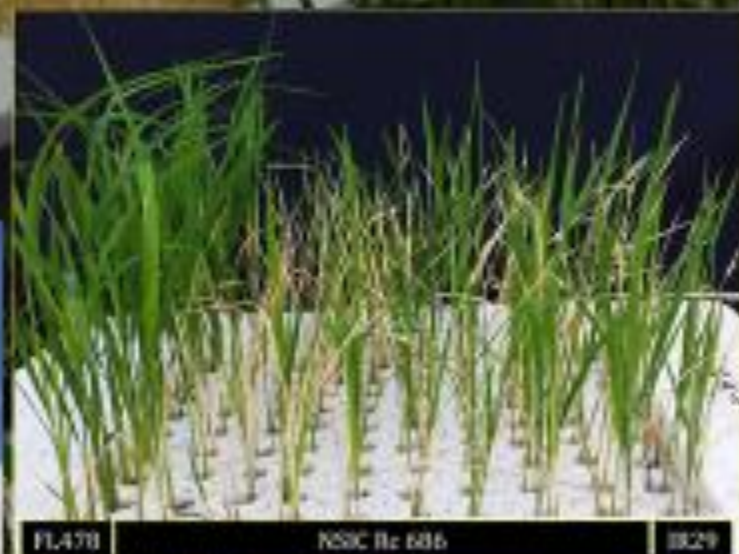
- Tolerance score based on % plant survival
- Stress imposition: 21 DAS/21 DAT
- Survival Score: 21 DA deSub

SUBMERGENCE AT VEGETATIVE

- Seedling vigor and grain yield under submergence
- Genotyping: Presence of the tolerance gene

Seedling: Injury score, 16 days from salinization

Field Screening of Salinity



Phenotyping for High and Cool Temperature Tolerance

Tolerance score: spikelet fertility
Grain yield under high/cool temp

Standard evaluation score (SES) for spikelet fertility (IRRI, 2014)

% Spikelet Fertility	Tolerance Score
>80	Highly Tolerant
61 - 80	Tolerant
41 - 60	Moderately Tolerant
11 - 40	Susceptible
<11	Highly Susceptible



Case Studies

- ❑ **Golden Rice**, a biofortified variety developed to address Vitamin A deficiency.
- ❑ Approved for commercial propagation in 2021 and registered as a variety in 2022. While it represents a major scientific and public health milestone, its deployment has faced regulatory and societal challenges.
- ❑ Another important area is the development of gene-edited crops, including rice lines with resistance to major diseases and improved yield traits. These initiatives demonstrate the potential of precision breeding in addressing both productivity and resilience.



Golden Rice

- biofortified with beta carotene in the grain due to introduction of a gene from yellow corn (*phytoene synthase*) and a gene from a common soil bacteria (*carotene desaturase*)
- a complementary approach to address Vitamin A deficiency in the country
- approved for commercial propagation in **July 2021**
- registered as “Malusog 1” rice variety in **April 2022**
- **currently unavailable for planting**





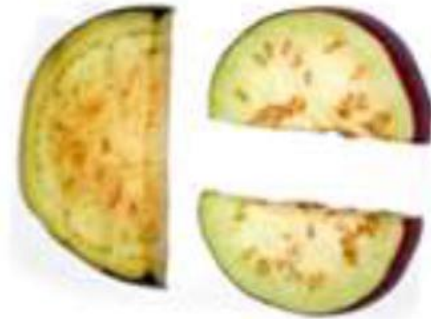
High Iron and Zinc Rice (HIZR)

- Contains ***OsNAS*** and Apple **ferritin** genes that facilitate the efficient uptake of Iron and Zinc from the soil and their subsequent storage in the grain.
- helps address the problem of Iron deficiency anemia and stunting in the country



Non-Browning Eggplant

Knocked out the **polyphenol oxidase gene** to prolong freshness of cut fruits



Low phytic acid corn

Reducing the phytic acid content of corn to improve its nutritional value by targeting the **ZMIPK1 gene**

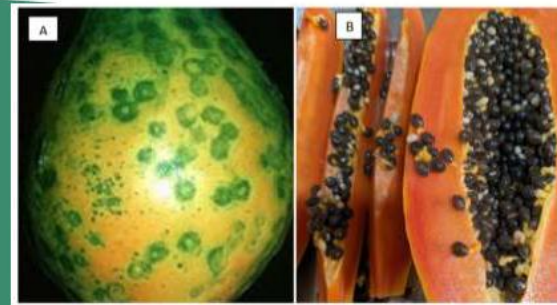


High lycopene tomato

Knocking out **lycopene cyclase genes** that convert lycopene to carotenes. The accumulation of lycopene results in redder tomatoes.

