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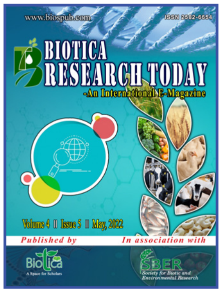

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Some Adaptational Mechanisms of Orchids

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Abstract

Orchidaceae belongs to the 84 families of vascular plants that cover species following the epiphytic life pattern. Orchids have specific adaptational mechanisms in the roots, stems, leaves, flowers, seed and other physiological processes. Under water scarcity, these orchids have developed pseudobulbs, a energy, water, and nutrient storage bulb for adaptations. A wax coating covering the surface of the leaf, also prevents evaporation and gas exchange in drier or hotter climate. Epiphytic orchids have adequate root systems to enable them to grow in a poor nutrient environment when they grow at slow rate. In such cases, velamen of orchids helps to absorb water and also help to absorb nutrients from rainfall. Orchid seeds do not have endosperm and require a fungal association with mycorrhiza to provide its energy till the development of roots and leaves. This symbiotic feature is another adaption to make the orchid seed to travel longer and further distances for survival. In comparison to the activity of C_3 photosynthesis, crassulacean acid metabolism (CAM) in many epiphytes plays a vital role in improving carbon gains and water use.

Introduction

Adaptations are specialized mechanisms that allow a plant or animal to live in a particular locality or habitat. These adaptations could make it very difficult for the plant to survive in a different place. The family Orchidaceae have derived as terrestrial forest understory herbs approximately 100 million years ago. Orchidaceae belongs to the 84 families of vascular plant families that cover species following the epiphytic life pattern (Kress, 1986). Among flowering plants, orchids are the second largest families (Willis, 2017) with most diverse groups of angiosperms consisting of nearly 25,000-30,000 species belonging to 750-800 genera. The family orchidaceae comprises of five subfamilies namely *Apostasioideae*, *Cypripedioideae*, *Vanilloideae*, *Orchidoideae*, *Epidendroideae*. Orchids cover about 8% of angiosperm species diversity (Chase *et al*., 2015). According to Govaerts *et al*. (2017), 29,199 species have been identified and accepted although several hundred new species are added each year. Botanically, orchids are monocot plants. They could be of epiphytic, terrestrial and lithophytic. Globally, orchids are epiphytic and/or lithophytic (70%), terrestrial (25%) and both lithophytic, epiphytic and terrestrial accounting to 5% (Arditti, 1992).

Habitat Adaptations

Tropical epiphytes have come across a very harsh life at certain times of the year. Even in the rainforest, they have to perform days or weeks without water and subsequently they have to shed their leaves and stems. The roots have an actively growing tip with the older parts being covered in an envelope of dead empty cells. The tip protects the inner tissues which help in the uptake of moisture from the atmosphere. This can have a blotting paper effect for the orchid.

Climatic Adaptations

A universal style of light requirement exists for individual species of orchids. The photosynthesis and growth of most orchids demand a low level of irradiance because they live in forests. Myco-heterotrophic orchid species acquire carbon through heterotrophic exploitation of mycorrhizal fungi and are usually light-independent. Orchids also have different light requirements at various stages of development after germination. Like other plants, orchids are also classified into short-day, long-day, or day-neutral. The system of night interruption can be applied to induce flowering by long-day orchids and improve flower quality in commercial cultivation. Moderate high temperatures generally enhance plant growth, but extremely high temperatures can hinder physiological activities. At high temperatures cellular membranes and ions become weaken and tissue necrosis occurs. When orchids are shifted from alpine habitat to a tropical habitat, their leaves show reduced rate of photosynthesis, stomatal conductance, transpiration and carboxylation efficiency. These experimental evidences have been used to develop strategies for commercial cultivation of orchids. For example, temperature manipulation is applied to control and synchronize flowering time in Cymbidium, Dendrobium, and Phalaenopsis.

