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Review Article

IMPROVEMENT FOR BIOTIC AND ABIOTIC STRESS TOLERANCE IN CROP PLANTS

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Abstract: *The field of biotechnology has extraordinary influence on science, law, the administrative condition social insurance, and business throughout the world. As the starting of agriculture, people have been manipulating crops to improve the yield and quantity. Product yields throughout the world are essentially diminished by the activity of herbivorous insects, pathogens, and parasites. Natural environmental stresses make this circumstance significantly worse. Biotechnology can be used to increase the yield of food crops, to improve biotic and abiotic stress tolerance, to modify the traits of the plant (e.g. oil content, percentage of lignin, cell structure), to make the conversion to liquid biofuels more efficient. Various genes have been discovered for biotic and abiotic stress tolerance. The genes discovered for biotic stress are aryloxyalkanoate, dioxygenase, enzymes (aad-1), nitrilase, Cry1Ac, Cry2AB, GTgene, AFP (anti-freezing protein gene) gene, Chitinase II and III gene, and Rps1-k. The genes discovered for abiotic stress are SgNCED1, SgNCED1, USP2, HSP70, BADH, and ALO, PVNCED1, HVA1, LeNCED1. CRISPRs (clustered regularly interspaced short palindromic repeats) are the short DNA sequences present in bacteria and archaeal genomes which are now currently used by researchers to edit the genome. In different plant species (calli, leaf discs) protoplasts have been successfully used to edit their genome through CRISPR/Cas9 system. The aims of the applications are to increase resistance to abiotic or biotic stress, to engineer metabolic pathways, and to increase grain yield. Incorporation of modern biotechnology, with regular traditional practices in a sustainable way, can fulfill the objective of achieving food security for the present and as well as in future.*

Keywords: biotechnology, biotic, abiotic, stress, environment, herbivorous insects, pathogens, parasites

Introduction

The Hungarian engineer, Karl Erky, coined the term biotechnology in 1917 to describe a method for large-scale pig production. In order to obtain useful goods, biotechnology can be characterized as the use of technology utilizing living organisms (Christou and Twyman, 2004; Strange and Scott, 2005). Researchers have found how genes could be exchanged from particular living organism to another organism. This may be known as hereditary control, hereditary building alternately hereditary upgrade (Key *et al*., 2008; Ramessar *et al*., 2007). In any case of the term, by including genes (DNA) starting with in turn organism, the procedure empowers the exchange for suitable characteristics (such as improvement for disease control) in a plant, animal or microorganism. Conventional breeding include collection of entity plants or animals based on visible or measurable qualities (Zhang *et al*., 2012; Zhu *et al*., 2013). By examining the DNA of an organism, researchers can utilize molecular markers to choose plants or animals that possess an advantageous gene, even in the deficiency of a visible trait. Thus, breeding is more precise and useful. For example, those universal foundation of tropical agribusiness need utilized molecular markers for disease-resistant (Dangl *et al*., 2013; Huot *et al*., 2014; Yuan *et al*., 2011). Tissue culture may be used for producing plants from disease free plant. This method empowers the propagation cost of crop planting material. Citrus, pineapples, avocados, mangoes, bananas, papaya cotton and maize have been grown through tissue culture (Bebber *et al*., 2013; Savary *et al*., 2006). There is use of transgenic techniques to produce plants for inducing resistance against different living organisms for example viruses, fungi, bacteria, nematodes, insects as biotic stress. Abiotic stress is those damaging impact from non-living states, which is all around living organism (Mundt, 2014; Steuernagel *et al*., 2016). Abiotic stress like dry season (water stress), unreasonable watering system (water logging), high or low temperatures (cold, hilling and heat), saltiness or salt and mineral poisonous quality caused a negative effect on crop plants at different plant growth, production, yield and

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seed formation (Godard *et al*., 2007; Godard *et al*., 2008; Yu *et al*., 2014).

