Review Article

A review on Breeding in Ornamental crops for abiotic stress tolerance

Abstract

Abiotic stresses are major concerns in agriculture sector affecting large parts of India. It is caused by Drought, salinity and temperature (high/low) representing a major constraint over crop growth rate and productivity. In ornamental crops meagre efforts have been done towards this way. Now a day's ornamental crops are the prospective way to earn higher income as compared to the other crops and have a significant role in national GDP. How can we grow Ornamental crops in stressed condition is one of the major challenge. To get tolerance power against abiotic stress various ways have been developed but among all methods very few have been proved worthy in case of ornamental crops. Interspecific and intergeneric hybridization is the basic way found hopeful strategy to improve tolerance against drought in some crops through domesticating abiotic stress-tolerant gens from their wild species into cultivated. Combination of both tissue culture and induces mutation approach (*In vitro* mutagenesis) is the one more important way for bringing stress tolerance and improvement in yield and quality of Ornamental crop plants. Genetic engineering is the modern tool which is used for breeding programme. The introduction of innovative characteristics such as new colours, biotic and abiotic stress tolerance in ornamental crops are usually difficult through predictable breeding, but by the use of genetic transformation we can get is easily.

Key words – Flower breeding, hybridization, mutation, genetic engineering, abiotic stress

Introduction

Phenotypic findings of a plant are displayed by its genotype, environment and the genotype environment interaction. When some environmental factors interfere with the complete appearance of genotypic potential, it is called stress. There are two types of stress, the first one is biotic (pathogens, pests, weeds, etc.) and second is abiotic depending on their biological/abiological nature. "Abiotic stresses outcome due to moisture, temperature (high/low), minerals (deficiency/toxicity), salinity, soil pH, air pollution, etc. Abiotic stress situations cause wide losses to agricultural production worldwide" (Boyer, 1982). "Exclusively, stress conditions such as drought, salinity or heat have been the subject of intense research" (Cushman and Bohnert 2000). However, in field condition, crops and other plants are usually subjected to a combination of different type abiotic stresses. In drought-prone areas, for example, many crops encounter a mixture of drought and other stresses, such as soil salinity or heat.

Characteristics of abiotic stresses

1.The physiognomies of an abiotic stress may vary significantly depending on the location.

2. The relative importance of different abiotic stresses is manly based on location.

3. During the crop season variation may occur in the degree of some stresses.

4. A given abiotic factor may affect the level of another abiotic stress, *e.g.*, in a saline soil, moisture stress would enhance salinity stress.

5. Different plant/crop species having different abilities to withstand in a given stress.

6. Different varieties of a crop also can have difference in their capabilities to tolerant abiotic stresses.

7. One abiotic stress can overlap the effect of another stress. For example, salinity stress generated some features produce by drought stress, so that strains develop for salt resistance also show enhance drought tolerance.

Drought

Drought is a condition of unusually dry weather within a geographic area resulted from the lack of rains. It is directed by various factors like high temperature, photon irradiance and scarcity of water. Drought is a low water potential condition resulted from high solute concentration.

Mechanism of drought tolerance

Drought escape

Drought escape can define as the aptitude of a plant or crop species to complete its life cycle before supply of water in soil is washed-out and became dormant seeds before the arrival of dry season. That type of plants is known as drought escapers since they skip the drought condition by rapid development.

Drought avoidance

These type of plants can store high amount of water to maintain relatively high tissue- water potential despite a shortage of soil-moisture. Drought avoidance is governed by maintenance of turgor through roots grow in deep soil, transpiration controlled by stomata to decrease water and by reduction of water loss through reduced epidermal i.e. reduced surface by smaller and thick leaves.

Drought tolerance

Those plant having ability to withstand in drought condition with low tissue water potential. Drought tolerance is the manner of turgor preservation via osmotic adjustment (a manner which induces solute accumulation in cell), increase in elasticity and reduce in cell size.

Effect of drought stress

Effect on Growth: Fall in turgor Pressure, due to cell sizes will be smaller.

Effect on Photosynthesis: Photosynthesis decreases due to disruption of PS II (Photo System II), stomatal closure, decrease in electron transport.

Decrease in nuclear acids and proteins: Protease activity increase, free amino acid increase, RNAase activity increase, RNA hydrolysis, DNA content falls down

Effect on Nitrogen Metabolism: Nitrate reductase activity decrease, nitrite reductase activity insensitive

Effect on Carbohydrate metabolism: Loss of starch and increase in simple sugars, carbohydrate translocation decreases.

