

## The Relationship between Genome Stability of Grassland Plants and Ecosystem Immunity

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**Abstract** This study explores the relationship between the genome stability of grassland plants and the anti-interference ability of ecosystems. Genome stability refers to the stable performance of plant genomes against internal and external pressures, while the anti-interference ability of ecosystems involves their ability to respond to environmental changes and disturbances. This study introduces the concept and measurement methods of genome stability, as well as the definition and composition of ecosystem anti-interference ability. Then, it explores in detail the close relationship between grassland plant genome stability and ecosystem anti-interference ability. Through case studies, the correlation between genome stability and species diversity, ecosystem function, and anti-interference ability was demonstrated. The response of genome stability to environmental change, especially in terms of climate change and habitat destruction, was also discussed. The potential applications of genome stability in ecosystem management and protection were studied, including ecosystem restoration and natural resource management. This study highlights the important relationship between the genome stability of grassland plants and the anti-interference ability of ecosystems, providing scientific basis for future ecological and biodiversity conservation research.

**Keywords** Grassland plants; Genome stability; Immunity; Environmental changes; Ecosystem management

As one of the important ecosystems on Earth, grassland ecosystems not only maintain rich biodiversity, but also play a crucial role in key ecological functions such as global carbon cycling, water cycling, and climate regulation (Xue et al., 2023). However, while grassland ecosystems are facing increasingly serious environmental disturbances and changes, their immunity is also facing challenges. In order to better understand and improve the immunity of grassland ecosystems, researchers are increasingly paying attention to the relationship between plant genome stability and ecosystem immunity.

In the past few decades, grassland ecosystems worldwide have been affected by multiple pressures such as climate change, land use change, invasive species, and pollution. These interference factors pose a huge threat to the stability and function of grassland ecosystems, triggering profound attention to the ecosystem immunity (Luo et al., 2022). The ecosystem immunity is an important concept in ecological research, which refers to the stability and resilience of ecosystems to external disturbances. Understanding and enhancing the ecosystem immunity is crucial for maintaining their health and function, as it helps them better maintain balance in the face of stress and change.

The purpose of this study is to systematically study the relationship between the stability of grassland plant genomes and the ecosystem immunity, aiming to provide important information about the maintenance and protection of grassland ecosystems for scientists, ecologists, policy makers, and ecosystem managers. Starting from the concept and measurement methods of genome stability, we explore the correlation between grassland plant genome stability and ecosystem immunity, including the impact on species diversity, ecosystem function, and anti-interference ability.

This study will combine the latest research findings and case studies to provide a comprehensive analysis in order to better understand the relationship between grassland plant genome stability and ecosystem immunity. Through in-depth research, promote the protection and management of grassland ecosystems, promote the progress of ecological research, and provide scientific basis for future environmental protection.

## **1 Definition and Measurement of Genome Stability of Grassland Plants**

The genome stability of grassland plants is an important component of ecosystem stability, which has complex relationships with environmental factors, internal genetic factors, and ecosystem characteristics. By conducting in-depth research on the definition, measurement methods, and influencing factors of genome stability, we can better understand the role of genome stability in grassland ecosystems, provide a foundation for the study of ecosystem immunity, and provide strong support for the protection and management of grassland ecosystems.

### **1.1 Concept of genome stability**

Genome stability refers to the stability ability of grassland plant genomes to internal and external pressures, which focuses on the maintenance and recovery ability of genome structure and function in the face of various disturbances and pressures. The concept of genome stability emphasizes the crucial role of the genome in maintaining the integrity of genetic information, reducing mutations, and maintaining normal growth and development.

In grassland ecosystems, varying degrees of genome stability may affect the survival and reproductive ability of plant individuals and communities, thereby having a profound impact on the stability of the entire ecosystem.

### **1.2 Measurement methods for genome stability**

In order to study and quantify the genome stability of grassland plants, researchers use multiple measurement methods. One commonly used method is to evaluate genome stability by measuring the speed of DNA damage and repair. This can include measuring DNA single strand breaks, double strand breaks, base damage, etc. (Wang et al., 2021).

Another method is to evaluate genome stability by analyzing the expression levels of DNA repair related genes. Higher gene expression levels are usually associated with higher genome stability. In addition, researchers can also use molecular marker techniques, such as microsatellite markers or SNP markers, to study genome differences between different plant individuals and understand their stability.

