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Advancement, Validation, and Selection of Nutrient-Dense Breeding Lines

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PART 01

Introduction & Key Concepts

Understanding the core concept and fundamental value of developing nutrient-dense breeding lines.

The Stark Reality of Global Micronutrient Deficiency

According to the joint data from the FAO and the WHO, over two billion people suffer from micronutrient deficiencies despite having enough to eat, particularly severe in developing countries and is one of the most significant public health challenges at present.

Iron Deficiency

Most common deficiency. Affects 162M children & 29% of women of childbearing age.

Zinc Deficiency

Affects ~210M children, directly causing stunted growth and low immunity.

Vitamin A Deficiency

Affects 250M children; a leading cause of childhood blindness.

Iodine Deficiency

The primary cause of preventable intellectual disabilities globally.

Limitations of Traditional Interventions

01 / Food Fortification

Adding micronutrients to processed foods to improve population nutritional

Core Advantages: Wide coverage, quick results.

Main Limitations: Relies on a well-established food industry, struggles to reach remote populations.

02 / Supplementation

Distributing vitamin or mineral pills/capsules for direct nutritional intervention.

Core Advantages: Highly targeted, direct and significant effects.

Main Limitations: Complex distribution, poor compliance, high long-term costs, unsustainable.

What are Nutrient-Dense Breeding Lines?

Definition

Plant varieties developed through traditional breeding or modern biotechnological methods to directionally increase the content of micronutrients (e.g., iron, zinc, provitamin A) critical to human health in the edible parts of crops and improve their bioavailability.

Orange Sweet Potatoes rich in β-carotene

Core Concept

Integrate nutritional intervention directly into the entire process of agricultural production, optimizing crop nutritional quality from the source. It allows people to naturally and continuously obtain the required micronutrients through their daily diet of staple foods or vegetables.

Core Goal

To improve the nutritional quality of staple crops, make staple foods a “natural nutrient bank”, aiming to effectively combat and reduce micronutrient deficiencies in vulnerable human populations through daily diets.

Significant Advantages of Nutrient-Dense Breeding

Sustainability

Once elite varieties are developed and promoted, farmers can save their own seeds, eliminating the need for continuous external input and creating a virtuous cycle.

Broad Coverage

Directly targets the poor populations who depend on staple foods, precisely addressing the vulnerable groups that traditional nutrition interventions struggle to reach effectively.

High Cost-Effectiveness

For every **$1** invested, over **$10** in health and socio-economic benefits are generated, proving to be an exceptionally efficient investment.

Cultural Adaptability

Uses staple crops that people are already accustomed to eating, eliminating the need to change existing dietary habits and cooking methods for easy adoption.Make staple foods a “natural nutrient bank”

PART 02

Advancement of Nutrient-Dense Breeding Lines

Mastering practical strategies for advancing promising nutrient-dense lines from early to late generations.

Four Primary Goals of Nutrient-Dense Breeding

01 Increase Content

Significantly increase the concentration of target micronutrients in the edible parts of the crop.

02 Improve Bioavailability

Ensure the nutrients are effectively absorbed by the human body, making them truly beneficial.

03 Maintain Agronomic Traits

New varieties must be comparable or superior to mainstream varieties in yield, disease resistance, and adaptability.

04 Ensure Sensory Quality

Nutrient-dense breeding should not sacrifice taste, color, or cooking quality to ensure consumer acceptance.

Types and Classification of High-Nutrition Traits

Three Core Categories for Crop Nutrient-Dense Breeding

Macronutrients (Major)

Required in large amounts for energy and structure. Focus on improving protein quality (lysine), starch digestibility, and dietary fiber content in staple cereals.

Micronutrients (Trace)

Targeting "hidden hunger". Biofortification prioritizes breeding crops with elevated levels of essential minerals like Iron (Fe) and Zinc (Zn) to combat global deficiencies.

Functional Ingredients

Non-essential but health-promoting compounds. Includes Flavonoids, antioxidants (anthocyanins), carotenoids (β-carotene in Golden Rice), and various vitamins.

Breeding Strategy Overview

Enhancing crop nutritional value is a key objective in modern agriculture. By systematically classifying traits into the three categories shown on the left, breeders can develop targeted strategies to address specific nutritional needs.

