Research status and countermeasures on cold resistance and photosynthetic physiological response of flowers

Xie Pengyuan¹, Yang Shuhua², and Qi Xiaoli¹*¹

¹College of Life Science, Jiamusi University, Jiamusi 154007, China
²The Institute of Vegetables and Flowers Chinese Academy of Agricultural Sciences, Beijing, 100000, China

*Corresponding author’s e-mail: qixiaoli3@tom.com

Abstract. With the increasing attention to environmental protection and treatment, the winter heating mode in most areas is gradually changing from coal to gas or coal to electricity. Due to a variety of uncontrollable factors, there is a short period of temperature lower than the sub-low temperature, which often brings serious constraints and losses to the commercial production and ornamental utilization of flowers. Low temperature is one of the main abiotic stresses in the growth of potted flowers. The growth, development and physiological metabolism of potted flowers are directly affected by low temperature. Among them, photosynthesis is the most sensitive process to low temperature. Photosynthesis is the most important physiological and biochemical process on the earth, so the study of photosynthetic physiological response of potted flowers under low temperature stress is very important practical significance and application value in the production of potted flower varieties.

1. Introduction
Low temperature is one of the main environmental factors affecting plant growth, development and distribution[1]. The injury of low temperature above zero to plants is called chilling injury. Subzero hypothermia can induce plants to freeze outside the cells and cause dehydration of plants. More seriously, freezing in the cells leads to cell death, and its damage to plants is called freezing injury (freezing)[2]. In this paper, the cold resistance of plants, photosynthetic response under low temperature stress and low temperature induced protein were reviewed in order to provide scientific reference for cold resistance of flowers, further development and utilization of low temperature flower industry and breeding of cold tolerant varieties.

2. Study on the evaluation of cold resistance of plants
The results showed that the effect of low temperature stress on plants was significantly greater than that of other environmental stress factors [3,4]. In order to resist low temperature stress, complex physiological and biochemical reactions occurred in plants, and the contents of soluble protein, soluble sugar and proline. And cell enzyme activity will change, thus affecting the normal metabolism of plants [5-7]. In recent years, due to the increase of the audience of all kinds of plants, the expansion of the scope of planting areas and the introduction of different regions, there has also been a new standard demand for the cold resistance of different plants. After years of research, The methods and indexes for the identification of cold resistance of many kinds of plants were screened out. On the whole, this identification method can be divided into two categories, one is direct identification, the
other is indirect identification, and most of the cold resistance identification methods for potted flowers can be indirect identification.

Indirect method is mainly the use of metabolic, biochemical and physical and chemical indexes related to cold resistance. Such as electrical conductivity, LT50, free proline content, soluble sugar content, photosynthetic capacity (net photosynthetic rate, chlorophyll fluorescence parameters), antioxidant enzyme activities (such as SOD, CAT, APX.) and unsaturated fatty acid content. Rohloff et al. (2012) used electrical conductivity as an index to evaluate the cold resistance of three strawberry genotypes. Davik et al. (2012) evaluated the cold resistance of 22 different strawberry genotypes by LT50. It was found that there were significant differences in resistance among different genotypes, ranging from -4.7°C to -12°C. Rizza et al. (2001) evaluated the cold resistance of 12 species of winter oats and 3 species of spring oats by using chlorophyll fluorescence parameters. The cold resistance and chlorophyll fluorescence parameters of 22 kinds of winter wheat were analyzed under field low temperature and artificially controlled low temperature in laboratory. It was found that there was a good correlation between chlorophyll fluorescence parameters and resistance under artificially controlled low temperature. However, in the actual field conditions, there are sometimes differences between the two.

3. Study on photosynthetic physiology under low temperature stress

Low temperature stress is one of the important abiotic stresses, and there are many effects of low temperature on plants. It can cause plant structure and development retardation, physiological metabolism disorder, photosynthetic efficiency is affected, cell membrane damage leading to cell ion and soluble matter leakage. Among them, photosynthesis (photosynthesis) is the most sensitive process to low temperature. Even in the dark, the photosynthetic efficiency of many C3 and C4 plants is affected by low temperature.

Among them, photosynthetic rate, as an important parameter for studying plant light sum, is also an important index for reflecting plant growth status, stress resistance and plant productivity, and chlorophyll content, as the basis of photosynthesis, reflects the overall photosynthetic efficiency of plants. Among them, Ni Huijing's study on the photosynthetic characteristics of cut red palm clearly reflected the close relationship between chlorophyll and plant photosynthetic rate, which was consistent with most of the studies so far [10-12]. However, some studies, such as Luoqinya and Qilonglin, have found that there is no significant correlation between photosynthetic rate and chlorophyll content when the leaves of Camellia are mature. After the cessation of photosynthesis, the stomata of the leaves were not completely closed, and there was still some CO2 gas exchange with the outside world [13].

