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Frost Stress Tolerances and Cut Roses: A Review

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ABSTRACT

In order to meet the challenges of providing food to the ever increasing population of the world, there is an insistent need to boost crop yield. Unfortunately, the production of agriculture decreasing due to various environmental factors including frost and cold are very important, especially in winter. Indeed, frost is the most important abiotic problem and one of the doctrine limiting factors affecting plant growth and development in winter. Despite various obvious symptoms under frost stress, the yellowing of leaves, weak germination, curling of leaves, decreased rate of cell swelling and wilting, reduced flower opening, curling of petals leads to the cells death. This severe damage is largely due to the sensitive drying associated with freezing during frost. In addition, signal transduction is to switch on frost response genes and transcription factors to mediating stress tolerance, thus underline mechanism of frost stress and genes involve in the frost/cold stress signal network is very important for plant growth and development. In present review, plant significances in daily life and issues related to abiotic stresses such as frost and cold tolerance mechanisms are discussed.

Key words: Abiotic stress, Cut rose, Frost tolerances, Ice-minus, Ice-plus bacteria.

As we all know that, Rose (*Rosa hybrida*) is one of the most important and economic ornamental plant in the world (Cuizhi and Robertson, 2003). The family of rose (Rosaceae) has been categorized by as an astonishingly large family of flowering plants (Ritz *et al*., 2005). The flower of this family, which has been characterized by five extricate petals and abundant stamens that jutted as a cup like base structure (Nybon, 2009). In addition, cut roses are one of the most famous and popular flower in the global floral trade. Rose has a deep relationship with human sentiments and has high demand in international markets on account of their use in almost every event (Evans, 2009). However, approximately more than 2,800 species of ornamental roses has been planted around the entire world. Rosa species are found throughout the colder and temperate regions of the northern hemisphere form the arctic to the subtropics (Kim and Janick, 2009). In addition, roses are famous ornamental crops, whether for domestic or commercial cut flowers. Rose plants varies in shape, color and ranging size with compact miniature roses and rose with climbing nature called climbers that can reach a height of a few meters. In addition, significant quantities of flowers are magnificent quality and quantity of rose and other ornamental flowers are grown in most of the steamy and temperate countries of the world (Khan, 2005) and then these flowers needs to transport to far distinct places via ships, or air. At present, there is no comprehensive report has been published regarding the control of frost formation on leaves, flowers and the whole plant surface. Meanwhile, there is no proper attempt have thrive prospectus, but an effort may made to find solution on first observation to authors of this issue. Although the current problem may determine the resistance of plants to frost, it emphasizes the mechanism process, flowering under frost stress, controlling aging and suggesting strategies can solve environmental anxiety problems. Thus, here we are reporting to expand the rose plant in order to have resistance toward the frost stress.

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Existing circumstances of rose in global counties

According to reports, the largest producers of commercial cut flowers are the Netherlands, the United States, Colombia, Kenya, Zimbabwe, Japan and Israel. On the other hand, the total area of ornamental plants produced in these countries is 223,145 hectares. Cut flowers are the leader in ornamental plants with total sales of $24.7 billion (Kndirli and Cakmak, 2007). Despite this, Rose is the most important ornamental plant in the world. At the Chinese and Nonetheless, Roses are also the most important ornamental plants worldwide and cut roses account for about 21% and 31% of all cut flowers traded in China and at the European auctions respectively (Heinrichs, 2008). Commercially, roses are usually harvested during the open germination and are highly susceptible to WDS during post-harvest handling. WDS causes abnormal flowers to open, flowers wilted,

pedicels (bent neck) atrophy and inability to open (Jin *et al*., 2006; Xue *et al*., 2008). Therefore, the effects of dehydration on the opening and senescence of cut rose roses have been studied at physiological and biochemical levels for decades (Kumar and Srivastaya 2008).

Transcriptional factors trigger or repress the expression of defense gene

Morphological changes that occur during flower opening usually include the growth and expansion of the petals, which is also important for rose flowers. The growth of petals is a complex process that integrates cell division and cell expansion. Like Arabidopsis thaliana, cell division is usually phased out in petals before bud opening and flower development and cell expansion promotes petal growth primarily in later stages. Similarly, in roses, the growth of petals depends to a large extent on the cell expansion in the late stages of flower opening. Ethylene is usually produced by higher plants associated with fruit ripening and specific triple reactions. Often, various biotic and abiotic stresses, including temperature fluctuations, water imbalances, salinity, pathogens or insect infestation, can have some specific types of negative effects on plant growth and development. On this issue of concern, nature always manifests itself in an adoptive way. In these circumstances, plants adopt various defense mechanisms to sense the stimulation of the surrounding environment. Transcription factors are known for their critical function of triggering or inhibiting defense gene expression during signal transduction and for the regulation of connectivity between various signaling pathways (Evans, 2009).

