Proceedings of RMBSEFEWS & Indian J.Sci.Res.: 89-92, 2018 ISSN: 0976-2876(Print)
ISSN: 2250-0138(Online)

ROLE OF TRANSGENIC PLANT IN AGRICULTURE FOR BETTER PRODUCTION

NIDHI SINGH[a1] AND K.K. PATEL[b]

[a]Department of Botany, R.R.P.G. College, Amethi, U.P., India
[b]Department of Botany, Nandini Nagar P.G. College, Gonda, U.P., India

ABSTRACT

At present, environmental degradation and the consistently growing population are two main problems on the planet earth. Fulfilling the needs of this growing population is quite difficult from the limited arable land available on the globe. Although there are legal, social and political barriers to the utilization of biotechnology, advances in this field have substantially improved agriculture and human life to a great extent. In fact, genetic engineering facilitates the transfer of desired characteristics into other plants which is not possible through conventional plant breeding. One of the vital tools of biotechnology is genetic engineering (GE) which is used to modify plants, animals and microorganisms according to desired needs. A variety of crops have been engineered for enhanced resistance to a multitude of stresses such as herbicides, insecticides, viruses and a combination of biotic and abiotic stresses in different crops including rice, mustard, maize, potato, tomato, etc. Apart from the use of GE in agriculture, it is being extensively employed to modify the plants for enhanced production of vaccines, hormones, etc. Vaccines against certain diseases are certainly available in the market, but most of them are very costly. Common food plants like banana, tomato, rice, carrot, etc. have been used to produce vaccines against certain diseases like hepatitis B, cholera, HIV, etc. Thus, the up- and down-regulation of desired genes which are used for the modification of plants have a marked role in the improvement of genetic crops. In this review, we have comprehensively discussed the role of genetic engineering in generating transgenic lines/cultivars of different crops with improved nutrient quality, biofuel production, enhanced production of vaccines and antibodies, increased resistance against insects, herbicides, diseases and abiotic stresses as well as the safety measures for their commercialization.

KEYWORDS: Transgenic, Herbicides, Vaccines, Conventional Antibodies, Insecticide, Abiotic, Plant breeding

The world population is increasing alarmingly and is projected to reach 8.5 bil-lion by 2025. To fulfill the food demand of every individual from limited natural resources is difficult. This, factor has resulted in food deficiency thereby causing malnutrition, which is a serious health problem these days. Producing crops with improved quality and quantity is imperative for growing food demand through sustainable agriculture that could be attained using conventional selection and breeding or through genetic engineering (Ashraf and Akram, 2009). Environmental stresses, population explosion and food shortage have caused serious problems to mankind on the globe. The application and development of biotechnology have led to opportunities and novel possibilities to enhance the qualitative and quantitative traits of organisms (Yamaguchi and Blumwald, 2005; Sun, 2008). Biotechnology for crop improvement has become a sustainable strategy to combat deficiencies in food by enhancing proteins, carbohydrates, lipids, vitamins and micronutrient composi-tion (Zimmermann and Hurrell, 2002; Sun, 2008). Since 1990s, the major emphasis of agricultural biotechnology can be found on traits for improvement in crops related to insect and herbicide resistance, nutritional quality, virus resistance, shelf life, and biofuel production. Transgenic plants have been developed through different genetic engineering techniques but with a number of legal, political and social problems (Ashraf and Akram, 2009). Considerable improvement in yield has been achieved by using trans-genic approach in a number of crops including wheat, rice, tobacco, brassica, and soybean, etc. and still there is a dire need to generate high yielding and quality transgenic.

TRANSGENIC PLANTS/CULTIVARS

According to an estimate, the world area of GM crops raised more or less from 1.7–102 million ha i.e. about 60-fold from 1996 to 2006 (James, 2006). Transgenic plants with improved traits have greater advantages as compared to those of wild plants (Jaworski and Cahoon, 2003; Mascia and Flavell, 2004; Ashraf and Akram, 2009), but with a few limitations (Altman, 1999; Krattiger, 2010; Cotter, 2011). In 1970s, scientists were able to ma-nipulate DNA at molecular level and the technology was referred to as genetic engineering. Recently, biotechnology has revolutionized crop improvement by producing GM crops with enhanced availability and utilization of im-portant traits (Icoz and Stotzky, 2008). Later on in 1996, only seven major crops suchas soybean, cotton, canola, tomato, potato,

[1]Corresponding author

maize and squash were used for generating transgenic crops. There after, the world area of transgenic crops grew enormously. In agriculture, yield is a major output and improvement in yield of plants is a major thrust area by counteracting biotic and abiotic environmental cues. Thus, crop cultivars with enhanced yield and stability are required. In this context, a substantial progress has been made in enhancing crop yield worldwide using advanced molecular biology tools.

