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ROLE OF IDEOTYPE BREEDING IN CROP IMPROVEMENT

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Yield is a complex character which depends on several other component traits directly as well as indirectly. Selection for yield is useful only in the advanced generations of crosses at relatively much higher population densities. There is proof that selection for high yield at low densities leads to the isolation of genotypes poorly adapted to crop densities. As a result, high yielding segregants present in the early generations may be lost due to non recognition. Therefore, alternative approaches of breeding are required to increase yields of crop varieties. A valuable additional approach is available through the breeding of crop ideotypes, plants with model characteristics known to influence photosynthesis, growth and (in cereals) grain production. Ideotype breeding is emphasized on individual morphological and physiological trait which enhances the yield. The value of each character is specified before initiating the breeding work. Thus, Ideotype breeding represents an attractive alternative breeding strategy contrast to the empirical breeding approaches of defect elimination and selection for yield per se.

Ideotype Concept

Ideotype: A biological model, which is expected to perform or behave in a predictable manner within a defined environment" (Donald, 1968). It is a hypothetical plant described in terms of traits that are thought to enhance genetic yield potential" (Donald and Rasmusson, 1987). Ideotype differs from Idiotype. The former refers to a combination of various plant characters which enhance the yield of economic produce, whereas the latter refers to the morphological features of the chromosomes of a particular plant species. Ideotypes are a popular concept for plant breeders, who designate as such the ideal combinations of traits in a particular genotype to reach a pre-set production objective within a given socio-economic context. The historical, 'genetic' view of ideotypes has been more recently extended to cover the design of plant genotypes for specific cropping systems (the 'agronomic' view), or even the ideal combination of parameters, identified from formal or simulation modeling, to a specific agronomic problem (the 'modelling' view). These different forms of ideotypes in turn lead to different strategies for breeding plants.

Crop Ideotype: In broad sense, crop Ideotype is a plant model which is expected to yield a greater quantity or quality of grains, fibre, oil or other useful product when developed as a cultivar" (Donald, 1968). The term, ideotype was first proposed by Donald in 1968 working on wheat. The crop ideotype includes several morphological and physiological traits which contribute for enhanced yield than currently prevalent crop cultivars. The morphological and physiological features of crop ideotype is required for irrigated cultivation or rainfed cultivation. Ideal plant types or model plants have been developed in several crops like

wheat, rice, maize, barley, cotton, and bean. Ideal plant type or model plant type also varies from species to species. Moreover, this is a difficult and slow method of cultivar development because various morphological, physiological and biochemical characters have to be combined a single genotype from different sources.

Types of ideotype

(i) Isolation Ideotype (ii) Competition Ideotype (iii) Crop Ideotype

1. Isolation ideotype

It is the model plant type that performs best when the plants are space-planted. In case of cereals. isolation ideotype is lax, free- tillering.

2. Competition ideotype

This ideotype performs well in genetically heterogeneous populations, such as the segregating generations of crosses. In case of cereals, competition ideotype is tall, leafy, free-tillering plant that is able to shade its less aggressive neighbours and, thereby, gain a larger share of radiation, nutrients and water.

3. Crop ideotype

This ideotype performs best at commercial crop densities because it is a poor competitor. It performs well when it is surrounded by plants of the same form. But it performs less well when it is surrounded by plants of other forms.

Characteristic of crop ideotype

In case of cereals, a crop ideotype is erect, separately tillered plant, with small erect leaves

- It should be a weak competitor.
- That is able to accept all the photosynthate either from its own green surface or from other parts of the plant.
- An ideotype will be the most efficient in utilizing its environmental resources.
- The ideotype, must include morphological and physiological characteristics that resultin a high harvest index.
- A crop ideotype must be grown, as far as possible, in a weed-free situation in view of it being a weak competitor.

Key Features of Ideotype Breeding

Designing of model

The phenotype of new variety to be developed is specified in terms of morphological and physiological traits in advance.

Selection

Selection is based on individual plant character which enhances the yields. Various plant characters are identified through correlation analysis. Characters showing positive association with yield are included in the model.

Exploits physiological variation

Genetic difference exists with regarding to various physiological characters such as photosynthetic efficiency, photo respiration, nutrient uptake, etc. Ideotype breeding makes use of genetically controlled physiological variation to increase crop yields, besides various agronomic traits.

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

Slow progress

It is a slow method of variety development because incorporation of various desirable characters from different sources into a single genotype takes more time. But sometimes undesirable linkage affects the progress adversely.

Continuous process

Ideotype is a moving goal which changes according to climatic situation, type of cultivation, national polley, market requirement etc. In other words, ideotype have to be redesigned depending upon above factors. Thus, development of crop ideotype is a continuous process, because new ideotype fulfill changing and increasing demands.

