



R&D Efforts in Hybrid Rice

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APSA 2007

November 7, 2007

Manila, Philippines



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The Beginning of Pioneer

Commitment to Farmers' Productivity and Profitability

- Henry A Wallace founded the Hi-Bred Corn Co. in 1926 – the first company to develop, produce and market hybrid maize seed
- Hybrid Rice effort initiated in India in late '80s
- Committed to increasing customer productivity and profitability
- Company success directly linked to customer success

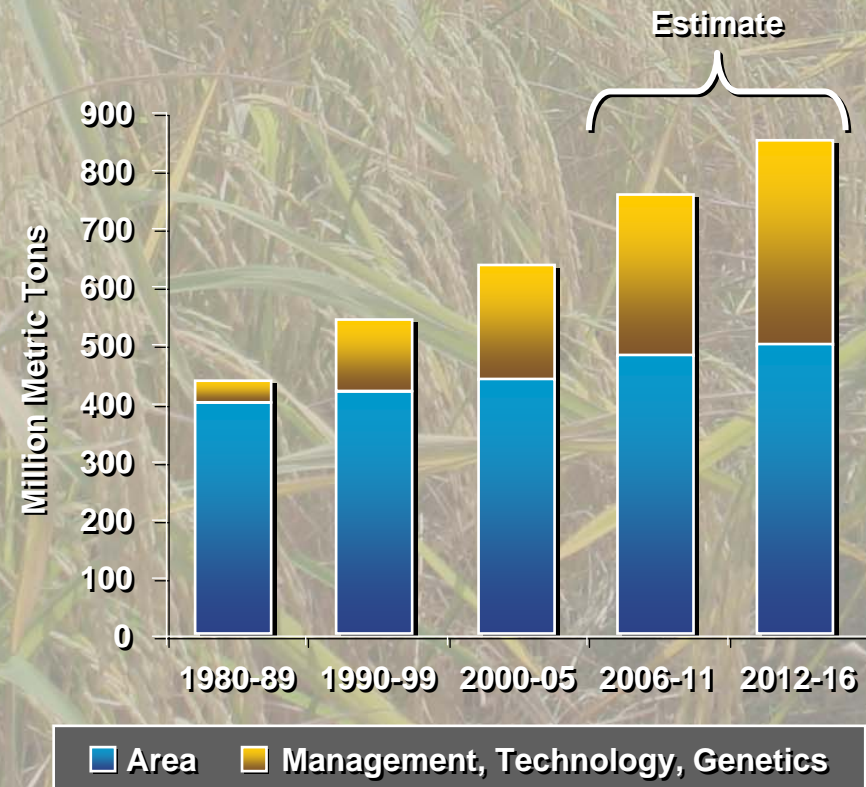


Growth in Total Maize Production

Area vs. Management, Technology & Genetics

- Crop yields will need to continue to increase to keep pace with increasing incomes, population, fuels and demand for meat
- Productivity gains driven by adoption of improved management, technology & genetics
- Since 1980
 - Global maize area increased 11%
 - Production increased 68%
- More than 74 million maize “virtual hectares” have been created since 1980

