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Review Article

Effect of Climate Change on Alpine Flowers

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Abstract

Global warming results in climate change that increases the intensity of rainfall, drought, dry spell, heat waves. This condition have profound impact on alpine plant ecology and induce migration or range shifts of species in search for their optimal growth conditions. These shifts subsequently lead to change in local species composition, often resulting in a relative increase of warm demanding species and a decreasing number of cold demanding species. The result of this change may cause habitat loss and disastrous extinction in those alpine environments. An alpine flower has been serving as source of genetic material for ornamental flower industry. Improvement of commercial cultivars through interspecific hybridization with wild relatives has also been the major way forward for transfer of important traits such as disease resistance. However, as a result of global warming, heat stress has become the major challenge for alpine ecosystem that is estimated to be 3% of terrestrial habitats. Here, I review literature regarding impacts of climate change on alpine flowers by using specific commercially important flowers as an example: *Dianthus*, *Primula* and *Rhododendron*. Then, I discuss ways to enhance *Rhododendron* breeding efficiency for heat stress using invitro growth conditions. Finally, I summarize with indicating future areas of research that should be undertaken.

Keywords

Alpine Flowers, Ecosystem, Climate Change, Heat Stress, *Rhododendron*

1. Introduction

Floriculture is well known economic sector around the world. This includes cut flowers, cut foliage, potted plants and bedding plants [1]. In countries such as China and India floriculture business is undertaken by small and big companies to satisfy local and international market. On the other hand, in some African countries such as Kenya and Ethiopia, floriculture is export oriented industry that contributes enormously for employment and economic development [1]. In this regard, the contribution of alpine flowers is enormous as most of ornamental plants derived from and serve as source of germplasm. For example, about 7500 ornamental and garden plants registered as native to China [2] and most ornamental plants derived from alpine areas such as Yunnan, Sichuan and Xizang [3]. However, alpine areas are under pressure due to climate change.

Currently, heat stress has become the global challenge driven by climate change and we are felling its effect day to day. Nearly 1.0 ℃ of global warming was recorded above pre-industrial levels due to global greenhouse gas emissions in 2017 and increasing 0.2 ℃ per decade. It is also estimated that, if global greenhouse gas emissions continues to increase at the current rate, global warming is likely to reach 1.5 ℃ between 2030 and 2052 [4]. This leads to increase in mean temperature in most land and ocean regions with devastating consequence on plant diversity and ecosystem [4]. Alpine habitat is one of the most affected ecosystems by global

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warming and climate change impact is more detectable than on lower elevation habitat [5].

Here, I first discuses alpine flowers using three examples. Then, I review the literature regarding impact of climate changes on alpine ecosystems. I also discuss climate change and *Rhododendron* breeding for heat stress.

2. Alpine Flowers

In total, about 1600 species registered around the world as commercial ornamental plants. Based on recent data, about 7500 ornamental and garden plants are considered as native to China [2]. In this regard, Yunnan province in China is popular source of alpine flowers with remarkable diversity [3]. Because of their hardy nature, alpine plants have unique position in plant kingdom. Here, I describe three most common alpine flowers popular in China and European alpine areas such as *Dianthus*, *Primula* and *Rhododendron*.

Dianthus species are distributed European Alps, Asia and African mountains. Commercially, it is cultivated in controlled condition throught the year in temperate areas in cool highlands of Colombia, China, and Kenya [6]. The genus *Dianthus* is belongs to Caryophyllaceae and contains more than 300 species of annuals and evergreen perennials. It is also source of top selling flower Carnation (*Dianthus caryophyllus* L.) [6]. Wild species of Dianthus extensively used as source of germplasm for improvement of carnation through breeding and create new cultivar. For instance, [6] screened 70 wild *Dianthus* accessions for resistance to bacterial wilt by using a cut-root soaking method and identified a highly resistant wild species, *D. capitatus.* The disease resistant character was then transferred to cultivated carnation by interspecific hybridization. However, currently wild species of Dianthus in alpine areas face risk of extinction and many of them are included in National and European Red Lists [7].