### **1.3 Factors affecting genome stability**

Genome stability is influenced by various factors, some of which are closely related to environmental and internal genetic factors. Environmental factors include radiation, chemicals, climate change, soil conditions, etc., which can directly or indirectly affect genome stability. Internal genetic factors include DNA repair mechanisms, genetic diversity, and genotype (Nisa et al., 2019).

The genome stability may vary among different plant species and individuals, which is related to their genetic background and ecological characteristics. In addition, the structure and function of ecosystems can also affect the genome stability of grassland plants, for example, species diversity and niche distribution may have an impact on genome stability.

## **2 Overview of the Ecosystem Immunity**

Understanding the definition, composition, and relationship between vulnerability and stability of ecosystem immunity is crucial for better understanding the function and ecological balance of ecosystems. In the face of increasingly severe environmental challenges and disturbances, in-depth research and protection of the ecosystem immunity are of great significance for maintaining biodiversity and ecological balance on Earth.

### **2.1 Definition of ecosystem immunity**

The definition of ecosystem immunity refers to the ability of an ecosystem to respond to external disturbances and environmental changes. It includes the stability, resilience, and resilience of ecosystems. The stability of an

ecosystem refers to the degree to which it can maintain its structure and function in the face of external disturbances; Resilience refers to the ability of an ecosystem to adapt and maintain its key functions after interference; Resilience refers to the degree to which an ecosystem can recover to a stable state in a relatively short period of time after being disturbed.

The core concept of ecosystem immunity is the ability to maintain structure, function, and services, or to quickly restore to a stable state in a short period of time. This ability enables ecosystems to continuously provide important ecological functions, such as material cycling, energy flow, and biodiversity maintenance, to maintain ecological balance (Yang et al., 2021).

## 2.2 Composition and function of ecosystems

The ecosystem is composed of biological communities and non biological environments, including factors such as plants, animals, microorganisms, soil, water bodies, climate, etc. These components interact with each other and together maintain the functionality and stability of the ecosystem (Figure 1).

Plants convert solar energy into organic matter through photosynthesis, providing food and oxygen, while also affecting the texture and moisture content of the soil. Animals participate in material and energy flow through food chains, pollination, and seed transmission. Microorganisms play a crucial role in decomposing organic matter and maintaining soil health. These components are interdependent and form a complex ecosystem network.



Figure 1 Complex ecosystem

## 2.3 Fragility and stability of ecosystems

The fragility of an ecosystem refers to its sensitivity to external disturbances and the strength of its resistance. Fragile ecosystems are often more susceptible to disruption, while ecosystems with strong anti-interference capabilities can better cope with stress and change. The stability of an ecosystem is the degree to which it can recover to its original state after being subjected to external shocks. A stable ecosystem can maintain its relative invariance in structure and function, and can quickly recover even after temporary disturbances. Stability is related to the immunity, but it is not the same because the ecosystem immunity includes the ability to maintain function and structure in the face of interference, while stability emphasizes the resilience of ecosystems.

The vulnerability and stability of ecosystems are influenced by various factors, including species diversity, ecosystem structure, environmental conditions, natural disturbances, and human disturbances. Species diversity typically enhances the ecosystem immunity, as diversity can provide backup functions and niches, increasing the resilience of ecosystems (Geng et al., 2019). In addition, the complexity and stability of ecosystem structures are closely related, as complex ecological networks can disperse stress and maintain functionality. However, interference factors introduced by human activities, such as land development, pollution, and climate change, may increase the vulnerability of ecosystems and reduce their immunity.

### 3 The Relationship between the Genome Stability of Grassland Plants and the Ecosystem Immunity

There is a close correlation between the genome stability of grassland plants and the ecosystem immunity. Plants with strong genome stability help maintain species diversity and ecosystem function, while the complex and diverse ecosystem structure and evolutionary history also have a significant impact on the anti-interference ability of ecosystems. Understanding these correlation relationships helps to better understand the function and stability of grassland ecosystems, providing scientific basis for ecosystem protection and management.