Biotechnology for biotic stress tolerance

The damage caused to plants by different living organisms including, viruses, fungi, bacteria, nematodes, insects, and weeds caused biotic stress. Dissimilar to that of abiotic stress which showed up to caused critical and harmful impact because of environmental change. Different varieties of pesticides, fungicides and herbicides are often utilized to control crop losses which became the cause of damages in crop yield and production (Isman and Grieneisen, 2014; Law *et al*., 2017; Yoon *et al*., 2013). The use of the chemicals caused harmful effects on crop plants as well as the environmental quality through causing chemical pollution in environment and soil (Ahanger *et al*., 2017; Mattah *et al*., 2015). Utilization of pesticides, fungicides and herbicides needs to get an essential analytics before applying on crop plants (Mabe *et al*., 2017; Mahmood *et al*., 2014). Residues of sprayed pesticides, fungicides which are usually residing on the fruits or vegetables became the cause of an immediate harmful effect on health of human. Crop plant yields fluctuate alongside their degree for affectability towards a specific pesticide, herbicide and fungicide, the applications of these chemicals also caused problems in metabolic pathways of plant (Aktar *et al*., 2009; Kim *et al*., 2017).

Insect-resistance inducible promoters

In potatoes, pest attacks or abiotic stress conditions caused the potato protease inhibitor II (pinII) gene expression. The insect attack on transgenic *Arabidopsis* plant which was carrying GUS gene along with potato pinII promoter showed response in the form of expression against insect attack (Bu *et al*., 2006; Liu *et al*., 1996). In most plants, the promoter of potato protease inhibitor II (pinII-2x) was induced and regarded as an ideal promoter of defense for gene expression (Bu *et al*., 2006). The expression of the promoters mannopine synthase (mas) (Godard, 2007; Li *et al*., 2013) and nopaline synthase (nos) promoter (An *et al*., 1990; Kim *et al*., 1993) was induced in leaf and stem tissues through injury and insect attack. Transgenic peanut (*Arachis hypogaea* L) from an inducible promoter PR1-a expressing transgene Cry1Ac confers enhanced resistance to the insect *Spodoptera litura* (Zhu-Salzman *et al*., 2004). Insect-inducible PR1-a promoter is considered an appropriate promoter for the production of transgenic genes for aphid resistance, as the expression of the genes under this promoter was only induced during the aphid attack (War *et al*., 2012). Induced expression under wound and insect attack was shown by Tomato Lipoxygenase D (TomLoxD) promoter (Yan *et al*., 2013). Transgenic broccoli expressing insecticide with Cry1Ab showed resistance to insect *Plutella xylostella* (Linnaeus) under inducible promoter PR-1a (Cao *et al*., 2001).

Nematode-inducible promoters

The most important and crops universal plant parasitic nematodes have became the basis of important production losses. There have been still litter attempts to separate the inducible promoters of nematodes. Promotors Pdf2.1, Pdf2.2 and Pdf2.3 showed induced expression in beet cyst nematode *Heterodera schachtii* infestation in on *Arabidopsis* (De Coninck *et al*., 2013; Siddique *et al*., 2011). The provoked outflow with root tie nematode *meloidogyne incognita* spoiling might have been indicated the GUS reporting gene combined with those nematode-responsive-root-specific promoter (AT1G26530) (Kumar *et al*., 2010). Creating RNAi-based transgenics alongside demonstrative promoters against plant parasitic nematodes might be a chance to be a perfect gas method for combating parasitic nematodes to plants (Banerjee *et al*., 2017; Coyne *et al*., 2018).

Pathogen-inducible promoters

A critical problem caused damaging to crop plants around the world are microbial, bacterial and contagious pathogens. Different intricate pathways have shown that the plants usually transmit pathogen-responsive proteins. On keep the contaminations of pathogens caused production of pathogen-responsive proteins, anti-viral and so forth to combat with the pathogenic attack. The safety for transgenic plants with pathogenic infections might have been expanded toward transgenic formation, pathogen-responsive proteins, antiviral genes and so on (Bebber *et al*., 2013; Christou and Twyman, 2004). Phenylalanine ammonia-lyase promoter (PAL1) has been found produced under the spoiling effects for the bacterial pathogen *Pseudomonas syringae* (Godard *et al*., 2007; Puthoff *et al*., 2010). A pathogen-responsive CMPG1 gene has also been identified to enhance tolerance against pathogenic attack.

Diseases

A large number of plant diseases perusing biotic stresses, including viruses, bacteria, fungi and nematodes caused losses of crop plant yield and production potential. Over 1978, a population of Geminiviruses might have been found in plants during different spans with single-stranded deoxyribonucleic acid (ssDNA) infections caused losses in crop plants (Moffat, 1999). The Geminiviridae has three genera, including Mastrevirus, Begomovirus and Curtovirus. The Begomovirus class has become the cause of loss of yield in cotton.