Morphological Adaptations

Orchids have shown specialized adaptations in the roots, stems, leaves, flowers, seed and other physiological processes. Epiphytic orchids do not have any vascular connection to the host tree. Orchid roots play important role in anchorage for the plant, photosynthesis, and water and nutrient uptake and storage. These adventitious roots usually develop from the rhizome. Orchid roots exhibit a spongy layer of cells outside the exodermis known as the velamen that functions as temporary water storage. Epiphytic orchids often have called pseudobulbs, enlarged portions of the stem which are used for storage of water and carbohydrate. The epiphytic biotope has to pass over the frequent periods of water and nutrient shortage. Presence of fleshy organs in roots, stems or leaves provides epiphytic orchids the ability to survive and grow in adverse climate. Epiphytic orchids have thick and succulent leaves with thick cell walls, cuticles and small substomatal chamber whereas those of terrestrial species are thin. Usually mature leaves exhibit active photosynthetic rate. Leaves are considered as sites for reduction of transpiration, water storage organs, retention of rain or condensed water and absorption of water as liquid or vapour. The hard leathery leaf type of orchids are drought tolerant due to their very thick cuticle and thick walled epidermis together with extensive lignification offering excellent protection against desiccation. Thick leaves exhibit Crassulacean Acid Metabolism (CAM), a very important adaptation to water stress. All thin orchid leaves show C_3 photosynthesis. Small and narrow leaves are better adapted exposed sites than broader ones because they lose heat more efficiently by convection. The orchid flowers can have a great diversification in size, colours and shape. The predominant colours are white, yellow, green and purple occurring in pure state or shades or in every possible combination. The orchid flowers exhibit mimicry like Spiders, Dancing girls, Bees, Ladies slipper, or Insects to make easy for pollination. Seeds of orchid are generally adapted for wind disbursal. In orchids, during germination a mycorrhizal fungus penetrates the testa and feeds the embryo. This symbiotic relationship is another spectacular adaption so the orchid seed could travel longer and further distances for survival.

Physiological Pathways

Most of the vascular epiphytes occurring in tropical and subtropical regions normally grow on tree trunks in forests and/or on rock surfaces in valleys. Unlike terrestrial plants, their roots have no contact with the soil. Therefore, water stress is a major limitation factor to their survival, growth and distribution. However, vascular epiphytes are more drought tolerant than terrestrials. Under water scarcity, vascular epiphytes exhibit morphological and anatomical adaptations in their leaves, stems and roots, including thickened cuticles, stomata surrounded by trichomes, a reduction in transpiring surface areas through sympodial growth, and development of aerial root systems. A modified photosynthetic pathway as an adaptation of orchids to the dry canopy habitat. The stomatal opening to take up carbon dioxide is always connected with large losses of water. To inhibit this loss, Crassulacean Acid Metabolism (CAM) involves a process that allows the uptake of carbon dioxide during the night when relative humidity is higher than during daylight periods. The prefixed carbon dioxide is stored in vacuoles and is utilized during the daytime for photosynthesis. When compared with the performance of C_3 photosynthesis, crassulacean acid metabolism (CAM) in many epiphytes plays a vital role in improving carbon gains and water use. Thick leaved vanillas, aerides, aranda, cattleyas and phalaenopsis use CAM metabolism while thin leaved oncidiums, bamboo orchids often use the more conventional photosynthetic pathways.

Nutrition

Orchids develop specialized root systems to enable them to grow in a poor nutrient environment as long as they grow at slow rate. In such cases, velamen of orchids helps to absorb water and also help to absorb nutrients from rainfall. However, the main source of nutrients is the slow decomposition of organic matter that accumulates in the tree crotches and among the bark, roots, rhizomes and roots of the orchid plants. Epiphytic orchids are adapted to the water deprived and nutrient deficient environment by growing more slowly, producing leaves that are thick and hard and diverting more energy into root formation. A greater air movement in the tree canopy helps to dry leaves rapidly after storms which prevent bacteria and fungi from penetrating into the plants. Abundant air movement, diffused light, porous potting mixtures will help to grow healthy plants which subsequently produce lots of blooms.

Conclusion

Living in a different climatic condition is a unique challenge for a plant life. Plants have adapted their roots, leaves, flowering behavior, flower structures, seed characters, growth, drought tolerance and other physiological processes depending upon varied climatic conditions such as dessert, tropical rain forest, aquatic environments, temperate grass lands, temperate rainforests and temperate deciduous forests. Epiphytic orchids have a number of specialized adaptations that help them survive in their unique environment.

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