#### 3.1 The impact of genome stability on ecosystems

##### 3.1.1 Genome stability and species diversity

There is a close correlation between the genome stability of grassland plants and species diversity within ecosystems (Mo et al., 2019). Species diversity is an important component of ecosystems and is crucial for maintaining their stability and immunity. Research has shown that grassland plants with strong genome stability may have a positive impact on species diversity in ecosystems.

Grassland plants with strong genome stability are usually better able to adapt to different niches because they have stronger mechanisms for gene repair and resistance, making them more adaptable to their ecological niches. This means that they can occupy different roles within the ecosystem, provide diverse ecological functions, and thus increase species diversity. Genome stability also has an impact on coexistence and competition among species. In an ecosystem, competition between different species may lead to the exclusion or extinction of certain species, thereby reducing species diversity. However, plants with strong genome stability may be more likely to coexist with other species, reducing competition pressure and contributing to the maintenance of species diversity. Genome stability can also affect the adaptive evolution of species, making it easier for species in ecosystems to cope with environmental changes and disturbances. This further enhances the stability and immunity of species diversity, thereby enhancing the stability of the ecosystem.

*Poa annua* has relatively high genome stability, which means its gene repair and resistance mechanisms are relatively strong. In a diverse grassland ecosystem, *Poa annua* can survive and reproduce in different niches. It coexists in synergy with other plant species, reducing competition pressure and helping to maintain species diversity. The genome stability of *Poa annua* also makes it more adaptable to different environmental pressures, such as climate change and soil impoverishment. This enables it to better maintain its growth and reproductive capacity in the face of environmental changes, providing stability for the entire ecosystem. Their existence helps to build complex ecological networks, improves the stability and immunity of ecosystems, and thus has a positive impact on the health and sustainability of the entire ecosystem.

##### 3.1.2 Genome stability and ecosystem function

The genome stability of grassland plants also has a profound impact on the functionality of ecosystems. The ecosystem functions include multiple aspects such as material circulation, energy flow, soil fertility maintenance, and water resource protection. The strength of genome stability may directly affect the maintenance and recovery of these functions.

Plants with strong genome stability are more likely to resume normal growth and reproduction after interference, thereby helping to maintain energy flow and material circulation in the ecosystem. This is crucial for the long-term stability of ecosystems as it ensures that critical ecological functions are not disrupted by interference (Geng et al., 2019). Genome stability can also affect the ecological niche distribution of plants. Plants with strong genome stability may be more likely to occupy key ecological niches, such as nitrogen fixation and the top of the food chain, thus playing an important role in the functionality of ecosystems. Genomic stability can also affect the adaptability and niche diversity of plants, thereby affecting the ecological functions in ecosystems. For example, some plants with strong genome stability may be more likely to survive and reproduce under drought conditions, thereby maintaining the protective function of water resources.

*Larix potaninii* is a tall tree that exhibits strong genome stability. They grow in the forests of the western United States and play a crucial ecological role. These trees exhibit strong resilience in the face of disturbances such as wildfires and pests, helping to maintain the long-term stability and diversity of forest ecosystems.

### 3.2 Factors affecting the ecosystem immunity

#### 3.2.1 Structure and function of ecological system

The structure and function of ecosystems are one of the important factors determining their immunity. The complexity and diversity of ecosystems are usually positively correlated with their anti-interference ability. The diversity of species composition can provide backup functions, making it easier for ecosystems to recover from disturbances. In addition, the interactions and synergies between different biological communities in ecosystems can also affect anti-interference capabilities (Yang et al., 2021). A stable ecosystem typically has a diverse species composition, complex food webs, and distribution of niches, which helps to mitigate the impact of disturbances.

Coral reefs are a complex ecosystem that includes corals, algae, fish, and other organisms. Its diverse species composition and complex interactions help resist disturbances such as rising sea temperatures and ocean acidification. The diversity of ecosystem structure and function of coral reefs helps to improve their immunity, making it easier to recover from interference.

#### 3.2.2 Ecosystem history and evolution

The history and evolution of ecosystems also have a significant impact on their immunity. The evolution process of an ecosystem can affect the stability of its internal structure and function. During the long-term evolution process, ecosystems may have formed specific niche distribution and interaction patterns, making them more anti-interference (Zhang et al., 2016). In addition, some ecosystems may have experienced multiple disturbance events in their evolutionary history, gradually developing anti-interference features, such as adaptability to fires, floods, or droughts.