Cotton leaf curl disease

The cotton leaf curl virus disease (CLCuD) is one of the serious diseases of cotton, which caused damage in cotton production. The indications are including thickening and yellowing about little veins on the down surface of leaf with shrinked margins. Margins twist descending alternately upward with hindered plant growth under disease attack because of decreased inter-nodal separation (Qazi *et al*., 2007; Zhou, 2013). Flowering, boll development, maturation, seed cotton generation and fiber quality are extremely effected (Amrao *et al*., 2010). CLCuD reveals to upward twisting (Fig. 1) alongside thickening of the cotton plant leaves, twisting alongside leaf thickening, enations on the underside of the leaves, and cotton plant hindering growth. Transgenic cotton expressing partial AC1 and βC1 gene of CLCuV can be used as virus resistance source in cotton breeding programs aiming to improve yield and potential of cotton (Sattar *et al*., 2013; Tahir *et al*., 2011).

Fig 1. Curling upward along with the thickening of cotton plant leaves.

Bacterial blight disease

Bacterial blight disease caused tannic-grey with white lesions along the veins of leaves of plants. In the tillering stage (Fig. 1), the stricks expands with plant growth, peaking at up to the blooming stage of plant. The additional harming show fate of the disease is Kresek, wherein those abandons of the entire plant transform pale yellow and shrivel of the early tillering phase throughout the seedling, bringing about an incomplete or totally finish crop yield (Ronald *et al*., 1992; Yang *et al*., 2006). Same time in the least development stages, leaf bud occurs, in spite of the fact that when kresek proceeds, harmful effect became extensive, post-flowering infections bring next to no sway for grain yield. The Xa1 gene which has been identified and transform in rice confers a resistance to Japanese race 1 of *Xanthomonas oryzae* pv. *oryzae*, against causal pathogen of disease bacterial blight (BB). One of the BB-resistance genes, Xa1, confers a high level of specific resistance to race 1 strains of Xoo in Japan (Antony *et al*., 2010; Gnanamanickam *et al*., 1999).

Figure 1. Symptoms in rice of bacterial leaf blight.

Cassava common mosaic disease

Leaves of CsCMD-affected cassava plants produce mosaic and chlorotic symptoms. There are dark and light green areas that are delimited by veins on some of the affected leaves. During relatively cool periods, the symptoms are most extreme and the disease is most affected by cassava grown in the semitropical areas of South America. The affected plants are often stunted in these relatively cool conditions and yield losses can be up to 60 per cent (Costa and Kitajima, 1972). CMD2 has been combined with CMD1 through genetic crossing to induce resistance against CsCMVD (Calvert and Thresh, 2002).

Viruses

In plants, the viruses that complete their life cycle are called plant viruses. Since all viruses are intracellular parasites, plant viruses often rely on plant cell machinery to complete their replication.

Gemini viruses

Geminiviruses in tropical and subtropical regions of the world are a group of small insects spread viruses as plant pathogenic viruses responsible for various crop diseases (Bilal *et al*., 2020; Moffat, 1999; Varma and Malathi, 2003). These viruses also contribute to epidemics, causing major crop losses. The recombination of various geminiviruses co-infecting the same plant, the expansion of agriculture into new growing areas and the transfer of contaminated plant material to new locations are various factors contributing to crop epidemics (Varsani *et al*., 2014; Yu *et al*., 2010).

Begomo viruses

Begomoviruses is the most significant genus of Geminiviruses. Begomoviruses are the largest and most economically important genus to date, comprising more than 200 species, and their number is still growing (Moffat, 1999; Yu *et al*., 2010).

Cotton leaf curl viruse

The economically relevant monopartite Geminivirus is the cotton leaf curl virus, which is transmitted in persistent circulatory forms by whitefly. CLCuV

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causes serious damage to *Gossipium hirsutum* in Pakistan, while *G. arborecum* is immune to a virus like this (Amrao *et al*., 2010; Calvert and Thresh, 2002; Sattar *et al*., 2013).

Genes to control biotic stress

Plants usually have two safe support levels that guard them against various types and strains of pathogens. Pathogenic strike produces on the surface of the plant distinguished by plant pattern recognition receptor (PRR). Those PRR generates signs that initiate defense-related genes also exchange of the core. The secondary ROS emission and actuation of pathogenesis-related (PRs) caused unsafe debilitating pathogens perusing plant pheromones (Kumar *et al*., 2010; Li *et al*., 2013). At the same time, inside the cell, pathogens frequently all the infuse sets of influencing particles that endeavor on mischief alternately thrashing the plant resistance system. The affecter particles harm the signaling and reaction from claiming transduction that disrupts the plant defense system (Fig. 3). Throughout stress conditions signal transmitted the abiotic stress sign required with control transmission factors (Bordenave *et al*., 2013; Singh and Singh, 2018).