This multi-faceted approach ensures that we not only address deficiencies in basic building blocks but also incorporate compounds that promote long-term health and well-being.

Goal: Improve human health through optimized plant genetics.

Genetic Basis of Nutritional Quality Traits

Complex Quantitative Traits

Most nutritional traits are polygenic (controlled by multiple minor-effect genes) and heavily influenced by the environment, requiring careful evaluation across conditions.

Interaction between Major & Minor QTLs

Significant improvement comes from 'gene pyramiding'—stacking multiple favorable QTLs (both major and minor) into a single elite variety.

Heritability & Genetic Variation

High heritability enables effective selection. Natural genetic variation in crop germplasm is the essential raw material for breeding.

Core Concept

The nutritional composition of plants is a complex phenotype governed by the dynamic interplay of genetics and the environment. To effectively improve these traits through biofortification, we must first understand their underlying genetic architecture.

Unlocking Breeding Potential

Integrating genetic knowledge to develop nutrient-dense crops

How to Determine Target Nutrients

Breeding objectives are the first step in nutrient-dense breeding, requiring a comprehensive consideration of nutrition, agronomy, and sociology to develop a scientific and rational plan.

01. Nutritional Needs Assessment

Based on dietary surveys and nutritional status data of the target population, identify the key micronutrients that are commonly deficient. For example, in major rice-producing areas, iron and zinc are often prioritized for fortification.

02. Intake & Bioavailability Analysis

Scientifically consider the natural content of the target element in the crop, its bioavailability for actual human absorption and utilization, and its retention rate during processing and cooking to ensure the practical value of the breeding results.

Field research is an important basis for determining breeding objectives.

HarvestPlus's Nutritional Target Calculation Formula

The HarvestPlus program under the CGIAR has proposed a classic formula to scientifically and quantitatively determine breeding target increments for crop biofortification, translating complex nutrition improvement goals into actionable quantitative indicators.

$$\frac{\text{Extra Nutrient Supplied Through Biofortification}}{\text{Nutrient Requirement}} = \text{Additional Percentage of Estimated Average Requirement Supplied}$$

$$\begin{aligned}\text{Extra Nutrient Supplied Through Biofortification} &= \text{Per Capita Consumption of Food Staple} \\ &\times \text{Increment in Density of Mineral/Vitamin Due to Plant Breeding} \\ &\times \text{Percent Retention in Processing/Storage/Cooking} \\ &\times \text{Percent Bioavailability as Consumed}\end{aligned}$$

Formula Application & Significance

- ✓ **Ensures breeding objectives focus on the amount the human body can actually "absorb and utilize", not just elemental content increase.**
- ✓ **This quantitative approach bridges the gap between laboratory analysis and real human nutrition needs, making biofortification breeding precise and result-oriented.**

Breeding Objective Setting: **30%-50% of the Estimated Average Requirement (EAR) from fortified staple foods.**

Three Main Strategies for Nutrient-Dense Breeding

01 Contenvional breeding

Utilizing the naturally occurring genetic variations, through traditional methods such as **hybridization, backcrossing** and systematic selection, new varieties with enhanced nutrition are cultivated.

02. Mutation breeding

Induce genetic mutations through physical rays or chemical mutagens, artificially create new sources of variation, and rapidly screen for high-nutrition mutants.

03. Transgenic / Gene Editing

Transgenic: The introduction of exogenous genes into the genome of recipient organisms to make them express new traits.

Gene Editing: Precise modification of the organism's own genome (knockout/knock-in)

Principles of Parent Selection and Matching

Trait Complementation

Parents should be complementary in target traits, such as crossing a "high-yield, low-sugar" parent with a "low-yield, high-nutrition" parent, to combine both advantages.

High Combining Ability

Parents need good general and specific combining ability, ensuring that offspring can exhibit significant heterosis after crossing with other parents.

Excellent Agronomic Traits

Parents must have good adaptability, disease resistance, and yield potential to avoid losing key foundational traits during breeding.

Donor Parent

Germplasm (landraces/wild relatives/mutants) with high target nutrient content.
Characteristics: excellent nutritional value, but often poor agronomic performance.

Recipient Parent

Locally promoted elite varieties.
Characteristics: high yield, disease resistance, strong adaptability, but low target nutrient content.