World Maize Production: 1980-2016





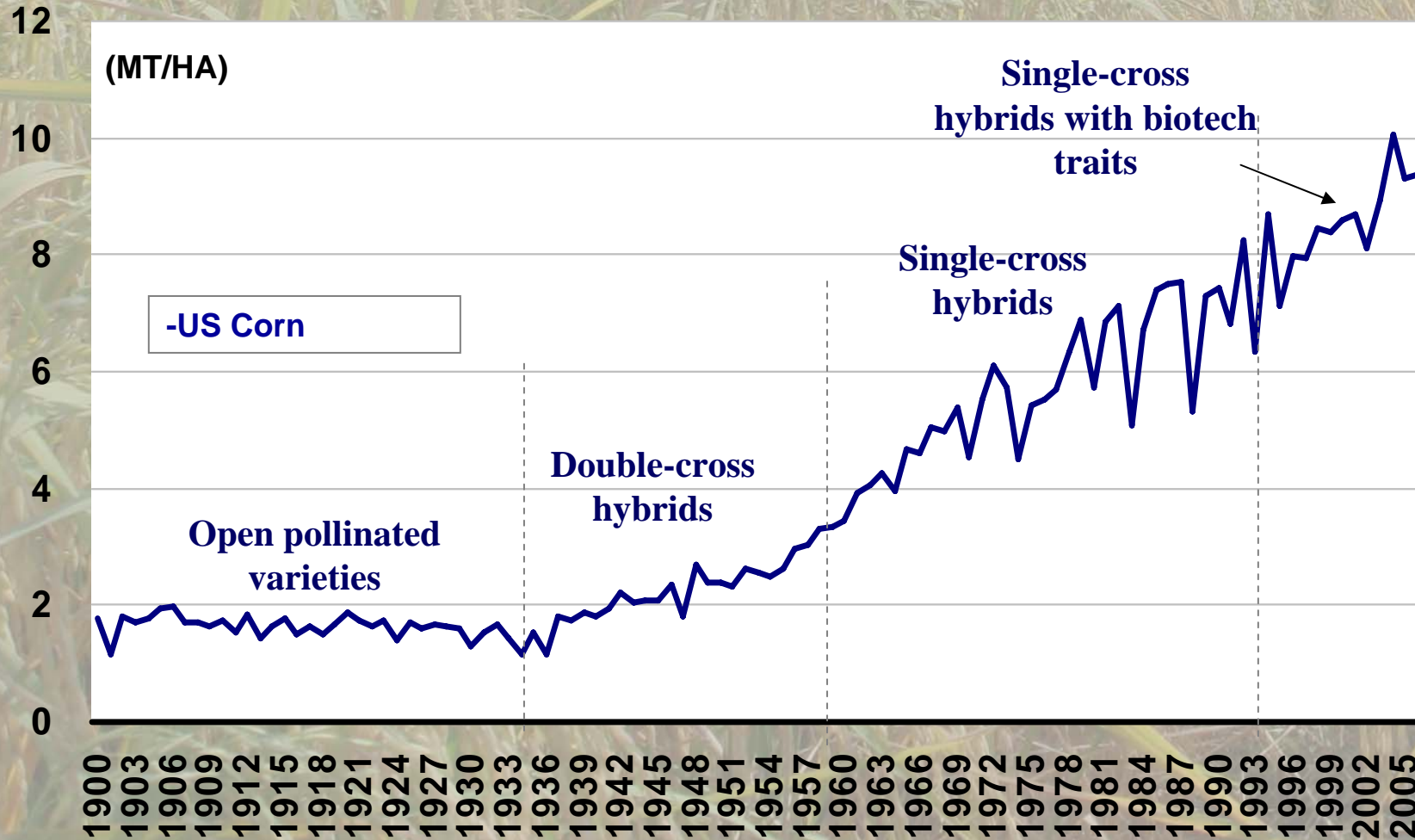
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U.S. Corn Yield Trends

