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FACULTY OF AGRICULTURE SCIENCES AND ALLIED INDUSTRIES

(Crop Improvement I (Kharif))

For

B.Sc. Ag (Third Year)

Course Instructor

Dr Shiv Prakash Shrivastav

FASAI(Genetics and Plant Breeding)

Rama University, Kanpur

IDEOTYPE BREEDING

Crop **ideotype** refers to model plants or ideal plant type for a specific environment. In broad sense an **ideotype is a biological model which is expected to perform or behave in a predictable manner within a defined 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.**

Ideotype Breeding

Ideotype breeding can be defined **as a method of crop improvement which is use to enhance genetic yield potential through genetic manipulation of individual plant character.**

Main features of ideotype breeding are

1. Emphasis on individual trait

In ideotype breeding, emphasis is given on individual morphological and physiological trait which enhances the yield. The value of each character is specified before initiating the breeding work.

2. Includes yield enhancing traits

Various plant characters to be included in the ideotype are identified through correlations analysis. Only those characters which exhibit positive association with yield are included in the model.

3. Exploits physiological variation

Genetic differences exist for vario us physiological characters such as photosynthetic efficiency, photo respiration, nutrient uptake, etc. Ideotype breeding makes use of genetically controlled physiological variation in increasing crop yields, besides various agronomic traits.

4. Slow progress

Ideotype breeding is a slow method of cultivar development, because incorporation of various desirable characters from different sources into a single genotype takes long time. Moreover, sometimes undesirable linkage affects the progress adversely.

5. Selection

In ideotype breeding selection is focused on individual plant character which enhance the yield

6. Designing of model

In ideotype breeding, the phenotype of new variety to be developed is specified in terms of morphological and physiological traits in advance.

7. Interdisciplinary approach

Ideotype breeding is in true sense an interdisciplinary approach, it involves scientist from the disciplines of genetics, breeding, physiology, pathology, entomology etc.

8. A continuous process

Ideotype breeding is a continuous process, because new ideotypes have to be developed to meet changing and increasing demands.

Differences between traditional and ideotype breeding

S. No	***Traditional Breeding***	***Ideotype Breeding***
1	The main objective is defined before initiating the breeding work.	The conceptual theoretical model is prepared before initiation of breeding work
2	Selection is focused on yield and some other characters.	Selection is focused on individual plant characters.
3	It usually includes various morphological and economic characters.	It includes various morphological, physiological and biochemical plant characters
4	Value of each character is not fixed in advance	Value of each trait is defined in advance.
5	This is a simple and rapid method of cultivar development	This is a difficult and slow method of cultivar development.
6	The phenotypic of a new variety is not specified in advance	Phenotype of new variety to be developed is specified in advance.

Features of crop ideotypes

The crop ideotype consists of several morphological and physiological traits which contribute for enhanced yield or higher yield than currently prevalent crop cultivars. The morphological and physiological features of crop ideotype differ from crop to crop and sometimes within the crop also depending upon whether the ideotype is required for irrigated cultivation or rainfed cultivation. Ideal plant types or model plants have been discussed in several crops like wheat, rice, maize, barley, cotton and beans. The important features of ideotype from some crops are :

Wheat

The term ideotype was coined by Donald in 1968 working on wheat. He proposed ideotype of wheat with following main features:

1. **A short strong stem.** It imparts lodging resistance and reduces the losses due to lodging.
2. **Erect leaves.** Such leaves provide better arrangement for proper light distribution resulting in high photosynthesis or CO_2 fixation.
3. **Few small leaves.** Leaves are the important sites of photosynthesis, respiration and transpiration. Few and small leaves reduce water loss due to transpiration.
4. **Larger ear.** It will produce more grains per ear.
5. **An erect ear.** It will get light from all sides resulting in proper grain development.
6. **Presence of awns.** Awns contribute towards photosynthesis.
7. A single culm.

RICE

The concept of plant type was introduced in rice breeding by Jennings in 1964, through the term ideotype was coined by Donald in 1968. He suggested that in rice an ideal or model plant type consists of

1. Semi dwarf stature
2. High tillering capacity and
3. Short, erect, thick and highly angled leaves
4. More panicles /m2,
5. High (55% ore more) harvest index.

Now emphasis is also given on physiological traits in the development of rice ideotype.

MAIZE

IN 1975, Mock and Pearce proposed ideal plant type of maize.