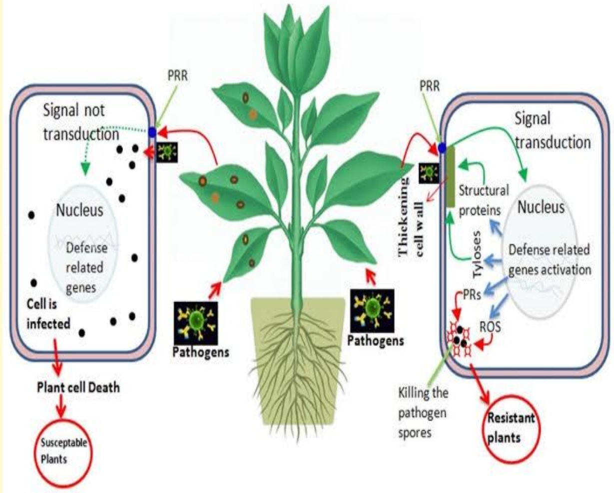

Figure 3. A graphical model of the relationship of plant-pathogen and molecular processes involved in tolerance and susceptibility to attacks by pathogens. PRR: receptor for pattern recognition, PRs: related to pathogenesis, ROS: reactive oxygen species.

Biotechnology for Abiotic Stress Tolerance

Along with abiotic stresses, drought and high temperature are the 2 main stresses that harmfully affect the potential and production of crop plants. Such abiotic stresses decrease farm earnings and agricultural benefits. The reduction of water up to 40% reasons the bringing down for maize yields up to 40% of yield while wheat with 21% of yield losses (Daryanto *et al*., 2016; Ronald *et al*., 1992). In Africa, agricultural crops, like cowpea, right now appearances dry season stress, decreasing yields from 34% to 68% (Farooq *et al*., 2017a). Under abiotic stress the creation for reactive oxygen species (ROS) takes place which caused harmful effects on carbohydrates, nucleic acids, lipids and proteins. This oxidative stress adversely affects plant development (Zhu-Salzman *et al*., 2004). Further, water deficiency and heat stress could harm transpiration, stomata conductance and photosynthesis in crop plant (Varsani *et al*., 2014).

Drought stress

Adaptation with water stress states is a standout amongst the significant tests for plant researchers and biotechnologists in the present situation for fast environmental change. Researchers are expanding their deliberations to explain different atmosphere triggered metabolic forms during cell division as well as gene levels in plants (Farooq *et al*., 2017b; Lamaoui *et al*., 2018). There is need to develop patterns to move forward water use efficiency by plant cells (Chen *et al*., 2017; Sehgal *et al*., 2018) available water. The tolerance inducible genes which have also been isolated and identify by using microarray techniques (Ye *et al*., 2018) use to produce transgenic crop plants, the phytohormone like ABA which help to maintain the stomata conductance is due to a stress responsive genes (Banerjee *et al*., 2017; Christou and Twyman, 2004). In *Arabidopsis* 1354 genes have been identified which up and down-regulated accompanying ABA applications or treatments, the most coding indicator transduction in plants (Huot *et al*., 2014). Likewise, it has been accounted that over outflow from claiming *capsicum annuum* dry season stress responsive 6 (CaDSR6) gene of *Arabidopsis* prompted elevated tolerance in dry season than for wild sort plants. Additionally indicated that those genes which are for stress-responsive to NaCl (SNAC1) controlled its signaling about suction phosphate synthesis kind 1-phosphatidylinositol-3-phosphate-5-kinase, 2C protein phosphates and in addition ABA receptor clinched alongside wheat plants under dry season stress (Key *et al*., 2008; Liu *et al*., 1996).