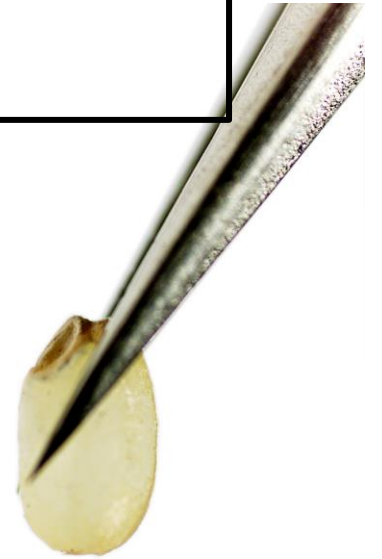


Virus-Resistant Papaya (PRSV) and Tomato



Key Opportunities

- 1) Strong government support and established biotechnology programs provide a solid foundation.
- 2) Phil has a progressive regulatory environment, including policies that facilitate the development and approval of plant breeding innovations.
- 3) Regional collaboration within ASEAN offers opportunities for shared learning and resource optimization.
- 4) Growing interest from the private sector, particularly in seed systems and biotechnology investments.
- 5) Increasing demand for climate-resilient, “**biofuel**”, and nutritious crops creates strong incentives for innovation.



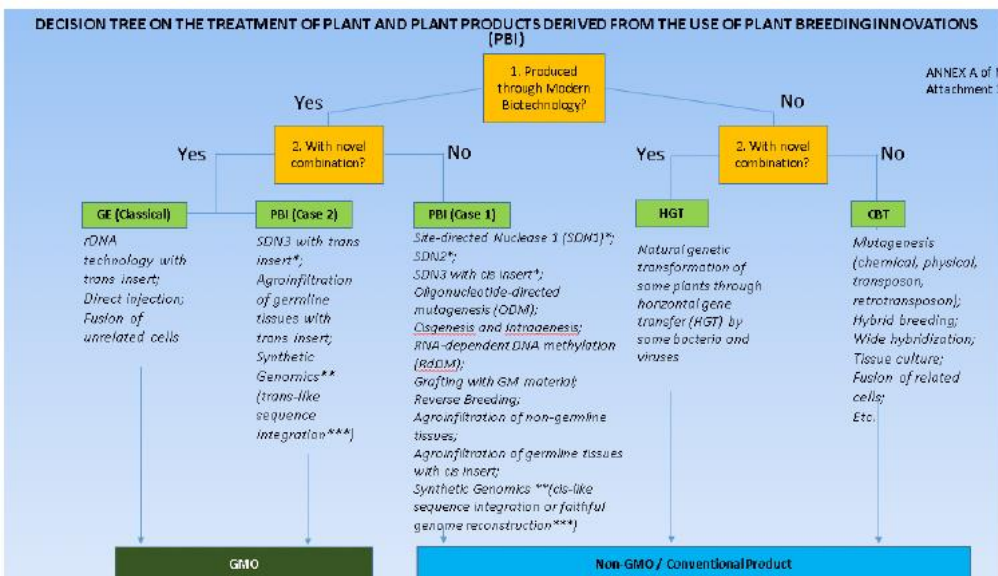
Challenges

- 1) Funding limitations and infrastructure gaps continue to constrain the adoption of advanced technologies- *“limited facilities, now focus on cost cutting”*
- 2) There are also regulatory and public perception issues, particularly concerning genetically modified crops.
- 3) Human resource capacity in emerging areas such as genomic selection, data science, and artificial intelligence needs to be strengthened.
- 4) Weak integration between breeding programs and seed systems limits the effective delivery of improved varieties to farmers.