Primula is an alpine plant with significant ornamental values. The beautiful attractive flowers, easiness of its cultivation and propagation make it one of the most commercially preferred and important ornamental plants in the world. Most species exist around alpine areas of Europe and Asia. Genus *Primula* in Primulaceae family contains at least 500 species that are classified in to 37 sections. In China about 300 *Primula* species registered of which 206 are considered as endemic that occur only in China mainly distributed in three provinces: Sichuan, Xizang and Yunnan. The existence of this genetic diversity of wild Primula is extremely important source of ornamental traits to improve the existing commercial cultivar. Most of the time, breeding of ornamental plants involves interspecific hybridization that is beneficial to develop novel cultivars. For instance, different garden cultivars known as japonica hybrids have been produced by interspecific hybridizations with several species of the same section obtained from wild *primula* from China. Cultivars such as *P. obconica*, *P. malacoides*, and *P.* × *polyantha* are very popular in floriculture industry as pot and garden plants that are developed as a result of intraspecific hybridization. Nevertheless, wild alpine *Primula* face huge challenge due to climate change as the temperature around the world alpine areas raised by 2 ℃ and the consequence will be discussed in detail in the next section of this paper.

Rhododendron is a woody alpine flowers on which most species adapted to mountain ecosystems. The genus *Rhododendron* is one of the largest in the family Ericaceae and contains 124 genera worldwide and most species are among the most popular woody ornamentals as landscape plants around the world. The genus contains more than 1,000 species classified into 8 subgenera and 405 are endemic to China [8-10]. Wild species of rhododendron has been source of genetic resource for rhododendron breeders. For instance, out of 291 *Rhododendron* species cultivated in Europe (temperate climate), 85 species originate from Sichuan, Xizang or Yunnan or shared among them [3]. However, alpine ecosystem is particularly vulnerable to climate change such as high temperatures [11, 12] and high altitude vegetation is more sensitive to long-term climate change that leads to species extinction [13]. Beyond this, the cultivated rhododendron cultivars are also vulnerable to climate change effect as they are derived from cold adapted wild plants in alpine.

3. Climate Change and Alpine Flowers

Alpine is a unique mountain environment that can be explained by its characteristic physiognomy and the vertical zonation of the vegetation. By definition, the areas lying above treeline is called alpine [14]. It is estimated about 3% of the terrestrial area of our planet is covered by alpine ecosystems, on which about 4% flora of the Earth reside [14, 15]. Alpine ecosystem has provided so many benefits to human being such as products (food; medicine and industrial material), functional value (land and watershede protection; air and water quality control), service value (educational; tourism and recreation) and existence value (Aesthetic / psychological benefits) [14]. It is also site for genetic resource for commercial ornamental flowers as it harbors so many species of wild flowers such as *Rhododendron* species. However, this ecosystem is under grave danger due to climate change.

The effect of climate change on species and ecosystem had been controversial for long time. However, recently, numerous research results have been published to show the extent of change as well as how alarming it is. The first clear evidence that showed the influence of global climate warming on species distribution reported 1996 [16]. Then, its impact became clear on the ecological response such as polar terrestrial and tropical marine environment [17]. Recent reports also showed conclusive evidence that global warming have a significant effect on alpine plant ecology and the warming is sufficient to stimulate migration and may cause habitat loss and disastrous extinction in those environments [5].

