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Genetic engineering of indica rice in support of sustained production of affordable and high quality food

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ABSTRACT
Genetic upgradation of indica rice is one of the major areas of potential usefulness. Conventional plant breeding programmes have contributed substantially to the improvement of rice, the world over. However, sexual and genetic incompatibility barriers limit conventional breeding techniques. In recent years, there has been a little shift of emphasis in research of crops plants from conventional breeding to genetic engineering under sustainable conditions. To achieve maximum benefit, the application of gene technology should focus on high priority problems for which solutions by conventional approaches are not available.

Key words : Rice, Production, Genetic engineering.

INTRODUCTION

The present world population of 6.1 billion is continually increasing and will probably double by the year 2030 (FAO, 2004). A considerable portion of this increase is likely to occur in the rice consuming natures of Asia. With the ever increasing pressure on arable land due to urban development, more and more food has to be produced from less and less land. Increasing productivity per unit area and time, therefore, remains the challenging task. Furthermore, considering the serious problems of soil health and environment, increased productivity must be accomplished on a sustainable basis. Genetic upgradation of our crop plants is one of the major areas of potential usefulness. Conventional plant breeding has contributed substantially to the crop improvement programme, the world over. However, conventional plant breeding techniques are limited by sexual and genetic incompatibility barriers.

During the recent past, modern biology has undergone significant development specially in the areas of cell and molecular biology. It has been possible to raise plants from single cells, isolated pollens and protoplasts. It has been possible to isolate genes from bacteria and such unrelated species and genera, and their to a wide array of plant species. It is widely recognized that genetic engineering can significantly strengthen plant breeding programmes and help to produce new varieties with desired agronomic traits. It enables plant breeders to achieve results more quickly and efficiently. Biotechnology is taking us from an era of hybrid plants to an era of transgenic plants and we are on the way from a "Green Revolution to a Gene Revolution". Indica-type rice (*Oryza sativa*) feeds more than two and half billion people, predominantly in developing countries followed by Japonica and Javanica types in humid and semi-humid Asia, where rice is the basic food. Rice productivity will have to be increased with considerable reduction in the input of agrochemicals under sustainable conditions (IRRI, 2003). This immerise task requires that traditional plant breeding is supported by every possible contribution from novel technical development. Genetic engineering, applied appropriately and with care, has the potential to contribute to the sustainable production of affordable food for the increasing population. To achieve maximum benefit, the application of gene technology should focus on important problems for which solutions by conventional approaches are not available and indica-type rice has been identified to suffer from such problems. Among the high priority problems to be solved are a) resistance to fungal diseases, b) resistance to Tungro virus, c) resistance to yellow stem borer (Scripophage incentulas), d) stable supply of pro-vitamin A, and e) improvement of nutritional quality. The problems mentioned are especially sever for people depending on Indica-type rice. It is, relatively easy to genetically engineer Japonica-type rice. Methods have been established for gene transfer to Indica rice breeding lines to study possible contributions from genetic engineering.

Methods for introducing genes into indica rice

Early attempts on genetic transformation to obtain transgenic plants focused mainly on the development of efficient and reproductible methods for transformation of major crop plants. However, successful methods are still Ilimited to Agrobacterium-mediated transformation system, direct gene transfer methods with plant protoplasts and biolistic method.

i) Agrobacterium tumefaciens –mediated gene transfer to dicots :

Agrobacterium tumefaciens is the etiological agent of crown gall diseases and produces crown gall tumors on more than one hundred susceptible plant species which commonly have a wound response. To Agrobacterium virulent strains of *Agrobacterium* contain large Ti plasminds, which are responsible for T-DNA transfer and subsequent isease symptoms. Ti plasmids have two sets of sequences necessary for gene transfer to plants. One is the T-DNA region which is flanked by 25-bp direct repeat border sequences responsible for gene (DNA) transfer to plants and other set is comprised of the virulence (Vir) gene sequences. The latter are not transferred during infection but aid excision of T-DNA from Ti plasmid, transfer to an infected plant cell, and insertion into the plant genome.

The Ti plasmid of *Agrobacterium fumefaciens* has been genetically engineered to create "disarmed" plasmids or vectors which can carry any DNA sequence of interest into an infected plant, without tumerous growth of the host plant. Ti plasmid derived cloning vectors are capable of replication in *Eacherichis coil* as well as in *Agrobacterium,* allowing for convenient manipulations. The vector is then transferred to an *Agrobacterium tumefeciens* host strain which is "disarmed" but still carrier the virulence functions necessary for infection of plant tissue. The final *Agrobacterium tumefaciens* strain crying the DNA of interest is grown in a overnight culture of use in co-cultivation experiments the very next day. Two selectable marker genes are usually carried on the plasmid, one for selection in bacteria and the other in plants. Introduction of foreign genes, into plants tissues by A. *tumefsciens* co-cultivation is at present the most widely used method for the study of plant gene expression I dicots.

Plants viruses as vecter for DNA (gene) transfer :

Techniques are being developed to use certain DNA and RNA plant viruses, e.g. caulimo viruses, Gemini viruses etc. The culiflower mosaic virus (C_aMV; a caulmo virus) is a DNA virus. A DNA segment