Contenvional Breeding Process

01 Parent Selection and Hybridization

Select parental lines with complementary desirable traits for artificial hybridization to create genetic variation.

02 Segregation and Selection (F_2-F_4)

In segregating generations, select individual plants with target traits through phenotypic evaluation.

03 Line Evaluation and comparison(F_5-F_7)

Grow selected individual plants as lines to evaluate the stability and uniformity of their traits.

04 Yield Comparison Trials

Adaptability Evaluation Across Locations/Years

Evaluate the yield and adaptability of promising lines across multiple locations and years to assess stress resistance and productivity.

05 Registration & Commercialization

License to Commercialize

Obtain variety rights through national or local registration and proceed with seed production and marketing.

Detailed Breeding Process

This is the most time-consuming stage in the breeding process, aiming to obtain genetically stable, homozygous elite lines. Depending on the selection strategy, there are three main classic methods:

Pedigree Method

Core Principle

Continuous observation, recording, and selection of individual plants starting from the F_2 generation to establish a complete "pedigree record".

Main Advantages

Allows for precise control of the genetic background and is highly efficient for selecting complex traits such as yield and quality.

Potential Limitations

Enormous workload for field recording, a relatively long breeding cycle, and high labor requirements.

SSD Method

Core Principle

Only one seed is harvested from each plant for planting, rapidly advancing generations to F_5/F_6 before selection begins.

Main Advantages

Can drastically shorten the breeding cycle, saves field planting space and management costs, and is suitable for greenhouse breeding.

Potential Limitations

The lack of early artificial selection may lead to the random loss of some favorable recessive genes or individual plants.

Bulk Method

Core Principle

Early-generation (F_2-F_4) populations are harvested and planted in bulk without selection, allowing the population to mix naturally before selection is applied.

Main Advantages

Extremely simple field operations, extensive management, and the ability to maintain large populations at very low cost.

Potential Limitations

Favorable genes may be eliminated under natural selection pressure, and selection efficiency is generally lower.

Key Decision Points in Breeding Advancement

Early Generation

80-90%

Culling Rate

Primary Goal
Rapidly reduce the overall population size for focus.

Selection Basis
Nutrient content analysis & basic agronomic traits.

Mid Generation

50-70%

Culling Rate

Primary Goal
Validate performance consistency & purify lines.

Selection Basis
Combined index of yield potential & nutrient traits.

Late Generation

5-10%

Lines Retained

Primary Goal
Identify the most stable & superior performers.

Selection Basis
Multi-environment trial stability & overall merit.

"Bottlenecks" in Breeding Advancement and Solutions

High Cost & Volume

Facing large sample throughput with high biochemical testing expenses.

Tiered Screening Strategy

Use NIR spectroscopy for rapid initial screening, followed by precise lab assays only for the shortlisted elite lines.

G × E Interaction

Nutrient traits show inconsistent performance across different growing locations.

Multi-Environment Testing (MET)

Conduct trials across diverse locations/years and calculate stability parameters to select for consistent performers.

Yield-Nutrient Conflict

Improving nutrient content often comes at the cost of reduced crop yield.

Weighted Selection Index

Construct a multi-trait index with optimized weights to simultaneously improve and balance both yield and nutrient traits.

Marker-Assisted Selection (MAS)

MAS is a modern biotechnology that uses DNA molecular markers closely linked to target traits for indirect selection in the laboratory, thereby accelerating the breeding process.

Common Molecular Marker Types

Mainly including SSR 、 InDel markers and CAPS、KASP markers, which have characteristics like high stability and rich polymorphism.

Leap in Breeding Efficiency

Large numbers of individuals can be tested for markers at the seedling stage, rapidly screening plants carrying target genes for high iron, high zinc, etc., greatly improving selection accuracy.

Advanced Selection Strategy:Genomic Selection (GS)

Core Principles

Unlike traditional MAS that relies on specific QTLs, GS uses **genome-wide markers**to establish a model between markers and phenotypes in a "training population", then predicts the**GEBV**(Genomic Estimated Breeding Value) of the "candidate population" for selection.

Core Logic: **From "finding genes" to "genome-wide prediction".**

Standard Process

01. Construct Training Population

Perform dual genotypic and phenotypic measurements on a large number of individuals.

02. Build Prediction Model

Use statistical models to accurately estimate the effect of each marker.

