Biotechnological Methods for the Improvement Cereals

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***Abstract*—Cereals are important for feed of human and animals because of they are valuable. Crop or cereal agriculture and importance of it has been improving worldwide. At the same time crops have taken place in biotechnology. In the world maize has been cultivated much after wheat, rice and barley. Biotechnological methods have reduced the time and cost for improve of plants. On the other hand it has increased the strength of programmes of improvement. In this study for cereal improvement; such as maize, wheat and rice; that we searched same biotechnological methods and some molecular approaches for cereals which have been used so far.**

***Index Terms*—maize, biotechnology, improvement, crop**

I. Introduction

Cereals are important for feed of human and animals. Today the world population is increasing at the most rapid rate ever. It is forecast that by the year 2050, the world's population will double to nearly 12 billion people. In fact it has been estimated that the world will need to produce more than twice as much food during the next 45 years as was produced since the beginning of agriculture 10000 years ago [1].

The cereal grains are very nutritious; generalised cereal grain contents (which will of course vary with species, growing conditions and variety) are: carbohydrates (70%), protein (10%), lipids (3%) [2]. Three important cereals – wheat, maize and rice – make up the bulk of world cereal production, but five other cereal crops also make important contributions to world nutrition, and to food and drink production. In order of global production tonnage, these are barley, sorghum, millet, oats and rye.

The development of molecular techniques and biotechnological methods for genetic analysis in the past decades has led to the increase of the knowledge of cereal genetics and our understanding of the architecture and behaviour of cereal genomes. This technique brings new useful information on the determinism of trait variation and the organization of genetic diversity within cereals species of agricultural interest. This information can be used for efficiently managing and exploiting cereal genetic resources [1]. Biotechnology is a revolution, so the revolution in our understanding of the molecular mechanisms underlying the processes of life, in particular our understanding of DNA, the prime genetic material, has resulted in the ability to manipulate those mechanisms to our requirements. These new approaches to plant breeding are set to revolutionise cereal technology. Already it is seeing the production of crops with properties unimaginable by conventional breeding techniques. It can anticipate cereal crops with improved yields and qualities, and novel, enhanced or optimised properties. So, this rewiev has so far searched some biotechnological methods for cereal improvement.

II. Methods

This research includes that various tissue culture techniques to use cereal breeding and to make transgenic cereals, such as micropropagation. At the same time this research contains genetic transformation methods in cereal.

III. Results and Discussions

A. Tissue Culture Techniques

Tissue culture techniques are essential to many types of academic inquiry, as well as to many applied aspects of cereal breeding. In the past, plant tissue culture techniques have been used in academic investigations of totipotency and the roles of hormones in cytodifferentiation and organogenesis.

Currently, tissue-cultured plants that have been genetically engineered provide insight into plant molecular biology and gene regulation. The techniques are also central to innovative areas of applied plant science, including plant biotechnology and agriculture. For example, select plants can be cloned and cultured as suspended cells from which plant products can be harvested [3].

Tissue culture has been exploited to create genetic variability from which crop plants can be improved to improve the state of health of the planted material and to increase the number of desirable germplasms available to the cereal breeder.

Tissue culture techniques for the culture of protoplasts, anthers, microspores, ovules and embryos have been used to create new genetic variation in the cereals, often via haploid production. Plant tissue culture techniques provide a set of techniques to produce plant pathogen-free. Embryo culture enables the breeder to successfully

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make wide crosses with a greater number of related species of wild plants and have access to a much wider range of genes that can be used for genetic improvement of plants. Micropropagation, which is a form of tissue culture, increases the amount of planting material to facilitate distribution and large scale planting. In this way, thousands of copies of a plant can be produced in a short time. Virus-free plants of many species have been produced by culture of meristematic tissue, somatic embryogenesis and grafting.

The use either one technique or another will depend on several factors, mainly of the species regeneration capacity. For example, haploid wheat has also been produced by this technique [4]. Interspecific and intergeneric hybrids of a number of agriculturally important cereals have been successfully produced, barley, rice, Hordeum x Secale and Triticum x Secale [3].

At least seven Canadian barley cultivars (Mingo, Rodeo, Craig, Winthrop, Lester and TB891-6) have been produced out of material selected from doubled haploids originating through the widely-used bulbosum method of cross-pollination and embryo rescue [4], [5].

As it is seen in Fig. 1, some breeders selected R1 lines from wheat genotype UP2338 which gave a maximum of 19 shoots from a single callus in the MS medium supplemented with IAA and kinetin [6].

