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Research Report

Advances in Transgenic Technology for Crop Cultivation and Stomatal Regulation as Potent Role in Agriculture

Muhammad Ehsan Haider[1], Muhstaq Hussain[2], Sikandar Ali[3], Muhammad Riaz[1], Nasir Hussain[4], Muhammad Saleem[1*], Shoaib Shafique[5], Saifullah[6]

[1]Department of Botany, University of Agriculture, Faisalabad, Pakistan
[2]Department of Botany, Government College University, Faisalabad, Pakistan
[3]Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad, Pakistan
[4]Department of Agronomy, University of Agriculture, Faisalabad, Pakistan
[5]Department of Biotechnology, Faisalabad Institute of Research Science and Technology, Faisalabad, Pakistan
[6]Department of Botany, Division of Science and Technology, University of education, Lahore, Pakistan

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***Corresponding author:** Muhammad Saleem

Abstract

Gossypium hirsutum L. is most essential cash crop which provide fiber to fabric industries globally. Cotton is the world leading crop, is plenteous and produced economically, manufacturing products of cotton relatively cheap. The threads can be prepared in to a wide-ranging fabrics variety like light-weight laces and voiles to heavy-weight sailcloth's and heavy piled velveteen's, appropriate for large diversity of wearing apparel, furnishings and much industrial consumption. Fabrics from cotton can be tremendously long-lasting and resilient to scratch. Reduction of water loss through leaves is a crucial phenomenon in cotton plants under drought stress. ABA is one of the most important stress hormones and participates in various crucial physiological processes during the plant life cycle, including stress responses, development and reproduction. Exogenous application of osmo protectants and various plant growth regulators have been found effectively to enhance drought tolerance in cotton. To increase the tolerance in cotton against drought stress, transcription factors are excellent candidates for the plant scientists. Cotton is an important cash crop worldwide. Although it is classified as one of the most salt-tolerant major crops and considered a pioneer crop in reclamation of saline soils, its growth and development as well as yield and fiber quality are negatively affected by excessive salts in the soil.

Keywords: Biological factors, cotton, importance, salinity, drought, salt tolerance.

INTRODUCTION

Success of Pakistani economy depends on positive progresses in industrial and agricultural sectors. In new period, viable agriculture will be the necessity of hour in perspective of liberalization and global trends. The production of crop encounters the several abiotic and biotic stresses mostly in arid and semi-arid areas [1, 2]. The macro and micro crops environments concrete way for naturally establishment of diverse agro climatic regions and quantum of damaging and opposing stress dynamics become convincing in restraining yield awareness in crop plants. In this perspective, physiological methodologies of plant in production of crops undertake important to undo the abiotic stresses mechanisms and to categorize categorical tolerance characters for contradicting the injurious stress attack during the ontogeny [3-5].

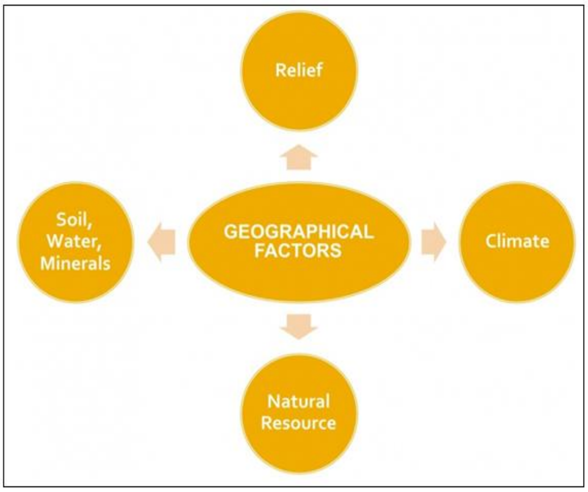

Fig-1: Shows the biological factors affecting the crop cultivation and production

According to rough estimate concerning the cotton production globally, eighty person is produced by China, Pakistan, Brazil, Turkey, India, Uzbekistan and USA. This crop gives a main percentage to GNP (gross national product) of numerous countries [6]. Cotton takes numerous colorants, is generally washable, and it can be pressed comparatively at higher temperatures [7, 8]. It is very comfy to wear as it discharges and absorbs the moisture rapidly. When warmness is preferred, it can be snoozed, a procedure benevolent the fabrics a silky surface. Many finishing procedures have been established to make the cotton resilient to stain, mildew and water; to upturn resilience to crumpling, thus reducing the need for pressing; and to lessen the contraction in washing to not extra than 1%. Non-woven cotton, formed by bonding the fibers together, is valuable for the production of disposable things to be utilized as bath towel, tea bags, polishing the cloths, bandages, table-cloths and disposable sheets for medical and in hospitals [9].