03. Predict Candidate Population

Only genotype is tested, and GEBV is quickly predicted using the model.

04. Implement Precise Selection

Select individuals with the highest GEBV as parents for the next generation.

Technical Advantages

Capture All-Effect Genes

Simultaneously utilize major and minor genes without omission.

Suitable for Complex Traits

Significantly better than traditional methods for quantitative traits.

Shorten Breeding Cycle

Improve early selection accuracy and accelerate genetic progress.

Case Study: Biofortified Orange Maize in Zambia

Project Background

Zambia suffers from severe vitamin A deficiency due to a diet reliant on white maize.

Core Objective

Develop orange maize varieties rich in β-carotene (provitamin A), while maintaining yields and disease-resistant.

Technical Path

Crossed high β-carotene germplasm with local varieties, combined with marker-assisted selection (MAS).

Promotion Results

significantly increased blood vitamin A levels in target populations; improved family nutrition while maintaining farmer incomes.

Application of Gene Engineering in Nutrient-Dense Breeding

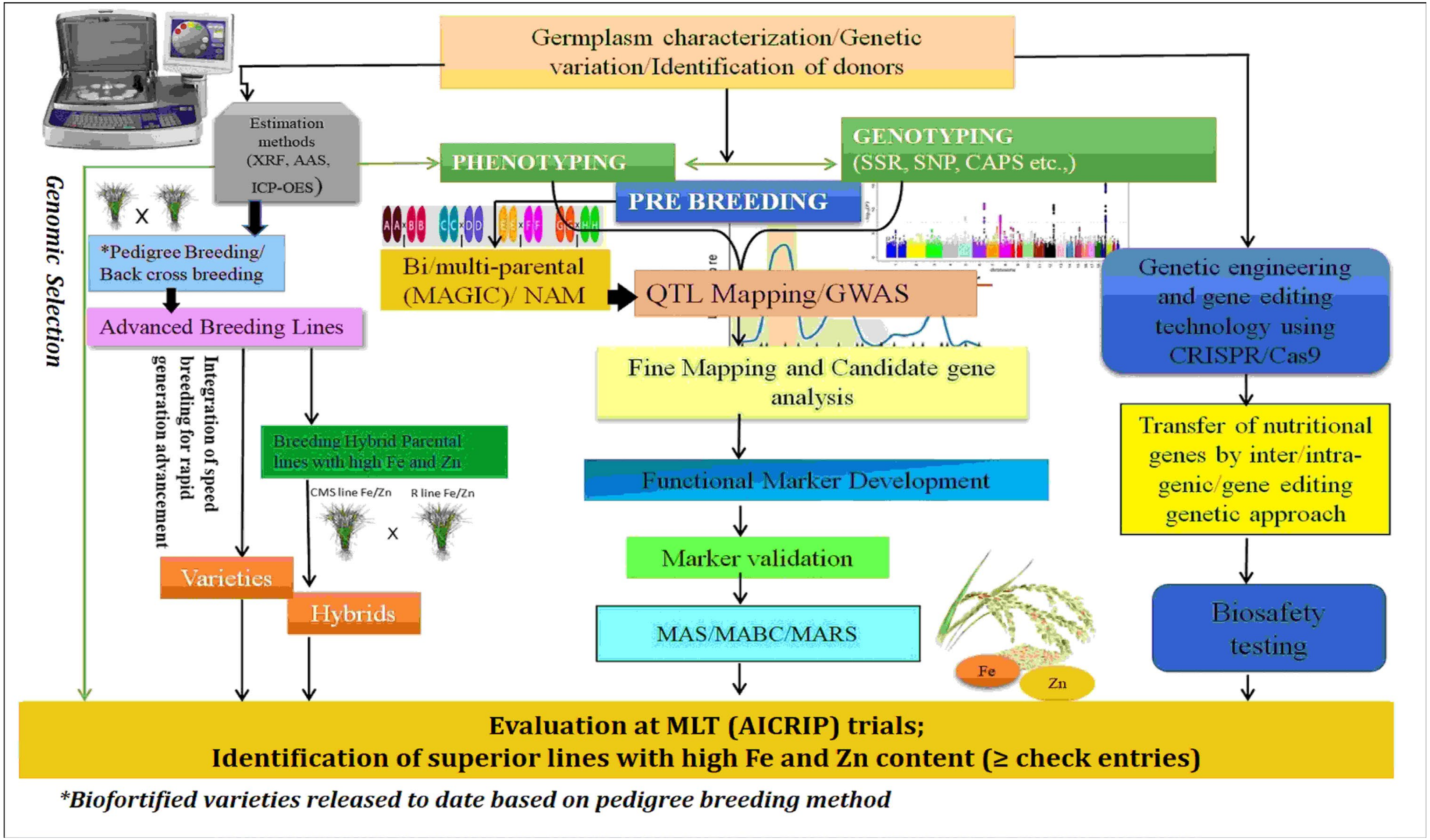
Transgenic:The introduction of exogenous genes into the genome of recipient organisms to make them express new traits