Redefining productivity



Source : USDA and IRRI



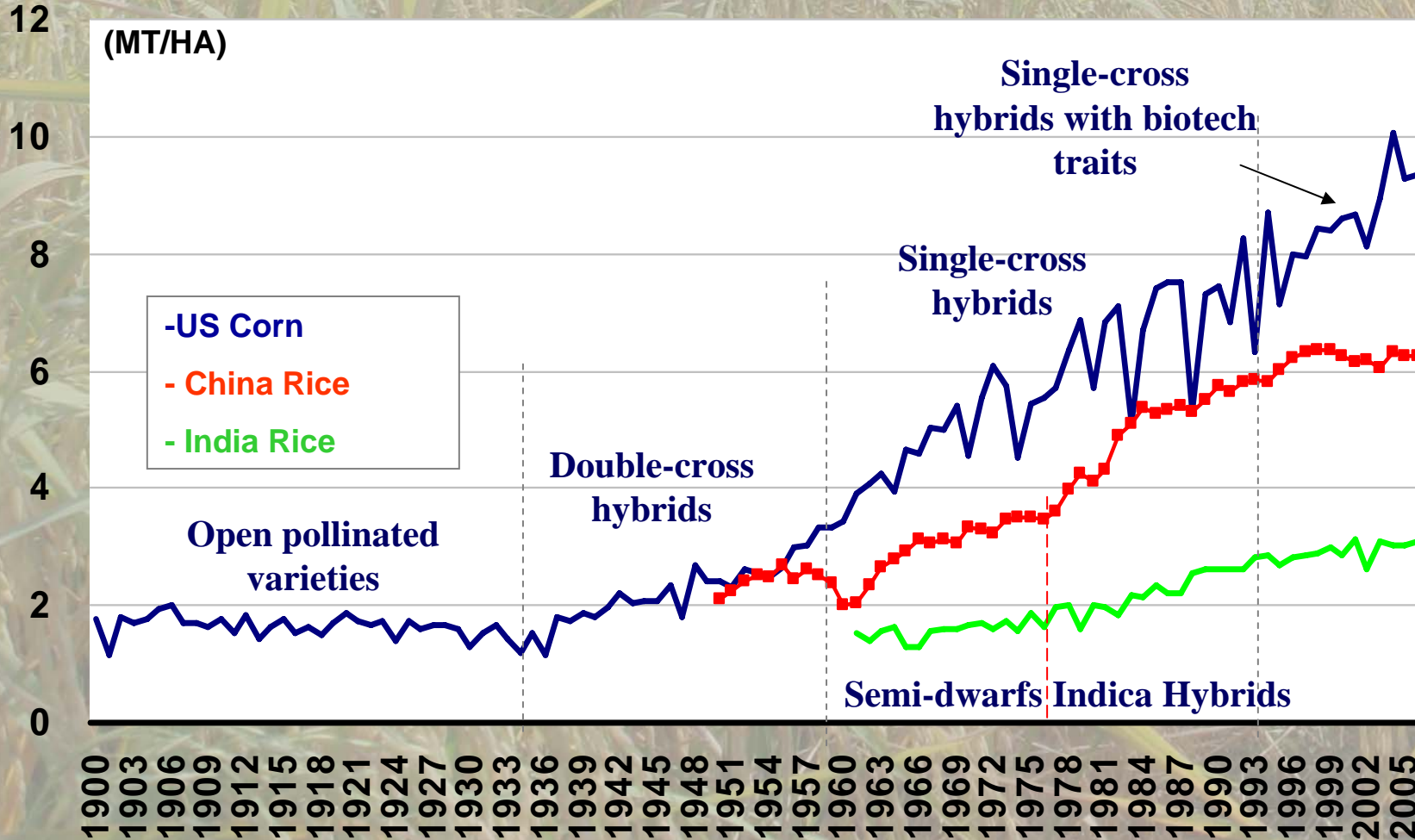
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Genetic Gain Improvements