In atmosphere the green-house gasses accumulation along with the CO2 in the atmosphere at very high level is very dangerous for agriculture crops and also for humans. It has been investigated that the GW (global warming) effects the agricultural regions and causes the environmental fluctuations. The plants are sessile in nature and they bears many of the environmental stresses for their survival, growth and generation continuity. Between all the stresses the serious danger for the global food security is higher temperature stress [10].

The water scarcity stress is main reason for extensive bio-chemical and morpho-physiological changes that badly affects development and the cotton productivity [11]. Commonly, drought stress harshly limits the growth of cotton and development too such as it effects on plant height, stem dry weight, leaf dry weight, node number, leaf area index, quality of fiber, canopy and the development of roots. Specially, the net rate of photosynthesis, rate of transpiration, conductance of stomata, efficiency of carboxylation and the water potential of leaves reduced considerably during the conditions of drought stress [12].

According to the results, fifty percent accumulation of dry matter of G. barbadense restricted under the drought stress conditions [13]. Furthermore, the conductance of stomata, the rate of transpiration and photosynthesis also reduced under the water deficit. Similar to other plants, cotton has developed a wide-ranging molecular, bio-chemical and morpho-physiological mechanisms in the response to manifold stresses which allow them to escape or tolerate the stresses for survival in bad environments. The mechanisms to drought tolerance are divided in to 4 categories: the avoidance to drought, escape from drought, tolerance to drought and the drought recovery [14]. According to the newspaper releases in the USDA, production of cotton is estimated to decline due to the drought stress. Likewise in Pakistan, production of cotton dropped by 34 percent to just 9.68 million bales in paradox of production of 14.4 million bales from the prior year because of the drought stress [15].

Advances in Transgenic for crop cultivation

It is possible to transfer specific traits or gene of interest that is drought tolerant genes, from an organism of interest into another organism to obtain the desired characteristic by genetic engineering or biotechnology [16]. Recently, scientists transformed various drought-tolerant genes into cotton, resulting in drought-resistant plants. Overexpressing of TsVP, an H+ -PPase gene from Thellungiella halophile in cotton improved shoot and root growth as compared to wild type. In addition, transgenic lines had higher chlorophyll content, improved photosynthesis and higher relative water content of leaves, and cell membrane damage was observed less than wild type. These properties improved root development and the lower solute potential resulting from higher solute content such as soluble sugars and free amino acids in the transgenic plants. These beneficial features enhanced drought tolerance in transgenic cotton, and seed cotton yield was 51% higher than wild type cotton plants. In another study, a gene, ScALDH21, from Syntrichia [17, 18].

Table-1: Shows the agents for crop production, cultivation, application and mode of action

Agents	Mode of application	Effects on stressed seeds or plants	Reference
Kinetin	Seed soaking before sowing	Alleviation of salinity effect on seed Germination	[12]
MCBuTTB (Cytokinin analog)	Seed soaking before sowing plus foliar spray at 45 days after planting	Enhancement of seed germination, seedling growth, and boll setting under salinity	[24]
Polystimuline (cytokinin analogue) Coronatine (COR)	Solution culture of seedling Applied hydroponically to cotton seedlings at the two leaf stage for 24 h.	Leading to recovery of damaged PS II centers Improving the antioxidative defense system and radicalscavenging activity	[17]
5-aminolevulinic acid (ALA)	Foliar spray	Improvement of salt tolerance through reduction of NaCl uptake	[19]
Gycinebetaine Calcium	Seed soaking	Allieviation of salt damage	[20]

sulphate	Seed soaking before sowing	Enhancement of seed germination, seedling growth under salinity	
VAM (vesicular arbuscular mycorrhizal)	Mixed with soil	Increased salt tolerance of cotton seedlings	[23]
Rs-5 strain (Klebsiella oxytoca) Rs-198 strain (Pseudomonas putida)	Inoculation through seed soaking	Enhancement of germination and emergence under salinity stress	[17]

Advances in Stomata regulation for crop cultivation

Reduction of water loss through leaves is a crucial phenomenon in cotton plants under drought stress [19]. Wilting and rolling of leaves result in less radiation and thus reduced water loss. Plants often show various xeromorphic characters and have structures that promote drought tolerance, such as thicker and smaller leaves, a thicker cuticle epidermis, more epidermal trichomes, thicker palisade tissues, smaller and denser stomata, a high ratio of palisades to spongy parenchyma thickness, and a developed vascular bundle sheath [20].