The effect of low temperature on photosynthesis can be reflected by measuring CO2 absorption, O2 release and chlorophyll fluorescence. The sudden exposure to low temperature of winter herbaceous plants Arabidopsis thaliana (Arabidopsis thaliana) and winter rye (Secale cereale L.) will lead to the decrease of CO2 absorption and O2 release. However, once adapted to low temperature, photosynthesis will return to a stronger level [14,15]. However, the photosynthetic efficiency of perennial evergreen woody plant Pinus elliottii (Pinus elliottii) decreased continuously at low temperature, and did not adapt to the phenomenon of restoring or enhancing photosynthesis after low temperature [16]. Rape (Brassicanapus) was tolerant to cold injury, and in the early winter from October to November, although the temperature decreased from 20°C to 2°C, the absorption of CO2 did not change. Only when the temperature decreased to below zero, the absorption of CO2 decreased. However, when the temperature rises to 2°C, the absorption of CO2 recovers [15]. Chlorophyll a fluorescence parameter Fv/Fm is the potential maximum quantum efficiency of plant leaf PSII. Under normal conditions, the change of chlorophyll a fluorescence parameter is very small, and it is a sensitive index for plants to be affected by low temperature. Plant Fv/Fm changes at low temperature [17]. The Fv/Fm of Norwegian spruce (Piceaabies) began to decrease strongly when the temperature decreased to 5°C in autumn, and maintained a low Fv/Fm [18] in the low temperature environment.
The effects of low temperature stress on plant photosynthesis not only directly damaged photosynthetic apparatus and related enzymes in dark response, but also affected photosynthetic electron transport, photophosphorylation and photoinhibition. The study of chlorophyll fluorescence characteristics is one of the ways to explore the damage. At present, the application of chlorophyll fluorescence analysis technology has made some progress in photosynthesis physiology, plant stress resistance physiology, crop yield potential prediction and so on. Chlorophyll fluorescence signals such as Feng Jiancan contain very rich information about the changes of photosynthesis process, so it is regarded as an internal index of the relationship between plant photosynthesis and environment.

4. Study on protein expression under low temperature stress
In the field of cold resistance physiology of plants, protein physiological metabolism is also a very important aspect. The change of protein content caused by low temperature stress and the study of related proteins induced by low temperature have attracted the attention of many researchers. Low temperature induced protein, also known as cold induced protein, is a new protein that appears with low temperature domestication or low temperature acclimation of plants.

The main techniques used in this study are protein two-dimensional electrophoresis and mass spectrometry. A large number of differential proteins have been analyzed and their functions have been studied. Guy & Haskell [19] et al. (1988) studied the cold resistance-related proteins of spinach at seedling stage. The results showed that the synthesis of these proteins increased in the early adaptation to low temperature stress, but decreased in the subsequent re-adaptation. Danyluk [20] et al. (1991) studied the protein changes of three different wheat varieties after low temperature stress. The results showed that the expression of 18 proteins increased significantly after treatment. In the following 4 weeks, 53 proteins were continuously overexpressed during the induction of tolerance, and 34 of these 53 proteins were proved to be related to cold resistance. In the study of protein changes of poplar under low temperature stress, Renaut [21] et al. (2004) obtained more than 800 differential protein spots, about 60 related to low temperature stress, and finally identified 26 protein spots. In these proteins, the main proteins related to energy metabolism were down-regulated or disappeared, and the up-regulated proteins were heat shock protein, associated protein, dehydration protein and so on. Chen Hu [22] (2012) identified 31 protein spots in longan seedlings under low temperature stress for 24 hours by two-dimensional electrophoresis and mass spectrometry, of which 36.7% of the protein spots were expressed after low temperature, such as ascorbic acid peroxidase, coffee acyl coenzyme A. In addition, the expression of 63.3% protein was decreased, such as 14-3-3 protein, copper and zinc superoxide dismutase, LEA protein and so on. The differential protein groups of yellow apricot [23] (2012) under low temperature stress and spraying ABA on Ganshu seedling leaves were separated by two-dimensional electrophoresis (2-DE), and 29 cold response proteins were successfully identified. These proteins are involved in photosynthesis, oxygen free radical scavenging, glucose metabolism, nitrogen metabolism, transcriptional regulation, protein processing, cell growth and division. The expression of 10 genes encoding differential proteins at the transcriptional level was analyzed, and it was found that there was no high correlation between them and the protein level.

5. Summary
The photosynthetic response of flowers to low temperature is an extremely complex process, and there are still many problems to be explored, some of which need to be further studied by researchers. The effect of low temperature stress on the growth and development of flowers. It varies according to plant variety, geographical location, stress degree and stress mode. The physiological mechanism and resistance of plants to low temperature stress are shown in photosynthetic response, osmotic regulation, scavenging of reactive oxygen species, ultrastructural changes of leaves and so on. At present, plants have made some progress in dealing with low temperature stress, but due to the wide variety of environmental factors and changes with other factors, the effects of compound environmental factors on plants need to be further studied. In order to select the varieties with strong cold resistance.
Acknowledgments
Authors wishing to acknowledge financial support from the Key Programs of Jiamusi University (Sjz2012-19), Provincial Training Programs of Innovation and Entrepreneurship for Undergraduates (201710222055), Natural Science Foundation of Heilongjiang Province of China (No.B2017015).