Maize vs. Rice



Source : USDA and IRRI

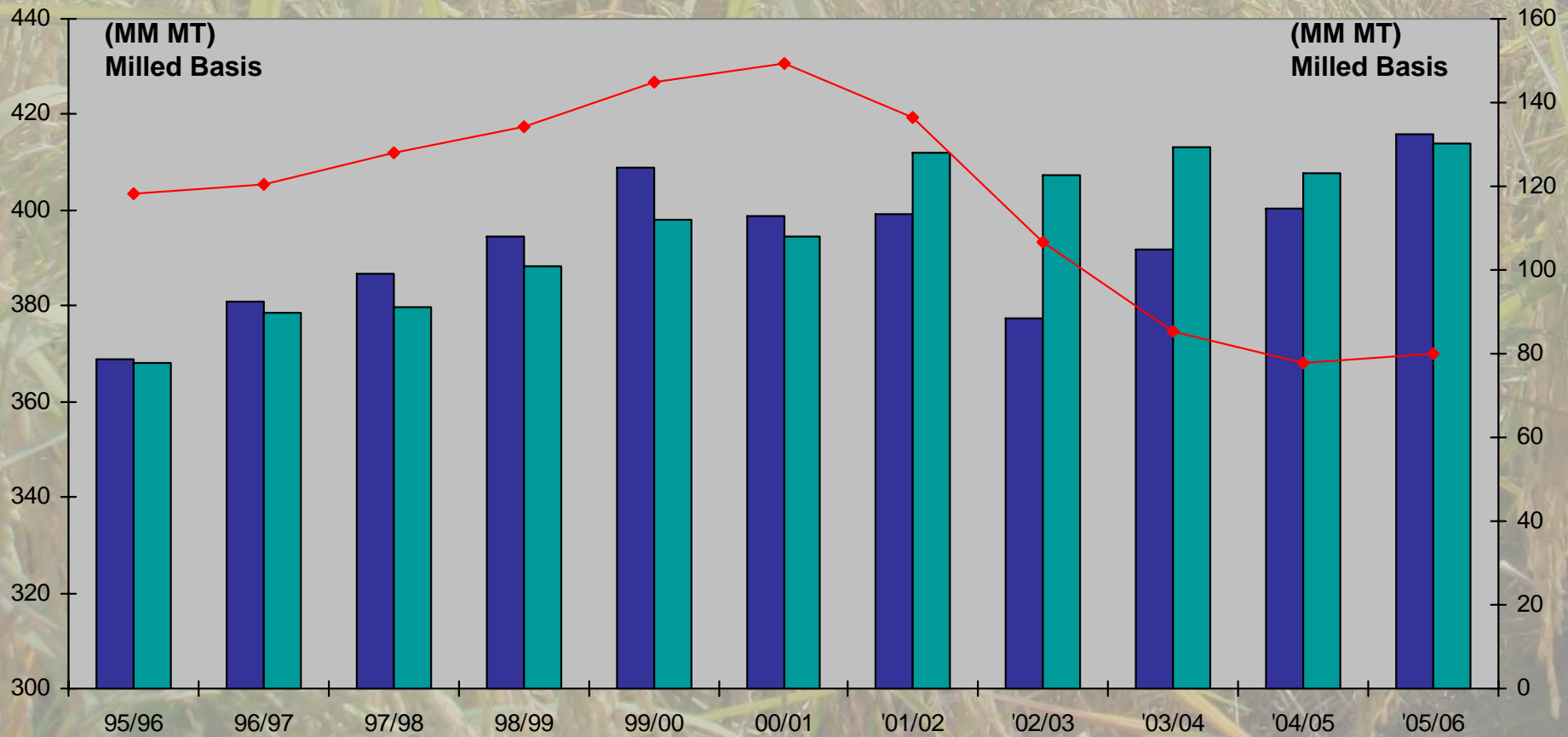
Importance of Rice

Rice is life

- Asia produces and consumes ~80% of the world's rice across diverse ecosystems
 - 80% Indica (Long grain)
 - 20% Japonica (Short grain)
- Rice provides the largest % of calories for human diets in Asia 30% overall and is as high as 70%
- Rice is the staple food for 40% of the world population

