Achieving High Yielding Plant Type Through Ideotype Breeding

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To accomplish the mark yield that is essential to endure the world population, crop varieties with a yield advantage of about 25% over currently grown varieties must be developed. Yield potential is defined as the yield of a variety when grown in environments to which it is adapted, with nutrients and water non-limiting and with pests, diseases, weeds, lodging, and other stresses effectively controlled (Carkner *et al.*, 2023). Plant breeding is mostly based on "defect elimination" or "selection for yield". A valuable additional approach is breeding for crop ideotypes; plants with model characteristics known to influence photosynthesis, growth and (in cereals) grain production. An optimized crop ideotype will make a minimum demand on resources per unit of dry matter produced. Further, in cereals, each unit of dry matter will include such a number of florets as to ensure that the ear has sufficient capacity to accept all photosynthates either from its own green surfaces or from other parts of the plant. The concept of plant type was introduced in rice breeding (Jennings, 1964) while the term ideotype was coined by Donald in 1968. These criteria are to be satisfied especially at high fertility, and when the total pressure by the community on environmental resources is intensified by high population density (Donald, 1968). The crop ideotype consists of those morphological and physiological traits that will contribute to higher yield than currently prevalent crop cultivars.

Features of ideotype breeding

Ideotype breeding or plant type breeding can be defined as a method of crop improvement which is used to enhance yield potential through genetic manipulation of individual plant characters are chosen in such a way that each character contributes towards increased economic yield. Main features of Ideotype breeding are briefly discussed below: Emphasis on Individual Trait:

Emphasis on individual traits

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.

Includes Yield Enhancing Traits

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

Exploits Physiological Variation

Genetic difference exists for various 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.

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.

I. **Selection:** In Ideotype breeding selection is focussed on individual plant character which enhances the yields.

II. **Designing of Model:** In Ideotype breeding, the phenotypes of new variety to be developed is specified in terms of morphological and physiological traits in advance.

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

IV. **A Continuous Process:** Ideotype breeding is a continuous process, because new Ideotype have to be developed to meet changing and increasing demands. Thus, development of Ideotype is a moving target.

Features of Crop Ideotype

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 is required for irrigated cultivation or rainfed cultivation. Ideal plant 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 bean. The important features of Ideotype for some crops are briefly described below:

Wheat

The term Ideotype was coined by Donald in 1968 working on wheat. He proposed Ideotype of wheat with following main features. A short strong stem. It imparts lodging resistance and reduces the losses due to lodging. Erect leaves. Such leaves provide better arrangement for proper light distribution resulting in high photosynthesis or CO_2 fixation. Few small leaves. Leaves are the important sites of photosynthesis, respiration, and transpiration. Few and small reduce water loss due to transpiration. Larger ear. It will produce more grains per ear. A presence of owns. Awns contribute towards photosynthesis. Presence of awns. Awns contribute towards photosynthesis. A single culm.

Considered tillering as important features of wheat flag type a wheat plant with moderately short but broad flag leaf, long flag leaf sheath, short ear extrusion with long ear, and moderately high tillering capacity should give yield per plant.

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 the rice an ideal or model plant type consists of semi dwarf stature. High tillering capacity, and Short, erect, thick and highly angled leaves. High biomass, high kernel weight with high numbers.

It was observed that reduced tillering contributed to lower biomass. Some of these lines shows good performance in temperate areas, where japonica grain quality is preferred (Sharma *et al.*,2013). Three of these lines were released as a variety in Yunnan province of China as Diancho 1, Diancho 2 and Diancho 3. Also develop the 'Super' Rice variety with a maximum yield 9 to 10.5t-ha^{-1}.

Maize

In 1975, Mock and Pearce proposed ideal plant type of maize. In Maize, higher yields were obtained from the plants consisting of Low tillers, large cobs, and angled leaves for good light interception. Planting of such type at closer spacings resulted in higher yields.

Barley

Rasmusson (1987) reviewed the work on Ideotype breeding and also suggested ideal plant type of six rowed barley. He proposed that in barley, higher yield can be obtained from a combination of Short stature, Long awns, High harvest index, and High biomass. Kernel weight and kernel number were found rewarding in increasing yield.

Cotton

In cotton, genotypes with zero branch, short stature, compact plant, small leaves and fewer sympodia were considered to enhance yield levels. Singh et al. (1974) proposed and ideal plant type of plant cotton growing belt. The proposed Ideotype includes short stature (90-120 cm), compact and sympodial plant habit making pyramidal shape, determinate the fruiting habit with unimodal distribution of bolling, short duration (150-165 days), responsive to high fertilizer dose, high degree of inter plant competitive ability, high degree of resistance to insect pests and diseases, and high physiological efficiency, Singh and Narayana (1993) proposed an Ideotype of above two species for rainfed conditions. The main features of proposed Ideotype include, earliness (150-165 days), fewer small and thick leaves, compact and short stature, interminate habit, spares hairiness, medium to big boll size, synchronous bolling, high response to nutrients, and resistance to insect and diseases.

Sorghum and Pearl millet

Improvement in plant type has been achieved in Sorghum and Pearl millet through the use of dwarfing genes. In these crop dwarf F1 hybrids have been developed which have made combine harvesting possible. Genetic improvements have been achieved

thorough modification of plant type in several crop species. New Ideotype have been proposed for majority of crop plants. Several desirable attributes of crop Ideotype with special reference to multiple cropping in the tropics and sub tropics. These features include: Superior population performance, high productivity per day, high photosynthetic ability, Low photo respiration, Photo and thermo sensitivity, high response to nutrients, high productivity per unit of water, Multiple resistances to insect and diseases, better protein quantity and quality. Crop canopies that can retain and fix a maximum of CO_2, and suitability to mechanization.

Future Prospects of Ideotype Breeding in India

In India, the future research on crop Ideotype should be directed towards following aspects:

1. India has attained self-adequate in the production of food grains through alteration of plant characters and development of high yielding varieties/ hybrids (Singh, 2013). 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.
2. To further the yield potential of food grain crops, Ideotype have to be evolved for straight varieties and hybrids. There is ample scope of developing hybrid Ideotype in crops like maize, sorghum, pearl millet and rice. China has developed hybrid rice for commercial which covers more than 18 million hectares.
3. Crop Ideotype have been developed in cereals and millets. There is ample scope for developing ideal plants or models plants in pulses, oilseeds, cotton and several other field crops. In these crops, again Ideotype have to be evolved both for irrigated as well as rainfed cultivation. In cotton, Ideotype have to be developed for regard to agroclimatic conditions.
4. 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 resistant cultivars through the use of transgenic plants.
5. Development of crop Ideotype is a continuous process, Ideotype is a moving goal which changes with advancement in knowledge, new requirements, change in economic policy, etc.
6. Ideotype should be developed to adverse condition such as heat cold, salinity, and drought conditions.

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