For example, the cotton variety, Gossypium hirsutum (G. hirsutum) YZ1, has smaller leaves as compared to G. hirsutum Y668. Stomata regulation plays a pivotal role in gas exchange between tissues and the atmosphere. It is one of the key mechanisms that allow plants to produce energy and maintain cellular function. Ninety per cent of water losses (transpiration) from plants occur though stomata openings [21]. In cotton, closure of the stomata is the first step to reduce water loss during drought conditions, when the rate of transpiration is very high. Stomata conductance could be a potential indicator of drought tolerance in cotton as there is a negative correlation between drought tolerance and stomata conductance [22, 23].

Features in Root development

All root traits are potentially important in the drought stress; however, hydraulic conductance and plant allometry have been of particular interest to researchers. Various scientists have reviewed the potential function of roots under drought stress. Similarly, the transgenic cotton plants harboured Arabidopsis that enhanced drought tolerance 1/homodomain glabrous 11 (AtEDT1/HDG11) gene had well-developed roots in addition to other drought-tolerant feature [24].

Application of Plant regulators

ABA (Absisic acid) is one of the most important stress hormones and participates in various crucial physiological processes during the plant life cycle, including stress responses, development and reproduction. Studies indicate that osmotic stress occurs due to high drought conditions or salt stress or when water availability is reduced through water loss and turgor pressure [25].

Osmotic stress promotes the synthesis of ABA, which activates gene expression and adaptive physiological changes. ABA synthesis is initiated, which occurs mostly in the plastids, with the exception of xanthoxin conversion to ABA, which takes place in the cytoplasm. Generally, ABA synthesis occurs in the roots. It is then transported via vascular tissues, and it shows stomatal closure responses in a variety of cells, such as guard cells [26].

ABA regulates many s5tress-related genes to enhance drought tolerance in cotton plants. Overexpressing an ABA-induced cotton gene GhCBF3 in Arabidopsis enhanced drought and salinity tolerance in transgenic lines, with higher proline content, relative water content and chlorophyll content in transgenic lines than those in wild type [27]. In the presence of ABA, stomatal aperture was smaller in transgenic lines, and expression level of AREB1 and AREB2 was remarkably higher than wild type. They suggested that GhCBF3 enhance drought and salt tolerance via ABA signaling pathway [28].

Foliar application of osmoprotectants and plant hormones, including ABA, gibberellic acid (GA3), salicylic acid (SA), proline, glycinebetaine and polyamines, has been reported to relieve the effects of stress [29].

These treatments elevated osmotic adjustment to improve turgor pressure and promoted accumulation of antioxidants to detoxify ROS, thus maintaining the integrity of membrane structures, enzymes and other macromolecules during drought conditions. The exogenous application of proline and glycinebetaine as a foliar spray has also been found to be effective in reducing the adverse effects of drought stress on cotton. In this way, GA exogenous application enhanced the net rate of photosynthesis, transpiration rate and stomata conductance in cotton [30-33].

Biochemical Factors affecting crop production

To increase the tolerance in cotton against drought stress, transcription factors are excellent candidates for the plant scientists. Various transcription factors (such as MYB, WRKY, ERF, NAC, bZIP) are involved in normal development as well as in stress (drought) response.These transcription factors have been cloned and proven useful tool for stress tolerance in cotton and/or in other plants [34]. The genetic engineering of transcription factor genes could activate drought tolerance pathways and enhance drought tolerance in cotton. Recently, a bZIP transcription factor gene, GhABF2, has been reported to be involved in the drought and salt tolerance in Arabidopsis and cotton. The transcriptomic analysis revealed that GhABF2- regulating genes related to ABA [35, 36].

Overexpressing GhABF2 cotton increased SOD and CAT activities as compared to wild-type plants. Moreover, overexpressed plants showed better results in the field and meanwhile its yield were recorded higher than wild type plants. In another case, an R2R3-type MYB transcription factor gene, GbMYB5, positively involved in response to drought stress in cotton [37, 38].

CONCLUSION

Soil salinity has been a major concern to global agriculture throughout human history. Currently over 800 million hectares of land throughout the world are salt-affect. This is over 6% of the world's total land area. In recent times, it has become even more prevalent as the intensity of land use increases globally. Cotton is an important cash crop worldwide. Although it is classified as one of the most salt-tolerant major crops and considered a pioneer crop in reclamation of saline soils, its growth and development as well as yield and fiber quality are negatively affected by excessive salts in the soil.

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