The coniferous forest ecosystem in North America, such as the Boyle Forest in Canada. This ecosystem has gone through a long evolutionary history and has formed many anti-interference features. Due to the long cold season and heavy rainfall, the trees in these coniferous forests have gradually evolved their tolerance to cold and humidity. Their coniferous leaves and bark can reduce water evaporation and protect trees from pests and diseases. In addition, the seeds of these trees require fire to release and reproduce. This means that over the long evolutionary history, these coniferous forest ecosystems have gradually adapted to fires and developed immunity against them. Therefore, these ecosystems can better maintain their structure and function in the face of natural disturbances such as fires.

## 4 Response of Genome Stability to Environmental Changes

Genome stability plays an important role in the response of grassland plants to different environmental changes and habitat destruction. It affects the adaptability, survival ability, and ecosystem stability of plants. Understanding and protecting genome stability in the face of global environmental issues can help maintain the health and sustainability of ecosystems and alleviate the pressure they face. This also provides new research directions and management strategies for ecological research and biodiversity conservation.

### 4.1 Expression of genome stability under different environmental conditions

Genome stability is one of the manifestations of the survival and reproductive ability of grassland plants under different environmental conditions. The genome stability of grassland plants may vary under different environmental conditions. When facing harsh environmental conditions such as drought, high temperature, or soil salinization, plants with higher genome stability typically exhibit better adaptability and survival ability. This stability is manifested in their ability to maintain normal growth and reproduction, reducing damage from environmental stress (Trivedi et al., 2020).

Some plants located in desert ecosystems, such as *Opuntia dillenii*, has high genome stability. They have adapted to the extreme drought and high temperature conditions of desert environments. By reducing water evaporation,



storing water, and resisting physiological and genetic mechanisms such as ultraviolet radiation, these plants can continue to grow and reproduce under harsh conditions, maintaining the stability of desert ecosystems.

#### 4.2 The relationship between genome stability and climate change

Climate change is a serious environmental problem currently facing the world, which has a direct impact on grassland ecosystems. There is a close relationship between genome stability and climate change, as grassland plants need to adapt to changing temperatures, precipitation, and seasonal changes. In the context of climate change, plants with higher genome stability may be more likely to adapt to new climate conditions (Snowdon et al., 2021).

Some alpine plants, such as *Leontopodium japonicum*, live in extremely cold and high altitude environments (Figure 2). Their genomic stability enables them to cope with the challenges of rising temperatures and snowlines. These plants may exhibit adaptive evolution, such as developing longer roots to obtain more water, or adjusting flowering time to adapt to temperature changes. Therefore, genome stability helps plants maintain their survival and reproductive ability under climate change conditions.



Figure 2 Thin snow grass in a high altitude environment

#### 4.3 Strategies for coping with genome stability and habitat destruction

Habitat destruction is another factor that threatens grassland ecosystems, including human activities such as land development, deforestation, and urban expansion. Genome stability plays a crucial role in plant survival and ecosystem restoration in the face of habitat destruction.

Some plant species have high genome stability, allowing them to rebuild populations after habitat destruction. For example, willows are a type of plant whose genome stability allows them to reoccupy land through dispersal and reproduction after land destruction. This is crucial for the restoration of ecosystems after habitat destruction, as these plants can quickly establish stable vegetation, maintain soil stability, reduce erosion, and attract other biological communities to return.

In addition, some plants with strong genome stability may have the potential for pollution resistance and soil remediation. They can help ecosystems combat pollution and habitat destruction by absorbing harmful substances, degrading pollutants, or improving soil quality. These plants can serve as important tools for ecosystem management and restoration, helping to reduce environmental pressure and improve ecosystem stability.

### 5 Application in Ecosystem Management and Protection

The research and application of genome stability have broad potential value for ecosystem management and biodiversity conservation. It provides us with a deeper understanding of the stability and resilience of ecosystems,

helping to develop more effective protection and management strategies to maintain the rich biodiversity and ecosystem health on Earth.

### 5.1 Genome stability and ecosystem restoration

The understanding and application of genome stability are crucial for ecosystem restoration. Ecosystem restoration refers to efforts to repair or rebuild ecosystems that have been disturbed or damaged in order to restore their health and function. Genome stability can play multiple roles in ecosystem restoration.