World Rice Supply and Demand

Ending stocks depleted to maintain consumption



Production Consumption Ending Stock

Source : USDA Foreign Agricultural Service



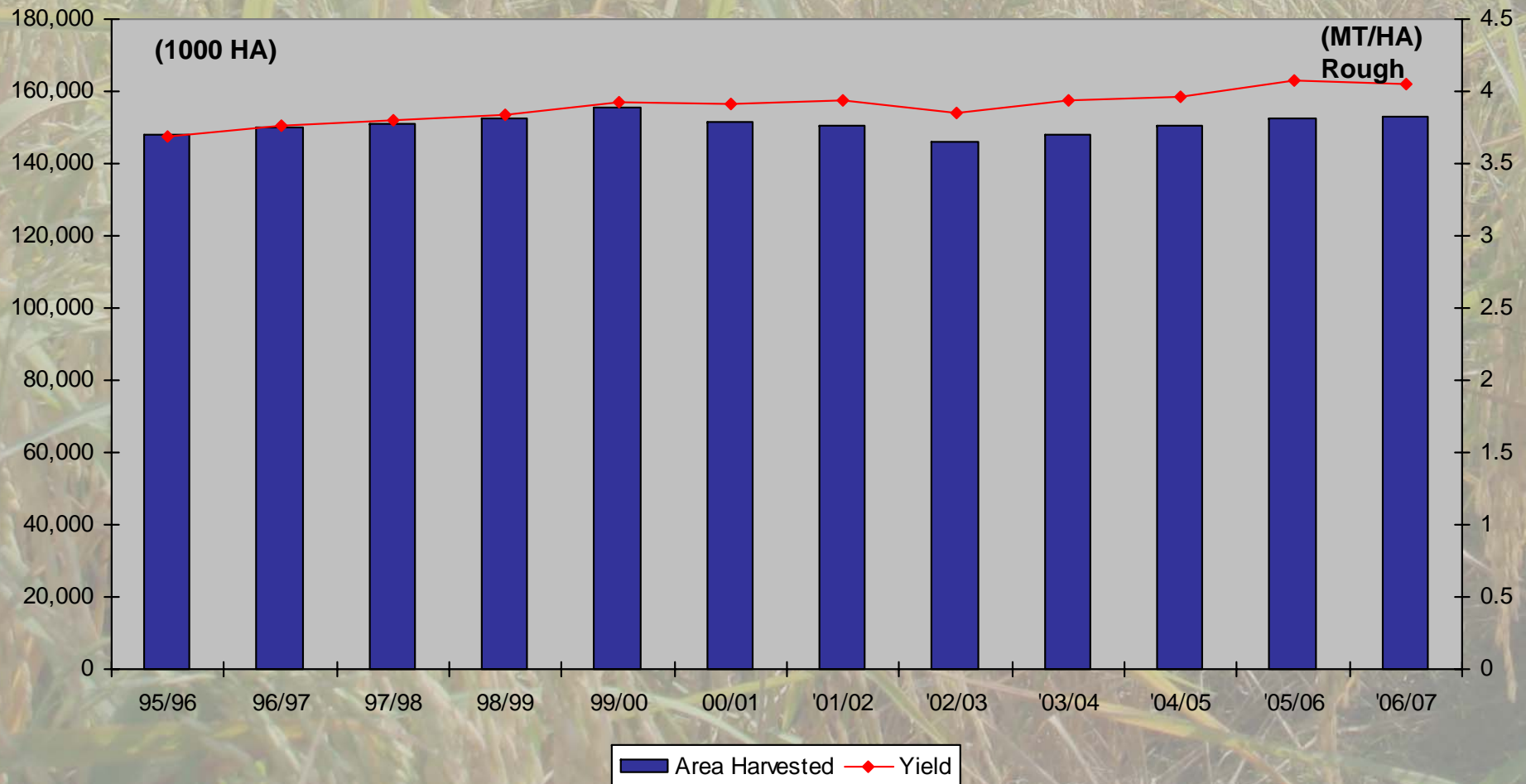
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World Rice Productivity

Rice area and yields are flat



Source : USDA Foreign Agricultural Service

Current Research Focused on Future Needs

Assume 10 years to develop, evaluate and commercialize a hybrid

- In the future we can assume that we will have:
 - Less land for rice
 - Competition with more competitive crops and urbanization
 - Less water for rice
 - Competition with more competitive crops and urbanization
 - Less labor
 - Competition with higher-paying industries
 - Increased climate variability
 - Increased frequency of extreme weather events
 - Increase in associated pests and diseases