Salt stress

"Salt stress occurs when there is an excessive amount of salt in the soil, which inhibits crop growth and finally leads to crop death. Reduction of water use efficacy, increase ions, induction of heat stress and reduces stem extension in plants caused by salt stress. Biological macromolecules are broken down due to generation of free ions. It was noticed that salinity stress resulted in decrease of high water content, production of hydrogen peroxide and electrolyte generate in plants" (Mandhania *et al*., 2006). "Salt accumulation is one of the hazardous factor in soil decreasing the production and quality of plants, causes adverse effects on sprouting, plant growth and development. Throughout the world, nearby 45 million hectares of irrigated land is affected by salt stress" (Munns and Tester 2008). Salt stress affects plants in various means such as; ion toxicity, physiological drought, nutritional disorders, modification of metabolic processes, oxidative stress, membrane incompetence and reduction of cell division.

The response of ornamental plants to salt stress

Salt effects on plants are the combined outcome of the composite interaction among various morphological, physiological and biochemical processes. Among all outcomes of salt stress reduction in rate of leaf growth is one of the first responses of plants to salinity (Blum, 1986) "primarily due to the osmotic effect of salt around the roots, which leads to a reduction in water supply to leaf cells. Availability of higher salt concentrations in soil can also inhibit root growth (Wild, 1988), with a reduction in length and total mass of plant roots" (Shannon and Grieve 1999) and of function. "Reduction in rate of cell elongation and division in leaves reduces their final size, resulting in a decrease in leaf area" (Alarcon *et al*., 1993; Matsuda and Riazi 1981). Leaf area reduction could be produced by a decrease in turgor in the leaves, as a significance of changes in cell wall properties or a reduction in photosynthetic rate Such concerns are seen in ornamental plants. As per suggested by (Cassaniti *et al*., 2009) "Loss in dry weight of shoot and leaf area were noticed as the first visible effects of salinity both in sensitive and tolerant species such as *Cotoneaster lacteus* and *Eugenia myrtifolia*, respectively". "Leaf thickening is an another common effect of heavy salt level, which appeared in ornamental plants such as *Coleus blumei* and *Salvia splendens"* (Ibrahim *et al*., 1991).

Heat stress

Heat stress is commonly characterised as a temperature rise that exceeds a threshold level for a long enough period of time to cause irreparable damage to plant growth and development. The negative effect of temperature higher than the optimal is called as heat stress. Plant survival, growth and development and the physiological processes would be affected by heat, the nature and extent of the effects depending mainly on the temperature, the plant species and the process in question. Heat stress can also define as the induction in temperature beyond a threshold level for a period of time sufficient to cause unalterable destruction to plant growth and development (Hall, 1992). Heat stress affects factory growth throughout its ontogeny, though heat- threshold position varies vastly at different experimental stages. Heat stress due to high ambient temperature is a serious trouble to crop product worldwide. Different worldwide circulation models forecast that greenhouse gases will gradually increase world's average ambient temperature. Because of very high temperatures, severe cellular damage and even cell death may occur within few minutes. At relatively high temperatures, direct injuries include protein declination, aggregation and increased fluidity of membrane lipids. Circular injuries include inactivation of enzymes, inhibition of protein conflation, protein declination and loss of membrane integrity.

Cold stress

Cold stress, which includes chilling (0–15°C) and freezing (<0°C), is an abiotic stress that has a negative impact on plant growth and agricultural productivity. Plant growth and development are frequently restricted by chilling stress, which has numerous important effects on plant cells. Cold stress is a thoughtful threat to the sustainability of crop yields. It can lead to major crop losses. Poor germination, stunted seedlings, yellowing of leaves, reduced leaf expansion and wilting, and may lead to death of tissue (necrosis) are different phenotypic symptoms of plants in response to cold stress. Cold stress also harshly affects the development of plants reproductive systems. "Severe membrane damage is one of the major negative effect of cold stress. Plants display cold or chilling stress at temperatures from 0-15 ◦C. Under such situations, plants try to maintain homeostasis to acquire freezing tolerance and this involves extensive reprogramming of gene expression and metabolism" (Cook *et al*., 2004; Thomashow, 1999).