INSECT AND DISEASE RESISTANCE

Bacillus thuringiensis (Bt) insect resistant crops are one of the most astounding achieve- ments in plant transgenic technology. Bt is a potent insecticide which comprises crystal protein endotoxin produced by some strains of soil bacterium B. thuringiensis (a soil bacterium). Scientists' endeavors to engineer plants to overexpress natural defense against a variety of pests including insects, fungi bacteria etc. also can be deciphered from the literature. The first Bt toxin gene was cloned in 1981 (Schnepf and Whiteley, 1981; Jain et al., 2007) and the field trial of transgenic tobacco expressing Bt toxin was performed in 1986. Furthermore, the first GM plant of japonica rice was produced in 1988 and then indica rice in 1990. Subsequently, genetically engineered corn, cotton and tomato were tested under field conditions in different countries and area under Bt crops was 1.2 Mha in 1996 (James, 1997, 2000). The foods from different plants always contain proteinase inhibitors which are usually destroyed by cooking. Thus, transgenic plants expressing proteinase inhibitor genes can be safe (Larry and Richard, 2002). Transfer of proteinase inhibitor genes into other plants will produce insect resistant crops (Larry and Richard, 2002). Brar and Khush (2007) have demonstrated that expression of cowpea trypsin inhibitor (CpTi) improves rice plant resistance against stem borer. Alpha-amylase inhibitor accumulates in plants and defends them against insects. Various types of proteinase inhibitors have been expressed in rice plants e.g. potato protease inhibitors II, oryzacystatin, cowpea trypsin inhibitors, soybean trypsin inhibitors (Xu et al., 1996; Sharma et al., 2004), trypsin inhibitor (Mochizuki et al., 1999), and barley trypsin inhibitors (Alfonso-Rubi et al., 2003).

HERBICIDE RESISTANCE

New chemicals such as glyphosate have been widely recommended for use because glyphosate is environmental-friendly as soil microorganisms are able to degrade it rapidly. The early herbicides were found to be very destructive for most plants and they created undesirable environmental impacts. By introducing glyphosate tolerance genes into crops, the herbicide can now be applied over the top of crops during the growing season to control weed population more effectively. Plants expressing transformed herbicide tolerance accounted for 71% of all transgenic crops grown worldwide in 1998 and 1999 (James, 1999). Herbicide tolerant soybean, corn, cotton and canola represent the major transgenic products (James, 1999; Liu 1999. Recently, Gaines et al. (2010) developed herbicide resistant Amaranthus palmeri by expressing glyph sate insensitive herbicide target site gene, 5-enolpyruvylshikimate-3 phosphate synthase (EPSP) that is involved in the shikimate cycle wherein it catalyzes the reversible addition of the enolpyruvyl moiety of phosphoenolpyruvate to shikimate 3-phosphate. In the western and central Africa considerable loss of maize was observed by a parasitic weed Striga hermonthica.

ABIOTIC STRESS TOLERANCE

Abiotic stresses such as salt, drought, flooding, extreme temperature and oxidative stresses often diminish plant growth and final yield. Agricultural productivity could be increased dramatically if crops were redesigned to better cope with environmental stresses. Expression of choline oxidase (codA) gene increases glycinebetaine production, which helps the cells in osmotic adjustment so that the plant can acclimate under different stresses. Studies with rice confirmed that chloroplast targeting the codA gene is a very effective way to enhance tolerance to these a biotic stresses. Transgenic regulations of solutes such as mannitol and proline have been used to promote stress tolerance in plants (Hasegawaet al., 2000). Van Camp et al. (1994) demonstrated that over-production of a superoxide dismutase (SOD) gene resulted in increased chilling tolerance in plants. This could be due to the reason that different stress environment (high light intensity, pathogens and cold) produce reactive oxygen species (ROS) which can damage to plants.

NUTRIENT RICH FOOD

Globally, 21% of children have been reported to suffer vitamin A deficiency (Sommer, 2001). In view of a projection, about 800,000 deaths in children and women of reproductive age occur due to vitamin A deficiency (Black, 2003; WHO, 2009). Vitamin A deficiency can adversely affect the eyes as well as it can cause childhood and maternal mortality. According to another projection, approximately 0.25 to 0.5 million malnourished children in the developing countries become blind each year mainly because of vitamin A deficiency and 50% of which die within a year of becoming blind (WHO, 2008). VAD is found in greater numbers in children and pregnant women. Nutritional deficiency is one of the key challenges of developing countries. In majority of the countries the staple food is rice which is deficient in vitamin A. The expression of vitamin A gene in rice will be an alternative to eradicate this VAD. No technology can overcome such deficiencies, but plant biotechnology tools have been very effective in improving the nutritional levels in some field crops: for example, lysine and threonine in cereals, methionine in leguminous plants, and vitamins A and E in crucifers and rice. Increases in the level of methionine and vitamins in crops to an appreciable level are all due to advanced biotechnological means. Transgenic rice containing four genes isolated from Narcissus and Erwinia has been obtained (Ye et al., 2000). Golden mustard is also developed by biotechnologists and is rich in provitamin A. In the future, this technology will be beneficial for other variety of potential crops. According to Panos (1998) there are three generations of GE crops. Some of the stable rice transgenic lines accumulate high amounts of provitamin A, giving the endosperm a yellow color, hence the name golden rice.

