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Review Article

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Adaptations of Different Breeding Approaches for Enhancing Rice Yield-An Overview

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ABSTRACT

The main goals of crop breeding plans and strategies are enhancement in production and quality but quantity is most important. Same case is with rice breeding programs. Some goals are different from region to region, country to country but even within the same country for the rice crop. Enhancement in yield is about the main goal for every rice breeder adapting any rice breeding program. Basically, all rice breeders emphasizes on the increasing crop genetic potential by developing different varieties. A big success came in the way of rice breeders who worked hard for improving rice genetic potential. There are many examples of these struggles like in green revolution production of semi dwarf varieties, new rice plant type and now hybrid rice. The major strategy for rice yield improvement is pedigree method but hybrid and populations improvement are included to the breeder's scheme of improvement rice genetic potential. Now, the improvement through biotechnology tools came in rice breeding yield enhancing programs. But there are stills many programs which are still under discussion that how to incorporate them in improving yield potential. There is need of time that we shall have to develop such breeding programs which are very cheap, time saving and costing low inputs but giving high yields as well as more quality.

Keywords: *Rice, Ideotype, Hybridization, Heterosis, the Male Sterility, Wider Hybridization, Genetic Engineering, MAS Breeding*

INTRODUCTION

The Rice (*Oryza sativa*) is second most cultivated cereal crop and the essential food for little bit more than half of the total world's population (Peng et al., 2000). It is a descendent type of wild grass which was probably grown in foothills of Eastern Himalayas (Sarkarung et al., 1995).

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But some rely on that rice is originated in southern India, after this, it extended towards the northern parts of the country and thus onwards to the China. After this, Rice plant approached towards the Korea, Philippines, Japan and then Indonesia (Anonymous, 1995).

The growth ratio of Rice production was about 3.69%/year in the earlier in 1980's but it decreased to 0.75%/year in the 1990's (Mackil and Xu, 1996). China and India are the top of the list in Rice producing countries. The major aim of crop breeding is to produce such varieties which have high yield potential, resistance to insects and diseases, well-improved grains and eating qualities (Kenong et al., 1997). Many believe on such breeding approaches that leads towards the synthesis of those varieties which are higher yielding along with higher quality (Chandler, 1969). There are many breeding techniques which are used and increase yield potential. These are;

1. Conventional Hybridization Approaches
2. Ideotype Breeding Approaches
3. Heterosis Breeding Approaches
4. Male Sterility Technique
5. Wider Hybridization Approaches
6. Genetic Engineering

1. Conventional Hybridization Approaches

It is a conventional method utilized to select the crop cultivars with greater yield potential. It contains two phases. The first phase is the production of variation via hybridization between two distinct plants (parents) (Annonymous, 1989). In the second phase, well-desired individuals are carefully chosen on the field observation basis and different yield trials. There is a deep research inserted in the field of the conventional breeding methodologies which is increasing day by day and put a huge improvement in crop breeding plans (Khush, 1995).

The conventional rice varieties are being evolved from favorable systems to be survived under the stress (Peng et al., 2008). Systematic screening tests of rice crop germplasm has depicted that there are best flood-resistant rice types locally present. Like, we can take the example of Indian varieties "FR13A" and "FR43B", "Kurkaruppan" variety of Sri Lanka and another example is "Goda Heenati" of the Indonesia (Wang et al., 2006). Complete study of these rice types showed that flooding resistance is under the control of one or fewer genes with great effects and the additional genes with small and modifying effects. Breeding tools adopted at IRRI with greater efforts led to the production of tolerant lines having suitable and better agronomic characters (Liu et al., 2004). Sudhir is the insect pest resistant variety which is released by Central Variety Release Committee, Indian Council of Agricultural Research, Government of India in 1999 (Xie et al., 2001).

However, there is no development of such a variety that combines all the desirable traits of flooding resistance along with grain yield. Major attempts are also made in breeding for progressed submergence tolerant by the use of double haploid lines, produced by using crosses among submergence tolerant and sensitive rice ancient cultivars. IRRI developed 2 DHL population for the submergence tolerant way by using crosses of a) IR 49830 × CT 6241 and b) FR 13A × IR 42. These were tested in Thailand and the Philippines. In the Thailand, a specific bimodal distributions of the lines for the survival after submergence was showed being supportive towards the concepts of the single gene for the submergence tolerant. But the results from Philippines were not supportive towards this theory (Tan et al., 2004).

2. Ideotype Breeding Approaches

Ideotype breeding approach is such a breeding approach that consists of modifying the plant architectures in a way of time tested system to get higher yield potential (Yang et al., 2002). So, selection for semi dwarf cereals like Wheat, Rice and Sorghum resulted in the doubling of the yield potentiality (Lawrence, 1976). The yield potential is determined by total dry mass or the biomass and harvest index (HI). Taller and conventional rice had HI of about 0.4 and biomass of approximately 13 tons per hectare. So, the maximum yield was about 4 tons per hectare. Then, it is notable that their yield could not be enhanced more by adding nitrogenous fertilizers because

of plant grew more and more tall and lodged so much badly that their yield reduced instead of increase (Xiao et al., 1996). To enhance the productivity potential of the topical rice it was important to better the harvests index and nitrogen response via increasing the lodging tolerance. This was carried out by falling the plant tallness by inserting of the recessive gene sd1 for semi-dwarfness (Jena & Khush 1990).