It has been observed that the *ERF* gene is not only stimulated by disease-related and pathogen infection stimulation, but also trigger the expression level on abiotic stresses. Therefore, ERF genes such as *RhERF* can improve the multiple stress resistance of transgenic plants. In addition, analysis of the overexpression of *ERF* genes indicates that these transcription factors can confer broad-spectrum resistance to pathogens and other abiotic stresses and can also make transgenic plants resistant to drought, salt and freezing. Therefore, the *RhERF* gene might be focus for specific research to explore the role of plant development in relation to abiotic stress tolerance (ethylene stimulation).

Progression of frost resistance plant

Various frost resistance mechanisms have evolved in alpine woody plants. In addition to enduring the presence of ice on tissues and the accompanying dehydration stress, some tissues and organs that depend on avoiding freezing (Gilbert, 2014). In many species, the mechanism by which they survive at freezing temperatures is unclear and therefore represents fertile ground for future research. In cold weather conditions, frost falls on plants and can cause significant damage. Agriculture suffers severe losses each year due to frost-damaged crops (Ladinig *et al*., 2013). Researchers hope that spraying ice-borne bacteria on a wide variety of plants can help to avoid annual damage caused by frost

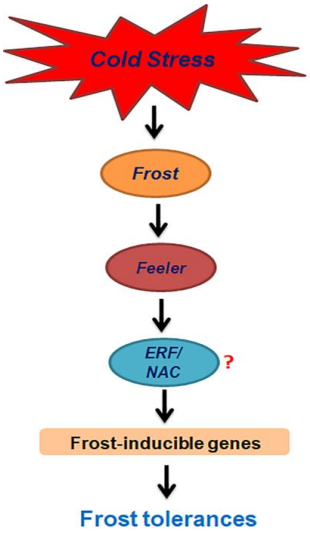


Fig 1: Frost stress tolerances regulating genes.

conditions. Negative ice bacteria are a common mutant of the wild type *P. syringae*. In addition, wild-type *P. syringae* bacteria are known as ice-suppressing bacteria. It contains a surface protein in its outer wall that helps to form frost, hence the name “ice +” (Kumar *et al*., 2008). In case of mutant *Pseudomonas syringae*, there is a lack of surface proteins that promote ointment, so these types of bacteria cannot promote the formation of frost and are therefore called as negative ice bacteria (Hirano and Upper, 2000). Both negative ice bacteria and ice plus bacteria are found in nature. However, spraying of negative ice bacteria on crops have been mass-produced using recombinant DNA technology. While, Prasanth *et al*. (2015) reported that the discovery of this bacterium was in the 1970s, when Dr. Lindow discovered that a specific bacterium isolated from dry leaf powder of frozen damaged plants introduced into plants that did not exist, these plants become very vulnerable to frost damage. He further continued to identify the bacterium as *Pseudomonas syringae*, the role of *P. syringae* in the ice nucleus and in 1977 discovered a mutant negative ice strain. The negative ice strain of *P. syringae* was also successfully developed by recombinant DNA technology. But now we can consider the recombinant *Pseudomonas syringae* (Ice in minus) as one of the most successful microorganisms introduced into the environment. The ice minus is the generic name for a strain of *Pseudomonas syringae*, which lacks the ability to produce surface proteins. Most wild-type strains of *P. syringae* are “ice plus”, have the ability to produce proteins found on the outer cell wall of bacteria and act as a nucleation center for ice crystals. The ice-minus variant of *P. syringae* is a mutant, lacking the gene responsible for ice-nucleating surface protein production. The lack of surface proteins provides a more unfavorable environment for the formation of ice. Both strains of *P. syringae* are naturally occurring. Sometimes water is mixed with the ice-nucleated active protein of *P. syringae* bacteria. These proteins act as effective nuclei, triggering the

formation of ice crystals at relatively high temperatures, so the droplets will turn into ice before falling to the ground. However, frost at the time of flowering delays maturity but only leads to a small decline in yield production (Chinnusamy *et al*., 2003).

Frost after flowering can lead to a sharp drop in production and a decline in grade loss. Frost during flowering usually causes abortion of flowers. The researchers observed that only the flowers that were opened during the frost were affected by the plants. The pods descend on the stem and the unopened buds continue to develop normally. A few days after the frost, the gap between the pods of the abortion was clearly visible on the stem. The damage is obvious because all open flowers show signs of damage during frost (Ladinig *et al*., 2013).

