Response of plant functional traits to climate change

Jing Zhang1, 2, *, Pengzhan Li1, 3, a
1 Shaanxi Provincial Land Engineering Construction Group Co., Ltd., Xi’an, China
2 Institute of Land Engineering and Technology, Shaanxi Provincial Land Engineering Construction Group Co., Ltd., Xi’an, China
3 Yan’an Branch of Shaanxi Provincial Land Engineering Construction Group Co., Ltd., Yan’an, China

*Corresponding author e-mail: jingzhangzhj@126.com, a15829581150@163.com

Abstract. Climate change has caused serious impacts on the ecosystem, including destroying the stability of the ecosystem and affecting the biodiversity of the ecosystem. Plant functional traits show good response and adaptation to environmental changes, and the change of plant functional traits will indicate climate change. It is a hot research topic to identify the mechanism of the effects of plant functional traits on climate change. By studying relevant references, this paper conducted in-depth studies on leaf functional traits, root traits and the relationship between leaf and root traits among plant functional traits. On this basis, the direction of climate change was further clarified by predicting the development trend of functional traits, and the relationship between plant functional traits and climate change was further discussed.

1. Introduction

1.1. Impact of climate change on ecosystems
Climate change is the biggest environmental problem. Increasing of public concern about greenhouse effect and global climate change caused by human activities has pay attention to its impact on the global ecological environment. Ecosystems will be damaged severely, and systematic structure, composition, spatial pattern, ecosystem function and productivity will be changed. Besides, reduction of living area, decline of biodiversity and degradation of ecosystem were also the result of climate change [1].

With the global climate change and increase of temperature in winter, the phenology of plants, the community structure and species composition of forest ecosystems has changed significantly in China. In addition, climate change also affects the whole biogeochemical cycle by affecting soil carbon pool, nitrogen pool, methane emission and soil respiration [2]. Under the background of global warming, the climate of our country has changed obviously in the past hundred years, including temperature has risen by 0.4 to 0.5℃. Climate warming was mainly manifested in the mean minimum temperature of the heating, while in winter the greatest contribution [3]. Global warming leads to global precipitation redistribution, glacier melting, permafrost melting and sea level rise, which not only endangers the balance of natural ecosystems, but also threatens human survival.
Climate change has a tremendous impact on terrestrial ecosystems, and biology, vegetation types and farmland ecosystems are closely related to climate change. This indicates that plants, as an important component of terrestrial ecosystems, respond to climate change in an all-round way. Plants become ideal carriers for climate change simulation research [4]. Due to the uncertainty of climate change, the complexity of ecosystems and the limitations of human perception, there are still many problems that cannot be clarified, but many evidences show that climate change is indeed occurring [5]. Therefore, it is urgent to explore the impacts of global climate change on ecosystems.

1.2. Indicative effect of plant functional traits on climate change
Changes of plant functional traits can be indicative of climate change. Plant functional traits respond to environmental changes. For example, with the change of environmental gradient from humidity to drought, the leaf area of plants decreases, the nitrogen and phosphorus content increases, the carbon-nitrogen ratio decreases, and the assimilation rate increases [6]. Plants adapt to environmental changes by adjusting external morphology and internal physiological characteristics, while changing their contribution to ecosystem functions [7]. These changes in plant physiological and functional traits, such as morphological, stomatal regulation, photosynthetic structure and pathways, plant photosynthesis, respiration rate and water physiology, and these changes in phenological and functional traits were indicators of global change. Changes of community characteristics that species richness or number of plant communities increase are also indicative of global warming. Plant functional traits not only reflect individual adaptation, but also reflect the functional characteristics of the ecosystem. Improving this research method that indicative role of plants in climate change can shorten the space-time scale and help to link global change with the dynamic changes of population and community levels [4].

Globally, plant leaf traits vary greatly in different habitats and species. Even in the same plant, their traits vary greatly in different environments, showing greater plasticity, reflecting the adaptability and indicative role of plants to the external environment [8]. This indicative function of plants to climate change is very obvious, and the functional characteristics of plants are attracting more and more attention from ecologists. However, the research on plant response to climate change is very limited in China. Therefore, we will understand the impact of climate change on plant functional traits by studying the indicative role of plants in climate change.