In mountainous regions, climate warming is expected to shift species' ranges to higher altitudes. The distributions of many terrestrial organisms are currently shifting in latitude in response to changing climate [18]. However, the rate of migration depends on each species' capacity that may be related to multiple internal species traits and external drivers of change [18]. On the other hand, it is believed that endemic plant species restricted to high elevations are more susceptible to habitat loss than those species found at lower elevations. This may be related to the fact that plant at high elevation are cold adapted, so when the temperature change they could not resist. Researchers were reported this phenomenon after observing plants on European high-mountain [19, 20]. In response to warming, plants from lower habitat of the mountan increase in abundance and move up; on the contrary, abundance of plant species at high elevation will reduce. Thus, higher elevation species are likely face extinction because of the combined effects of climate change and competition [21]. However, to withstanding extinction from climate change depends on species' ability. Recently researchers from University of Zurich conducted an experiment on three alpine flowers (*Campanula pulla* L., *Primula clusiana* L., *Dianthus alpinus* L.) and one evergreen grass (*Festuca pseudodura*) endemic to Austrian Alps using computer models. They found that because of their longevity, the plants (*Festuca pseudodura* and *Primula clusiana*) may survive longer than expected in their habitats under the climate changes, but produce offspring that are increasingly maladapted. On the other hand their population size may decrease faster than the contraction of the species range. However, for short adult lifespan species (*Campanula pulla* and *Dianthus alpines*) rapid seedling production creates an opportunity for natural selection and ultimately, survival under climate change. Based on the above result, researchers suggested that instead of focusing on species' local range it is better to monitor demography of local population as a way of monitoring biodiversity change [22].

4. Climate Change and *Rhododendron* Breeding for Heat Stress

Different research findings demonstrated that the rise in temperature is responsible for shifts in flowering dates. For instance, it was reported that early flowering of *Rhododendron arboretum* due to climate change [23]. On contrary, it was also reported that the link between climate warming and delayed phenology on the central Tibetan Plateau [24]. High temperature induce stress in plants and ultimately reduced tissue water status and photosynthesis efficiency, then affect plat at different life stages [25].

To avert climate change effect on wild as well as cultivated rhododendron; priority should be given for urgent conservation, collection, evaluation of wild rhododendrons and rapid development of hybrid not only for ornamental attributes, but also tolerant to hot summer season.

Conventional breeding methods, based on selection and evaluation of germplasm on field and greenhouse, is time and resource consuming. Tissue culture based techniques emerged as alternative for invitro selection, evaluation and conservation of germplasm. It is feasible and cost effective tool that enable development of biotic and abiotic stress tolerant plant [26].

Most works related heat stress experiment on Rhododendron mainly conducted on pot [27-31], which consumes time and resource. In order to develop cultivar that combine, high ornamental quality, heat tolerant, disease resistant characters, it is important to search new approach that enable screening and comparison of available germplasm rapid and simple. *Rhododendron* is woody perennial plant that has long breeding cycles and development of improved cultivars resistant to biotic and abiotic stress may require many breeding cycles and years [32]. To reduce breeding cycle for rapid cultivar development, tissue culture based in vitro selection and germplasm screening method is feasible and cost effective tool for developing stress tolerant plants [26]. Nevertheless, there is no previous work related to tissue culture based invitro comparison or screening of *Rhododendron* cultivars for heat stress.

Tissue culture based invitro conservation is also another dimension that has to be considered [33]. This system could be used for short term and mid-term conservation of wild rhododendron plants as a means to fight species extinction due to climate change.

5. Conclusions

In summary, climate change is real and its effect is visible more on alpine ecosystem and the extinction of some plant genetic resource expected. Alpine ecosystem harbors wild species that are sources of economically important ornamental flowers. Therefore, research effort should focus generating information with regard to species extinction risk for alpine flowers such as *Rhododendron*, so that it could help the conservation effort. For instance, wild *Rhododendron* species and there improved progenies used commercially are threatened by climate change. This implies that breeding for heat stress tolerance also another priority. To improve the breeding efficiency for heat stress tolerance and for conservation, tissue culture based invitro techniques are more preferred.

Abbreviations

IPCC Intergovernmental Panel on Climate Change

Author Contributions

Elyas Gebremariam is the sole author. The author read and approved the final manuscript.

Conflicts of Interest

The author declares no conflicts of interest.

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