Tolerance for Cold stress

Plants which can survival at very lower temperature conditions relies on their physiological, sub-molecular reactions triggered by those plant ahead purposes of presentation on low temperature (John *et al*., 2016). These plants could survive under chilling temperature. Water availability, development, photorespiration, photoperiod are usually imperative factors that figure out the deacclimation and reacclimation for plants under chilling stress (Hossain *et al*., 2018; John *et al*., 2016). Perfect solutes, proteins, antioxidants and outflow for chilling responsive genes have a significant role in chilling tolerance (John *et al*., 2016). Modified gene interpretation for specific proteins for chilly tolerance assume an important role in the survival of plants and increasing crop plant yield (Ban *et al*., 2017). Various genes have been isolated and identified to control chilling stress like TFs and CBF/DREB. Chilling stress caused harm on photosynthetic machinery, including photo-systems and photosynthetic pigments, adjusting the outflow for photosynthetic genes (Jan *et al*., 2018) in plants. The violaxanthinde-epoxidasegene (LeVDE), directed for temperature rhythms. The over expression about gene expanded quenching non-photochemical, Fv/Fm and oxidizable P700, quantum yield, and action of xanthophyllcycle and mitigated PSI and PSII photoinhibition at low temperature stress (Thakur *et al*., 2020).

Genes to Overcome abiotic Stress

Plants developed various resistance methods throughout creation of composite signaling cascade in varying stress conditions (AbuQamar *et al*., 2009). Plant exposed to biotic and abiotic stresses, endorse to trigger kinase surge and specific ion channels remain turn on, or producing reactive oxygen species phytoharmones such as jasmonic acid, abscisic acid (Atkinson and Urwin, 2012). A basic model need been suggested over (Fig. 4), the place separate components about reactions on abiotic focuses on plants alongside their comparing would exhibited for finer understanding.

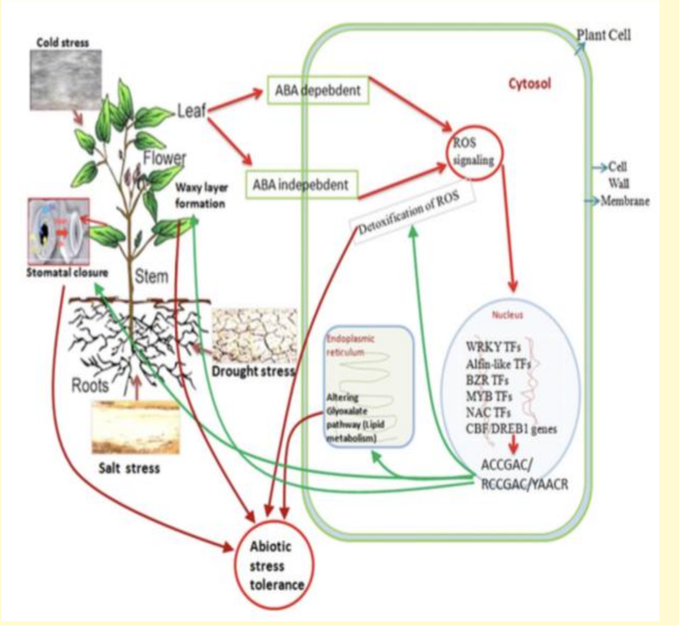

Figure 4. Simple model of different signaling pathway involved in plants to overcome the abiotic stresses. ABA: abscisic acid, ROS: reactive oxygen species.

Plant cell sensors or receptors placed in the cell divider alternately recognize stress conditions. Abiotic stress indicator transduction caused (i) ABA-dependent (ii) ABA-independent pathways. In the ABA-dependent pathway, ABRE is the fundamental ABA responsive components that initiate the stress receptive genes. On the other hand, in the ABA-independent pathway for dehydration responsive components may also be included which alongside drought, chilling also salt stress receptive genes parameter (Fig. 4). These signals are usually established by cell surface sensors that produced from plants.

Abiotic and biotic tolerance

CRISPR/Cas9 is a recently developed technology for genome editing and it has widely connected for perception mutation, gene modification, utilitarian gene analysis, Furthermore mix for remote genes to gene pyramiding, genes knockouts, protein conveyance on genomic, gene interpretation repression/activation, Furthermore epigenome altering to different organisms (Zhang *et al*., 2014). There are large numbers of reports on the utilization of this genome editing system in plant genome around ~ 20 crop species in crop plants have been edited genetically through CRISPR (Gao *et al*., 2017; Wu *et al*., 2014). A preview of CRISPR/Cas9-based gene edited plants now has biotic and abiotic stress tolerance.

Conclusion

Plants are frequently exposed with different biotic and abiotic stresses, which cause important disaster over crop yields around the world. Thus, it might make logical that understanding stress tolerance in crop plants now a day's biotechnology enable those achievements for nourish and feed humanity through improving crop plant yield and potential under stressful environmental conditions.

Conflict of interest

The authors declared absence of any conflict of interest.

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