2. Research status

2.1. Response of leaf functional traits to climate change
There have been a lot of studies on leaf traits around the world. Many large-scale studies have found that leaf size decreases with the decrease of annual mean temperature and annual water fall. The drier the habitat of the same species is the smaller the leaf area [9]. Leaf size decreases with the increase of altitude, and the stem of plant branchlets is more prone to embolism under unfavorable conditions such as low temperature. In the environment with high wind speed, plants may choose small leaves to avoid being blown away easily by the wind; in the forest where strong winds may occur at any time during the growing season, small leaves can effectively reduce the contact surface with air, thus protecting plants from damage. In short, leaf size is closely related to plant growth. When environmental conditions improve, plant leaves become larger.

Leaf mass per area (LMA) is one of the important characters of plant growth, which can reflect the adaptation of plants to different habitats. Due to the differences in scale, region and soil, LMA varies with the annual average temperature [9]. On a global scale, LMA increased with the decrease of annual precipitation, and drought increased the LMA of plant leaves. At present, there are few studies on the effect of temperature increasing time on leaf traits. The response process of time series of plant leaf traits was not studied in detail.
2.2. Response of interrelationship of leaf traits to climate change
The total amount of carbon fixed by a single leaf during its life depends on its productivity and persistence time. Leaf nitrogen concentration per leaf mass of species with long leaf life and high LMA tends to be lower in leaf productivity and leaf mass per unit mass, and leaf nitrogen concentration per leaf mass was higher in species with short leaf life and low LMA [10]. In previous large-scale studies, there were fewer species shared between each sample point (changes in the environment were accompanied by changes in species) [11], so the role of species and environment could not be distinguished.

Relative to single character, the relationship between characters is more stable [9]. The changes in the relationship between leaf traits indicated that the effects of environmental changes on different leaf traits were different, and plants adapted to the changed environment to the greatest extent depending on the changes in different traits. The relationship between leaf traits and environmental constraints was directly related.

2.3. Response of root traits to climate change
Fine roots are the organs of plants that absorb water and nutrients. The characteristics of fine roots can carry certain environmental information, which is a good indicator of the growth and distribution of plants [12]. The role of fine roots in sustaining plant growth and responding to climate change is critical. However, the research on plant root characters is very limited at present.

The odds of global climate change are relatively low, but ecological responses are large-scale and coherent. This results in complex ecosystem communities undergoing ongoing reorganization due to global climate change. It is not clear how short-term disturbances affect long-term environmental change, and how the inherent population development process affects community viability and stability [13]. Global changes have a great impact on plant functional traits [14]. At present, the research in this field mainly focuses on plant physiology, phenology, species division and community composition. In addition, physiological and ecological studies are generally short-term experiments, while long-term large-scale experiments are currently lacking in functional traits research.

3. Developing trend
To study the indicative effect of plant functional traits on global climate change, and to determine the interrelationship among various indicators based on plant physiological, plant biochemical and ecological characteristics, and to establish a network indicator system from plant individuals, communities to ecosystem functions, is the development direction of research [4]. Due to the correlation between many leaf traits, multiple traits should be considered when considering the influence of climate change on leaf traits. The adaptation strategy of plants to the environment is realized through the functional tradeoff and covariation among traits [15]. In Qinghai-Tibet plateau, there are few studies on the response of plant leaf functional characters to climate change [16]. Especially in the context of multi-level changes of alpine habitats caused by climate warming, studies on functional character responses of plant leaves are more scarce [4].

Plant functional traits have attracted the attention of ecologists in recent years. From plant individual, population, community to ecosystem, functional traits have proved to be an effective technique to explore ecological problems. With the development of technology and large-scale data, functional traits become an important tool to predict the impact of global climate change on ecosystem. In the selection and measurement of functional traits, most studies tend to select soft traits that are easy to be measured in large quantities. In the future, more hard traits related to plant metabolism, such as physiological traits, need to be measured to make up for the current deficiency [17]. In addition, the above ground part of the functional characteristics of the study is far more than the underground character, and the underground character for the study of plant growth and development is crucial. Therefore, more underground traits need to be measured in the future. In addition, stem, seed, canopy, and overall plant traits are also critical to climate change responses and will need to be measured more in the future. Although scholars at home and abroad have realized that functional diversity is the key to explain the
impact of diversity on ecosystem functions, there is still no standard method for quantitative research. There are many difficulties in the definition and differentiation of functional groups and the measurement of functional diversity [18]. Therefore, in this regard, a standard method for quantitative determination of plant functional traits is needed in the future.

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