References:
[1] Boyer J S. (1982) Plant productivity and environment. Science, 218(4571): 443 -448.
[2] Pearce R S. (2001) Plant freezing and damage. Ann Bot, 87(4): 417-424.
[3] AMEGLIO T,PIGEON D, ARCHILLA O. (2003) Adaptation to cold temperature and response to freezing in roses. Acta Horticulturae, 618: 515–520.
[4] LI X F,ZHU J J,WANG Q L,et al. (2013) Research on the disturbance of frost damage to forest. Acta Ecologica Sinica, 33(12): 3563－3574.
[5] Li C H,Zhang Y M, Feng Y Q, et al. (2017) Evaluation and comparison of cold resistance of apple dwarf rootstocks. Southwest Agricultural Journal, (5): 1183-1188.
[6] Li R X, Ji X l, Hu X J, et al. (2017) Analysis and comprehensive evaluation of cold resistance of 6 species of plants with laughter. Journal of Applied Ecology, (5): 1464-1472.
[7] Wang Y Q. (2012) Study on cold resistance of Fenghua rose. Horticulture and Seedlings, 2012(7): 32-34.
[8] Liu S, Chen N T, Dong Z X, Sun G X, Li H, Guan S Y. (2017) Cloning and functiona l analysis of the cold resistance gene ICE1 in Arabidopsis thaliana. Journal of Northwest A&F University(Natural Science Edition), 45( 05): 175-182.
[9] He H W, Zhao M, Wu P, Long F, Zou Y, Lin W, Lin G M. (2017) Identification of cold resistance of 18 Banana Germplasm Seedlings. Southwest China Journal of Agricultural Sciences, 30(02): 315-321.
[10] Ni Huijing. (2016) Study on photosynthetic characteristics of anthurium cut flowers. Shandong Agricultural University.
[11] Wang Qian. (2016) Study on photosynthetic characteristics of elite clones of liriodendron chinense. Shandong Agricultural University.
[12] Jiang Zizhu, Zhu Hengguang, Zhang Qian, Song Beiguang, Meng Lijun, Yang Deguang. (2015) Research Progress of Plant Photosynthesis under Low Temperature Stress. Crops, (03): 23-28.
[13] Luo Qinya, Qi Longlin, and Fang Xi, et al. (1993) Study on photosynthesis of five species of camellia plants. Forest Research,(03):311-316.
[14] Hurry V,Strand A,Furbanek R,et al. (2000) The role of inorganic phosphate in the development of freezing tolerance and the acclimatization of photosynthesis to low temperature is revealed by the pho mutants of Arabidopsis thaliana. Plant J, 2000 ,24(3): 383-396.
[15] quist G, Huner N P A. (1993) Cold-hardening-induced resistance to photoinhibition of photosynthesis in winter rye is dependent upon an increased capacity for photosynthesis. Planta,189(1): 150-156.
[16] Ensminger I,Sveshnikov D, Campbell D A, et al. (2004) Intermittent low temperatures constrain spring recovery of photosynthesis in boreal Scots pine forests. Glob Change Biol, 10(6): 995 -1008.
[17] Hendrickson L, Ball M, Wood J, et al. (2004) Low temperature effects on photosynthesis and growth of grapevine. Plant Cell Environ, 2004, 27 (7): 795 -809.
[18] Lundmark T,Bergh J,Strand M, et al. (1998) Seasonal variation of maximum photochemical efficiency in boreal Norway spruce stands. Trees Struct Func,1998 ,13 (2):63 -67.
[19] Guy C L, Haskell D. (1988) Detection of polypeptides associated with the cold acclimation process in spinach. Electrophoresis, 9(11): 787-96.
[20] Danyluk J, Rassart E, Sarhan F. (1991) Gene expression during cold and heat shock in wheat. Biochem Cell Biol, 69(5-6): 383-391.
[21] Renaut J, Lutts S, Hoffmann L, et al. (2004) Responses of poplar to chilling temperature:
proteomics and physiological aspects. Plant Biol, 6(1): 81-90.

[22] Chen Hu. (2017) Genetic diversity analysis of longan germplasm resources and effect of low temperature on shilong longan. Nanning: Guangxi University, 10-50.

[23] Huang Xing, Yang Litao, Zhang Baoqing, et al. (2013) Cloning and expression analysis of the mature induced protein gene (SoASR) of sugarcane ABA stress. Biotechnology Bulletin, (2): 93-99.