Policy and Regulatory Environment

- The Philippines has one of the most established biosafety regulatory systems in the developing world.
- Among the first countries in Southeast Asia to implement policies on plant breeding innovations, including gene-edited products.
- A key feature of the regulatory framework is the differentiation between transgenic and non-transgenic products, which can facilitate faster approval processes for certain technologies.

Policy on Plant Breeding Innovations



Note: Techniques listed under PBI Case 1 and Case 2 may expand as new technologies emerge. Any PBI technique must be able to produce a non-GM or both non-GM and GM plant as a final product.
* In addition to the new CRISPR-Cas9-based Prime Editing (Anzalone et al., 2019) ** Different from, but converges with Synthetic Biology, which specializes on sequences/genetic elements (e.g. unnatural base pairs) genomic that are not found in nature (beyond novel combination). *** Pertains to a largely synthetic assembled genome.

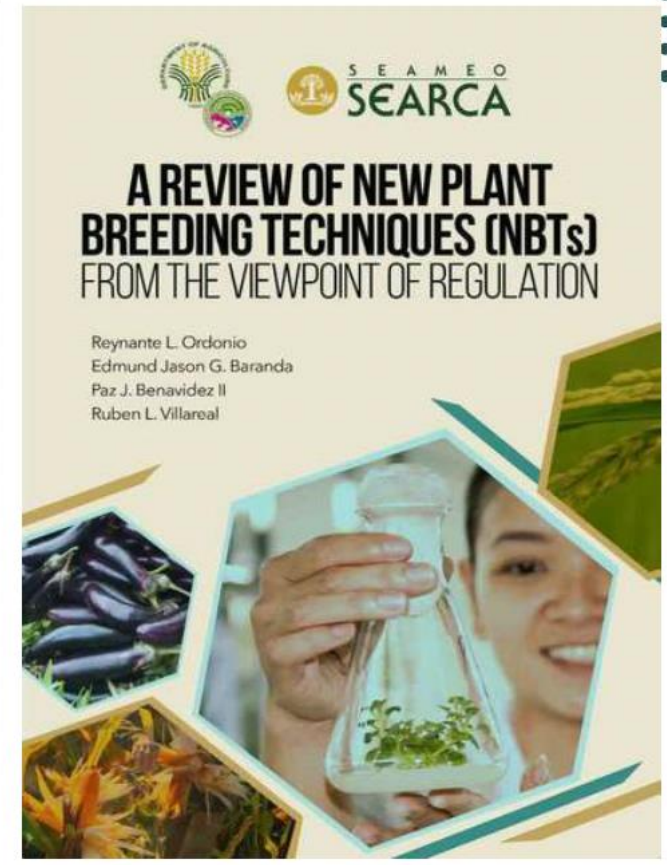
RESOLUTION NO. 001 Series of 2020

THE REGULATION OF PLANT AND PLANT PRODUCTS DERIVED FROM THE USE OF PLANT BREEDING INNOVATIONS (PBIs) OR NEW PLANT BREEDING TECHNIQUES (NBTs)

WHEREAS, pursuant to Section 4.1 of Executive Order No. 514, Series of 2006, otherwise known as "Establishing the National Biosafety Framework, Prescribing Guidelines for its Implementation, Strengthening the National Committee on Biosafety of the Philippines, and for Other Purposes", the National Committee on Biosafety of the Philippines (NCBP) shall be the lead body to coordinate and harmonize inter-agency and multi-sector efforts to develop biosafety policies in the Philippines;

WHEREAS, during the 13th meeting held on 19 March 2019, the NCBP accepted the technical study commissioned by the Department of Agriculture (DA) entitled "A Review of the New Plant Breeding Techniques (NBTs) from the Viewpoint of Regulation" which looked into the state of the art, regulatory landscape, applicable domestic laws and policies, and current capabilities of public R&D institutions on New Plant Breeding Techniques;