VACCINES AND ANTIBODIES

Growth of new pathogens like HIV, hanta virus, hepatitis C virus and SARS has caused hue and cry and the problem is getting more complex day by day. Infectious diseases are the most dangerous problems in the present world and each year one third of all deaths are caused by the infectious agents. In view of Guzman and Feuerstein (2004) 15% of new cancers (e.g. gastric cancer, hepatocarcinoma and cervical cancer) are due to infectious microorganisms. Vaccination is a sound means of preventing infection and a very cost efficient method. Today, vaccines are used against both infectious and non-infectious diseases. Plant genetic engineering technology is now being widely used for (al., 2002; Walmsley and Arntzen, 2003 "biopharming", or production of pharmaceuticals in plants (Raskin et al.). Antibodies produced in plants are thought to be particularly suitable for topical immunotherapy. Expressions of antibodies in transgenic plants (plant bodies) have been first shown by Hiatt et al. (1989). After that, experiments were widely carried out for vaccine production using plants as bioreactors. The vaccines produced from transgenic plants have high efficiency in passive immunization of bacterial or viral diseases and are currently under clinical trials (Ko and Koprowski, 2005; Ma et al., 2005). The antigens produced by the transgenic plants are also edible that is why the plant based vaccine production is gaining market day by day. The production of edible vaccines (a surface protein from Streptococcus) in transgenic tobacco was first reported in 1990 and published as a patent (Mason and Arntzen, 1995). Plants were used as bioreactors to produce antigens induced by plant transgenic vectors, which in turn, produce vaccines for the treatment of various diseases (Tiwari et al., 2009; Rigano et al., 2009).

VIRAL ANTIGENS

Plants derived vaccines and commercially available yeast-derived vaccines have shown equivalent immunogenicity in mice (Thanavala et al., 1995; Thanavala and Lugade, 2010). Mason et al. (1992) demonstrated that DNA coding for the hepatitis B virus major surface antigen (HBsAg) was incorporated into tobacco plants via Agrobacterium transformation. The HBsAg in transgenic tobacco got expressed and retained the capability of self association. The HBsAg isolated from transgenic tobacco was analyzed and found analogous to HBsAg obtained from human serum and recombinant yeast. Tacket et al. (1998) for the first time got the successful human trial against ETEC. Transgenic potatoes expressing HBsAg were also obtained by Richter et al. (2000) and have been shown to cause high immunogenicity in mice. Kapusta et al. (1999) obtained transgenic lettuce containing expression plasmids for HBsAg. This transgenic lettuce was given to three adult volunteers orally but only two showed response to the orallyfed vaccine. Elkholy et al. (2009) demonstrated that expression of recombinant hepatitis B surface antigen (rHBsAg) in banana can be used as edible vaccine against hepatitis B virus (HBV) infection. Transgenic tobacco plants expressing E. coli heat labile enterotoxin B subunit (LTB) possess the capability of a vaccine or booster vaccine against ETEC (enterotoxigenic E. coli) and cholera (Qadri et al., 2005; Svennerholm, 2011).

REFERENCES

Ashraf M., Akram N.A., Arteca R.N. and Foolad M.R., 2010. The physiological, biochemical and molecular roles of brassinosteroids and salicylic acid in plant processes and salt tolerance. Crit. Rev. Plant Sci., **29**:162–90.

Ashraf M. and Akram N.A., 2012. Improving salinity tolerance of plants through conventional 534 P. Ahmad et al. / Biotechnology Advances, **30**: 524–540.

Alfonso-Rubi J., Ortego F., Castanera P., Carbonero P. and Diaz I., 2003. Transgenic expression of trypsin inhibitor CMe from barley in indica and japonica rice, confers resistance to the rice weevil Sitophilus oryzae. Transgenic Res., **12**:23–31.

Brar D.S. and Khush G.S., 2007. Breeding rice for resistance to biotic stresses: conventional and molecular approaches. Sabrao J., **45**:225–34.

James C., 2010. A global overview of biotech (GM) crops, adoption, impact and future prospects. GM Crops, **1**:8-12.

Yamaguchi-Shinozaki K., 2003. OsDREB genes in rice, (Oryza sativa L.) encode transcription activators that function in drought, high salt and cold responsive gene expression. Plant J., **33**:751–63.