Genome Editing: Precise modification of the organism's own genome (knockout/knock-in),achieving precise improvement of crop traits.

Key Achievements on Transgenic

•**High Oleic Soybean:** Knocking out the *FAD2* gene increases oleic acid content from 20% to over 80%, making it healthier.
•**High Amylose Rice:** Editing the Waxy gene makes it suitable for special populations like diabetics.
•**Low Phytic Acid Corn:** Knocking out phytic acid synthesis genes significantly improves the bioavailability of iron and zinc.

Integrated breeding approaches for rice Fe/Zn biofortification



Senguttuvel et al., Frontiers in Plant Science,2023

PART 03

Validation of Nutrient-Dense Breeding Lines

Learning robust methods to validate the authenticity, stability, and heritability of key nutrient traits.

Validation of Nutrient-Dense Breeding Lines

What is Validation?

The systematic process of confirming the core attributes of an identified nutrient trait to ensure its reliability for further research.

Authenticity
Genuine trait, not an artifact

Repeatability
Consistent across trials

Genetic Stability
Heritable across generations

Adaptability
Performs well in varied environments

Why Validate?

- Eliminate false positives caused by random measurement errorsor transient environmental fluctuations.
- Confirm the trait has a strong genetic basis and can be reliablyinheritedby progeny.

The Three Dimensions of Validation

01

Genotypic Validation

GOAL

Confirm the trait is heritable and linked to specific genetic factors.

METHODS

Molecular markers, segregation analysis to map trait loci.

02

Phenotypic Validation

GOAL

Confirm the trait is stable across diverse environments, locations, and growing seasons.

METHODS

Conduct multi-environment trials (METs) and estimate broad-sense heritability.

03

Functional Validation

GOAL

Verify the increased nutrient is bioavailable and delivers actual nutritional impact.

METHODS

In vitro digestion assays, animal feeding trials, and human intervention studies.

Genotypic Validation

CORE GOAL

To confirm that the nutrient trait is heritable and directly linked to specific, identifiable genetic factors within the organism.

Key Validation Methods

Segregation Analysis

Observe trait segregation in F_2 or backcross populations to statistically determine the number of major genes controlling the trait.

Backcrossing

Systematically transfer the target trait into a different genetic background to confirm its expression remains consistent across environments.

Marker Validation

Utilize PCR-based markers (SSRs, SNPs) to directly confirm the physical presence of the target gene or QTL in the elite breeding line.

Phenotypic Stability Validation

CORE GOAL

To confirm the target trait exhibits consistent, predictable, and stable performance across a wide range of environmental conditions.

Heritability (H^2)

Proportion of phenotypic variation due to genetics. Values >0.6 indicate effective selection potential for the trait.

Genotype × Environment Interaction (GEI)

Quantifies the differential response of genotypes across varying environments, highlighting adaptive performance.

Stability Parameters

Tools (Finlay-Wilkinson, AMMI, GGE) to identify crop lines with robust, consistent yields across diverse locations.

Environmental Stability Assessment

Research Methodology

•**MET Trials**: Evaluate of Nutrient-Dense Breeding Lines across at least 2 years × 2 locations.

•**GGE Biplot:** Visualize Genotype × Environment (GE) interactions.

Core Assessment Objective

Identify and select superior crop lines that demonstrate high yield, high nutrient content, and consistent stability across variable growing environments.

Functional Validation

CORE GOAL

To confirm the increased nutrient is bioavailable and has a significant nutritional impact on target organisms.

