agronomy

Editorial

# The Diversification of Adaptive Strategies for Karst-Adaptable Plants and the Utilization of Plant Resources in Karst Ecosystems

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## 1. Karst Environment

Karst landforms, which account for approximately 15% of the world's total land area, are mainly concentrated in low latitudes, including Southeast Asia, the European Mediterranean, the east coast of North America, the west coast of South America, and the marginal areas of Australia. The concentrated and contiguous karst is mainly distributed in southwest China, northern and southern Europe, and the east of the United States. Strong karstification causes the karst soil environment to be dry, and to have a high content of calcium (magnesium) and bicarbonate, a high pH, a high content of nitrate, and a low content of ammonium. A karst environment with a high spatiotemporal heterogeneity seriously affects the growth and development of plants. Faced with these heterogeneous environments, plants have adopted diversified adaptive strategies. The selected papers published in this Special Issue of *Agronomy* demonstrated some achievements on the physiological and ecological adaption of plants to heterogeneous karst environments, and they also explore how to extend the service period of plant resources in karst regions.

## 2. Karstification–Photosynthesis Coupling

Karstification–photosynthesis coupling is the most fundamental physiological and ecological mechanism used by plants to adapt to a karst environment, and is the "engine" that drives the biogeochemical cycle in nature. Karst-adaptable plants can "turn waste into treasure", convert bicarbonate formed by carbonate rock dissolution into organic matter, effectively improving the utilization of plant resources, and greatly enhance the biodiversity and carbon sink capacity of the ecosystem [1,2]. The efficient use of bicarbonate by plants is the core mechanism of karst adaptability. Plant utilization of the soluble inorganic carbon from the soil varies with plant species and altitude [3]. The physiological effects of bicarbonate in plants depends on its concentration in the soil, and appropriate levels promote growth and development by enhancing photosynthesis, water, and the nutrient metabolism of *Coix lacryma-jobi* L. [4].

## 3. The Response of Plant Nitrogen Assimilation

In karst environments, the differential response of plants to inorganic carbon and nitrogen assimilation determines the adaptation to soils with a high content of nitrate and a low content of ammonium. Karst-adaptable plants are more likely to use nitrates, and the positive effects on carbon and nitrogen assimilation are also higher than in the non-karst-adaptable plants [5]. At the same time, karst-adaptable plants can coordinate the distribution of nitrate assimilation between roots and leaves and the balance between internal demand and external supply of nitrogen [6].



**Citation:** Wu, Y.; Wu, Y. The Diversification of Adaptive Strategies for Karst-Adaptable Plants and the Utilization of Plant Resources in Karst Ecosystems. *Agronomy* **2023**, *13*, 2135. https://doi.org/10.3390/agronomy13082135

Received: 2 August 2023
Revised: 11 August 2023
Accepted: 12 August 2023
Published: 15 August 2023

## 4. Diversified Water Metabolisms of Karst Plants

Karst plants respond to water with species specificity. Compared with photosynthetic parameters, plant electrophysiological information can quickly, and in real-time, reflect water metabolism in plant cells [3,7]. In karst environments, the water metabolism patterns of different plant species were clearly different. *Coriaria nepalensis* maintained a high photosynthetic rate, with a high leaf intracellular water-holding capacity and high root water uptake ability. *Broussonetia papyrifera* maintained a stable intracellular water transport and photosynthetic rate by efficiently using the transpired water. *Elaeocarpus decipiens* displayed low transpiration, low photosynthesis, and low instantaneous water-use efficiency [7].

## 5. Responses of Plants to Karst Soil Environments

Other physical and chemical properties of soils also profoundly affect species diversity and the growth and development of karst plants. Plant diversity and soil seed banks are significantly influenced by soil properties. Orchards have the highest seed density, while primary forests have the highest plant diversity [8]. The Golden *Camellia* species grown on calcareous soils with strong Ca absorption and accumulation displayed a good adaptation to a high content of Ca [9]. The adaptability of plants to the environment changes with plant growth and development. *Zanthoxylum planispinum* 'dintanensis' leaf functional traits change with growth and development, which is also a manifestation of the influence of the soil environment [10]. The synergistic change of the stoichiometric relationship between plants and soil nutrients is also another effective mechanism for plants to adapt to karst environments [11,12].

## 6. The Adaptability of Karst Plants to the Biological Environment

The interaction between plants and their biological environment is an important aspect of adaptation. *Broussonetia papyrifera* and *Platycladus orientalis* exhibited different adaptation mechanisms to karst environments with different water and nutrient niches and different levels of competition for water and nutrients [13]. Arbuscular mycorrhizal fungi, which are root symbionts, promote nutrient uptake and utilization, improve resource utilization, and promote root morphological development and nutrient utilization in highly heterogeneous soil patches [14]. Soil microorganisms can also regulate litter decomposition and nutrient utilization by acting synergistically with plants [11,12].

## 7. Extending the Service Period of Plant Resources in Karst Areas

Due to the limited retention and transport of nutrients in karst soil environments, it is necessary to consider extending the service period of plant resources while developing and utilizing karst-adaptable plant resources. The return on investment of an artificial *Zanthoxylum* forest is varies significantly depending on the planting year, and the management of the forest can be used as a reference [10]. Short-term 1-methylcyclopropene (1-MCP) treatment can regulate the metabolism of blueberry fruits and improve the shelf quality of blueberries [15]; and 1-MCP, combined with an $SO_2$ treatment, can delay postharvest aging of bamboo (*Chimonobambusa quadrangularis*) shoots in karst mountains and extend the shelf life of fresh bamboo shoots [16].

## 8. Concluding Remarks

In short, the works in this Special Issue can help with understanding the karst-adaptability of plants from multiple perspectives, and they provide a scientific reference for the selection of karst-adaptable plants and the restoration of vegetation in karst areas. Further, they provide theoretical support for organic integration towards the economic, social, and environmental sustainability of karst areas, and the beautiful vision that "green water and green mountains are golden mountains and silver mountains".

**Author Contributions:** Y.W. (Yanyou Wu) and Y.W. (Yansheng Wu) cooperated to complete this article. All authors have read and agreed to the published version of the manuscript.

**Acknowledgments:** We gratefully acknowledge all the authors that participated in this Special Issue and the support of the National Natural Science Foundation of China (No. U1612441-2), as well as Plan Projects of Science and Technology of Guizhou Province (No. (2021)YB453).

**Conflicts of Interest:** The authors declare no conflict of interest.

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