Factors Affecting Ideotype

There are several factors which affect development of ideal or model plant type. Being a concept initially coined by and for plant breeders, ideotypes carry an obvious genetic dimension: which optimal combination of genes (or QTLs) to build the desired phenotypes. However, this genetic view was rapidly complemented by an agronomic view, when ideotypes began to be thought as the plant component of a cropping system. Because, ideotypes can only be defined relative to a production objective, they also bear a clear socio-economic dimension, especially regarding their acceptability: a plant type that would not be adopted by growers could hardly be ideal. Finally, ideotypes are basically virtual prototypes of plants not existing at the time they are designed. As such, they are conceptual models, that may or may not be formalized mathematically but which in all cases are based on sets of decision rules upon which the choice of traits to assemble and the optimal combinations of these can be decided. These four dimensions (genetic, agronomic, modeling and socio-economic) are all legitimate, but can sometimes be strongly conflicting. Thus, ideotype differences based on crop species, cultivation practices, socio-economic condition of farmers and economic use of plant parts.

1. Crop Species

Ideotype differs from crop to crop which depends upon genetic dimensions of crop species. High tillering is more important in case of monocots whereas, in dicots, branching is one of the important features of ideotype.

2. Cultivation practices

The ideotype also differs with regards to crop cultivation practices. The features of irrigated crop differ from that of rainfed crop. The rainfed crop needs for drought resistance fewer and smaller leaves to reduce water loss through transpiration. Irrigated crops require higher input use efficiency.

3. Socio-economic Condition of Farmers

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

4. Economic Use

The Ideotype also varies according to the economic use of the plant or plant parts. For example, when the crop is grown for grain purpose, dwarf types (short stature) are useful in sorghum, pearl millet or other cereals. Tall stature or more and larger leafy genotypes is desirable one when these crops are cultivated for fodder purpose.

Steps in Ideotype Breeding Programme

Ideotype breeding consists of following four important steps.

1. Development of Conceptual Model

Ideotype consists of the combinations of various morphological and physiological traits. The values of various morphological and physiological traits are specified in advance to develop a conceptual theoretical model. For Example, value 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 through appropriate breeding strategies.

2. Selection of Base Material

After development of conceptual model of ideotype the selection of appropriate base material is an important step. Genotype with broad genetic base and wider adaptability should have be used in the development of a model plant type so that the new plant type can be successfully grown over a wide range of environmental condition with stable yield. Genotypes for plant stature, maturity duration and leaf characteristics are selected from the global gene pool of the concerned crop species. Genotypes resistant or tolerant to drought, soil salinity, alkalinity, disease 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 is combining of various morphological and physiological traits from different selected genotypes into single genotype. Knowledge of the association between various characters is essential before starting hybridization programme, because it help in combining of various characters. Mutation breeding and heterosis breeding are used for the development of ideal plant types in majority of field crops. Backcross technique is commonly used for transfer of oligogenic traits from selected germplasm lines into the background of an adapted genotype.

4. Selection of Ideal Plant Type

Plant combining desirable morphological and physiological traits are selected in segregating population and intermated to achieve the desired plant type. Morphological features are judged through visual observation 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. This task is completed with the help of scientist from the disciplines of physiology, soil science, pathology and entomology. Finally, genotypes combining traits specified in the conceptual model are selected, multiplied, tested over several locations, and released for commercial cultivation.

Merits and Demerits of Ideotype Breeding

Merits:

- Ideotype breeding is an effective method of enhancing yield through genetic manipulation of various morphological and physiological crop characters which contributes towards enhanced yield. Thus, it exploits both morphological and physiological variation.
- Ideotype breeding is an effective method of breaking yield barriers through the use of genetically controlled physiological variation for various characters contributing towards higher yield.

- Ideotype breeding provides solution to several problems like tolerance to abiotic and biotic stresses by combining desirable genes for these traits from different sources into a single genotype.
- It is efficient method of developing cultivars for specific or environment.

Demerits:

- Incorporation of several desirable morphological and physiological and disease resistance traits from different sources into a single genotype is a difficult task. Sometimes, combining of some characters is not possible due to tight linkage between desirable and undesirable characters. Presence of such linkage hinders the progress of ideotype breeding.
- Ideotype breeding is a slow method of cultivar development, because combining together of various morphological and physiological features from different sources takes more time than traditional breeding where improvement is made in yield and one or two other characters.
- Ideotype breeding is not a substitute for traditional or conventional breeding. It is a supplementary to the former.
- Ideotype is a moving object which changes with change in knowledge, new requirements, national policy, etc. Thus new ideotype have to evolved to meet the changing and increasing demands for economic products.

Future Prospects of Ideotype Breeding

India has achieved self sufficient in the production of food grains through modification of plant characters and development of high yielding varieties/ hybrids. The further breakthrough in yield and quality has to be achieved through the exploitation of physiological variation. Ideotype both for high and low input technology condition have to be developed. Crop ideotype have been developed mainly in cereals and millets thus, there is ample scope for developing ideal plants or models plants in pulses, oilseeds and several other field crops. In these crops, again ideotype have to be evolved with regard to varying agro cliamatic conditions. In addition to traditional breeding approaches, biotechnological approaches, especially tissue culture and protoplast technology, have to be utilized in future for designing new plant types. Biotechnology may help in the development of insect and disease resistant cultivars through the use of transgenic plants. Ideotype should be developed for adverse abiotic stresses such as heat cold, salinity, and drought conditions which adversely affecting crop production throughout the world.

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