Hybrid Rice R&D Objective

Develop products that increase farmer productivity and profitability

- Increased productivity and profitability through
 - High yielding hybrids
 - Grain yield, plant architecture
 - Biotic stress resistance
 - Insects, diseases
 - Abiotic stress resistance
 - Salinity, drought, submergence, cold and heat tolerance
 - Herbicide tolerance
 - Increasing labor costs, timing of labor availability, direct seeding
 - Grain quality
 - High quality will earn premiums for farmers



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High Yielding Products

Grain yield, plant architecture, maturity

Flag leaf and overall height

Panicle position and size

Number of grains

Number of productive tillers





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Stress Resistance

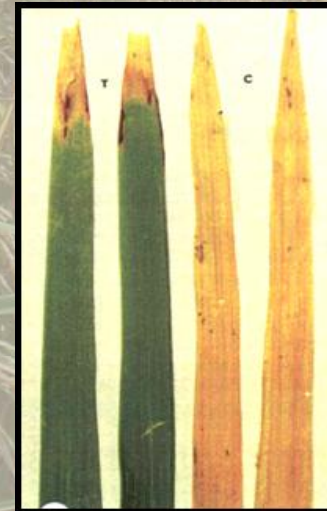
Biotic and abiotic stress resistance/tolerance

Biotic Stress

- Pests
 - Stemborer
 - Leaf Folder
 - Brown Plant Hopper
- Disease
 - BLB
 - Blast
 - Sheath Blight

Abiotic Stress

- Drought
- Salinity
- Submergence
- Extreme Heat/Cold



Herbicide Tolerance

Increasing labor costs, timing of availability, direct seeding

- Off-farm opportunities compete for rural laborers
- Timely weeding is critical in the first 3-6 weeks
- Manual weeding 15-20 labor days/HA/weeding
- Direct seeding and herbicide use will increase with less water for weed control and less labor for transplanting