Understanding the genome stability of plant species can help ecologists and conservation experts choose plant species suitable for restoration projects. Plants with higher genome stability are more likely to survive and reproduce under harsh conditions, so they are usually more reliable tools for ecosystem restoration (Trivedi et al., 2020; Yang et al., 2021). If it is necessary to restore a wetland ecosystem affected by salinization, selecting plants with adaptability to saline alkali environments, such as *Suaeda glauca*, can improve the chances of successful restoration.

The study of genome stability helps to understand the adaptive evolution of plants during ecosystem restoration. After introducing plant species for restoration, long-term monitoring and genome analysis can reveal how plants adapt to new environments. This helps improve recovery strategies to better support plant survival and reproduction, and ultimately promote the restoration of the entire ecosystem.

### 5.2 Application of genome stability in natural resource management

Genome stability also has potential application value for natural resource management. In forest management, understanding the genome stability of different tree species can help select the most suitable tree species for specific environmental conditions, in order to improve the growth and disease and pest resistance of trees. This contributes to sustainable forest management and the protection of timber resources. In grassland management and animal husbandry, understanding the genome stability of grassland plants can help determine when to graze and when to rest the grassland to maintain its productivity and health. In water resource management, understanding the genome stability of aquatic plants can help manage water quality and restore lake ecosystems. Understanding the genome stability of wetland plants can guide wetland protection and restoration work for wetland and river ecosystems that are resistant to climate change.

### 5.3 Genome stability and conservation of biodiversity

Protecting biodiversity is one of the key goals of global environmental protection today. The study of genome stability can provide new tools and strategies for biodiversity conservation.

Understanding the stability of the genome can help identify and protect key species (Morigengaowa et al., 2019). Species with high genome stability play an important role in the stability and function of ecosystems, so protecting these species can have a positive impact on the entire ecosystem.

The study of genome stability can reveal genetic exchange and gene flow between different species. This helps us understand how the genetic diversity of species is maintained and how measures are taken to protect it in ecosystems.

The application of genome stability can also help manage the spread of invasive and invasive species. Understanding which species have high genome stability can help predict their adaptability and potential invasion risks in new environments.

## 6 Conclusion and Outlook

Genome stability refers to the stable performance of plant genomes against internal and external pressures, while the ecosystem immunity involves their ability to respond to environmental changes and disturbances. Plants with strong genome stability are usually better able to adapt to different niches, reduce competitive pressure, and have a positive impact on ecosystem diversity and function. Genome stability has a profound impact on the functions of ecosystems, including material cycling, energy flow, soil fertility maintenance, and water resource protection.

Plants with strong genome stability are more likely to recover their normal functions after interference, which helps maintain the long-term stability of ecosystems. Genome stability also plays an important role in responding to environmental changes and habitat destruction. Understanding the performance of genome stability under different environmental conditions can help predict the adaptability of plants to climate change and habitat destruction.

Although we have made some important discoveries, there are still many unknown areas that need further research on the relationship between grassland plant genome stability and ecosystem immunity. Further research on the molecular mechanisms underlying genome stability, particularly its performance under different environmental conditions. This will help us gain a deeper understanding of why certain plants have stronger genome stability. Further explore how genome stability affects the stability and function of the entire ecosystem. This can be achieved through long-term field observations and experiments. Study the adaptive evolution of plants under different environmental conditions to better predict and manage the response of ecosystems. Utilizing modern biotechnology such as CRISPR-Cas9, explore the potential applications of genome editing technology to improve the genome stability and immunity of plants.

The study of the relationship between the genome stability of grassland plants and the ecosystem immunity is of great importance for ecology and biodiversity conservation. Understanding the genomic stability of plants helps us better understand the stability and function of ecosystems, providing scientific basis for ecosystem management and protection. These studies not only help us better understand the complexity of nature, but also guide us in more effective management of natural resources, restoration of disturbed ecosystems, and protection of endangered species. In the face of global environmental challenges such as climate change, habitat destruction, and biodiversity loss, research on genome stability provides us with new tools and strategies that help maintain ecological balance on Earth. In the future, we can look forward to more in-depth research on the relationship between genome stability and ecosystem anti-interference ability, as well as the application of these research results in actual ecosystem management and protection, to promote sustainable development of the global ecological environment.

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