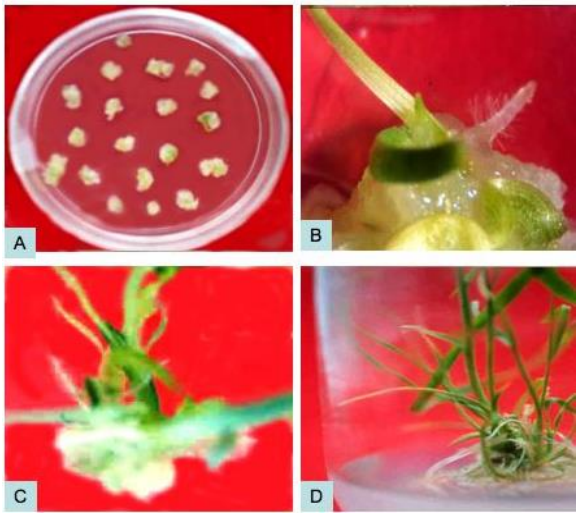

Figure 1. A: Callusing in Indian wheat genotypes of in vitro selected lines using mature embriyo cultures. B: Initiation of shoot and root primodia. C: Multiple shoot induction and elongation. D: Multiple shoot regeneration of in vitro selected lines.

B. Genetic Transformation and Transgenic Cereals

The original method devised for the production of the first GM (Genetically Modified) plants in 1983 depended on the use of the natural bacterial vector *Agrobacterium tumefaciens*. This technology was the first method successfully applied to maize. The first experiments to engineer disease resistance in barley focused on barley yellow dwarf virus. Some researchers transformed barley with a construct containing the coat protein of the virus under control of the constitutive 35S promoter [7], [8]. This decade has been many advances in the biotechnological methods and there are examples of genetic transformation for all major cereals. Microprojectile bombardıment or biolistic method for plant transformation is relatively recent innovation. This method has so far proved to be the most versatile method for cereal transformation and has been used to transform all major cereals. Since that time, significant improvements have been made to the *Agrobacterium Tumefaciens* techniques, and these techniques can now also be applied to cereals. First successful generation of transgenic wheat plants was reported by particle bombardment of plasmid vector pBARGUS into cells of type-C, long-term regenerable embryogenic callus [9], [10]. Data for wheat, barley and oats are summarised in and a recent summary of a diverse range of GM techniques is available [11], [12]. Some researchers obtained regeneration in wheat var. Sonalika using Kinetin (0.5-1.5 mg l^{-1}) with IAA (0.5 mgl^{-1}) in MS media [13]. As it is seen in Fig. 2, the other target for GM development, together with herbicide tolerance, was insect resistance, specifically the potential that might be provided by the toxins found in the soil bacterium *Bacillus thuringiensis* (Bt). For many years Syngenta also worked on the development of a *Fusarium*-resistant wheat but this project was suspended in 2007, also after concerns about exports of GM wheat from the USA [2].

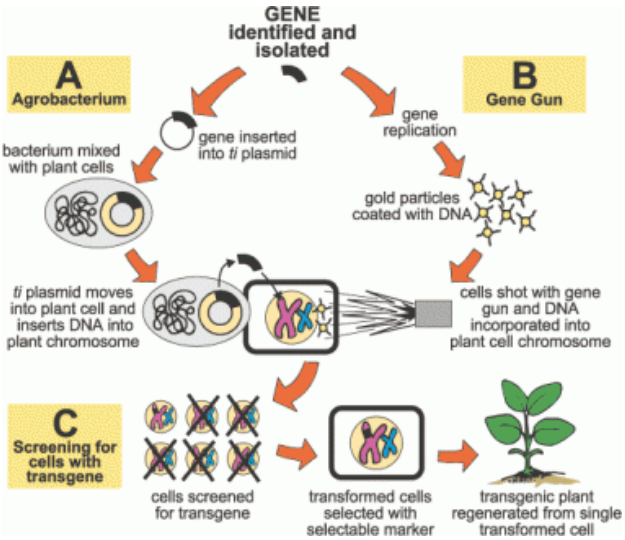

Figure 2. Agrobacterium gene transfer (source: http:bhandarysbioclass.blogspot.in)

C. Molecular Mapping and Marker-Assisted Selection in Cereals

A large number of cereal studies have used molecular markers as a tool to identify major genes, QTLs, or to introduce new characters in elite germplasm. In wheat, for example molecular markers have been identified that are associated with more than 40 traits of economic importance such as grain protein content, preharvest sprouting tolerance, vernalization response, dwarfing genes, bread-making quality, leaf rust resistance, cereal cyst nematode resistance, etc. [1]. Marker-assisted selection provides a potential for increasing selection efficiency by allowing for earlier selection and reducing plant population size used during the selection [1].

