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# Ideotype Breeding

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Broadly sense, an ideotype is a biological model designed to function or respond in a predictable way within a specific environment. More specifically, crop ideotype is a plant model which is expected to yield greater quantity of grains, fibre, oil or other useful product when developed as a cultivar. The term ideotype was first proposed by Donald in 1968 working on wheat.

## Fundamental aspect of Ideotype:

- A crop ideotype represents a model plant tailored for a particular environment
- An ideotype is different from an idiotype
- It comprises morphological, physiological, and biochemical traits
- The ideotype is a constantly evolving target.
- It is a challenging and time-consuming approach to cultivar development

## Key Steps in Developing an Ideotype

- Formulation of a conceptual and theoretical framework.
- Identification and selection of appropriate base material.
- Integration of desirable traits into a single genotype.
- Selection of the optimal or model plant type.

## Formulation of a conceptual and theoretical framework.

- An ideotype is made up of a range of morphological and physiological traits, with specific values assigned to these traits to construct a conceptual theoretical model.
- For example,

1. Plant height plays a crucial role in fodder crops.
2. Maturity duration is a key factor in rainfed conditions.
3. In the same way, traits like leaf number, leaf angle, leaf size, photosynthetic rate, and others are defined based on the crop and growing conditions.

## Selection of Base Material

- After developing the conceptual model of an ideotype, selecting the base material is a crucial step.
- The genotype chosen to create a model plant type should possess a broad genetic base and wide adaptability, enabling the new plant type to be successfully cultivated across diverse environmental conditions with consistent yield.
- Genotypes exhibiting traits like plant stature, maturity duration, leaf size, and leaf angles are selected from the global gene pool of the respective crop species.

- Genotypes showing resistance or tolerance to drought, soil salinity, alkalinity, diseases, and insect pests are identified from the gene pool with the collaboration of physiologists, soil scientists, pathologists, and entomologists.

## Integration of Preferred Traits

1. The next crucial step involves merging various morphological and physiological traits from different selected genotypes into a single genotype.
2. Understanding the relationships among various traits is essential before initiating a hybridization program, as it aids in the effective combination of those traits.
3. Various breeding procedures such as single cross, three-way cross, multiple cross, backcross, and composite crossing are interconnected and utilized in developing ideal plant types for most field crops. Techniques like mutation breeding and heterosis breeding are also employed. The backcross method is particularly common for transferring oligogenic traits from selected germplasm lines into the genetic background of an adapted genotype

## Selection of Ideal Plant Type

- Plants that exhibit desirable morphological and physiological traits are selected from the segregating population and intercrossed to develop the targeted plant type
- Morphological traits are assessed through visual inspection, while physiological parameters are measured using advanced instruments.
- Screening for resistance to drought, soil salinity, alkalinity, diseases, and insect pests is conducted under controlled conditions, with the assistance of experts in physiology, soil science, pathology, and entomology.
- Finally, genotypes that combine the traits outlined in the conceptual model are selected, propagated, evaluated across multiple locations, and released for commercial cultivation.

## Features of Crop Ideotype

- The crop ideotype comprises various morphological and physiological traits that contribute to improved or higher yields compared to the existing crop cultivars.
- The morphological and physiological characteristics of a crop ideotype are tailored for either irrigated or rainfed cultivation.
- An ideal plant or ideotype, is needed for both irrigated and rainfed cultivation.
- Ideal plant types or model plants have been studied in various crops such as wheat, maize, cotton, and pulses.

## Factors Impacting Ideotypes

Several factors influence the development of an ideal plant type, which are briefly outlined below:

**Crop Species**: Ideotypes vary between crops. The ideotype of monocots differs notably from that of dicots. For monocots, tillering is a key trait, while in dicots, branching is an important characteristic of the ideotype

**Cultivation:** The ideotype also varies depending on the type of crop cultivation. Traits of irrigated crops differ from those of rainfed crops. Rainfed crops require drought resistance and have fewer, smaller leaves to minimize water loss through transpiration. In dicots, indeterminate types are preferred for rainfed conditions, as they can produce an additional flush of flowers if the initial flush is affected by drought.

**Socio -economic Condition of Farmers:** The socio-economic conditions of farmers also influence the crop ideotype. For instance, dwarf sorghum is ideal for mechanical harvesting in the USA, but it is unsuitable for African farmers who use the stalks for fuel or building huts.

**Economic**: Ideotypes also vary depending on the economic use of the crop. For example, dwarf types of sorghum and pearl millet are preferred when the crop is grown for grain production. However, when these crops are cultivated for fodder, taller plants are more desirable. Additionally, less leafy types are favored for grain purposes, while more leafy genotypes with larger leaves are preferred for fodder crops.

## Merits of ideotype breeding

- Ideotype breeding is an effective method for enhancing crop yield by altering various physiological and morphological traits.
- Specialists in plant breeding, physiology, biochemistry, entomology, and plant pathology collaborate, each contributing to the development of model plants by focusing on traits related to their field of expertise.
- Combining the ideal genes for these traits from multiple sources into a single genotype provides solutions to challenges such as disease and pest resistance, lodging resistance, maturity duration, yield, and quality within a specific timeframe.
- It is an effective approach for developing cultivars tailored to specific situations or environments.

## Demerits of ideotype breeding

- Integrating traits from various sources into a single genotype is a challenging task.
- Ideotype breeding is generally a slower process.
- It is an expensive method.
- It is not a substitute over traditional or conventional breeding methods.
- It is a moving object.

## Selection indices

Tools like the Multi-Trait Genotype Ideotype Distance Index (MGIDI) play a vital role in developing plant ideotypes. They assist breeders in selecting plants possessing desirable traits that match the ideal model, thereby enhancing yield and adaptability in targeted environments. Selection indices are mathematical formulas used to evaluate the overall performance of genotypes based on multiple traits. They assign weights to different traits, reflecting their importance in the ideotype.

**Types of Selection Indices**

- Classical Selection Indices, such as the Smith-Hazel Index, utilize linear equations to calculate the genetic value of each genotype by analyzing measurable traits.
- Genotypic Values: Some indices consider predicted genotypic values (e.g., REML/BLUP) to account for genetic relationships and improve the accuracy of selection.
- Multi-Trait Genotype Ideotype Distance Index (MGIDI): This index specifically measures the distance between a genotype and the ideal plant type (ideotype) based on multiple traits.

**How Selection Indices Help in Ideotype Breeding:**

- Recognizing Superior Genotypes: Selection indices aid in pinpointing genotypes that perform well across multiple traits, making them ideal candidates for achieving the target ideotype.
- Enhancing Genetic Improvement: Selection indices enable more efficient and effective plant breeding by accounting for multiple traits and their economic significance.
- Adapting to Specific Conditions: Selection indices can be customized to focus on particular environmental settings, ensuring the chosen ideotype is optimally suited for the target growing conditions.

## Future Prospects

Crop ideotypes have been developed for vegetables, and there is now potential to design them for traits such as fresh market appeal, fruit quality, and processing suitability. Significant opportunities exist for creating ideal or model plants within solanaceous, brassicaceous, and cucurbitaceous vegetable groups. The development of crop ideotypes is an ongoing process; the ideotype is a dynamic target that evolves with shifting needs, scientific advancements, economic policy changes, and other influencing factors. Alongside conventional breeding techniques, biotechnological approaches—especially tissue culture and protoplast technology will play a crucial role in the future development of new plant varieties. Biotechnology also supports the creation of insect-resistant cultivars through the use of transgenic plants. Hybrid Ideotype development has a lot of potential in tomato, cabbage, cucumber and okra etc.

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