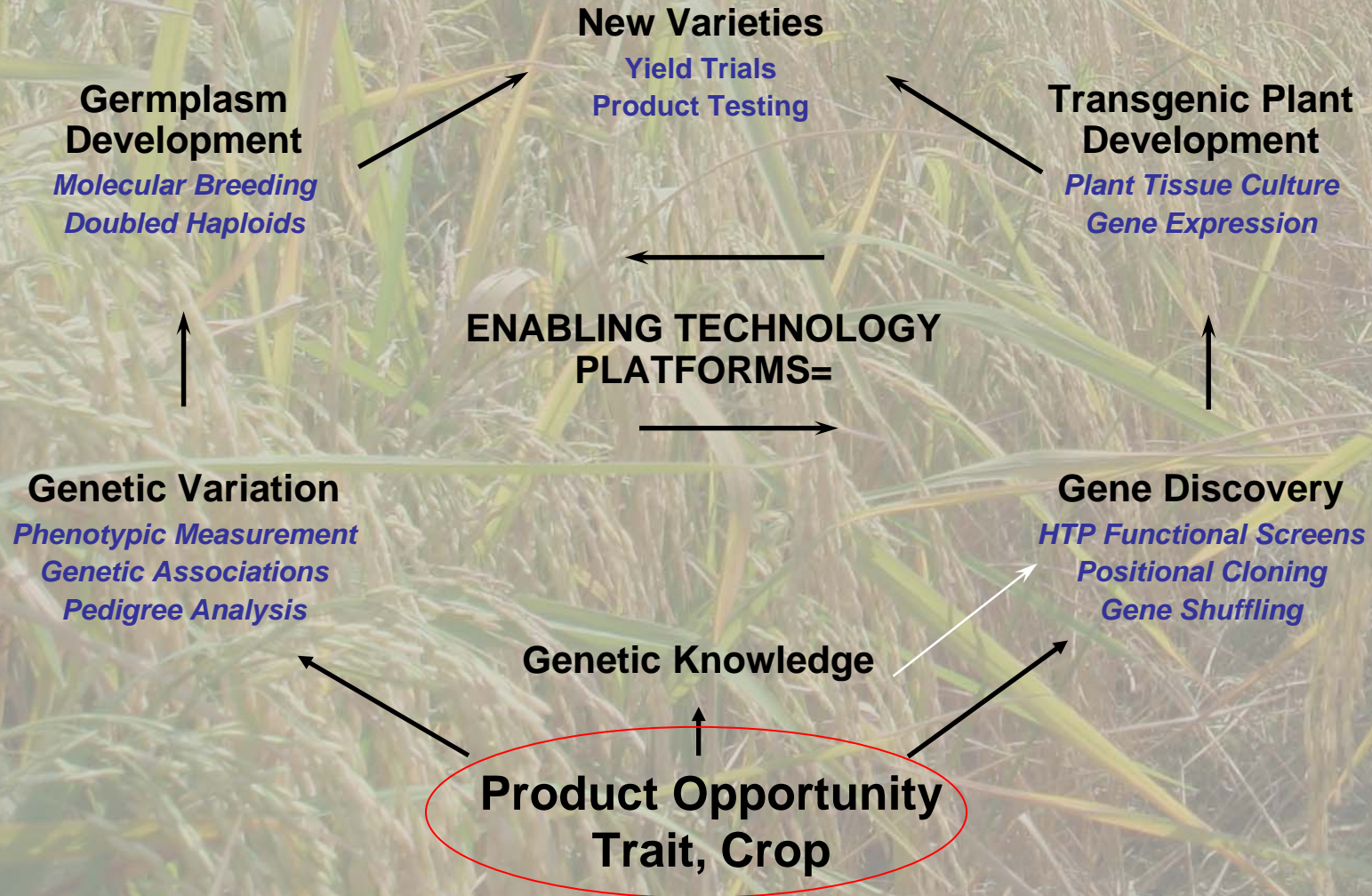
Grain Quality

High-quality grain will earn premiums for farmers

- Grain size and shape
 - Length/width ratio
- Milling standards
 - Milling %- brown rice removed
 - HRR-% whole grain
 - Whiteness-polishing
 - Chalkiness-opaqueness
- Chemical characteristics
 - Amylose content
 - Low <20% moist/sticky
 - Intermediate 20-25% most commonly preferred
 - Gelatinization temp- cooking time
 - Gel consistency-hardening of cooked rice upon cooling



Technical Paths to Products





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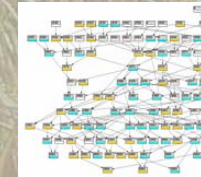
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Molecular Genetics Platform

IRRI Rice lines are the source of genes for product development

Germplasm Collection

Largely pedigree-based breeding germplasm



Rice first food crop to have its genome sequenced

Genetic Information

High capacity genotyping facilities to characterize germplasm at the gene and haplotype level



Core breeding germplasm

Genetic Knowledge

Germplasm-based marker-trait associations enable better breeding decisions to maximize genetic gain

A	A	T	A	C	G	A	T
A	A	T	A	C	G	A	T
A	A	T	A	C	G	A	T
A	A	T	A	C	G	A	T
A	A	T	A	C	G	A	T
G	A	T	A	C	A	A	VD C
G	A	T	A	C	A	A	VD C
G	A	T	A	C	A	A	VD C
G	A	T	A	C	A	A	VD C
G	A	T	A	C	A	A	VD C