In Vitro Digestion

Laboratory simulation of human digestion processes to estimate the potential bioavailability of nutrients before in-vivo testing.

Animal Feeding Trials

Controlled experiments using animal models (e.g., rats, pigs) to directly measure nutrient absorption, utilization, and physiological responses.

Human Intervention Studies (The Gold Standard)

Randomized Controlled Trials (RCTs) with human participants to assess real-world impacts on nutritional biomarkers (e.g., serum levels).

PART 04

Multi-Trait Selection Tools

Applying advanced multi-trait selection tools for effective breeding.

Limitations of Single-Trait Selection

The "Fallacy" of Single Trait

If directional selection is based solely on a single trait such as iron content, it often leads to the dilemma of "gaining one thing at the expense of another." This one-sided selection method tends to cause the degradation of other key agronomic traits such as yield potential and disease resistance, ultimately failing to meet the comprehensive needs of actual agricultural production.

⚠ **Warning:**
Excellent single-index performance ≠ Overall excellent variety

Multi-Trait Comprehensive Selection

A scientific breeding strategy should establish a multi-dimensional evaluation system. It is necessary to consider yield potential, nutritional quality, disease resistance, and adaptability across multiple dimensions for synergistic improvement and comprehensive identification. Only then can excellent varieties with high yield and quality, and adaptable to complex environments, be selected.

Core Principle:
Comprehensive Consideration & Synergistic Optimization

Challenges in Multi-Trait Selection

Need for Simultaneous Improvement

A successful nutrient-dense variety must not only have high nutrient content but also possess excellent agronomic traits such as high yield, disease resistance, stress tolerance, and good quality.

Negative Correlations Between Traits

Many important traits exhibit negative correlations. For example, in some crops, High nutrition vs. high yield;High nutrition vs. excellent taste; Disease resistance vs. yield

Risks of Single-Trait Selection

Focusing solely on increasing nutrient content may lead to the degradation of other important traits such as yield and disease resistance, resulting in varieties with poor overall performance that are unacceptable to farmers.

Tandem Selection and Independent Culling Levels

Tandem Selection

Core Method

Perform continuous selection for different traits sequentially. For example, first select high-yielding individuals, then further select those with high nutritional quality from the high-yielding population.

Main Advantages

Simple and intuitive process, requiring no complex statistical analysis, making it easy to promote and apply in early breeding work.

Main Limitations

Relatively low selection efficiency, and during continuous selection, it is very easy to lose gene combinations controlling different desirable traits.

Independent Culling Levels

Core Method

Set a minimum passing threshold for each target trait. An individual is only retained if its performance in all traits meets or exceeds the corresponding thresholds.

Main Advantages

Simple operation and effectively guarantees the basic level of each trait, avoiding neglect of other key traits due to over-focus on a single dominant trait.

Main Limitations

Prone to "false elimination", unable to reflect the relative importance of different traits, and lacks inclusiveness for individuals with excellent performance in some traits.

Smith-Hazel Index

Basic Principle

A classic linear selection index model. By assigning weighted coefficients (b) to target traits, multiple independent traits are combined into a single index value (I) to achieve joint selection of multiple traits.

$$I = b_1X_1 + b_2X_2 + \ldots + b_nX_n$$

X: Phenotypic Value | b: Weight Coefficient

Core Goal: Maximize the **total genetic progress** of the next generation population across all target traits.

Weight Coefficient (b) Calculation

Coefficients (b) are not subjectively set but derived from solving simultaneous equations using three core biological parameter matrices based on statistical principles:

Heritability (h^2): Ability to pass traits to offspring

Economic Weight (w): Practical production value

Covariance (G/C): Genetic/phenotypic correlation

Advantages & Disadvantages

Core Advantages

Rigorous theoretical basis, comprehensively considers trait importance and genetic characteristics to achieve**Best Linear Unbiased Prediction (BLUP)**.

Main Limitations

Relies on accurate estimation of genetic parameters, requiring long field trial cycles and high costs, limiting its rapid application in base populations.

Multiplicative Index & MGIDI Index

Multiplicative Index

Core Principle

Directly multiply the phenotypic values of each trait to obtain a comprehensive evaluation index. This method uses the mathematical properties of products to reflect the synergistic effects between traits.