1. Stiff-vertically-oriented leaves above the ear.
2. Maximum photosynthetic efficiency.
3. Efficient translocation of photysynthate into grain.
4. Short interval between pollen shed and silk emergence.
5. Small tassel size.
6. Photoperiod insensitivity
7. Cold tolerance
8. Long Grain -filling period

BARLEY

Rasmusson (1987) reviewed the work on ideotype breeding and also suggested ideal plant type of six rowed barley.

1. Short stature
2. Long awns
3. High harvest index
4. High biomass.

Kernel weight and kernel number were found rewarding in increasing yield.

COTTON

Ideotype for irrigated cultivation

1. Short stature (90-120 cm)
2. Compact and sympodial plant habit making pyramidal shape
3. Determinate in fruiting habit with unimodal distribution of bolling
4. Short duration (150-165 days)
5. Responsive to high fertilizer dose
6. High degree of inter plant competitive ability
7. High degree of resistance to insect pests and diseases, and
8. High physiological efficiency.

Rainfed conditions (Singh and Narayanan 1993)

1. Earliness (150-165 days)
2. Fewer small and thick leaves
3. Compact and short stature, indeterminate habit
4. Sparse hairiness,
5. Medium to big boll size
6. Synchronous bolling
7. High response to nutrients
8. Resistance to insects and diseases.

FACTORS AFFECTING IDEOTYPES

There are several factors which affect development of ideal plant type. These are briefly discussed below:

1. Crop Species

Ideotype differs from crop to crop. The ideotype of monocots significantly differs from those of dicots. In monocots, tillering is more important whereas in dicots branching is one of the important features of ideotype.

2. Cultivation

The ideotype also differs with regard to crop cultivation. The features of irrigated crops differ from that of rainfed crop. The rainfed crop needs drought resistance, fewer and smaller leaves to reduce water loss through transpiration. In dicots, indeterminate types are required for rainfed conditions, because indeterminate type can produce another flush of flowers if the first flush in affected by drought conditions.

3. Socio -economic Condition of Farmers

Socio-economic condition of farmers also determines crop ideotype. For example, dwarf *Sorghum* is ideal for mechanical harvesting in USA, but it is not suitable for the farmers of Africa where the stalks are used for fuel or hut constructions.

4. Economic Use

The ideotype also differ according to the economic use of the crop, for example, dwarf types are useful in *Sorghum* and pearl millet when the crop is grown for grain purpose. But when these crops are grown for fodder purpose, tall stature is desirable one. Moreover, less leafy types are desirable for grain purpose and more leafy genotypes for fodder purpose. The larger leaves are also desirable in case of fodder crop.

STEPS IN IDEOTYPE BREEDING

Ideotype breeding consists of four important steps,

1. Development of Conceptual Model

The values of various morphological and physiological traits are specified to develop a conceptual theoretical model. For example, values for plant height, maturity duration, leaf size, leaf number, angle of leaf, photosynthetic rate etc., are specified. Then efforts are made to achieve this model.

2. Selection of Base Material

Selection of base material is an important step after development of conceptual model of ideotype. Genotypes to be used in devising a model plant type should have broad genetic base and wider adaptability. Genotypes for plant stature, maturity duration, leaf size and angle and resistance are selected from the global gene pool of the concerned crop species. Genotypes resistant or tolerant to drought, soil salinity, alkalinity, diseases and insects are selected from the gene pool with the cooperation of physiologist, soil scientist, pathologist and entomologist.

3. Incorporation of Desirable Traits

The next important step in combining of various morphological and physiological traits from different selected **genotypes into single genotype** . Various breeding procedures, *viz* single cross, three way cross, multiple cross, backcross, composite crossing, intermating, mutation breeding, heterosis breeding etc., are used for the development of ideal plant types in majority of field crops.

4. Selection of Ideal Plant Type

Plants combining desirable morphological and physiological traits are selected in segregating populations and intermated to achieve the desired plant type. Morphological features are judged through visual observations and physiological parameters are recorded with the help of sophisticated instruments. Screening for resistance to drought, soil salinity, alkalinity, disease and insects is done under controlled conditions.

PRACTICAL ACHIEVEMENTS

Ideotype breeding has significantly contributed to enhanced yields in cereals (wheat and rice) and millets (*Sorghum* and pearl millet) through the use of dwarfing genes, resulting in green revolution. Semidwarf varieties of wheat and rice are highly responsive to water use and nitrogen application and have wide adaptation. The Norin 10 in wheat and Dee-geo-Woo-gen in rice are the sources of dwarfing genes. The genic cytoplasmic male sterile systems in *Sorghum* and pearl millet laid the foundation of green revolution in Asia (Swaminathan, 1972). Thus ideotype breeding has been more successful for yield improvement in cereals and millets than in other crops.