Breeding methods for abiotic stress tolerance

Wide distant hybridization

"Wide distant (interspecific and intergeneric) hybridization has become a promising approach to increase tolerance power against abiotic stresses of some crops through introducing stress-tolerant trait from relative wild species to cultivated, for the wild species usually have high abiotic stress-tolerant trait that cultivars do not possess" (Abraham *et al*., 2004; Cattivelli *et al*., 2008). "For example, an improved drought-tolerant perennial ryegrass (*Lolium perenne*) was developed through intergeneric hybridization by inheriting drought tolerance of Atlas fescue (*Festuca mairei*)" (Wang and Bughrara 2008). "In addition, many cultivars of chrysanthemum are developed with upgraded drought tolerant have been bred through interspecific hybridization" (Cheng et al., 2010). Develop interspecific hybrids between *Dendrenthema morifolium*and and *Dendrenthema nankingense* by using ovary rescue, to improve cold tolerance in cultivated species (Cheng et al., 2009).

In vitro mutagenesis

To improve stress tolerance as well as yield and quality of crop plants, *In vitro* mutagenesis is an important technique. *In vitro* mutagenesis technique is a combination of both tissue culture technique and induce mutation approach. One NaCl tolerant chrysanthemum species (*Chrysanthemum morifolium* Ramat.) variant (E2) has been converted in a stable form by using *in vitro* mutagenesis using ethylmethanesulfonate (EMS) as the chemical mutagen. Salt stress tolerance was displayed by the ability of the plant to maintain both flower quality and yield under stress conditions. Enhanced tolerance of the E2 variant has been attributed to the increased activity of superoxide dismutase (SOD), ascorbate peroxidase (APX), and dehydroascorbatereductase (DHAR), and, to a lesser extent of membrane damage than NaCl treated control plants. Isoform analysis shown that a rise in total SOD exertion in the E2 variant was solely due to significant activation of the Cu/ Zn isoform. Elevated situations of carotenoids and ascorbate in E2 leaves have been reflected in their advanced free revolutionary scavenging capacity (RSC) expressed in terms of DPPH (-diphenyl-1 picrylhydrazyl) scavenging capability. Data reflect that a proper balance between enzymatic andnon-enzymatic defence systems is needed for combating saltness stress in chrysanthemum. "More performance of the E2 get under same saltness stress condition, indeed in the alternate time, confirms the inheritable stability of the swab- forbearance character. On the whole, the E2 variant, developed through0.025 EMS treatment, might be considered as a NaCl tolerant strain showing positive characters towards NaCl stress" (Hossain et al., 2006).

Genetic engineering for abiotic stress tolerance

Development of plant varieties with a high level of tolerance against abiotic stresses is essential for getting full yield potential and to stabilize production. Due to the crowd of abiotic stresses and their complex genetic control the development of breeding for tolerance to abiotic stresses using conventional methodologies has been very disappointing. "Stress tolerant crop production by genetic engineering need to identify the key of genetic factors underlying stress tolerance in plants and introducing these genes into crops. Introduction of molecular change in crop plants by genetic engineering takes less time as compared to plant breeding methods, only wanted gene can be transferred, whereas, in traditional breeding methodology is connected with simultaneous transfer of undesired gene" (Roy et al., 2001). Recent advances in cellular and molecular biology have made it possible to clone important genes and mobilize them in any organism across barriers of sexual hybridization for stable expression and transmission. All living organisms have evolved mechanisms for avoidance or forbearance to one or further of the abiotic stresses. Plants producing pivotal enzymes or proteins from different organisms involved in abiotic stress forbearance mechanisms have shown significant advantage over their wild type controls under stressed-out terrain. The enhanced position of compatible osmolytes, radical scavengers and other transgene products identified with the degree of forbearance. Farther understanding of the molecular mechanisms of stress perception, signal transduction and response by shops and other organisms may help to mastermind plants with high situations of forbearance to multiple stresses. Perspectives and fresh approaches for further perfecting the forbearance to abiotic stresses through inheritable engineering are bandied.

Conclusion

Abiotic stress caused by temperature, drought or salinity represents a major constraint over crop growth and productivity. Breeding methods like interspecific, intergeneric hybridization, *in vitro* mutagenesis and genetic engineering for improving abiotic stress tolerance in ornamental crops have proven to be the potential approaches. Genetic engineering improved abiotic stress tolerance through adding one or more new traits that are not already found in that organism.