D. Molecular Genetic Approaches to Maize Improvement

New technologies continue to increase our understanding of transgenic cereal. For example, the complete DNA sequence of the maize genome, along with more comprehensive transcriptome, proteome and metabolome information, will continue to drive innovations in molecular breeding and biotechnology. These additional layers of information help to further unravel the complexities of how genes and gene networks function to produce productive maize plants. This knowledge will lead to improved predictions and capabilities to assemble native gene variation through molecular breeding as well as more optimal gene selection and regulation in the development of future biotechnology products [14].

The main approach to improve maize quality protein has been the use of the *opaque-2* gene (*o2*) [15]. This mutant gene confers High Lysine (HL) content to maize endosperm but has pleiotropic negative effects on agronomic traits. *Opaco-2 modifier* genes can overcome the adverse effects of the *o2* gene, resembling normal maize in kernel phenotype and agronomic performance, and holding superior quality protein. These kinds of modified *o2* genotypes are generally called "Quality Protein Maize" (QPM) [15], [16].

The other research, such as, High Oil Corn (HOC) contains 50 to 100% more oil and higher quality proteins than normal yellow dent corn. High oil corn is attractive as a livestock feed because it has greater energy than normal corn and can replace some of the more expensive sources of fats and proteins [16], [17].

As application of molecular markers in gene diversity studies of cereals, DNA fingerprinting of using cereals species and cultivated varieties has a long scientific history in molecular approaches. RFLP was the first marker system used in genotyping and gene diversity studies in wheat, barley and maize, which has been considered as state-of- art for a long time but with improving of marker technologies in the last decade new marker types such as RAPDs, AFLPs, SSRs and SNPs were considered to be more effective, cheap and informative [1].

Method of Marker - assisted selection as the one of the molecular approaches provides a potential for increasing selection efficiency by allowing for earlier selection and reducing plant population size used during the selection. The predictive value of genetic markers used in MAS (Marker-assisted selection) depends on their inherent repeatability, map position and linkage with economically important traits (quantitative or qualitative) [1].

IV. Conclusion

By 2030, the world's population is expected to grow to 8.1 billion at a rate of over 75 million people per year. Almost all of the population increases will occur in developing countries, so; great efforts were made to study different types of biotechnological methods for improvement of cereal species. The rewiev work done so far for the improvement of some cereals demonstrates the potential of these techniques in the improvement of biotechnological methods. Current progress in tissue culture and genetic transformation of cereals combined with biotechnological applications continue for the development of transgenic plants. In conclusion, it is expected that the presented some results on corn,wheat and barley will clarify some peculiarities of cereal culture and transformation. Hopefully this will be useful for researchers working on further improvements of transformation technologies.

In a world with increasing global need and expectation for food and energy security, the molecular genetic approaches and the biotechnology and yield advances in cereal takes on even greater importance. It is clear that we have the genetic tools based on genomics-based breeding and second-generation biotech traits, together with the continued gains from improved agricultural practices and production systems and double cereal yields to per acre.

Current development of DNA marker based technologies; that is the concept of marker –assisted selection provides one of the most powerful genomics tool for new solution for selecting and maintaining desirable genotype. Once molecular markers closely linked to the trait of key interest are identified, marker–assisted selection can be performed in early segregating populations and at juvenile stage from an early generation.

Bt cereal cultivation or transgenic cereals reduces the use of chemical insecticides and thus provides environmental and economic benefits leading to sustainable agricultural production. The success stories of transgenic cereals cultivation are available in many studies. However, the increasing cultivation of transgenic cereals has raised a wide range of concern with respect to food safety, environment effects and socioeconomic issues. The major concerns are related to possible toxicity and allergenicity of that foods and products. The environmental risks include the introgression of transgenes into natural crop populations, impact of gene flow, effect on non-target organisms, evolution of pest resistance and loss of biodiversity. Wider acceptability of transgenic cereals has raised a series of social and ethical issues, which includes restricted access to genetic resources and new technologies, loss of tradition of saving seeds and dominance of private sector and capital investing technology for poor farmers.

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