Extensive phenotypic databases will enable gene discovery for key traits

Genetic Discovery

Germplasm-based phenotype-to-gene associations enable native trait discovery



Plant Breeding

Genetics

Extensive,
documented, and
cross-referenced
genetics library

+

Genomics

Association
map of elite genetics

+

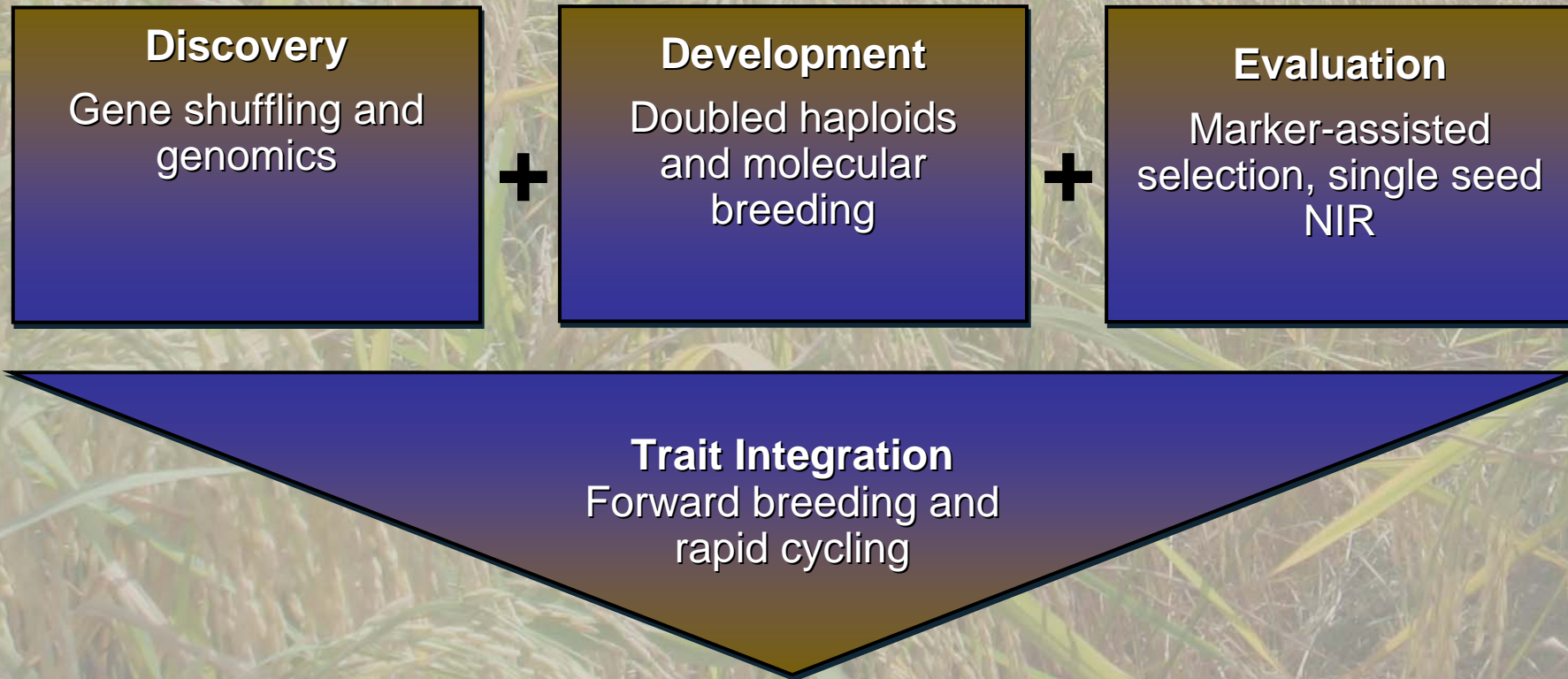
Evaluation

Knowledge of
customers and their
growing conditions

Expert Analysis

Mathematicians, Statisticians, Modelers,
Bioinformatics Experts, Breeders,
Scientists, Agronomists

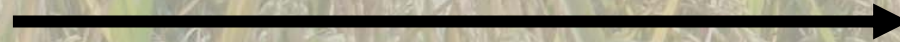
Innovative Enabling Technologies



Product Timeline

Time from discovery to pre-launch ranges from 6 to 13 years

**Gene
Discovery**



**Product
Pre-Launch**

World rice productivity
World population
World rice supply and demand

*Rice area and yields are flat
Increasing in developing countries reliant on rice for nutrition
Ending stocks depleted to maintain consumption*

***The Time From Discovery to Pre-Launch Must Decrease
To Meet Growing Demand***



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Science, Solutions and Customer Success





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Thank You