To enhance the yield potentials of the semi-dwarf rice, IRRI researchers proposed modifications of the plant architecture with the given below characteristics:

- Less number of tillers
- No infertile tillers
- 200-250 grains production per panicle
- Dark green, very thick and straight leaves
- Vigorous and deeper root system

This proposed Ideotype model depicted the New Plant Type shown in IRRI's systematic plan. This was the model by which IRRI's researchers were able to get high yield via Ideotype breeding.

3. Heterosis Breeding Approaches

Rice hybrids with the yield increase of about 10%-15% with best inbred lines were familiarized in China in the mid of 1970s and now they are planted to approximately 46% of the rice cultivated land in China (Multani et al., 1994). IRRI and NARS have introduced many hybrids by good inbred lines with good yield potential. This enhancement in the yield is due to greater biomass, high spikelet's numbers and to an extent greater grain weight. Due to the greater potential of the hybrid rice yield, many countries are working on the projects to exploit the advantages of this technology. But there are many problems in the road of heterosis breeding (Brar 1997).

These are limited numbers of the parental lines along with suitable characters, lower frequency of the maintainers and the restorer line among best and elite breeding lines, narrow genetic base, lack of tolerance to biotic stresses and bad grains quality of the some parental lines. Thus, it is vital in heterosis breeding to develop such breeding lines that have improved parental lines to enhance the breeding efficiency. The numbers of maintainer lines and restorer lines are significantly enhanced after launching the maintainers and restorers lines improvement breeding programs. Very diverse parental lines with good grain quality and resistance are developed in China and IRRI (Datta et al., 1990).

Now, we take the example of indica rice hybrids. The recent levels of the heterosis in indica rice hybrid produced for tropics are economically good but more levels of these would be much attractive. Research at the IRRI has showed high heterosis for grain yields in the tropical japonica/indica crosses than in indica/indica crosses (Hei et al., 1994).

4. Male Sterility Technique

In rice, there are 3 important types of CMS or restoration systems which are CMS-BT (borotype), CMS-WA (Wild abortive) and CMS-HL (Honglian). The first on commercial level used CMS-WA germplasm was discovered by Chinese researcher Long Ping Yuan in 1970's. It was used in developing the three line system of hybrid rice. Due to gametophytic system, the CMS-BT is considered most studied rice CMS systems on the genetic levels and basically it is derived through indica variety's cytoplasm (Datta et al., 1997).

Cytoplasmic male sterility due to resulting from nuclear-cytoplasmic interaction are commercially utilized for the synthesis of F1 hybrids in many crops like maize, sunflower, sorghum and sugarbeet. Major improvement has been made in producing high yielding hybrid rice varieties dependent on the CMS systems consisting of 19 million hectares in China. The first CMS line was utilized to create commercially utilized F1 hybrids were developed in 1973 from single male sterile plant *Oryza sativa* f. spontanea designated as the wild abortive (WA) (Tu et al., 2000).

5. Wider Hybridization Approaches

Crop genetic pools are extended by hybridization of different crop varieties with the wild species like weedy races/strains as well as intra-specific crosses. These gene

pools are used for developing the improved traits like yield etc. Wild races of the rice are good source of the resistance breeding approaches (Xu et al., 1996). Like, there were no cultivated rice variety which was tolerant to the grassy stunt *Oryza nivara* but a wild rice near to the cultured rice was found to resistant to this and through backcross this good trait was transferred into the cultivated rice very easily and clearly. When genes are being shifted from the more distant species, many specific techniques like embryo rescue are used to replicate inter-specific hybrid (Hayakawa et al., 1992).

6. Genetic Engineering

Protocols for the rice transformation are developed that permit the transfer of foreign genes from diversified biologically introduced systems into the rice. There are many ways through which the DNA direct transfer is possible like protoplast based, biolistic and agrobacterium-mediated transfer methods are very prominent. The major goals for rice crop improvement by transformation is to incorporate disease and insect resistance (Ye et al., 2000).

Malnutrition diseases are the major cause of 24,000 deaths in a day. "Golden Rice" shows the concept of genetic engineering for the production of nutrient-rich staple crops that can play a vital role in reduction and limiting the problems of malnutrition in developing countries. The big issues of micronutrient lacking are protein deficiency, energy, zinc, iron iodine and vitamin A. These disorders are more prominent in such countries where rice is used as staple food. Golden Rice is a rice type produced by genetic engineering which contains provitamin A (b carotene). It fulfills the requirements of malnutrition like major deficient nutrient Vitamin A (Ye et al., 2000).

CONCLUSION

To increase the rice yield along with quality is the main objective of rice crop breeding. There are various approaches and strategies that are used to enhance the rice yield. The conventional hybridizations, ideotype breeding's schemes, heterosis breeding schemes, the male sterility, wider hybridization and genetic engineering are the methods that are being utilized for rice breeding. But all of them, Genetic engineering is getting more popular as it has new approaches and techniques but heterosis breeding is mostly utilized all around the world. Hence, we should adopt more and more tools to do better rice breeding to fulfill the requirements of rice deficiency.

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