WHEREAS, DA recommended to create a Technical Working Group (TWG) that will look into NBTs and help in developing guidelines or amending existing biosafety guidelines to address issues unique to NBTs that do not fall under the DOST-DA-DENR-DOH-DILG Joint Department Circular No.1, Series of 2016 (JDC1), otherwise known as "Rules and Regulations for the Research and Development, Handling and Use, Transboundary Movement, Release into the Environment, and Management of Genetically-Modified Plant and Plant Products Derived from the Use of Modern Biotechnology";



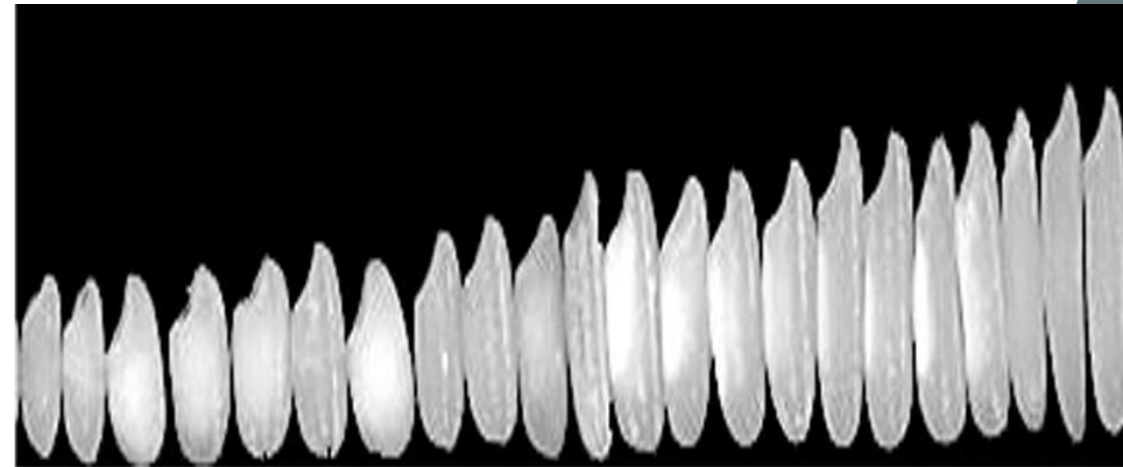
Southeast Asia's 1st Policy on Products of PBIs

Collaboration and Private Sector

- Collaboration plays a critical role in the Philippine breeding landscape.
- Partnerships with international organizations such as IRRI, UPLB, as well as collaborations with local universities and private sector stakeholders, are essential for advancing research and innovation.
- Public-private partnerships, in particular, offer opportunities to strengthen seed systems and accelerate the scaling of improved varieties.

Future Vision (5–10 Years)

- ❑ Philippines aims to significantly modernize its breeding systems.
- ❑ Key targets include reducing the breeding cycle from over 10 years to approximately 5 to 7 years, increasing the number of breeding cycles per year, and expanding the adoption of genomic and digital technologies.
- ❑ There is also a strong emphasis on developing climate-resilient, high-yielding, Biofuels, Low GHG emission varieties, and nutrition-sensitive crop varieties.



Recommendations

- 1) At the national level, there is a need to invest in infrastructure for accelerated or speed breeding and digital systems, as well as to strengthen human resource capacity.
- 2) At the regional level, ASEAN collaboration should be enhanced to harmonize regulatory frameworks and promote shared innovation platforms.
- 3) Research priorities should focus on integrating genomics, phenotyping, and data analytics to drive more efficient and impactful breeding programs.

Key Takeaways

- 1) Accelerated breeding is not merely about adopting new technologies—it requires a comprehensive transformation of breeding systems and communication.
- 2) Philippines has a strong foundation in terms of policy, institutions, and scientific capacity.
- 3) The path forward depends on how effectively we integrate science, technology, and delivery systems to achieve faster and more sustainable genetic gains -- ***Communication***



INVENTION happens in Universities
and Research Institutions

Partnering with the Industry is when
INNOVATION happens.

Innovation is the act of turning
research results into revenues—
into **economic and social gains**.

In the end, what matters is building
PARTNERSHIPS.



"The reality of Accelerated Breeding is won or lost at the farmer and consumer level, where applicability and sustainability is tested."