Genes regulation of frost resistances

Recent advances in the fields of biotechnology and genetic engineering offer new strategies for the development of mutant plants that are more tolerant to cold stress. The rapid development of recombinant DNA technology and the development of precise and efficient gene transfer protocols have led to efficient transformation of many crop species and the production of transgenic lines (Wani *et al*., 2008; Wani and Gosal, 2011). Many genes that respond to freezing stress have been isolated and characterized. Many studies have shown that the expression of cold regulatory genes is critical for cold tolerance in plants (Knight *et al*., 1999; Tamminen *et al*., 2001; Hsieh *et al*., 2002). In addition, many reported studies demonstrate the sensation of mutation methods in promoting tolerance to low temperature stress. At the same time, Kenji and Tsuyoshi (2013) reviewed the citations and reported the cold tolerance of many cold-stressed host genes in different species, such as the chloroplast GPAT (glycerol 3-phosphate acyltransferase) of pumpkin, the largest genus of Cucurbita and Arabidopsis. The unsaturation of fatty acids in phosphatidylglycerols increases the ratio of unsaturated fatty acids in plant cell membranes, thereby increasing cold tolerance (Murata *et al*., 1992). The citrus LEA gene CuCOR19 enhances the cold tolerance of transgenic tobacco (Hara *et al*., 2003). Similarly, the expression of the wheat dehydrin WCS19 (Danyluk *et al*., 2002), Arabidopsis COR15A (Artus *et al*., 1996) and the coexpression of RAB18 and CO47 or LTI29/XERO2 and LTI30/ERD10 (Puhakainen *et al*., 2004) improved the proposed freeze resistance of Arabidopsis transgenic plants. The freeze-tolerance of transgenic strawberry leaves expressing wheat dehydrin WCO410 was improved. Overexpression of rice TPP1 (trehalose 6-phosphate phosphatase) enhances cold tolerance in rice (Ge *et al*., 2008). Since trehalose is a non-reducing disaccharide that acts as a stress-protecting metabolite, the accumulation of trehalose enhances cold tolerance and other abiotic stresses (Jang *et al*., 2003). These results indicate that defense genes play an important role in plant response to low temperatures.

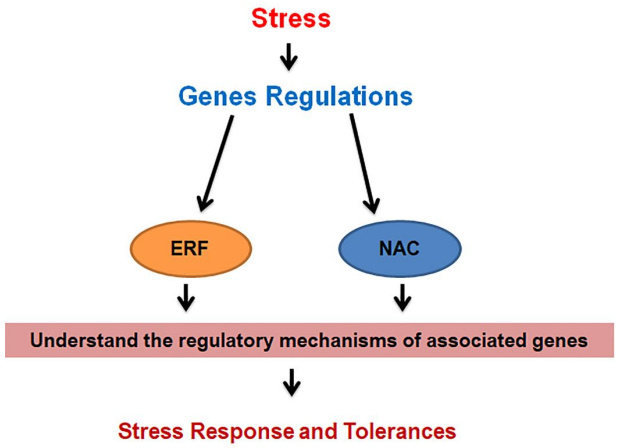


Fig 2: Gene regulation modulating stress response and tolerances.

CONCLUSION AND FUTURE PROSPECTIVE

Low temperature stresses are the major environmental factor that not only limit where crops can be grown but also reduces yields depending on the weather in a particular growing season. Except for years of extreme stress, which can lead to a sharp drop in production, it is almost certain that extreme pressures are small and it is almost certain that losses in large areas are small and produce comparable production declines each year. To meet future global food needs, crop yields must be increased in challenging environments. With conventional breeding, it is difficult to produce complete and timely resistance to biotic and abiotic stresses. In addition, analysis of overexpression of *ERF* genes indicates that these transcription factors can confer broad-spectrum resistance to pathogens and other abiotic stresses and can also make transgenic plants resistant to drought, salinity and freezing.

Often, various biotic and abiotic stresses, including temperature fluctuations, water imbalances, salinity, pathogens or insect infestation, can have some specific types of negative effects on plant growth and development. On this issue of concern, nature always manifests itself in an adoptive way. In these circumstances or internal hints, plants adopt various defense mechanisms to sense the stimulation of the surrounding environment and then change it. Transcription factors are known for their critical function of triggering or inhibiting defense gene expression in signal transduction and for the regulation of connectivity between various signaling pathways (Ge *et al*., 2008). It has been observed that the *ERF* gene is not only stimulated by disease-related and pathogen infection stimulation, but also because abiotic stress can trigger its expression level. Therefore, ERF genes such as RhERF can improve the multiple stress resistance of transgenic plants. Therefore, various challenges should be noted in terms of cold pressure. As noted above, low temperature sensation is believed to involve various major aspects and each sensor can sense a particular aspect of stress. Elucidating the regulatory and signaling mechanisms of cold stress is an

important goal to gain a complete understanding of the cold signaling mechanism.

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