Advantages

Simple and intuitive calculation logic, no need to estimate complex genetic parameters; severely penalizes individuals with obvious shortcomings, which is conducive to selecting excellent genotypes without defects.

MGIDI Index

Core Principle

First, dimensionality reduction is performed on multi-trait data through principal component analysis (PCA), and then the geometric distance between each genotype and the predefined "ideotype" in the reduced-dimensional space is calculated. A smaller distance indicates a closer proximity to the ideal state.

Advantages

Can effectively handle multiple highly correlated trait indicators and eliminate data redundancy; supports visualization of breeding goals, making selection results more intuitive and reliable.

MTSI Index

Core Principle

MTSI (Multi-trait stability index) is a comprehensive selection index that combines both the mean performance and stability of traits. It uses the WAASB parameter as the core basis to quantify and evaluate the stability performance of genotypes.

Four-Quadrant Screening Strategy

Plot a "Mean Performance vs. WAASB" scatter plot to divide genotypes into four quadrants. Individuals in the**"High Mean Performance - Low WAASB"**quadrant balance high yield (high nutrition) and environmental adaptability, making them ideal choices in breeding.

Breeding Improvement Advantages

It breaks through the limitations of traditional single-trait selection, organically integrating the mean performance of yield (or nutritional quality) with environmental stability, thus achieving synchronous improvement and enhancement of breeding objectives.

Expected Gain Index

Core Principle

Traditional selection indices rely on determining "economic weights", a process often biased by subjective judgments.

The Expected Gain Index takes the opposite approach: breeders first set specific **expected genetic gains** for each trait based on breeding objectives. Then, through algorithmic models, the optimal index weights needed to achieve these target gains are automatically derived.

Key Advantages

Strong goal orientation: Directly quantifies breeding objectives into specific selection criteria, with clear and intuitive logic, significantly reducing the subjectivity in weight setting.

Wide adaptability: Particularly suitable for complex breeding projects requiring **balanced improvement of multiple traits** such as yield, quality, and resistance, effectively balancing genetic antagonism between different traits.

Comparison of Selection Indices

	Tandem Selection	Independent Culling	Smith-Hazel	MGIDI	MTSI
Required Params	No special requirements	Set thresholds for each trait	Heritability, genetic correlation, etc.	Only multi-trait phenotypic data	Multi-year, multi-location G×E data
Key Advantages	Simple and intuitive logic	Simple, ensures basic population level	Max response, theoretically optimal	Handles complex traits, visualizable	Improves mean and stability simultaneously
Main Disadvantages	Low efficiency, may lose good combinations	May eliminate good plants, no weights	Difficult and complex parameter estimation	Requires understanding of PCA	Relies on comprehensive multi-environment
Applicable Scenarios	Preliminary screening of large populations	Clear bottom line for single traits	Mature projects with sufficient parameters	Multi-trait improvement and pyramiding	Breeding requiring high cultivar stability

A Case Study:Selection Index_Smith-Hazel Index

01
Collect Data
Measure phenotypic values (YLD, Fe, Res) for each individual in the population.

02
Estimate Parameters
Calculate the phenotypic variance-covariance matrix P and genetic matrix G from data.

03
Determine Weights
Set economic weights w, e.g., YLD:0.5, Fe:0.3, Res:0.2.

04
Calculate Coefficients b
Use $b = P^{-1}Gw$ to obtain weight coefficients for each trait.

05
Calculate Index I
$I = b_1x_1 + b_2x_2 + b_3x_3$ to get the composite score per individual.

06
Selection & Application
Select individuals with highest index values as parents for next generation.

Figure: Typical lesions of rice blast on a rice leaf
(one of the resistance traits improved in this case study).

Future trends-- Integration of Genomics, Phenomics, and Environmentomics

G×E×M Integration Paradigm

Future precision breeding will be a complex systematic engineering integrating **Genomics**,**Phenomics**,**Envirotyping**, and **Management**.

Environmentomics Characterization

Comprehensive use of IoT sensors,UAV remote sensing, andautomatic weather stations for dynamic, precise, and high-throughput monitoring of crop microenvironments.

Digital Agriculture & AI Decision

Based on big data mining and AI algorithms, integrate G×P×E data to predict optimal varieties and management practices.

Thank You

THANKS FOR LISTENING