References

Abraham, E.M., Huang, B., Bonos, S.A. and Meyer, W.A. 2004. Evaluation of drought resistance for Texas bluegrass, Kentucky bluegrass, and their hybrids. Crop Science, 44:1746-1753.

Alarcon, J.J., Sanchez-Blanco, M.J., Bolarin, M.C. and Torrecillas, A. 1993. Water relations and osmotic adjustment in Lycopersicon esculentum and L. pennellii during short term salt exposure and recovery, Physiologia Plantarum 89: 441-447.

Blum, A. 1986. Salinity resistance, In: Plant Breeding for Stress Environments, 1163-1169, CRC Press, Boca Raton.

Cassaniti, C., Li Rosi, A. and Romano, D. 2009. Salt tolerance of ornamental shrubs mainly used in the Mediterranean landscape. Acta Horticulturae, 807: 675-680.

Cattivelli, L., Rizza, F., Badeck, F.W., Mazzucotelli, E., Mastrangelo, A.M., Francia, E., Mare, C., Tondelli, A. and Stanca, A.M. 2008. Drought tolerance improvement in crop plants: an integrated view from breeding to genomics. Field Crops Research, 105:1-14.

Cheng, X., Chen, S., Chen, F., Deng, Y., Fang, W., Tang, F., Liu, Z. and Shao, W. 2010. Creating novel chrysanthemum germplasm via interspecific hybridization and backcrossing, Euphytica, 177:45-53.

Cheng, X., Chen, S.M., Chen, F.D., Fang W.M., Deng Y.M. and She, L.F. 2009. Interspecific hybrids between Dendranthema morifolium (Ramat.) Kitamura and D. nankingense (Nakai) Tzvel achieved using ovary rescue and their cold tolerance characteristics. Euphytica, 172:101-108.

Cook, D., Fowler, S., Fiehn O. and Thomashow, M.F. 2004. A prominent role for the CBF cold response pathway in configuring the low temperature metabolome of Arabidopsis. Proceedings of the National Academy of Sciences (USA), 101:15243-15248.

Cushman, J.C. and Bohnert, H.J. 2000. Genomic approaches to plant stress tolerance. Current Opinion in Plant Biology, 3:117-124.

Dunemann, F., Illgner, R. and Stange, I. 2002. Transformation of rhododendron with genes for abiotic stress tolerance. Acta horticulturae, 113-120.

Hall, A. E. 1992. Breeding for heat tolerance. Plant Breeding Reviews. 10: 129-168.

Hossain, Z., Mandal, A.K.A., Datta, S.K. and Biswas, A.K. 2006. Development of NaCl-tolerant strain in chrysanthemum morifolium through *in vitro* mutagenesis. Plant Biology, 8(4): 450-461.

Ibrahim, K.M., Collins, J.C. and Collin, H.A. 1991. Effects of salinity on growth and ionic composition of Coleus blumei and Salvia splendens. Journal of Horticulture Science, 66: 215-222.

J.S. Boyer 1982. Plant productivity and environment. Science, 218: 443-448.

Mandhania, S, Madan, S, Sawhney, V, Haryana, C.C.S. 2006. Antioxidant defense mechanism under salt stress in wheat seedlings. Biologia Plantarum, 50(2): 227-231.

Matsuda, K. and Riazi, A. 1981. Stress-induced osmotic adjustment in growing regions of barley leaves. Plant Physiology, 68: 571-576.

Munns R, Tester M. 2008. Mechanisms of salinity tolerance. Annual Review of Plant Biology, 59: 651 -681.

Roy, B., Noren, S.K., Mandal, A.B., andBasu, A.K. 2011. Genetic engineering for abiotic stress tolerance in Agricultural crops. Biotechnology, 10: 1-22.

Shannon, M.C. and Grieve, C.M. 1999. Tolerance of vegetable crops to salinity. Scientia Horticulturae, 78: 5-38.

Thomashow, M.F. 1999. Plant cold acclimation: freezing tolerance genes and regulatory mechanisms. Annual Review of Plant Biology, 50:571-599.
Wang, J.P. and Bughrara, S.S. 2008. Evaluation of drought tolerance for Atlas fescue, perennial ryegrass, and their progeny. Euphytica, 164:113-122.
Wild, A. 1988. Russell's soil conditions and plant growth. 11th edn. Harlow, Longman.